

# **EWL C++ Library Reference Manual**

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# Contents

Section number	Title	Page
<b>Chapter 1</b>		
<b>Introduction</b>		
1.1	About the EWL C++ Library Reference Manual.....	53
<b>Chapter 2</b>		
<b>The C++ Library</b>		
2.1	The EWL C++ Library Overview.....	57
2.2	Definitions.....	57
2.2.1	Arbitrary-Positional Stream.....	58
2.2.2	Character.....	58
2.2.3	Character Sequences.....	58
2.2.4	Comparison Function.....	58
2.2.5	Component.....	59
2.2.6	Default Behavior.....	59
2.2.7	Handler Function.....	59
2.2.8	Iostream Class Templates.....	59
2.2.9	Modifier Function.....	59
2.2.10	Object State.....	59
2.2.11	Narrow-oriented Iostream Classes.....	60
2.2.12	NTCTS.....	60
2.2.13	Observer Function.....	60
2.2.14	Replacement Function.....	60
2.2.15	Required Behavior.....	60
2.2.16	Repositional Stream.....	60
2.2.17	Reserved Function.....	61
2.2.18	Traits.....	61
2.2.19	Wide-oriented IOSTREAM Classes.....	61
2.3	Additional Definitions.....	61
2.3.1	Multi-Thread Safety.....	61

Section number	Title	Page
2.3.1.1	EWL C++ Thread Safety Policy.....	62
2.4	Methods of Descriptions.....	63
2.4.1	Structure of each sub-clause.....	63
2.4.2	Other Conventions.....	63
2.4.2.1	Character sequences.....	63
2.4.2.2	Byte strings.....	63
2.4.2.3	Multibyte strings.....	64
2.4.2.4	Wide-character sequences.....	64
2.4.2.5	Functions within classes.....	64
2.4.2.6	Private members.....	64
2.5	Library-wide Requirements.....	65
2.5.1	Library contents and organization.....	65
2.5.1.1	Library Contents.....	65
2.5.1.2	Headers.....	65
2.5.1.3	Freestanding Implementations.....	66
2.5.2	Using the library.....	67
2.5.2.1	Headers.....	67
2.5.2.2	Linkage.....	67
2.5.3	Constraints on programs.....	67
2.5.3.1	Reserved Names.....	67
2.5.3.2	External Linkage.....	68
2.5.3.3	Headers.....	68
2.5.3.4	Derived classes.....	68
2.5.3.5	Replacement Functions.....	68
2.5.3.6	Handler functions.....	69
2.5.3.7	Other functions.....	69
2.5.3.8	Function arguments.....	69
2.5.4	Conforming Implementations.....	70

## Chapter 3

Section number	Title	Page
<b>Language Support Library</b>		
3.1	Types.....	71
3.2	Implementation properties.....	72
3.2.1	Numeric limits.....	72
3.2.2	is_specialized.....	72
3.2.3	min.....	72
3.2.4	max.....	73
3.2.5	digits.....	73
3.2.6	is_signed.....	73
3.2.7	is_integer.....	73
3.2.8	is_exact.....	74
3.2.9	radix.....	74
3.2.10	epsilon.....	74
3.2.11	round_error.....	74
3.2.12	min_exponent.....	75
3.2.13	min_exponent10.....	75
3.2.14	max_exponent.....	75
3.2.15	max_exponent10.....	75
3.2.16	has_infinity.....	76
3.2.17	has_quiet_NaN.....	76
3.2.18	has_signaling_NaN.....	76
3.2.19	has_denorm.....	76
3.2.20	has_denorm_loss.....	77
3.2.21	infinity.....	77
3.2.22	quiet_NaN.....	77
3.2.23	signaling_NaN.....	77
3.2.24	denorm_min.....	78
3.2.25	is_iec559.....	78
3.2.26	is_bounded.....	78

Section number	Title	Page
3.2.27	is_modulo.....	78
3.2.28	traps.....	79
3.2.29	tinyness_before.....	79
3.2.30	round_style.....	79
3.2.31	Type float_round_style.....	79
3.2.32	Type float_denorm_style.....	80
3.2.33	numeric_limits specializations.....	80
3.3	Start and termination.....	81
3.3.1	abort.....	81
3.3.2	atexit.....	82
3.3.3	exit.....	82
3.4	Dynamic Memory Management.....	83
3.4.1	Storage Allocation and Deallocation.....	83
3.4.2	Single Object Forms.....	83
3.4.2.1	operator new.....	83
3.4.2.2	operator delete.....	84
3.4.3	Array Forms.....	84
3.4.3.1	operator new[].....	84
3.4.3.2	operator delete[].....	85
3.4.4	Placement Forms.....	85
3.4.4.1	Placement operator new.....	85
3.4.4.2	Placement operator delete.....	85
3.4.5	Storage Allocation Errors.....	85
3.4.5.1	Class Bad_alloc.....	86
3.4.5.2	Constructor.....	86
3.4.5.3	Assignment Operator.....	86
3.4.5.4	destructor.....	86
3.4.5.5	what.....	86
3.4.5.6	type new_handler.....	87

Section number	Title	Page
3.4.5.7	set_new_handler.....	87
3.5	Type identification.....	87
3.5.1	Class type_info.....	88
3.5.1.1	Constructors.....	88
3.5.1.2	Assignment Operator.....	88
3.5.1.3	operator==.....	88
3.5.1.4	operator!=.....	88
3.5.1.5	before.....	89
3.5.1.6	name.....	89
3.5.2	Class bad_cast.....	89
3.5.2.1	Constructors.....	89
3.5.2.2	Assignment Operator.....	89
3.5.2.3	what.....	90
3.5.3	Class bad_typeid.....	90
3.5.3.1	Constructors.....	90
3.5.3.2	Assignment Operator.....	90
3.5.3.3	what.....	90
3.6	Exception Handling.....	91
3.6.1	Class exception.....	91
3.6.1.1	Constructors.....	91
3.6.1.2	Assignment Operator.....	91
3.6.1.3	destructor.....	91
3.6.1.4	what.....	92
3.6.2	Violating Exception Specifications.....	92
3.6.2.1	Class bad_exception.....	92
3.6.2.1.1	Constructors.....	92
3.6.2.1.2	Assignment Operator.....	92
3.6.2.1.3	what.....	92
3.6.2.1.4	type unexpected_handler.....	93

Section number	Title	Page
3.6.2.1.5	set_unexpected.....	93
3.6.2.1.6	unexpected.....	93
3.7	Abnormal Termination.....	93
3.7.1	type terminate_handler.....	93
3.7.2	set_terminate.....	94
3.7.3	terminate.....	94
3.7.4	uncaught_exception.....	94
3.8	Other Runtime Support.....	95

## Chapter 4 Diagnostics Library

4.1	Exception Classes.....	97
4.1.1	Class logic_error.....	97
4.1.2	Class domain_error.....	98
4.1.3	Class invalid_argument.....	98
4.1.4	Class length_error.....	98
4.1.5	Class out_of_range.....	99
4.1.6	Class runtime_error.....	99
4.1.7	Class range_error.....	99
4.1.8	Class overflow_error.....	100
4.1.9	Class underflow_error.....	100
4.2	Assertions.....	100
4.3	Error Numbers.....	101

## Chapter 5 General Utilities Libraries

5.1	Requirements.....	103
5.1.1	Equality Comparisons.....	103
5.1.2	Less Than Comparison.....	104
5.1.3	Copy Construction.....	104
5.1.4	Default Construction.....	104



Section number	Title	Page
5.1.5	Allocator Requirements.....	104
5.2	Utility Components.....	105
5.2.1	Operators.....	106
5.2.1.1	operator!=.....	106
5.2.1.2	operator>.....	106
5.2.1.3	operator<=.....	106
5.2.1.4	operator>=.....	106
5.3	Pairs.....	107
5.3.1	Constructors.....	107
5.3.2	operator ==.....	107
5.3.3	operator <.....	107
5.3.4	make_pair.....	108
5.4	Function objects.....	108
5.4.1	Arithmetic operations.....	108
5.4.1.1	plus.....	109
5.4.1.2	minus.....	109
5.4.1.3	multiplies.....	109
5.4.1.4	divides.....	110
5.4.1.5	modulus.....	110
5.4.1.6	negate.....	110
5.4.2	Comparisons.....	110
5.4.2.1	equal_to.....	111
5.4.2.2	not_equal_to.....	111
5.4.2.3	greater.....	111
5.4.2.4	less.....	112
5.4.2.5	greater_equal.....	112
5.4.2.6	less_equal.....	112
5.4.3	Logical operations.....	112
5.4.3.1	logical_and.....	113

Section number	Title	Page
5.4.3.2	logical_or.....	113
5.4.3.3	logical_not.....	113
5.4.4	Negators.....	114
5.4.4.1	Unary_negate.....	114
5.4.4.2	binary_negate.....	114
5.4.5	Binders.....	115
5.4.5.1	Template class binder1st.....	115
5.4.5.2	bind1st.....	115
5.4.5.3	Template class binder2nd.....	115
5.4.5.4	bind2nd.....	116
5.4.6	Adaptors for Pointers to Functions.....	116
5.4.6.1	pointer_to_unary_function.....	116
5.4.6.2	class pointer_to_binary_function.....	116
5.4.6.3	pointer_to_binary_function.....	116
5.4.7	Adaptors for Pointers to Members.....	117
5.4.7.1	mem_fun_t.....	117
5.4.7.2	mem_fun1_t.....	117
5.4.7.3	mem_fun.....	118
5.4.7.4	mem_fun_ref_t.....	118
5.4.7.5	mem_fun1_ref_t.....	118
5.4.7.6	mem_fun_ref.....	118
5.4.7.7	const_mem_fun_t.....	119
5.4.7.8	const_mem_fun1_t.....	119
5.4.7.9	const_mem_fun_ref_t.....	120
5.4.7.10	const_mem_fun1_ref_t.....	120
5.5	Memory.....	120
5.5.1	allocator members.....	120
5.5.1.1	address.....	121
5.5.1.2	allocate.....	121

Section number	Title	Page
5.5.1.3	deallocate.....	121
5.5.1.4	max_size.....	121
5.5.1.5	construct.....	122
5.5.1.6	destroy.....	122
5.5.2	allocator globals.....	122
5.5.2.1	operator==.....	122
5.5.2.2	operator!=.....	123
5.5.3	Raw storage iterator.....	123
5.5.3.1	Constructors.....	123
5.5.3.2	operator *.....	124
5.5.3.3	operator=.....	124
5.5.3.4	operator++.....	124
5.5.4	Temporary buffers.....	125
5.5.4.1	get_temporary_buffer.....	125
5.5.4.2	return_temporary_buffer.....	125
5.5.5	Specialized Algorithms.....	125
5.5.5.1	uninitialized_copy.....	125
5.5.5.2	uninitialized_fill.....	126
5.5.5.3	uninitialized_fill_n.....	126
5.6	Template Class auto_ptr.....	126
5.6.1	auto_ptr constructors.....	129
5.6.2	operator =.....	129
5.6.3	destructor.....	130
5.6.4	auto_ptr Members.....	130
5.6.5	operator*.....	130
5.6.6	operator->(.....	130
5.6.7	get.....	130
5.6.8	release.....	131
5.6.9	reset.....	131

Section number	Title	Page
5.6.10	auto_ptr conversions.....	131
5.6.10.1	Conversion Constructor.....	131
5.6.10.2	operator auto_ptr_ref.....	132
5.6.11	operator auto_ptr.....	132
5.7	C Library.....	132
5.8	Date and Time.....	132

## Chapter 6 Strings Library

6.1	Character traits.....	135
6.1.1	Character Trait Definitions.....	135
6.1.1.1	character .....	136
6.1.1.2	character container type .....	136
6.1.1.3	traits .....	136
6.1.1.4	NTCTS .....	136
6.1.2	Character Trait Requirements.....	136
6.1.2.1	assign.....	136
6.1.2.2	eq.....	137
6.1.2.3	lt.....	137
6.1.2.4	compare.....	137
6.1.2.5	length.....	137
6.1.2.6	find.....	137
6.1.2.7	move.....	138
6.1.2.8	copy.....	138
6.1.2.9	not_eof.....	138
6.1.2.10	to_char_type.....	138
6.1.2.11	to_int_type.....	138
6.1.2.12	eq_int_type.....	139
6.1.2.13	get_state.....	139
6.1.2.14	eof.....	139

Section number	Title	Page
6.1.3	Character Trait Type Definitions.....	139
6.1.4	struct char_traits<T> .....	140
6.2	String Classes.....	140
6.3	Class basic_string.....	140
6.3.1	Constructors and Assignments.....	141
6.3.1.1	Constructors.....	141
6.3.1.2	Destructor .....	143
6.3.1.3	Assignment Operator.....	143
6.3.1.4	Assignment & Addition Operator basic_string.....	143
6.3.2	Iterator Support.....	144
6.3.2.1	begin.....	144
6.3.2.2	end.....	144
6.3.2.3	rbegin.....	144
6.3.2.4	rend.....	144
6.3.3	Capacity.....	145
6.3.3.1	size.....	145
6.3.3.2	length.....	145
6.3.3.3	max_size.....	145
6.3.3.4	resize.....	145
6.3.3.5	capacity.....	146
6.3.3.6	reserve.....	146
6.3.3.7	clear.....	146
6.3.3.8	empty.....	146
6.3.4	Element Access.....	147
6.3.4.1	operator[].....	147
6.3.4.2	at.....	147
6.3.5	Modifiers.....	147
6.3.5.1	operator+=.....	147
6.3.5.2	append.....	148

Section number	Title	Page
6.3.5.3	assign.....	148
6.3.5.4	insert.....	149
6.3.5.5	erase.....	149
6.3.5.6	replace.....	150
6.3.5.7	copy.....	150
6.3.5.8	swap.....	151
6.3.6	String Operations.....	151
6.3.6.1	c_str.....	151
6.3.6.2	data.....	151
6.3.6.3	get_allocator.....	151
6.3.6.4	find.....	152
6.3.6.5	rfind.....	152
6.3.6.6	find_first_of.....	152
6.3.6.7	find_last_of.....	153
6.3.6.8	find_first_not_of.....	153
6.3.6.9	find_last_not_of.....	154
6.3.6.10	substr.....	154
6.3.6.11	compare.....	155
6.3.7	Non-Member Functions and Operators.....	155
6.3.7.1	operator+.....	155
6.3.7.2	operator==.....	156
6.3.7.3	operator!=.....	157
6.3.7.4	operator<.....	157
6.3.7.5	operator>.....	158
6.3.7.6	operator<=.....	158
6.3.7.7	operator>=.....	159
6.3.7.8	swap.....	159
6.3.8	Inserters and extractors.....	160
6.3.8.1	operator>>.....	160

Section number	Title	Page
6.3.8.2	operator<<.....	160
6.3.8.3	getline.....	161
6.4	Null Terminated Sequence Utilities.....	161
6.4.1	Character Support.....	161
6.4.2	String Support.....	162
6.4.3	Input and Output Manipulations.....	162

## Chapter 7 Localization Library

7.1	Supported Locale Names.....	165
7.2	Strings and Characters in Locale Data Files .....	166
7.2.1	Character Syntax.....	167
7.2.2	Escape sequences.....	167
7.2.3	Errors.....	168
7.2.4	String Syntax.....	168
7.3	Locales.....	169
7.3.1	Class locale.....	169
7.3.1.1	Combined Locale Names.....	170
7.3.2	Locale Types.....	171
7.3.2.1	locale::Category.....	171
7.3.2.2	locale::facet.....	172
7.3.2.3	locale::id.....	172
7.3.2.4	Constructors.....	173
7.3.2.5	destructor.....	173
7.3.3	Locale Members.....	173
7.3.3.1	combine.....	174
7.3.3.2	name.....	174
7.3.4	Locale Operators.....	174
7.3.4.1	operator ==.....	174
7.3.4.2	operator !=.....	175

Section number	Title	Page
7.3.4.3	operator ().....	175
7.3.5	Locale Static Members.....	175
7.3.5.1	global.....	175
7.3.5.2	classic.....	176
7.3.6	Locale Globals.....	176
7.3.6.1	use_facet.....	176
7.3.6.2	has_facet.....	177
7.3.7	Convenience Interfaces.....	177
7.3.8	Character Classification.....	177
7.3.9	Character Conversions.....	177
7.3.9.1	toupper.....	178
7.3.9.2	tolower.....	178
7.4	Standard Locale Categories.....	178
7.4.1	The Ctype Category.....	179
7.4.1.1	Template Class Ctype .....	179
7.4.1.1.1	is.....	180
7.4.1.1.2	scan_is.....	180
7.4.1.1.3	scan_not.....	180
7.4.1.1.4	toupper.....	181
7.4.1.1.5	tolower.....	181
7.4.1.1.6	widen.....	181
7.4.1.1.7	narrow.....	181
7.4.1.2	ctype Virtual Functions.....	182
7.4.1.2.1	do_is.....	182
7.4.1.2.2	do_scan_is.....	182
7.4.1.2.3	do_scan_not.....	182
7.4.1.2.4	do_toupper.....	182
7.4.1.2.5	do_tolower.....	183
7.4.1.2.6	do_widen.....	183



Section number	Title	Page
7.4.1.2.7	do_narrow.....	183
7.4.1.3	Template class ctype_byname.....	183
7.4.1.3.1	ctype_byname Constructor.....	183
7.4.1.3.2	Classification.....	184
7.4.1.3.3	Case Transformation.....	185
7.4.1.4	ctype Specializations.....	188
7.4.1.5	Specialized Ctype Constructor and Destructor.....	189
7.4.1.5.1	Constructor.....	189
7.4.1.5.2	destructor.....	189
7.4.1.5.3	Specialized Ctype Members.....	189
7.4.1.6	ctype<Char> Static Members.....	190
7.4.1.6.1	classic_table.....	190
7.4.1.7	Class ctype_byname<char> .....	190
7.4.1.7.1	ctype_byname<char> Constructor.....	191
7.4.1.8	Template Class Codecvt.....	191
7.4.1.8.1	codecvt Members.....	191
7.4.1.8.1.1	out.....	191
7.4.1.8.1.2	unshift.....	191
7.4.1.8.1.3	in.....	192
7.4.1.8.1.4	always_noconv.....	192
7.4.1.8.1.5	length.....	192
7.4.1.8.1.6	max_length.....	192
7.4.1.8.1.7	codecvt Virtual Functions.....	193
7.4.1.9	Template Class Codecvt_byname.....	194
7.4.1.10	Codecvt_byname Keywords.....	195
7.4.1.10.1	noconv.....	195
7.4.1.10.2	UCS-2.....	195
7.4.1.10.3	JIS.....	195
7.4.1.10.4	Shift-JIS.....	196

Section number	Title	Page
7.4.1.10.5	EUC.....	196
7.4.1.10.6	UTF-8.....	196
7.4.1.11	Extending codecvt by derivation.....	197
7.4.2	The Numeric Category.....	198
7.4.2.1	Template Class Num_get.....	198
7.4.2.2	Num_get Members.....	198
7.4.2.2.1	get.....	198
7.4.2.2.2	Num_get Virtual Functions.....	199
7.4.2.3	Num_put Members.....	200
7.4.2.3.1	put.....	200
7.4.2.3.2	Num_put Virtual Functions.....	200
7.4.2.4	The Numeric Punctuation Facet.....	200
7.4.2.4.1	Numpunct Members.....	201
7.4.2.4.1.1	decimal_point.....	201
7.4.2.4.1.2	thousands_sep.....	201
7.4.2.4.1.3	grouping.....	201
7.4.2.4.1.4	truename.....	201
7.4.2.4.1.5	falsename.....	202
7.4.2.4.1.6	numpunct virtual functions.....	202
7.4.2.4.1.7	Template Class Numpunct_byname.....	202
7.4.2.4.1.8	Numeric_wide.....	205
7.4.2.5	Extending numpunct by derivation.....	205
7.4.3	The Collate Category.....	206
7.4.3.1	Collate Members.....	206
7.4.3.1.1	compare.....	206
7.4.3.1.2	transform.....	207
7.4.3.1.3	hash.....	207
7.4.3.1.4	collate Virtual Functions.....	207
7.4.3.2	Template Class Collate_byname .....	208

Section number	Title	Page
7.4.3.2.1	Collate Data Section.....	208
7.4.3.2.2	Rule Format.....	209
7.4.3.2.3	Text-Argument:.....	209
7.4.3.2.4	Modifier:.....	209
7.4.3.2.5	Relation:.....	209
7.4.3.2.6	Reset:.....	209
7.4.3.2.7	Relationals.....	210
7.4.3.2.8	French collation.....	211
7.4.3.2.9	Contraction.....	211
7.4.3.2.10	Expansion.....	211
7.4.3.2.11	Ignorable Characters.....	212
7.4.3.3	Extending collate by derivation.....	214
7.4.4	The Time Category.....	217
7.4.4.1	Time_get Members.....	217
7.4.4.2	Time_get Virtual Functions.....	218
7.4.4.3	Format Parsing.....	220
7.4.4.4	ISO 8601 week-based year .....	225
7.4.4.5	Template Class Time_get_byname.....	225
7.4.4.6	Time_put Members.....	226
7.4.4.7	Time_put Virtual Functions.....	226
7.4.4.8	Template Class Time_put_byname Synopsis.....	227
7.4.4.9	Extending The Behavior Of The Time Facets.....	227
7.4.4.10	Extending locale by using named locale facilities.....	227
7.4.4.10.1	abbrev_weekday.....	228
7.4.4.10.2	weekday.....	229
7.4.4.10.3	abbrev_monthname.....	229
7.4.4.10.4	monthname.....	229
7.4.4.10.5	date_time.....	229
7.4.4.10.6	am_pm.....	230

Section number	Title	Page
7.4.4.10.7	time_12hour.....	230
7.4.4.10.8	date.....	230
7.4.4.10.9	time.....	230
7.4.4.10.10	time_zone.....	231
7.4.4.10.11	utc_offset.....	231
7.4.4.10.12	default_century.....	231
7.4.4.11	Extending by derivation.....	235
7.4.4.12	Timepunct_byname.....	237
7.4.5	The Monetary Category.....	240
7.4.5.1	A sample Money class.....	241
7.4.5.2	Template Class Money_get.....	246
7.4.5.2.1	Money_get Members.....	247
7.4.5.2.1.1	get.....	247
7.4.5.2.1.2	Money_get Virtual Functions.....	248
7.4.5.3	Template Class Money_put.....	248
7.4.5.3.1	Money_put Members.....	249
7.4.5.3.1.1	put.....	249
7.4.5.3.1.2	Money_put Virtual Functions.....	249
7.4.5.4	Class Moneypunct.....	250
7.4.5.4.1	Moneypunct Members.....	251
7.4.5.4.1.1	decimal_point.....	251
7.4.5.4.1.2	thousands_sep.....	251
7.4.5.4.1.3	grouping.....	252
7.4.5.4.1.4	curr_symbol.....	252
7.4.5.4.1.5	positive_sign.....	252
7.4.5.4.1.6	negative_sign.....	252
7.4.5.4.1.7	frac_digits.....	253
7.4.5.4.1.8	pos_format.....	253
7.4.5.4.1.9	neg_format.....	253

Section number	Title	Page
	7.4.5.4.1.10 Moneypunct Virtual Functions.....	254
7.4.5.5	Extending moneypunct by derivation.....	255
7.4.5.6	Template Class Moneypunct_byname.....	256
7.4.5.7	Data file syntax.....	257
7.4.5.7.1	decimal_point.....	258
7.4.5.7.2	thousands_sep.....	258
7.4.5.7.3	grouping.....	258
7.4.5.7.4	curr_symbol.....	259
7.4.5.7.5	positive_sign.....	259
7.4.5.7.6	negative_sign.....	259
7.4.5.7.7	frac_digits.....	260
7.4.5.7.8	pos_format / neg_format.....	260
7.4.6	The Message Retrieval Category.....	261
7.4.6.1	Messages Members.....	262
7.4.6.1.1	open.....	262
7.4.6.1.2	get.....	263
7.4.6.1.3	close.....	263
7.4.6.1.4	Messages Virtual Functions.....	263
7.4.6.2	EWL C++ implementation of messages.....	264
7.4.6.3	Template Class Messages_byname Synopsis.....	266
7.4.6.4	Extending messages by derivation.....	267
7.4.7	Program-defined Facets.....	269
7.5	C Library Locales.....	269

## Chapter 8 Containers Library

8.1	Container Requirements.....	271
8.1.1	All containers must meet basic requirements.....	271
8.1.2	Unless specified containers meet these requirements.....	272
8.1.3	Sequences Requirements.....	272

Section number	Title	Page
8.1.3.1	Additional Requirements.....	272
8.1.4	Associative Containers Requirements.....	273
8.2	Sequences.....	274
8.2.1	Template Class Deque.....	274
8.2.1.1	Constructors.....	274
8.2.1.2	assign.....	275
8.2.1.3	resize.....	275
8.2.1.4	insert.....	275
8.2.1.5	erase.....	276
8.2.1.6	swap.....	276
8.2.2	Template Class List.....	276
8.2.2.1	Constructors.....	276
8.2.2.2	assign.....	277
8.2.2.3	resize.....	277
8.2.2.4	insert.....	277
8.2.2.5	push_front.....	278
8.2.2.6	push_back.....	278
8.2.2.7	erase.....	278
8.2.2.8	pop_front.....	278
8.2.2.9	pop_back.....	278
8.2.2.10	clear.....	279
8.2.2.11	splice.....	279
8.2.2.12	remove.....	279
8.2.2.13	remove_if.....	279
8.2.2.14	unique.....	280
8.2.2.15	merge.....	280
8.2.2.16	reverse.....	280
8.2.2.17	sort.....	280
8.2.2.18	swap.....	281

Section number	Title	Page
8.2.3	Container Adaptors.....	281
8.2.4	Template Class Queue.....	281
8.2.4.1	operator ==.....	281
8.2.4.2	operator <.....	282
8.2.5	Template Class Priority_queue.....	282
8.2.5.1	Constructors.....	282
8.2.5.2	push.....	282
8.2.5.3	pop.....	283
8.2.6	Template Class Stack.....	283
8.2.6.1	Public Member Functions.....	283
8.2.6.1.1	Constructors.....	283
8.2.6.1.2	empty.....	283
8.2.6.1.3	size.....	284
8.2.6.1.4	top.....	284
8.2.6.1.5	push.....	284
8.2.6.1.6	pop.....	284
8.2.7	Template Class Vector.....	284
8.2.7.1	Constructors.....	285
8.2.7.2	assign.....	285
8.2.7.3	capacity.....	285
8.2.7.4	resize.....	286
8.2.7.5	insert.....	286
8.2.7.6	erase.....	286
8.2.7.7	swap.....	286
8.2.8	Class Vector<bool>.....	287
8.3	Associative Containers.....	287
8.3.1	Template Class Map.....	287
8.3.1.1	Constructors.....	287
8.3.1.2	Map Element Access.....	288

Section number	Title	Page
8.3.1.2.1	operator [].....	288
8.3.1.3	Map Operations.....	288
8.3.1.3.1	find.....	288
8.3.1.3.2	lower_bound.....	288
8.3.1.3.3	upper_bound.....	289
8.3.1.3.4	equal_range.....	289
8.3.1.4	Map Specialized Algorithms.....	289
8.3.1.4.1	swap.....	289
8.3.2	Template Class Multimap.....	290
8.3.2.1	Constructors.....	290
8.3.2.2	Multimap Operations.....	290
8.3.2.2.1	find.....	290
8.3.2.2.2	lower_bound.....	291
8.3.2.2.3	equal_range.....	291
8.3.2.3	Multimap Specialized Algorithms.....	291
8.3.2.3.1	swap.....	291
8.3.3	Template Class Set.....	292
8.3.3.1	Constructors.....	292
8.3.3.2	Set Specialized Algorithms.....	292
8.3.3.2.1	swap.....	292
8.3.4	Template Class Multiset.....	293
8.3.4.1	Constructors.....	293
8.3.4.2	Multiset Specialized Algorithms.....	293
8.3.4.2.1	swap.....	293
8.3.5	Template Class Bitset.....	293
8.3.5.1	Constructors.....	294
8.3.5.2	Bitset Members.....	294
8.3.5.2.1	operator &=.....	294
8.3.5.2.2	operator  =.....	295



Section number	Title	Page
8.3.5.2.3	operator ^=.....	295
8.3.5.2.4	operator <<=.....	295
8.3.5.2.5	operator >>=.....	295
8.3.5.2.6	Set.....	296
8.3.5.2.7	reset.....	296
8.3.5.2.8	operator ~.....	296
8.3.5.2.9	flip.....	297
8.3.5.2.10	to_ulong.....	297
8.3.5.2.11	to_string.....	297
8.3.5.2.12	count.....	297
8.3.5.2.13	size.....	298
8.3.5.2.14	operator ==.....	298
8.3.5.2.15	operator !=.....	298
8.3.5.2.16	test.....	298
8.3.5.2.17	any.....	299
8.3.5.2.18	none.....	299
8.3.5.2.19	operator <<.....	299
8.3.5.2.20	operator >>.....	299
8.3.5.3	Bitset Operators.....	300
8.3.5.3.1	operator &.....	300
8.3.5.3.2	operator  .....	300
8.3.5.3.3	operator ^.....	300
8.3.5.3.4	operator >>.....	301
8.3.5.3.5	operator <<.....	301

## Chapter 9 Iterators Library

9.1	Requirements.....	303
9.1.1	Input Iterators.....	303
9.1.2	Output Iterators.....	304

Section number	Title	Page
9.1.3	Forward Iterators.....	304
9.1.4	Bidirectional Iterators.....	304
9.1.5	Random Access Iterators.....	304
9.2	Header iterator.....	304
9.3	Iterator Primitives.....	305
9.3.1	Iterator Traits.....	305
9.3.2	Basic Iterator.....	305
9.3.3	Standard Iterator Tags.....	306
9.3.4	Iterator Operations.....	306
9.3.4.1	advance.....	306
9.3.4.2	distance.....	306
9.4	Predefined Iterators.....	307
9.4.1	Reverse iterators.....	307
9.4.1.1	Template Class Reverse_iterator.....	307
9.4.1.2	Reverse_iterator Requirements.....	307
9.4.1.3	Constructors.....	307
9.4.1.4	base.....	307
9.4.1.5	Reverse_iterator operators.....	308
9.4.2	Insert Iterators.....	311
9.4.2.1	Class back_insert_iterator.....	311
9.4.2.2	Constructors.....	311
9.4.2.2.1	operator =.....	311
9.4.2.3	Back_insert_iterator Operators.....	311
9.4.2.3.1	Operator *.....	311
9.4.2.3.2	Operator ++.....	312
9.4.2.4	back_inserter.....	312
9.4.3	Template Class Front_insert_iterator.....	312
9.4.3.1	Constructors.....	312
9.4.3.2	Front_insert_iterator operators.....	313

Section number	Title	Page
9.4.3.3	front_inserter.....	313
9.4.4	Template Class Insert_iterator.....	314
9.4.4.1	Constructors.....	314
9.4.4.2	Insert_iterator Operators.....	314
9.4.4.3	inserter.....	315
9.5	Stream Iterators.....	315
9.5.1	Template Class Istream_iterator.....	315
9.5.1.1	Constructors.....	315
9.5.1.2	destructor.....	316
9.5.1.3	Istream_iterator Operations.....	316
9.5.2	Template Class Ostream_iterator.....	317
9.5.2.1	Constructors.....	317
9.5.2.2	destructor.....	317
9.5.2.3	Ostream_iterator Operators.....	317
9.5.3	Template Class Istreambuf_iterator.....	318
9.5.3.1	Constructors.....	318
9.5.3.2	Istreambuf_iterator Operators.....	318
9.5.3.3	equal.....	319
9.5.4	Template Class Ostreambuf_iterator.....	319
9.5.4.1	Constructors.....	320
9.5.4.2	Ostreambuf_iterator Operators.....	320
9.5.4.3	failed.....	320
9.6	_EWL_RAW_ITERATORS.....	321

## Chapter 10 Algorithms Library

10.1	Header algorithm.....	323
10.1.1	Non-modifying Sequence Operations.....	323
10.1.1.1	for_each.....	323
10.1.1.2	find.....	324

Section number	Title	Page
10.1.1.3	find_if.....	324
10.1.1.4	find_end.....	324
10.1.1.5	find_first_of.....	325
10.1.1.6	adjacent_find.....	325
10.1.1.7	count.....	326
10.1.1.8	count_if.....	326
10.1.1.9	mismatch.....	326
10.1.1.10	equal.....	327
10.1.1.11	search.....	327
10.1.1.12	search_n.....	328
10.1.2	Mutating Sequence Operators.....	328
10.1.2.1	copy.....	328
10.1.2.2	copy_backward.....	328
10.1.2.3	swap.....	329
10.1.2.4	swap_ranges.....	329
10.1.2.5	iter_swap.....	329
10.1.2.6	transform.....	330
10.1.2.7	replace.....	330
10.1.2.8	replace_copy.....	330
10.1.2.9	replace_copy_if.....	331
10.1.2.10	fill.....	331
10.1.2.11	fill_n.....	331
10.1.2.12	generate.....	332
10.1.2.13	generate_n.....	332
10.1.2.14	remove.....	332
10.1.2.15	remove_if.....	333
10.1.2.16	remove_copy.....	333
10.1.2.17	remove_copy_if.....	333
10.1.2.18	unique.....	334

Section number	Title	Page
10.1.2.19	unique_copy.....	334
10.1.2.20	reverse.....	334
10.1.2.21	reverse_copy.....	335
10.1.2.22	rotate.....	335
10.1.2.23	rotate_copy.....	335
10.1.2.24	random_shuffle.....	336
10.1.2.25	partition.....	336
10.1.2.26	stable_partition.....	336
10.1.3	Sorting And Related Operations.....	337
10.1.3.1	sort.....	337
10.1.3.2	stable_sort.....	337
10.1.3.3	partial_sort.....	338
10.1.3.4	partial_sort_copy.....	338
10.1.3.5	nth_element.....	339
10.1.3.6	lower_bound.....	339
10.1.3.7	upper_bound.....	339
10.1.3.8	equal_range.....	340
10.1.3.9	binary_search.....	340
10.1.3.10	merge.....	340
10.1.3.11	inplace_merge.....	341
10.1.3.12	includes.....	341
10.1.3.13	set_union.....	342
10.1.3.14	set_intersection.....	342
10.1.3.15	set_difference.....	343
10.1.3.16	set_symetric_difference.....	343
10.1.3.17	push_heap.....	344
10.1.3.18	pop_heap.....	344
10.1.3.19	make_heap.....	344
10.1.3.20	sort_heap.....	345

Section number	Title	Page
10.1.3.21	min.....	345
10.1.3.22	max.....	345
10.1.3.23	min_element.....	346
10.1.3.24	max_element.....	346
10.1.3.25	lexicographical_compare.....	347
10.1.3.26	next_permutation.....	347
10.1.3.27	prev_permutation.....	347
10.1.4	C library algorithms.....	348
10.1.4.1	bsearch.....	348
10.1.4.2	qsort.....	348

## Chapter 11 Numerics Library

11.1	Numeric type requirements.....	351
11.2	Numeric arrays.....	352
11.2.1	Template Class Valarray.....	352
11.2.1.1	Constructors.....	352
11.2.1.2	Destructor.....	353
11.2.1.3	Assignment Operator.....	353
11.2.1.4	operator[].....	354
11.2.1.5	operator[].....	354
11.2.1.6	valarray unary operators.....	354
11.2.1.7	Valarray Computed Assignment.....	355
11.2.2	Valarray Member Functions.....	356
11.2.2.1	size.....	356
11.2.2.2	sum.....	357
11.2.2.3	min.....	357
11.2.2.4	max.....	357
11.2.2.5	shift.....	358
11.2.2.6	cshift.....	358

Section number	Title	Page
11.2.2.7	apply.....	358
11.2.2.8	resize.....	358
11.2.3	Valarray Non-member Operations.....	359
11.2.3.1	Valarray Binary Operators.....	359
11.2.3.2	Valarray Logical Operators.....	360
11.2.4	Non-member logical operations.....	360
11.2.4.1	valarray transcendentals.....	361
11.2.5	Class slice.....	362
11.2.5.1	Constructors.....	362
11.2.5.2	slice access functions.....	363
11.2.5.2.1	start.....	363
11.2.5.2.2	size.....	363
11.2.5.2.3	stride.....	363
11.2.6	Template Class Slice_array .....	363
11.2.6.1	Constructors.....	364
11.2.6.2	Assignment Operator.....	364
11.2.6.3	slice_array computed assignment.....	364
11.2.6.4	Slice_array Fill Function.....	364
11.2.7	Class Gslice.....	365
11.2.7.1	Constructors.....	365
11.2.7.2	Gslice Access Functions.....	365
11.2.7.2.1	start.....	365
11.2.7.2.2	size.....	365
11.2.7.2.3	stride.....	366
11.2.8	Template Class Gslice_array.....	366
11.2.8.1	Constructors.....	366
11.2.8.2	Assignment Operators.....	366
11.2.8.3	Gslice_array Computed Assignment.....	367
11.2.8.4	Fill Function.....	367

Section number	Title	Page
11.2.9	Template Class Mask_array .....	367
11.2.9.1	Constructors.....	367
11.2.9.2	Assignment Operators.....	368
11.2.9.3	Mask_array Computed Assignment.....	368
11.2.9.4	Mask_array Fill Function.....	368
11.2.10	Template Class Indirect_array.....	369
11.2.10.1	Constructors.....	369
11.2.10.2	Assignment Operators.....	369
11.2.10.3	Indirect_array Computed Assignment.....	369
11.2.10.4	indirect_array fill function.....	370
11.3	Generalized Numeric Operations.....	370
11.3.1	Header <numeric>.....	370
11.3.1.1	accumulate.....	370
11.3.1.2	inner_product.....	371
11.3.1.3	partial_sum.....	371
11.3.1.4	adjacent_difference.....	372
11.4	C Library.....	372
11.4.1	<cmath> .....	372
11.4.2	<cstdlib>.....	373

## Chapter 12 Complex Class

12.1	Header complex.....	375
12.1.1	_EWL_CX_LIMITED_RANGE.....	375
12.1.2	Header <complex> forward declarations.....	376
12.2	Complex Specializations.....	376
12.3	Complex Template Class.....	376
12.3.1	Constructors and Assignments.....	377
12.3.1.1	Constructors.....	377
12.3.2	Complex Member Functions.....	377



Section number	Title	Page
12.3.2.1	real.....	378
12.3.2.2	imag.....	378
12.3.3	Complex Class Operators.....	378
12.3.4	Overloaded Operators and Functions.....	380
12.3.4.1	Overloaded Complex Operators.....	380
12.3.5	Complex Value Operations.....	382
12.3.5.1	real.....	383
12.3.5.2	imag.....	383
12.3.5.3	abs.....	383
12.3.5.4	arg.....	383
12.3.5.5	norm.....	384
12.3.5.6	conj.....	384
12.3.5.7	polar.....	384
12.3.6	Complex Transcendentals.....	385
12.3.6.1	cos.....	385
12.3.6.2	cosh.....	385
12.3.6.3	exp.....	386
12.3.6.4	log.....	386
12.3.6.5	log10.....	386
12.3.6.6	pow.....	387
12.3.6.7	sin.....	387
12.3.6.8	sinh.....	387
12.3.6.9	sqrt.....	387
12.3.6.10	tan.....	388
12.3.6.11	tanh.....	388

## Chapter 13 Input and Output Library

13.1	Input and Output Library Summary.....	389
13.2	Iostreams requirements.....	389

Section number	Title	Page
13.2.1	Definitions.....	390
13.2.2	Type requirements.....	390
13.2.3	Type SZ_T.....	390

## Chapter 14 Forward Declarations

14.1	The Streams and String Forward Declarations.....	391
14.2	Header iosfwd.....	391
14.3	Header stringfwd.....	391

## Chapter 15 Iostream Objects

15.1	Header iostream.....	395
15.1.1	Stream Buffering.....	395
15.2	The Standard Input and Output Stream Library.....	396
15.2.1	Narrow stream objects.....	396
15.2.1.1	istream cin.....	396
15.2.1.2	ostream cout.....	397
15.2.1.3	ostream cerr.....	397
15.2.1.4	ostream clog.....	397
15.2.2	Wide stream objects.....	398
15.2.2.1	wistream wcin.....	398
15.2.2.2	wostream wcout.....	398
15.2.2.3	wostream wcerr.....	398
15.2.2.4	wostream wclog.....	399

## Chapter 16 Iostreams Base Classes

16.1	Header ios.....	401
16.1.1	Template Class fpos.....	401
16.2	Typedef Declarations.....	402
16.3	Class ios_base.....	402
16.3.1	Typedef Declarations.....	403

Section number	Title	Page
16.3.2	Class ios_base::failure.....	403
16.3.2.1	failure.....	403
16.3.2.2	failure::what.....	403
16.3.3	Type fmtflags.....	403
16.3.4	Type iostate.....	404
16.3.5	Type openmode.....	405
16.3.6	Type seekdir.....	405
16.3.7	Class Init.....	406
16.3.7.1	Class Init Constructor.....	406
16.3.7.2	Destructor.....	406
16.3.8	ios_base fmtflags state functions.....	406
16.3.8.1	flags.....	407
16.3.8.2	setf.....	409
16.3.8.3	unsetf.....	410
16.3.8.4	precision.....	411
16.3.8.5	width.....	412
16.3.9	ios_base locale functions.....	413
16.3.9.1	imbue.....	413
16.3.9.2	getloc.....	413
16.3.10	ios_base storage function.....	414
16.3.10.1	xalloc.....	414
16.3.10.2	word.....	414
16.3.10.3	pword.....	414
16.3.10.4	register_callback.....	415
16.3.10.5	sync_with_stdio.....	415
16.3.11	ios_base .....	416
16.3.11.1	ios_base Constructor.....	416
16.3.11.2	ios_base Destructor.....	416
16.4	Template class basic_ios.....	416

Section number	Title	Page
16.4.1	basic_ios Constructor.....	417
16.4.2	Destructor.....	417
16.4.3	Basic_ios Member Functions.....	418
16.4.3.1	tie.....	418
16.4.3.2	rdbuf.....	419
16.4.3.3	imbue.....	420
16.4.3.4	fill.....	421
16.4.3.5	copyfmt.....	422
16.4.4	basic_ios iostate flags functions.....	422
16.4.4.1	operator bool.....	422
16.4.4.2	operator !.....	422
16.4.4.3	rdstate.....	423
16.4.4.4	clear.....	425
16.4.4.5	setstate.....	426
16.4.4.6	good .....	427
16.4.4.7	eof.....	427
16.4.4.8	fail.....	428
16.4.4.9	bad.....	429
16.4.4.10	exceptions.....	431
16.5	ios_base manipulators.....	431
16.5.1	fmtflags manipulators .....	432
16.5.2	adjustfield manipulators.....	432
16.5.3	basefield manipulators.....	433
16.5.4	floatfield manipulators.....	433
16.5.5	Overloading Manipulators.....	434

## Chapter 17 Stream Buffers

17.1	Stream buffer requirements.....	437
17.2	Class basic_streambuf .....	438

Section number	Title	Page
17.2.1	basic_streambuf Constructor.....	438
17.2.1.1	Destructor.....	439
17.2.2	basic_streambuf Public Member Functions.....	439
17.2.2.1	Locales.....	439
17.2.2.2	basic_streambuf::pubimbue.....	439
17.2.2.3	basic_streambuf::getloc.....	440
17.2.3	Buffer Management and Positioning.....	440
17.2.3.1	basic_streambuf::pubsetbuf.....	440
17.2.3.2	basic_streambuf::pubseekoff.....	441
17.2.3.3	basic_streambuf::pubseekpos.....	442
17.2.3.4	basic_streambuf::pubsync.....	443
17.2.4	Get Area.....	444
17.2.4.1	basic_streambuf::in_avail.....	444
17.2.4.2	basic_streambuf::snextc.....	444
17.2.4.3	basic_streambuf::sbumpc.....	445
17.2.4.4	basic_streambuf::sgetc.....	446
17.2.4.5	basic_streambuf::sgetn.....	447
17.2.5	Putback.....	447
17.2.5.1	basic_streambuf::sputbackc.....	447
17.2.5.2	basic_streambuf::sungetc.....	449
17.2.6	Put Area.....	449
17.2.6.1	basic_streambuf::putc.....	449
17.2.6.2	basic_streambuf::putn.....	450
17.2.6.3	basic_streambuf Protected Member Functions.....	450
17.2.7	Get Area Access.....	451
17.2.7.1	basic_streambuf::eback.....	451
17.2.7.2	basic_streambuf::gptr.....	451
17.2.7.3	basic_streambuf::egptr.....	451
17.2.7.4	basic_streambuf::gbump.....	452

Section number	Title	Page
17.2.7.5	<code>basic_streambuf::setg</code> .....	452
17.2.8	Put Area Access.....	452
17.2.8.1	<code>basic_streambuf::pbase</code> .....	452
17.2.8.2	<code>basic_streambuf::pptr</code> .....	453
17.2.8.3	<code>basic_streambuf::epptr</code> .....	453
17.2.8.4	<code>basic_streambuf::pbump</code> .....	453
17.2.8.5	<code>basic_streambuf::setp</code> .....	453
17.2.9	<code>basic_streambuf</code> Virtual Functions.....	454
17.2.9.1	Locales.....	454
17.2.9.2	<code>basic_streambuf::imbue</code> .....	454
17.2.10	Buffer Management and Positioning.....	454
17.2.10.1	<code>basic_streambuf::setbuf</code> .....	454
17.2.10.2	<code>basic_streambuf::seekoff</code> .....	455
17.2.10.3	<code>basic_streambuf::seekpos</code> .....	455
17.2.10.4	<code>basic_streambuf::sync</code> .....	456
17.2.11	Get Area.....	456
17.2.11.1	<code>basic_streambuf::showmanyc</code> .....	456
17.2.11.2	<code>basic_streambuf::xsgetn</code> .....	456
17.2.11.3	<code>basic_streambuf::underflow</code> .....	457
17.2.11.4	<code>basic_streambuf::uflow</code> .....	457
17.2.12	Putback.....	458
17.2.12.1	<code>basic_streambuf::pbackfail</code> .....	458
17.2.13	Put Area.....	458
17.2.13.1	<code>basic_streambuf::xsputn</code> .....	458
17.2.13.2	<code>basic_streambuf::overflow</code> .....	459

## Chapter 18 Formatting and Manipulators

18.1	Headers.....	461
18.2	Input Streams.....	461

Section number	Title	Page
18.2.1	Template class <code>basic_istream</code> .....	462
18.2.1.1	<code>basic_istream</code> Constructors.....	462
18.2.1.2	Destructor.....	462
18.2.2	Class <code>basic_istream::sentry</code> .....	463
18.2.2.1	Class <code>basic_istream::sentry</code> Constructor.....	463
18.2.2.2	Destructor.....	464
18.2.2.3	<code>sentry::Operator bool</code> .....	464
18.2.3	Formatted input functions.....	464
18.2.3.1	Common requirements.....	464
18.2.3.2	Arithmetic Extractors Operator <code>&gt;&gt;</code> .....	464
18.2.3.3	<code>basic_istream</code> extractor operator <code>&gt;&gt;</code> .....	465
18.2.3.4	Overloading Extractors.....	467
18.2.4	Unformatted input functions.....	469
18.2.4.1	<code>basic_istream::gcount</code> .....	470
18.2.4.2	<code>basic_istream::get</code> .....	471
18.2.4.2.1	Remarks .....	472
18.2.4.3	<code>basic_istream::getline</code> .....	473
18.2.4.4	<code>basic_istream::ignore</code> .....	475
18.2.4.5	<code>basic_istream::peek</code> .....	476
18.2.4.6	<code>basic_istream::read</code> .....	477
18.2.4.7	<code>basic_istream::readsome</code> .....	478
18.2.4.8	<code>basic_istream::putback</code> .....	479
18.2.4.9	<code>basic_istream::unget</code> .....	481
18.2.4.10	<code>basic_istream::sync</code> .....	482
18.2.4.11	<code>basic_istream::tellg</code> .....	483
18.2.4.12	<code>basic_istream::seekg</code> .....	483
18.2.5	Standard <code>basic_istream</code> manipulators.....	485
18.2.5.1	<code>basic_ifstream::ws</code> .....	485
18.2.5.2	<code>basic_iostream</code> Constructor.....	487

Section number	Title	Page
18.2.5.2.1	Destructor.....	487
18.3	Output streams.....	487
18.3.1	Template class basic_ostream.....	487
18.3.1.1	basic_ostream Constructor.....	488
18.3.1.2	Destructor.....	488
18.3.2	Class basic_ostream::sentry.....	489
18.3.2.1	Class basic_ostream::sentry Constructor.....	489
18.3.2.2	Destructor.....	489
18.3.2.3	sentry::Operator bool.....	490
18.3.3	Formatted output functions.....	490
18.3.3.1	Common requirements.....	490
18.3.3.2	Arithmetic Inserter Operator <<.....	490
18.3.3.3	basic_ostream::operator<<.....	492
18.3.3.4	Overloading Inserters.....	493
18.3.4	Unformatted output functions.....	495
18.3.4.1	basic_ostream::tellp.....	495
18.3.4.2	basic_ostream::seekp.....	495
18.3.4.3	basic_ostream::put.....	497
18.3.4.4	basic_ostream::write.....	497
18.3.4.5	basic_ostream::flush.....	499
18.3.5	Standard basic_ostream manipulators.....	501
18.3.5.1	basic_ostream:: endl.....	501
18.3.5.2	basic_ostream::ends.....	502
18.3.5.3	basic_ostream::flush.....	503
18.4	Standard manipulators.....	504
18.4.1	Standard Manipulator Instantiations.....	504
18.4.2	resetiosflags.....	505
18.4.3	setiosflags.....	505
18.4.4	setbase.....	506



Section number	Title	Page
18.4.5	setfill.....	507
18.4.6	setprecision.....	507
18.4.7	setw.....	508
18.4.8	Overloaded Manipulator.....	509

## Chapter 19 String Based Streams

19.1	Header <sstream>.....	511
19.2	Template class basic_stringbuf.....	511
19.2.1	basic_stringbuf constructors.....	512
19.2.2	Member functions.....	513
19.2.2.1	basic_stringbuf::str.....	513
19.2.3	Overridden virtual functions.....	514
19.2.3.1	basic_stringbuf::underflow.....	514
19.2.3.2	basic_stringbuf::pbackfail.....	514
19.2.3.3	basic_stringbuf::overflow.....	515
19.2.3.4	basic_stringbuf::seekoff.....	515
19.2.3.5	basic_stringbuf::seekpos.....	516
19.3	Template class basic_istream.....	516
19.3.1	basic_istream Constructor.....	516
19.3.2	Member functions.....	517
19.3.2.1	basic_istream::rdbuf.....	517
19.3.2.2	basic_istream::str.....	518
19.4	Class basic_ostringstream.....	519
19.4.1	basic_ostringstream Constructor.....	519
19.4.2	Member functions.....	520
19.4.2.1	basic_ostringstream::rdbuf.....	520
19.4.2.2	basic_ostringstream::str.....	522
19.5	Class basic_stringstream.....	522
19.5.1	basic_stringstream Constructor.....	523

Section number	Title	Page
19.5.2	Member functions.....	524
19.5.2.1	basic_stringstream::rdbuf.....	524
19.5.2.2	basic_stringstream::str.....	525

## Chapter 20 File Based Streams

20.1	Header fstream.....	527
20.2	File Streams Type Defines.....	527
20.3	Template class basic_filebuf.....	528
20.3.1	basic_filebuf Constructors.....	528
20.3.1.1	Constructor.....	528
20.3.1.2	Destructor.....	529
20.3.2	Member functions.....	529
20.3.2.1	basic_filebuf::is_open.....	529
20.3.2.2	basic_filebuf::open.....	529
20.3.2.3	basic_filebuf::close.....	531
20.3.3	Overridden virtual functions.....	531
20.3.3.1	basic_filebuf::showmanyc.....	531
20.3.3.2	basic_filebuf::underflow.....	532
20.3.3.3	basic_filebuf::pbackfail.....	532
20.3.3.4	basic_filebuf::overflow.....	532
20.3.3.5	basic_filebuf::seekoff.....	533
20.3.3.6	basic_filebuf::seekpos.....	533
20.3.3.7	basic_filebuf::setbuf.....	533
20.3.3.8	basic_filebuf::sync.....	534
20.3.3.9	basic_filebuf::imbue.....	534
20.4	Template class basic_ifstream.....	534
20.4.1	basic_ifstream Constructor.....	534
20.4.2	Member functions.....	535
20.4.2.1	basic_ifstream::rdbuf.....	536

Section number	Title	Page
20.4.2.2	basic_ifstream::is_open.....	536
20.4.2.3	basic_ifstream::open.....	537
20.4.2.4	basic_ifstream::close.....	538
20.5	Template class basic_ofstream.....	538
20.5.1	basic_ofstream Constructors.....	539
20.5.2	Member functions.....	540
20.5.2.1	basic_ofstream::rdbuf.....	540
20.5.2.2	basic_ofstream::is_open.....	541
20.5.2.3	basic_ofstream::open.....	541
20.5.2.4	basic_ofstream::close.....	543
20.6	Template class basic_fstream.....	543
20.6.1	basic_fstream Constructor.....	543
20.6.2	Member Functions.....	544
20.6.2.1	basic_fstream::rdbuf.....	544
20.6.2.2	basic_fstream::is_open.....	545
20.6.2.3	basic_fstream::open.....	546
20.6.2.4	basic_fstream::close.....	547
<b>Chapter 21</b>		
<b>C Library Files</b>		
<b>Chapter 22</b>		
<b>Strstream</b>		
22.1	Header strstream.....	551
22.2	Strstreambuf Class.....	551
22.2.1	Strstreambuf constructors and Destructors.....	552
22.2.1.1	Constructors.....	552
22.2.1.2	Destructor.....	553
22.2.2	Strstreambuf Public Member Functions.....	553
22.2.2.1	freeze.....	553
22.2.2.2	pcount.....	554

Section number	Title	Page
22.2.2.3	str.....	554
22.2.3	Protected Virtual Member Functions.....	555
22.2.3.1	setbuf.....	555
22.2.3.2	seekoff.....	555
22.2.3.3	seekpos.....	556
22.2.3.4	underflow.....	556
22.2.3.5	pbackfail.....	557
22.2.3.6	overflow.....	557
22.3	istream Class.....	558
22.3.1	Constructors and Destructor.....	558
22.3.1.1	Constructors.....	558
22.3.1.2	Destructor.....	559
22.3.2	Public Member Functions.....	559
22.3.2.1	rdbuf.....	559
22.3.2.2	str.....	560
22.4	ostream Class.....	560
22.4.1	Constructors and Destructor.....	560
22.4.1.1	Constructors.....	560
22.4.1.2	Destructor.....	561
22.4.2	Public Member Functions.....	561
22.4.2.1	freeze.....	561
22.4.2.2	pcount.....	562
22.4.2.3	rdbuf.....	563
22.4.2.4	str.....	563
22.5	Strstream Class.....	564
22.5.1	Strstream Types.....	564
22.5.2	Constructors and Destructor.....	564
22.5.2.1	Constructors.....	564
22.5.2.2	Destructor.....	564

Section number	Title	Page
22.5.3	Public Member Functions.....	565
22.5.3.1	freeze.....	565
22.5.3.2	pcount.....	565
22.5.3.3	rdbuf.....	565
22.5.3.4	str.....	566

## Chapter 23 Bitvector Class Library

23.1	Nested types.....	569
23.1.1	allocator_type.....	569
23.1.2	size_type.....	569
23.1.3	difference_type.....	569
23.1.4	value_type.....	570
23.1.5	reference.....	570
23.1.6	const_reference.....	571
23.1.7	iterators and pointers.....	571
23.2	Constructors.....	572
23.2.1	Destructor.....	573
23.2.2	Assignment.....	573
23.3	Capacity.....	574
23.3.1	size.....	574
23.3.2	empty.....	574
23.3.3	capacity.....	574
23.3.4	max_size.....	575
23.3.5	reserve.....	575
23.3.6	get_allocator.....	575
23.4	Iteration.....	576
23.5	Access.....	576
23.5.1	front.....	576
23.6	Insertion.....	577

Section number	Title	Page
23.6.1	push_back.....	577
23.6.2	insert.....	578
23.7	Erase.....	579
23.7.1	pop_back.....	579
23.7.2	clear.....	579
23.7.3	erase.....	579
23.8	Miscellaneous.....	580
23.8.1	resize.....	580
23.8.2	swap.....	580
23.8.3	flip.....	581
23.8.4	invariants.....	581
23.9	Namespace scope functions.....	581

## Chapter 24 EWL\_UTILITY

24.1	Header ewl_utility.....	583
24.2	Basic Compile-Time Transformations.....	584
24.2.1	remove_const.....	584
24.2.2	remove_volatile.....	584
24.2.3	remove_cv.....	585
24.2.4	remove_pointer.....	585
24.2.5	remove_reference.....	586
24.2.6	remove_bounds.....	586
24.2.7	remove_all.....	586
24.3	Type Query.....	587
24.3.1	is_same.....	587
24.4	CV Query.....	587
24.4.1	is_const.....	587
24.4.2	is_volatile.....	587
24.5	Type Classification.....	588

Section number	Title	Page
24.5.1	is_signed / is_unsigned.....	589
24.6	POD classification.....	590
24.7	Miscellaneous.....	591
24.7.1	compile_assert.....	591
24.7.2	array_size.....	591
24.7.3	can_derive_from.....	592
24.7.4	call_traits.....	592
24.7.5	is_empty.....	593
24.7.6	compressed_pair.....	593
24.7.7	alloc_ptr.....	594

## Chapter 25 EWL C++ Debug Mode

25.1	Overview of EWL C++ Debug Mode.....	597
25.1.1	Types of Errors Detected.....	597
25.1.2	How to Enable Debug Mode.....	597
25.2	Debug Mode Implementations.....	598
25.2.1	Debug Mode Containers.....	600
25.2.1.1	deque.....	600
25.2.1.2	list.....	601
25.2.1.3	string.....	601
25.2.1.4	vector.....	602
25.2.1.5	tree-based containers - map, multimap, set, multiset.....	603
25.2.1.6	cdeque.....	604
25.2.1.7	slist.....	605
25.2.1.8	hash-based containers - map, multimap, set, multiset.....	606
25.2.2	Invariants.....	606

## Chapter 26 Hash Libraries

26.1	General Hash Issues.....	609
------	--------------------------	-----

Section number	Title	Page
26.1.1	Introduction.....	609
26.1.2	Namespace Issues.....	610
26.1.2.1	Fully Qualified Reference.....	610
26.1.2.2	Namespace Alias.....	610
26.1.2.3	Using Declaration.....	611
26.1.2.4	Using Directive.....	611
26.1.2.5	Compatibility Headers.....	612
26.1.2.6	Constructors.....	612
26.1.2.7	Iterator Issues.....	613
26.1.2.8	Capacity.....	613
26.1.2.9	insert.....	615
26.1.2.10	insert.....	616
26.1.2.11	erase.....	616
26.1.2.12	Observers.....	617
26.1.2.13	Set Operations.....	617
26.1.2.14	Global Methods.....	618
26.1.3	Incompatibility with Previous versions of Hash Containers.....	619
26.2	Hash_set.....	619
26.2.1	Introduction.....	619
26.2.2	Old Hashset Headers.....	620
26.2.3	Template Parameters.....	620
26.2.4	Nested Types.....	621
26.2.5	Iterator Issues.....	621
26.2.6	hash_set.....	621
26.3	Hash_map.....	621
26.3.1	Introduction.....	622
26.3.2	Old Hashmap Headers.....	622
26.3.3	Template Parameters.....	622
26.3.4	Nested Types.....	623



Section number	Title	Page
26.3.5	Iterator Issues.....	624
26.3.6	Element Access.....	624
26.4	Hash_fun.....	624

## Chapter 27 Metrowerks::threads

27.1	Overview of EWL Threads.....	627
27.2	Mutex and Locks.....	628
27.3	Threads.....	631
27.4	Condition Variables.....	633
27.5	call_once.....	638
27.6	thread_specific_ptr.....	640

## Chapter 28 EWL std::tr1

28.1	Overview of EWL Implementation of Technical Report 1.....	643
28.2	Template class Sig class result_of .....	643
28.2.1	result_of.....	644
28.2.2	Public Members.....	644
28.2.2.1	get_result_type.....	644
28.3	Template class T class reference_wrapper.....	645
28.3.1	reference_wrapper.....	645
28.3.2	Public Member Functions.....	646
28.3.2.1	ref.....	646
28.3.2.2	cref.....	646
28.4	Template class Sig class function.....	646
28.4.1	Constructors Destructors and Assignment Operator.....	647
28.4.1.1	Constructor.....	647
28.4.1.2	Destructor.....	647
28.4.2	Public Member Functions.....	649
28.4.2.1	Member_function.....	649

Section number	Title	Page
28.5	Template class T class shared_ptr.....	649
28.6	Template class T class enable_shared_from_this.....	649
28.6.1	Constructors Destructors and Assignment Operator.....	650
28.6.1.1	Constructor.....	650
28.6.1.2	Destructor.....	650
28.6.2	Public Member Functions.....	651
28.6.2.1	Member_function.....	651
28.7	Template class T0, class T1, ... class T9 class tuple.....	651
28.7.1	Constructors Destructors and Assignment Operator.....	652
28.7.1.1	Constructor.....	652
28.7.1.2	Destructor.....	653
28.7.2	Public Member Functions.....	654
28.7.2.1	Member_function.....	654
28.8	Template bind.....	655
28.8.1	sort predicate.....	660
28.8.2	remove_if predicate.....	661
28.8.3	function.....	662

## Chapter 29 Ewlconfig

29.1	C++ Switches, Flags and Defines.....	665
29.1.1	_CSTD.....	666
29.1.2	_Inhibit_Container_Optimization.....	666
29.1.3	_Inhibit_Optimize_RB_bit.....	666
29.1.4	_EWL_DEBUG.....	667
29.1.5	__ewl_error.....	667
29.1.6	_EWL_ARRAY_AUTO_PTR.....	667
29.1.7	_EWL_CFILE_STREAM.....	667
29.1.8	__EWL_CPP__.....	668
29.1.9	_EWL_EXTENDED_BINDERS.....	668

Section number	Title	Page
29.1.10	<code>_EWL_EXTENDED_PRECISION_OUTP</code> .....	669
29.1.11	<code>_EWL_FORCE_ENABLE_BOOL_SUPPORT</code> .....	669
29.1.12	<code>_EWL_FORCE_ENUMS_ALWAYS_INT</code> .....	670
29.1.13	<code>_EWL_IMP_EXP</code> .....	670
29.1.14	<code>__EWL_LONGLONG_SUPPORT__</code> .....	671
29.1.15	<code>_EWL_MINIMUM_NAMED_LOCALE</code> .....	671
29.1.16	<code>_EWL_NO_BOOL</code> .....	672
29.1.17	<code>_EWL_NO_CONSOLE_IO</code> .....	672
29.1.18	<code>_EWL_NO_CPP_NAMESPACE</code> .....	672
29.1.19	<code>_EWL_NO_EXCEPTIONS</code> .....	672
29.1.20	<code>_EWL_NO_EXPLICIT_FUNC_TEMPLATE_ARG</code> .....	673
29.1.21	<code>_EWL_NO_FILE_IO</code> .....	674
29.1.22	<code>_EWL_NO_IO</code> .....	674
29.1.23	<code>_EWL_NO_LOCALE</code> .....	674
29.1.24	<code>_EWL_NO_REFCOUNT_STRING</code> .....	674
29.1.25	<code>_EWL_NO_VECTOR_BOOL</code> .....	674
29.1.26	<code>_EWL_NO_WCHART</code> .....	675
29.1.27	<code>_EWL_NO_WCHART_LANG_SUPPORT</code> .....	675
29.1.28	<code>_EWL_NO_WCHART_C_SUPPORT</code> .....	675
29.1.29	<code>_EWL_NO_WCHART_CPP_SUPPORT</code> .....	675
29.1.30	<code>_EWL_POSIX_STREAM</code> .....	676
29.1.31	<code>_EWL_WIDE_FILENAME</code> .....	676
29.1.32	<code>_EWL_WFILEIO_AVAILABLE</code> .....	676
29.1.33	<code>_STD</code> .....	677



# Chapter 1

## Introduction

This reference manual describes the contents of the Embedded Warrior Library for C++. The C++ Standard library provides an extensible framework, and contains components for: language support, diagnostics, general utilities, strings, locales, containers, iterators, algorithms, numerics, and input/output. Additionally, EWL C++ offers extra facilities for input/output, threads, and other components.

### 1.1 About the EWL C++ Library Reference Manual

This section describes each chapter in this manual. The various chapter's layout is guided by the ISO (International Organization for Standardization) C++ Standard.

[The EWL C++ Library Overview](#) of this manual describes the language support library that provides components that are required by certain parts of the C++ language, such as memory allocation and exception processing.

[Language Support Library](#) discusses the ANSI/ISO language support library.

[Diagnostics Library](#) elaborates on the diagnostics library that provides a consistent framework for reporting errors in a C++ program, including predefined exception classes.

[General Utilities Libraries](#) discusses the general utilities library, which includes components used by other library elements, such as predefined storage allocator for dynamic storage management.

[Strings Library](#) discusses the strings components provided for manipulating text represented as sequences of type `char`, sequences of type `wchar_t`, or sequences of any other "character-like" type.

[Localization Library](#) covers the localization components extend internationalization support for character classification, numeric, monetary, and date/time formatting and parsing among other things.

[Containers Library](#) discusses container classes: lists, vectors, stacks, and so forth. These classes provide a C++ program with access to a subset of the most widely used algorithms and data structures.

[Iterators Library](#) discusses iterator classes.

[Algorithms Library](#) discusses the algorithms library. This library provides sequence, sorting, and general numerics algorithms.

[The Numerics Library \(clause 26\)](#) discusses the numerics library. It describes numeric arrays, generalized numeric algorithms and facilities included from the ISO C library.

[Complex Class](#) describes the components for complex number types

[Input and Output Library](#) overviews the input and output class libraries.

[The Streams and String Forward Declarations](#) discusses the input and output streams forward declarations.

[The Standard Input and Output Stream Library](#) discusses the initialized input and output objects.

[Iostreams Base Classes](#) discusses the `iostream_base` class.

[Stream Buffers](#) discusses the stream buffer classes.

[Formatting and Manipulators](#) discusses the formatting and manipulator classes.

[String Based Streams](#) discusses the string based stream classes.

[File Based Streams](#) discusses the file based stream classes.

[C Library Files](#) discusses the namespace C Library functions.

[The Strstream Class Library \(Annex D\)](#) discusses the non standard string stream classes.

[Bitvector Class Library](#) discusses the boolean vector class library.

[EWL\\_Utility](#) utilities used for non standard headers.

[Overview of EWL C++ Debug Mode](#) describes the Embedded Warrior Library for C++ debug mode facilities.

[Hash Libraries](#) describes nonstandard "hash" libraries.

[Metrowerks::threads](#) is a reference to threads support in the Embedded Warrior Libraries.

[EWL std::tr1](#) is a reference about items that are proposed for inclusion in the Embedded Warrior Library

[C++ Switches, Flags and Defines](#) is a chapter on the various flags that you can use to create a customized version of the EWL C++ Library





## Chapter 2

# The C++ Library

This chapter is an introduction to the Embedded Warrior Library for C++.

### 2.1 The EWL C++ Library Overview

This section introduces you to the definitions, conventions, terminology, and other aspects of the EWL C++ library.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Definitions](#) standard C++ terminology
- [Additional Definitions](#) additional terminology
- [Multi-Thread Safety](#) multi-threaded policy
- [Methods of Descriptions](#) standard conventions
- [Library-wide Requirements](#) library requirements

### 2.2 Definitions

This section discusses the meaning of certain terms in the EWL C++ library.

- [Arbitrary-Positional Stream](#)
- [Character](#)
- [Character Sequences](#)
- [Comparison Function](#)
- [Component](#)
- [Default Behavior](#)

- [Handler Function](#)
- [Iostream Class Templates](#)
- [Modifier Function](#)
- [Object State](#)
- [Narrow-oriented Iostream Classes](#)
- [NTCTS](#)
- [Observer Function](#)
- [Replacement Function](#)
- [Required Behavior](#)
- [Repositional Stream](#)
- [Reserved Function](#)
- [Traits](#)
- [Wide-oriented Iostream Classes](#)

## 2.2.1 Arbitrary-Positional Stream

A stream that can seek to any position within the length of the stream. An arbitrary-positional stream is also a repositional stream

## 2.2.2 Character

Any object which, when treated sequentially, can represent text. A character can be represented by any type that provides the definitions specified.

## 2.2.3 Character Sequences

A class or a type used to represent a character. A character container class shall be a `POD` type.

## 2.2.4 Comparison Function

An operator function for equality or relational operators.

## 2.2.5 Component

A group of library entities directly related as members, parameters, or return types. For example, a class and a related non-member template function entity would be referred to as a component.

## 2.2.6 Default Behavior

The specific behavior provided by the implementation, for replacement and handler functions.

## 2.2.7 Handler Function

A non-reserved function that may be called at various points with a program through supplying a pointer to the function. The definition may be provided by a C++ program.

## 2.2.8 Iostream Class Templates

Templates that take two template arguments: `charT` and `traits`. `CharT` is a character container class, and `traits` is a structure which defines additional characteristics and functions of the character type.

## 2.2.9 Modifier Function

A class member function other than constructors, assignment, or destructor, that alters the state of an object of the class.

## 2.2.10 Object State

The current value of all non-static class members of an object.

## 2.2.11 Narrow-oriented Iostream Classes

The instantiations of the `iostream` class templates on the character container class. Traditional `iostream` classes are regarded as the narrow-oriented `iostream` classes.

## 2.2.12 NTCTS

Null Terminated Character Type Sequences. Traditional `char` strings are NTCTS.

## 2.2.13 Observer Function

A `const` member function that accesses the state of an object of the class, but does not alter that state.

## 2.2.14 Replacement Function

A non-reserved C++ function whose definition is provided by a program. Only one definition for such a function is in effect for the duration of the program's execution.

## 2.2.15 Required Behavior

The behavior for any replacement or handler function definition in the program replacement or handler function. If a function defined in a C++ program fails to meet the required behavior when it executes, the behavior is undefined.

## 2.2.16 Repositional Stream

A stream that can seek only to a position that was previously encountered.

## 2.2.17 Reserved Function

A function, specified as part of the C++ Standard Library, that must be defined by the implementation. If a C++ program provides a definition for any reserved function, the results are undefined.

## 2.2.18 Traits

A class that encapsulates a set of types and functions necessary for template classes and template functions to manipulate objects of types for which they are instantiated.

## 2.2.19 Wide-oriented IOSTREAM Classes

The instantiations of the `IOSTREAM` class templates on the character container class `wchar_t` and the default value of the traits parameter.

## 2.3 Additional Definitions

The Embedded Warrior Library has one additional definition the docato-extra-info-title Multi-Thread Safetydocato-reference-uri [/projects/CodeWarrior/MCU/EWL-CPP-Reference/topics/EWL170\\_LibIntro.Multi-Thread\\_Safety](/projects/CodeWarrior/MCU/EWL-CPP-Reference/topics/EWL170_LibIntro.Multi-Thread_Safety) Multi-Thread Safety define precautions when used with multi-threaded systems.

### 2.3.1 Multi-Thread Safety

EWL C++ Library is multi-thread safe provided that the operating system supports thread-safe system calls.

Library has locks at appropriate places in the code for thread safety. The locks are implemented as a mutex class -- the implementation of which may differ from platform to platform.

This ensures that the library is MT-Safe internally. For example, if a buffer is shared between two string class objects (via an internal refcount), then only one string object will be able to modify the shared buffer at a given time.

Thus the library will work in the presence of multiple threads in the same way as in single thread provided the user does not share objects between threads or locks between accesses to objects that are shared.

### 2.3.1.1 EWL C++ Thread Safety Policy

EWL C++ is Level-1 thread safe. That is:

- It is safe to simultaneously call const and non-const methods from different threads to distinct objects.
- It is safe to simultaneously call const methods, and methods from different threads to the same object as long as such methods and const methods
  - Are guaranteed to not alter the state of an object
  - Do not invalidate outstanding references or iterators of a container
- It is not safe for different threads to simultaneously access the same object when at least one thread calls non-const methods, or methods that invalidate outstanding references or iterators to the object. The programmer is responsible for using thread synchronization primitives (e.g. mutex) to avoid such situations.

Simultaneous use of allocators such as new and malloc are thread safe.

Simultaneous use of global objects such as cin and cout is not safe. The programmer is responsible for using thread synchronization primitives to avoid such situations. EWL C++ provides an extension to standard C++ (std::mutex) to aid in such code. For example:

#### Listing: EWL Mutex Example

```
#include <iostream>
#include <iomanip>

#include <mutex.h>

std::mutex cout_lock;

int main()
{
    cout_lock.lock();

    std::cout << "The number is " <<

    std::setw(5) << 20 << '\n';

    cout_lock.unlock();
}
```

```
}
```

Note that if only one thread is accessing a standard stream then no synchronization is necessary. For example, one could have one thread handling input from `cin`, and another thread handling output to `cout`, without worrying about mutex objects.

## 2.4 Methods of Descriptions

Conventions used to describe the C++ Standard Library.

### 2.4.1 Structure of each sub-clause

The Embedded Warrior Library descriptions include a short description, notes, remarks, cross-references, and examples of usage.

### 2.4.2 Other Conventions

Some other terminology and conventions used in this reference.

#### 2.4.2.1 Character sequences

- A letter is any of the 26 lowercase or 26 uppercase letters
- The decimal-point character is represented by a period, `.`
- A character sequence is an array object of the types `char`, `unsigned char`, or `signed char`.
- A character sequence can be designated by a pointer value `S` that points to its first element.

#### 2.4.2.2 Byte strings

- A null-terminated byte string, or NTBS, is a character sequence whose highest-addressed element with defined content has the value zero (the terminating null character).

- The length of an NTBS is the number of elements that precede the terminating null character. An empty NTBS has a length of zero.
- The value of an NTBS is the sequence of values of the elements up to and including the terminating null character.
- A static NTBS is an NTBS with static storage duration.

### 2.4.2.3 Multibyte strings

- A null-terminated multibyte string, or NTMBS, is an NTBS that consists of multibyte characters.
- A static NTMBS is an NTMBS with static storage duration.

### 2.4.2.4 Wide-character sequences

- A wide-character sequence is an array object of type `wchar_t`
- A wide character sequence can be designated by a pointer value that designates its first element.
- A null-terminated wide-character string, or NTWCS, is a wide-character sequence whose highest addressed element has the value zero.
- The length of an NTWCS is the number of elements that precede the terminating null wide character.
- An empty NTWCS has a length of zero.
- The value of an NTWCS is the sequence of values of the elements up to and including the terminating null character.
- A static NTWCS is an NTWCS with static storage duration.

### 2.4.2.5 Functions within classes

Some procedures, copy constructors, assignment operators, (non-virtual) destructors or virtual destructors, that can be generated by default may not be described.

### 2.4.2.6 Private members

To simplify understanding, where objects of certain types are required by the external specifications of their classes to store data. The declarations for such member objects are enclosed in a comment that ends with exposition only, as in:



```
// streambuf* sb; exposition only
```

## 2.5 Library-wide Requirements

The requirements that apply to the entire C++ Standard library.

- [Library contents and organization](#)
- [Using the library](#)
- [Constraints on programs](#)
- [Conforming Implementations](#)
- [Reentrancy](#)

### 2.5.1 Library contents and organization

The Embedded Warrior Library is organized in the same fashion as the ANSI/ISO C++ Standard.

#### 2.5.1.1 Library Contents

Definitions are provided for Macros, Values, Types, Templates, Classes, Function and, Objects.

All library entities except macros, operator new and operator delete are defined within the namespace std or `namespace` nested within namespace std.

#### 2.5.1.2 Headers

The components of the EWL C++ Library are declared or defined in various headers.

**Table 2-1. EWL C++ Library headers:**

C++	Headers	C++	Headers
<algorithm>	<bitset>	<complex>	<deque>
<exception>	<fstream>	<functional>	<iomanip>

*Table continues on the next page...*

**Table 2-1. EWL C++ Library headers: (continued)**

C++	Headers	C++	Headers
<ios>	<iosfwd>	<iostream>	<istream>
<iterator>	<limits>	<list>	<locale>
<map>	<memory>	<new>	<numeric>
<ostream>	<queue>	<set>	<sstream>
<stack>	<stdexcept>	<streambuf>	<string>
<typeinfo>	<utility>	<valarray>	<vector>
<b>C Functional</b>	<b>Headers</b>	<b>C Functional</b>	<b>Headers</b>
<cassert>	<cctype>	<cerrno>	<cfloat>
<ciso646>	<climits>	<clocale>	<cmath>
<csetjmp>	<csignal>	<cstdarg>	<cstddef>
<cstdio>	<cstdlib>	<cstring>	<ctime>
<cwchar>	<cwctype>		

Unless noted otherwise, the contents of each C style header `cname` will be the same as that of the corresponding header `name.h`. In the EWL C++ Library the declarations and definitions (except for names which are defined as macros in C) are within namespace scope of the namespace `std`.

**NOTE**

The names defined as macros in C include: `assert`, `errno`, `offsetof`, `setjmp`, `va_arg`, `va_end`, and `va_start`.

### 2.5.1.3 Freestanding Implementations

A freestanding implementation has an implementation-defined set of headers. This set shall include at least the following headers.

**Table 2-2. EWL C++ Freestanding Implementation Headers**

Header	Description
<cstddef>	Types
<limits>	Implementation properties
<cstdlib>	Start and termination
<new>	Dynamic memory management
<typeinfo>	Type identification
<exception>	Exception handling
<cstdarg>	Other runtime support

The Embedded Warrior Library header `<cstdlib>` includes the functions `abort()`, `atexit()`, and `exit()`.

## 2.5.2 Using the library

A description of how a C++ program gains access to the facilities of the C++ Standard Library.

### 2.5.2.1 Headers

A header's contents are made available to a translation unit when it contains the appropriate `#include` preprocessing directive.

A translation unit shall include a header only outside of any external declaration or definition, and shall include the header lexically before the first reference to any of the entities it declares or first defines in that translation unit.

### 2.5.2.2 Linkage

The Embedded Warrior Library for C++ has external "C++" linkage unless otherwise specified

Objects and functions defined in the library and required by a C++ program are included in the program prior to program startup.

## 2.5.3 Constraints on programs

Restrictions on C++ programs that use the facilities of the Embedded Warrior Library for C++.

### 2.5.3.1 Reserved Names

EWL reserves certain sets of names and function signatures for its implementation.

Names that contain a double underscore ( \_ \_ ) or begins with an underscore followed by an upper-case letter is reserved to the EWL library for its use.

Names that begin with an underscore are reserved to the library for use as a name in the global namespace.

User code can safely use macros that are all uppercase characters and underscores, except for leading underscores. Library code will either be in `namespace std` or in `namespace Metrowerks`. Implementation details in `namespace std` will be prefixed by a double underscore or an underscore followed by an uppercase character. Implementation details in `namespace Metrowerks` are nested in a nested namespace, for example:

```
Metrowerks::details
```

### 2.5.3.2 External Linkage

Each name from the Embedded Warrior Library for C declared with external linkage is reserved to the implementation for use as a name with extern "C" linkage, both in `namespace std` and in the global namespace.

### 2.5.3.3 Headers

The behavior of any header file with the same name as a Embedded Warrior Library public or private header is undefined.

### 2.5.3.4 Derived classes

Virtual member function signatures defined for a base class in the C++ Standard Library may be overridden in a derived class defined in the program.

### 2.5.3.5 Replacement Functions

If replacement definition occurs prior to the program startup then replacement functions are allowed.

A C++ program may provide the definition for any of eight dynamic memory allocation function signatures declared in header `<new>`.

### Listing: Dynamic Memory Allocators

```
operator new(size_t)
operator new(size_t, const std::nothrow_t&)

operator new[](size_t)
operator new[](size_t, const std::nothrow_t&)

operator delete(void*)
operator delete(void*, const std::nothrow_t&)

operator delete[](void*)
operator delete[](void*, const std::nothrow_t&)
```

### 2.5.3.6 Handler functions

The EWL C++ library provides default versions of the following handler functions:

```
unexpected_handler
terminate_handler
```

A C++ program may install different handler functions during execution, by supplying a pointer to a function defined in the program or the library as an argument to:

```
set_new_handler
set_unexpected
set_terminate
```

### 2.5.3.7 Other functions

In certain cases the EWL C++ depends on components supplied by a C++ program. If these components do not meet their requirements, the behavior is undefined.

### 2.5.3.8 Function arguments

If a C++ library function is passed incorrect but legal arguments the behavior is undefined.

## 2.5.4 Conforming Implementations

EWL is an ANSI/ISO Conforming implementation as described by the ANSI/ISO Standards in section 17.4.4

## Chapter 3

# Language Support Library

This chapter describes the implicit functions and temporary objects that may be generated during the execution of some C++ programs. It also contains information about the headers for those function, objects and defined types.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Types](#) covers predefined types
- [Implementation properties](#) covers implementation defined properties
- [Start and termination](#) covers functions used for starting and termination of a program
- [Dynamic Memory Management](#) covers operators used for dynamic allocation and release of memory.
- [Type identification](#) covers objects and functions used for runtime type identification.
- [Exception Handling](#) covers objects and functions used for exception handling and errors in exception handling.
- [Other Runtime Support](#) covers variations of the standard C library support functions.

### 3.1 Types

The header `<cstddef>` contains the same types and definitions as the standard C `stddef.h` with the changes shown in the following table.

**Table 3-1. Header `<cstddef>`**

NULL	The <b>macro</b> NULL is an implementation-defined C++ constant value. EWL defines this as 0L.
offsetof	This <b>macro</b> accepts a restricted set of type arguments that shall be a POD structure or a POD union. The result of applying the <code>offsetof</code> macro to a field that is a static data member or a function member is undefined.

*Table continues on the next page...*

**Table 3-1. Header <cstdlib> (continued)**

ptrdiff_t	No change from standard C. An signed integral <b>type</b> large enough to hold the difference between two pointers.
size_t	No change from standard C. An unsigned integral <b>type</b> large enough to hold the result of the sizeof operator.

## 3.2 Implementation properties

The headers <limits>, <climits>, and <float> supply implementation dependent characteristics for fundamental types.

### 3.2.1 Numeric limits

The numeric\_limits component provides a C++ program with information about various properties of the implementation's representation of the fundamental types.

Specializations including floating point and integer types are provided.

- The member `is_specialized` shall be true for specializations of `numeric_limits`.
- Members declared `static const` in the `numeric_limits` template specializations are usable as integral constant expressions.
- Non-fundamental standard types, do not have specializations.

All static members shall be provided but they do not need to be used.

### 3.2.2 is\_specialized

The data member for distinguishing specializations. The default value is false.

```
static const bool is_specialized = false;
```

### 3.2.3 min



The minimum positive normalized value is returned.

```
static T min() throw();
```

### 3.2.4 max

The minimum finite value for floating point types with denormalization.

```
static T max() throw();
```

#### Remarks

The maximum positive normalized value is returned.

### 3.2.5 digits

Designates the number of non-signed digits that can be represented for integral types. The number of radix digits in the mantissa for floating point types

```
static const int digits = 0;
```

### 3.2.6 is\_signed

True if the number is signed.

```
static const bool is_signed = false;
```

### 3.2.7 is\_integer

True if the number is an integer.

## Implementation properties

```
static const bool is_integer = false;
```

### 3.2.8 is\_exact

True if the number is exact.

```
static const bool is_exact = false;
```

#### Remarks

All integer types are exact, but not all floating point types are exact.

### 3.2.9 radix

Specifies the base or radix of the exponent of a floating point type or base of an integral type.

```
static const int radix = 0;
```

### 3.2.10 epsilon

The difference between 1 and the least value greater than 1.

```
static T epsilon() throw();
```

### 3.2.11 round\_error

A function to measure the rounding error.

```
static T round_error() throw();
```

## Remarks

Returns the maximum rounding error.

### 3.2.12 min\_exponent

Holds the minimum exponent so that the radix raised to one less than this would be normalized.

```
static const int min_exponent;
```

### 3.2.13 min\_exponent10

Stores the minimum negative exponent that 10 raised to that power would be a normalized floating point type.

```
static const int min_exponent10 = 0;
```

### 3.2.14 max\_exponent

The maximum positive integer so that the radix raised to the power one less than this is representable.

```
static const int max_exponent = 0;
```

### 3.2.15 max\_exponent10

The maximum positive integer so that the 10 raised to this power is representable.

```
static const int max_exponent10 = 0;
```

### 3.2.16 has\_infinity

True if the type is positive for infinity.

```
static const bool has_infinity = false;
```

### 3.2.17 has\_quiet\_NaN

True if the type has a quiet "Not a Number".

```
static const bool has_quiet_NaN = false;
```

### 3.2.18 has\_signaling\_NaN

True if the type is a signaling "Not a Number".

```
static const bool has_signaling_NaN = false;
```

### 3.2.19 has\_denorm

Distinguishes if the floating point number has the ability to be denormalized.

```
static const float_denorm_style has_denorm = denorm_absent;
```

#### Remarks

The static variable `has_denorm` equals `denorm_present` if the type allows denormalized values. The variable `has_denorm` equals `denorm_absent` if the type does not allow denormalized values. The variable `has_denorm` equals `denorm_indeterminate` if the type is indeterminate for denormalized values.

### 3.2.20 `has_denorm_loss`

Is true if there is a loss of accuracy because of a denormalization loss.

```
static const bool has_denorm_loss = false;
```

### 3.2.21 `infinity`

Determines a positive infinity.

```
static T infinity() throw();
```

#### Remarks

Returns a positive infinity if available.

### 3.2.22 `quiet_NaN`

Determines if there is a quiet "Not a Number".

```
static T quiet_NaN() throw();
```

#### Remarks

Returns a quiet "Not a Number" if available.

### 3.2.23 `signaling_NaN`

Determines if there is a signaling "Not a Number".

```
static T signaling_NaN() throw();
```

## Remarks

Returns a signaling "Not a Number" if available.

### 3.2.24 denorm\_min

Determines the minimum positive denormalized value.

```
static T denorm_min() throw();
```

## Remarks

Returns the minimum positive denormalized value.

### 3.2.25 is\_iec559

The value is true if and only if the type adheres to IEC 559 standard

```
static const bool is_iec559 = false;
```

### 3.2.26 is\_bounded

The value is true if the set of values representable by the type is finite.

```
static const bool is_bounded = false;
```

## Remarks

All predefined data types are bounded.

### 3.2.27 is\_modulo

This value is true if the type is modulo. A type is modulo if it is possible to add two positive numbers and have a result that wraps around to a third number that is less.

```
static const bool is_modulo = false;
```

### Remarks

This value is generally true for unsigned integral types and false for floating point types.

## 3.2.28 traps

The value is true if trapping is implemented for the type.

```
static const bool traps = false;
```

## 3.2.29 tinyness\_before

This value is true if tinyness is detected before rounding.

```
static const bool tinyness_before = false;
```

## 3.2.30 round\_style

This value is the rounding style as a type `float_round_style`.

```
static const float_round_style round_style =  
round_toward_zero;
```

### Remarks

See Also [Floating Point Rounding Styles](#)

### 3.2.31 Type `float_round_style`

An enumerated type in `std` namespace that is used to determine the characteristics for rounding floating point numbers.

**Table 3-2. Floating Point Rounding Styles**

Enumerated Type	Value	Meaning
<code>round_indeterminate</code>	-1	The rounding is indeterminable
<code>round_toward_zero</code>	0	The rounding is toward zero
<code>round_to_nearest</code>	1	Round is to the nearest value
<code>round_toward_infinity</code>	2	The rounding is to infinity
<code>round_toward_neg_infinity</code>	3	The rounding is to negative infinity

### 3.2.32 Type `float_denorm_style`

The presence of denormalization is represented by the `std` namespace enumerated type `float_denorm_style`.

**Table 3-3. Floating Point Denorm Styles**

Enumerated Type	Value	Meaning
<code>denorm_indeterminate</code>	-1	Denormalization is indeterminable
<code>denorm_absent</code>	0	Denormalization is absent
<code>denorm_present</code>	1	Denormalization is present

### 3.2.33 `numeric_limits` specializations

All members have specializations but these values are not required to be meaningful. Any value that is not meaningful is set to 0 or `false`.

#### C Library

The contents of `<climits>` are the same as standard C's `limits.h` and the contents of `<cfloat>` are the same as standard C's `float.h`.

**Table 3-4. Header `<climits>`**

<code>CHAR_BIT</code>	<code>CHAR_MAX</code>	<code>CHAR_MIN</code>	<code>INT_MAX</code>
-----------------------	-----------------------	-----------------------	----------------------

*Table continues on the next page...*



**Table 3-4. Header <climits> (continued)**

INT_MIN	LONG_MAX	LONG_MIN	MB_LEN_MAX
SCHAR_MAX	SCHAR_MIN	SHRT_MAX	SHRT_MIN
UCHAR_MAX	UINT_MAX	ULONG_MAX	USHRT_MAX

The header <float> is the same as standard C float.h

**Table 3-5. Header <float>**

DBL_DIG	DBL_EPSILON	DBL_MANT_DIG
DBL_MAX	DBL_MAX_10_EXP	DBL_MAX_EXP
DBL_MIN	DBL_MIN_10_EXP	DBL_MIN_EXP
FLT_DIG	FLT_EPSILON	FLT_MANT_DIG
FLT_MAX	FLT_MAX_10_EXP	FLT_MAX_EXP
FLT_MIN	FLT_MIN_10_EXP	FLT_MIN_EXP
FLT_RADIX	FLT_ROUNDS	LDBL_DIG
LDBL_EPSILON	LDBL_MANT_DIG	LDBL_MAX
LDBL_MAX_10_EXP	LDBL_MAX_EXP	LDBL_MIN
LDBL_MIN_10_EXP	LDBL_MIN_EXP	

### 3.3 Start and termination

The header <cstdlib> has the same functionality as the standard C header stdlib.h in regards to start and termination functions except for the functions and macros as described below.

**Table 3-6. Start and Termination Differences**

Macro	Value	Meaning
EXIT_FAILURE	1	This macro is used to signify a failed return
EXIT_SUCCESS	0	This macro is used to signify a successful return

The return from the `main` function is ignored on the Macintosh operating system and is returned using the native event processing method on other operating systems.

### 3.3.1 abort

Terminates the Program with abnormal termination.

```
abort(void)
```

#### Remarks

The program is terminated without executing destructors for objects of automatic or static storage duration and without calling the functions passed to `atexit`.

### 3.3.2 atexit

The `atexit` function registers functions to be called when `exit` is called in normal program termination.

```
extern "C" int atexit(void (* f)(void))
extern "C++" int atexit(void (* f)(void))
```

#### Remarks

If there is no handler for a thrown exception `terminate` is called. The registration of at least 32 functions is allowed.

- Functions registered with `atexit` are called in reverse order.
- A function registered with `atexit` before an object of static storage duration will not be called until the object's destruction.
- A function registered with `atexit` after an object of static storage duration is initialized will be called before the object's destruction.

The `atexit()` function returns zero if the registration succeeds, non zero if it fails.

### 3.3.3 exit

Terminates the program with normal cleanup actions.

```
exit(int status)
```

#### Remarks

The function `exit()` has additional behavior in the following order:

- Objects with static storage duration are destroyed and functions registered by calling `atexit` are called.
- Objects with static storage duration are destroyed in the reverse order of construction. If the `main()` function contains no automatic objects control can be transferred to `main()` if an exception thrown is caught in `main()`.
- Functions registered with `atexit` are called
- All open C streams with unwritten buffered data are flushed, closed, including streams associated with `cin` and `cout`. All `tmpfile()` files are removed.
- Control is returned to the host environment.

If `status` is zero or `EXIT_SUCCESS`, a successful termination is returned to the host environment.

If `status` is `EXIT_FAILURE`, an unsuccessful termination is returned to the host environment.

Otherwise the status returned to the host environment is implementation-defined.

## 3.4 Dynamic Memory Management

The header `<new>` defines procedures for the management of dynamic allocation and error reporting of dynamic allocation errors.

### 3.4.1 Storage Allocation and Deallocation

This clause covers storage allocation and deallocation functions and error management.

### 3.4.2 Single Object Forms

Dynamic allocation and freeing of single object data types.

### 3.4.2.1 operator new

Dynamically allocates signable objects.

```
void* operator new (std::size_t size) throw(std::bad_alloc);  
void* operator new (std::size_t size,
```

```
const std::nothrow_t&)throw();
```

#### Remarks

The `nothrow` version of `new` returns a `null pointer` on failure. The normal version throws a `bad_alloc` exception on error.

Returns a pointer to the allocated memory.

### 3.4.2.2 operator delete

Frees memory allocated with `operator new`.

```
void operator delete(void* ptr) throw();  
void operator delete(void* ptr, const std::nothrow_t&  
throw());
```

## 3.4.3 Array Forms

Dynamic allocation and freeing of array based data types.

### 3.4.3.1 operator new[]

Used for dynamic allocation or array based data types.

```
void* operator new[]  
(std::size_t size) throw(std::bad_alloc);  
void* operator new[]  
(std::size_t size, const std::nothrow_t&)throw();
```

## Remarks

The default `operator new` will throw an exception upon failure. The `nothrow` version will return `NULL` upon failure.

### 3.4.3.2 `operator delete[]`

Operator `delete[]` is used in conjunction with `operator new[]` for array allocations.

```
void operator delete[]  
(void* ptr) throw();  
void operator delete[]  
(void* ptr, const std::nothrow_t&) throw();
```

## 3.4.4 Placement Forms

Placement operators are reserved and may not be overloaded by a C++ program.

### 3.4.4.1 Placement operator `new`

Allocates memory at a specific memory address.

```
void* operator new (std::size_t size, void* ptr) throw();  
void* operator new[] (std::size_t size, void* ptr) throw();
```

### 3.4.4.2 Placement operator `delete`

The placement delete operators are used in conjunction with the corresponding placement new operators.

```
void operator delete (void* ptr, void*) throw();  
void operator delete[] (void* ptr, void*) throw();
```

## 3.4.5 Storage Allocation Errors

C++ provides for various objects, functions and types for management of allocation errors.

### 3.4.5.1 Class `Bad_alloc`

A class used to report a failed memory allocation attempt.

### 3.4.5.2 Constructor

Constructs a `bad_alloc` object.

```
bad_alloc() throw();  
bad_alloc(const bad_alloc&) throw();
```

### 3.4.5.3 Assignment Operator

Assigns one `bad_alloc` object to another `bad_alloc` object.

```
bad_alloc& operator=(const bad_alloc&) throw();
```

### 3.4.5.4 destructor

Destroys the `bad_alloc` object.

```
virtual ~bad_alloc() throw();
```

### 3.4.5.5 what

An error message describing the allocation exception.

```
virtual const char* what() const throw();
```

Returns a null terminated byte string "bad\_alloc".

### 3.4.5.6 type new\_handler

The type of a handler function that is called by operator new or operator new[].

```
typedef void (*new_handler)();
```

If new requires more memory allocation, the new\_handler will:

- Allocate more memory and return.
- Throw an exception of type bad\_alloc or bad\_alloc derived class.
- Either call abort or exit.

### 3.4.5.7 set\_new\_handler

Sets the new handler function.

```
new_handler set_new_handler  
(new_handler new_p) throw();
```

Returns zero on the first call and the previous new\_handler upon further calls.

## 3.5 Type identification

The header <typeinfo> defines three types for type identification and type identification errors.

The three classes are:

- [Class type\\_info](#)
- [Class bad\\_cast](#)
- [Class bad\\_typeid](#)

## 3.5.1 Class `type_info`

Class `type_info` contains functions and operations to obtain information about a type.

### 3.5.1.1 Constructors

A private constructor is included to prevent copying of this object.

```
type_info(const type_info& rhs);
```

### 3.5.1.2 Assignment Operator

A private assignment is included to prevent copying of this object.

```
type_info& operator=(const type_info& rhs);
```

### 3.5.1.3 `operator==`

Returns true if types are the same.

```
bool operator==(const type_info& rhs) const;
```

Returns true if the objects are the same type.

### 3.5.1.4 `operator!=`

Compares for inequality.

```
bool operator!=(const type_info& rhs) const;
```

Returns true if the objects are not the same type.



### 3.5.1.5 before

Is true if this object precedes the argument in collation order.

```
bool before(const type_info& rhs) const;
```

Returns true if the `this` pointer precedes the argument the collation order.

### 3.5.1.6 name

Returns the name of the class.

```
const char* name() const;
```

## 3.5.2 Class `bad_cast`

A class for exceptions thrown in runtime casting.

### 3.5.2.1 Constructors

Constructs an object of class `bad_cast`.

```
bad_cast() throw();  
bad_cast(const bad_cast&) throw();
```

### 3.5.2.2 Assignment Operator

Copies an object of class `bad_cast`.

```
bad_cast& operator=(const bad_cast&) throw();
```

### 3.5.2.3 what

An error message describing the casting exception.

```
virtual const char* what() const throw();
```

Returns the null terminated byte string "bad\_cast".

## 3.5.3 Class bad\_typeid

Defines a type used for handling typeid exceptions.

### 3.5.3.1 Constructors

Constructs an object of class bad\_typeid.

```
bad_typeid() throw();  
bad_typeid(const bad_typeid&) throw();
```

### 3.5.3.2 Assignment Operator

Copies a class bad\_typeid object.

```
bad_typeid& operator=(const bad_typeid&) throw();
```

### 3.5.3.3 what

An error message describing the typeid exception.

```
virtual const char* what() const throw();
```

Returns the null terminated byte string "bad\_typeid".

## 3.6 Exception Handling

The header <exception> defines types and procedures necessary for the handling of exceptions.

### 3.6.1 Class exception

A base class for objects thrown as exceptions.

#### 3.6.1.1 Constructors

Constructs an object of the exception class.

```
exception() throw();  
exception(const exception&) throw();
```

#### 3.6.1.2 Assignment Operator

Copies an object of exception class.

```
exception& operator=(const exception&) throw();
```

#### 3.6.1.3 destructor

Destroys an exception object.

```
virtual ~exception() throw();
```

### 3.6.1.4 what

An error message describing the exception.

```
virtual const char* what() const throw();
```

Returns the null terminated byte string "exception".

## 3.6.2 Violating Exception Specifications

Defines objects used for exception violations.

### 3.6.2.1 Class bad\_exception

A type used for information and reporting of a bad exceptions.

#### 3.6.2.1.1 Constructors

Constructs an object of class bad\_exception.

```
bad_exception() throw();  
bad_exception(const bad_exception&) throw();
```

#### 3.6.2.1.2 Assignment Operator

Copies an object of class bad\_exception

```
bad_exception& operator=  
(const bad_exception&) throw();
```

#### 3.6.2.1.3 what

An error message describing the bad exception.

```
virtual const char* what() const throw();
```

Returns the null terminated byte string "bad\_exception".

#### 3.6.2.1.4 type unexpected\_handler

A type of handler called by the `unexpected` function.

```
typedef void (*unexpected_handler)();
```

The `unexpected_handler` calls `terminate()`.

#### 3.6.2.1.5 set\_unexpected

Sets the `unexpected` handler function.

```
unexpected_handler set_unexpected  
(unexpected_handler f) throw();
```

Returns the previous `unexpected_handler`.

#### 3.6.2.1.6 unexpected

Called when a function ends by an exception not allowed in the specifications.

```
void unexpected();
```

May be called directly by the program.

## 3.7 Abnormal Termination

Types and functions used for abnormal program termination.

### 3.7.1 type terminate\_handler

A type of handler called by the function `terminate` when terminating an exception.

```
typedef void (*terminate_handler)();
```

The `terminate_handler` calls `abort()`.

### 3.7.2 `set_terminate`

Sets the function for terminating an exception.

```
terminate_handler set_terminate  
(terminate_handler f) throw();
```

The `terminate_handler` shall not be a null pointer.

The previous `terminate_handler` is returned.

### 3.7.3 `terminate`

A function called when exception handling is abandoned.

```
void terminate();
```

Exception handling may be abandoned by the implementation (for example the default handler) or may be called directly by the program (uncaught exception) among other reasons. These errors in the exception handling mechanism are handled using `terminate`.

### 3.7.4 `uncaught_exception`

Determines an uncaught exception.

```
bool uncaught_exception();
```

Throwing an exception while `uncaught_exception` is true can result in a call of `terminate`.

Returns true if an exception is uncaught.

## 3.8 Other Runtime Support

The C++ headers `<cstdarg>`, `<csetjmp>`, `<ctime>`, `<csignal>` and `<cstdlib>` contain macros, types and functions that vary from the corresponding standard C headers.

**Table 3-7. Header `<cstdarg>`**

<code>va_arg</code>	A macro used in C++ Runtime support
<code>va_end</code>	A macro used in C++ Runtime support
<code>va_start</code>	A macro used in C++ Runtime support
<code>va_list</code>	A type used in C++ Runtime support

If the second parameter of `va_start` is declared with a function, array, reference type or with a type for which there is no parameter, the behavior is undefined

**Table 3-8. Header `<csetjmp>`**

<code>setjmp</code>	A macro used in C++ Runtime support
<code>jmp_buf</code>	A type used in C++ Runtime support
<code>longjmp</code>	A function used in C++ Runtime support

The function `longjmp` is more restricted than in the standard C implementation.

**Table 3-9. Header `<ctime>`**

<code>CLOCKS_PER_SEC</code>	A macro used in C++ Runtime support
<code>clock_t</code>	A type used in C++ Runtime support
<code>clock</code>	A function used in C++ Runtime support

If a signal handler attempts to use exception handling the result is undefined.

**Table 3-10. Header `<csignal>`**

<code>SIGABRT</code>	A macro used in C++ Runtime support
<code>SIGILL</code>	A macro used in C++ Runtime support
<code>SIGSEGV</code>	A macro used in C++ Runtime support
<code>SIG_DFL</code>	A macro used in C++ Runtime support
<code>SIG_IGN</code>	A macro used in C++ Runtime support
<code>SIGFPE</code>	A macro used in C++ Runtime support
<code>SIGINT</code>	A macro used in C++ Runtime support
<code>SIGTERM</code>	A macro used in C++ Runtime support
<code>SIG_ERR</code>	A macro used in C++ Runtime support

*Table continues on the next page...*

**Table 3-10. Header <csignal> (continued)**

sig_atomic_t	A macro used in C++ Runtime support
raise	A type used in C++ Runtime support
signal	A function used in C++ Runtime support

**NOTE**

All signal handlers should have C linkage.

**Table 3-11. Header <cstdlib>**

getenv	A function used in C++ Runtime support
system	A function used in C++ Runtime support



## Chapter 4

# Diagnostics Library

This chapter describes objects and facilities used to report error conditions.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Exception Classes](#)
- [Assertions](#)
- [Error Numbers](#)

### 4.1 Exception Classes

The library provides for exception classes for use with logic errors and runtime errors. Logic errors in theory can be predicted in advance while runtime errors can not. The header `<stdexcept>` predefines several types of exceptions for C++ error reporting.

There are nine exception classes.

- [Class Logic\\_error](#)
- [Class domain\\_error](#)
- [Class Invalid\\_argument](#)
- [Class Length\\_error](#)
- [Class Out\\_of\\_range](#)
- [Class Runtime\\_error](#)
- [Class Range\\_error](#)
- [Class Overflow\\_error](#)
- [Class Underflow\\_error](#)

### 4.1.1 Class `logic_error`

The `logic_error` class is derived from the [Class `exception`](#) and is used for exceptions that are detectable before program execution.

#### Constructors

```
logic_error(const string& what_arg);
```

Constructs an object of class `logic_error`. Initializes `exception::what` to the `what_arg` argument.

### 4.1.2 Class `domain_error`

A derived class of logic error the `domain_error` object is used for exceptions of domain errors.

#### Constructors

```
domain_error(const string& what_arg);
```

Constructs an object of `domain_error`. Initializes `exception::what` to the `what_arg` argument

### 4.1.3 Class `invalid_argument`

A derived class of `logic_error` the `invalid_argument` is used for exceptions of invalid arguments.

#### Constructors

```
invalid_argument(const string& what_arg);
```

Constructs an object of class `invalid_argument`. Initializes `exception::what` to the `what_arg` argument

### 4.1.4 Class `length_error`

A derived class of `logic_error` the `length_error` is use to report exceptions when an object exceeds allowed sizes.

#### Constructors

```
length_error(const string& what_arg);
```

Constructs an object of class `length_error`. Initializes `exception::what` to the `what_arg` argument

### 4.1.5 Class `out_of_range`

A derived class of `logic_error` an object of `out_of_range` is used for exceptions for out of range errors.

#### Constructors

```
out_of_range(const string& what_arg);
```

Constructs an object of the class `out_of_range`. Initializes `exception::what` to the `what_arg` argument

### 4.1.6 Class `runtime_error`

Derived from the [class `exception`](#) the `runtime_error` object is used to report errors detectable only during runtime.

#### Constructors

Constructs an object of the class `runtime_error`. Initializes `exception::what` to the `what_arg` argument

### 4.1.7 Class `range_error`

## Assertions

Derived from the `runtime_error` class, an object of `range_error` is used for exceptions due to runtime out of range errors.

### Constructors

```
runtime_error(const string& what_arg);  
range_error(const string& what_arg);
```

Constructs an object of the class `range_error`. Initializes `exception::what` to the `what_arg` argument

## 4.1.8 Class `overflow_error`

The `overflow_error` object is derived from the class `runtime_error` and is used to report arithmetical overflow errors.

### Constructors

```
overflow_error(const string& what_arg);
```

Constructs an object of the class `overflow_error`. Initializes `exception::what` to the `what_arg` argument

## 4.1.9 Class `underflow_error`

The class `underflow_error` is derived from the class `runtime_error` and is used to report the arithmetical underflow error.

### Constructors

```
underflow_error(const string& what_arg);
```

Constructs an object of the class `underflow_error`. Initializes `exception::what` to the `what_arg` argument

## 4.2 Assertions

The header `<cassert>` provides for the `assert` macro and is used the same as the standard C header `assert.h`.

### 4.3 Error Numbers

The header `<cerrno>` provides macros: `EDOM`, `ERANGE` and `errno` to be used for domain and range errors reported by using the `errno` facility. The `<cerrno>` header is used the same as standard C header `errno.h`.



## Chapter 5

# General Utilities Libraries

This clause describes components used by other elements of the Standard C++ library. These components may also be used by C++ programs.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Requirements](#)
- [Utility Components](#)
- [Pairs](#)
- [Function objects](#)
- [Memory](#)
- [Template Class Auto\\_ptr](#)
- [C Library](#)
- [Date and Time](#)

### 5.1 Requirements

This section describes the requirements for template arguments, types used to instantiate templates and storage allocators used as general utilities.

#### 5.1.1 Equality Comparisons

The equality comparison operator is required. The `(==)` expression has a `bool` return type and specifies that for `x == y` and `y == z` that `x` will equal `z`. In addition the reciprocal is also true. That is, if `x == y` then `y` equals `x`. Also if `x == y` and `y == z` then `z` will be equal to `x`.

## 5.1.2 Less Than Comparison

A less than operator is required. The `(<)` expression has a `bool` return type and states that if `x < y` that `x` is less than `y` and that `y` is not less than `x`.

## 5.1.3 Copy Construction

A copy constructor for the general utilities library has the following requirements:

- If the copy constructor is `TYPE(t)` then the argument must be an equivalent of `TYPE`.
- If the copy constructor is `TYPE(const t)` then the argument must be the equivalent of `const TYPE`.
- `&T`, denotes the address of `T`.
- `&const T`, denotes the address of `const T`.

## 5.1.4 Default Construction

A default constructor is not necessary. However, some container class members may specify a default constructor as a default argument. In that case when a default constructor is used as a default argument there must be a default constructor defined.

## 5.1.5 Allocator Requirements

The general utilities library requirements include requirements for allocators. Allocators are objects that contain information about the container. This includes information concerning pointer types, the type of their difference, the size of objects in this allocation, also the memory allocation and deallocation information. All of the standard containers are parameterized in terms of allocators.



The allocator class includes the following members

**Table 5-1. Allocator Members**

Expression	Meaning
pointer	A pointer to a type
const_pointer	A pointer to a const type
reference	A reference of a type
const_reference	A reference to a const type
value_type	A type identical to the type
size_type	An unsigned integer that can represent the largest object in the allocator
difference_type	A signed integer that can represent the difference between any to pointers in the allocator
rebind	The template member is effectively a typedef of the type to which the allocator is bound
address(type)	Returns the address of type
address(const type)	Returns the address of the const type
allocate(size)	Returns the allocation of size
allocate(size, address)	Returns the allocation of size at the address
max_size	The largest value that can be passed to allocate
Ax == Ay	Returns a bool true if the storage of each allocator can be deallocated by the other
Ax != Ay	Returns a bool true if the storage of each allocator can not be deallocated by the other
T()	Constructs an instance of type
T x(y)	x is constructed with the values of y

Allocator template parameters must meet additional requirements

- All instances of an allocator are interchangeable and compare equal to each other
- Members must meet the requirements in [Table 5-2](#)

Implementation-defined allocators are allowed.

**Table 5-2. The Typedef Members Requirements**

Member	Type
pointer	T*
const_pointer	T const*
size_type	size_t
difference_type	ptrdiff_t

## 5.2 Utility Components

This sub-clause contains some basic template functions and classes that are used throughout the rest of the library.

### 5.2.1 Operators

The Standard C++ library provides general templated comparison operators that are based on `operator==` and `operator<`.

#### 5.2.1.1 `operator!=`

This operator determines if the first argument is not equal to the second argument.

```
template <class T> bool operator!=(const T& x, const T& y);
```

#### 5.2.1.2 `operator>`

This operator determines if the first argument is less than the second argument.

```
template <class T> bool operator>(const T& x, const T& y);
```

#### 5.2.1.3 `operator<=`

This operator determines if the first argument is less than or equal to the second argument.

```
template <class T> bool operator<=(const T& x, const T& y);
```

### 5.2.1.4 operator>=

This operator determines if the first argument is greater than or equal to the second argument.

```
template <class T> bool operator>=(const T& x, const T& y);
```

## 5.3 Pairs

The utility library includes support for paired values.

### 5.3.1 Constructors

The pair class contains various constructors to fit each pairs needs.

```
pair();
```

Initializes its members as with default type constructors.

```
template<class U, class V> pair(const pair< U, V> & p);
```

Initializes and does any implicit conversions if necessary.

### 5.3.2 operator ==

The pair equality operator returns true if each pair argument is equal to the other.

```
template <class T1, class T2>  
bool operator==(const pair<T1, T2>& x, const pair<T1, T2>& y);
```

### 5.3.3 operator <

The pair less than operator returns true if the second pair argument is less than the first pair argument.

```
template <class T1, class T2> bool operator <
    const pair<T1, T2>& x, const pair<T1, T2>& y);
```

### 5.3.4 make\_pair

Makes a pair of the two arguments.

```
template <class T1, class T2>
    pair<T1, T2> make_pair(const T1& x, const T2& y);
```

#### Remarks

Returns a pair of the two arguments.

## 5.4 Function objects

Function objects have the operator() defined and used for more effective use of the library.

When a pointer to a function would normally be passed to an algorithm function the library is specified to accept an object with operator() defined. The use of function objects with function templates increases the power and efficiency of the library.

Struct Unary\_function and Struct Binary\_function classes are provided to simplify the typedef of the argument and result types.

#### NOTE

In order to manipulate function objects that take one or two arguments it is required that their function objects provide the defined types. If the function object takes one argument then argument\_type and result\_type are defined. If the function object takes two arguments then the first\_argument\_type, second\_argument\_type, and result\_type must be defined.

## 5.4.1 Arithmetic operations

The utility library provides function object classes with operator() defined for the arithmetic operations.

### 5.4.1.1 plus

Adds the first and the second and returns that sum.

```
template <class T> struct plus : binary_function<T,T,T>
{
    T operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns x plus y.

### 5.4.1.2 minus

Subtracts the second from the first and returns the difference.

```
template <class T> struct minus : binary_function<T,T,T> {
    T operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns x minus y.

### 5.4.1.3 multiplies

Multiplies the first times the second and returns the resulting value.

```
template <class T> struct multiplies : binary_function<T,T,T>
{
    T operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns  $x$  multiplied by  $y$ .

#### 5.4.1.4 divides

Divides the first by the second and returns the resulting value.

```
template <class T> struct divides : binary_function<T,T,T>
{
    T operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns  $x$  divided by  $y$ .

#### 5.4.1.5 modulus

Determines the modulus of the first by the second argument and returns the result.

```
template <class T> struct modulus : binary_function<T,T,T>
{
    T operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns  $x$  modulus  $y$ .

#### 5.4.1.6 negate

This function returns the negative value of the argument.

```
template <class T> struct negate : unary_function<T,T>
{
    T operator()(const T& x) const;
};
```

#### Remarks

Returns the negative of  $x$ .

### 5.4.2 Comparisons

The utility library provides function object classes with `operator()` defined for the comparison operations.

### NOTE

For the `greater`, `less`, `greater_equal` and `less_equal` template classes specializations for pointers yield a total order.

#### 5.4.2.1 `equal_to`

Returns true if the first argument is equal to the second argument.

```
template <class T> struct equal_to :  
    binary_function<T,T,bool>  
{  
    bool operator()(const T& x, const T& y) const;  
};
```

#### Remarks

Returns true if x is equal to y.

#### 5.4.2.2 `not_equal_to`

Returns true if the first argument is not equal to the second argument.

```
template <class T> struct not_equal_to :  
    binary_function<T,T,bool>  
{  
    bool operator()(const T& x, const T& y) const;  
};
```

#### Remarks

Returns true if x is not equal to y.

#### 5.4.2.3 `greater`

Returns true if the first argument is greater than the second argument.

```
template <class T> struct greater : binary_function<T,T,bool>  
{  
    bool operator()(const T& x, const T& y) const;  
};
```

#### Remarks

Returns true if x is greater than y.

#### 5.4.2.4 less

Returns true if the first argument is less than the second argument.

```
template <class T> struct less : binary_function<T,T,bool>
{
    bool operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns true if x is less than y.

#### 5.4.2.5 greater\_equal

Returns true if the first argument is greater than or equal to the second argument.

```
template <class T> struct greater_equal :
binary_function<T,T,bool>
{
    bool operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns true if x is greater than or equal to y.

#### 5.4.2.6 less\_equal

Returns true if the first argument is less than or equal to the second argument.

```
template <class T> struct less_equal :
binary_function<T,T,bool> {
    bool operator()(const T& x, const T& y) const;
};
```

#### Remarks

Returns true if x is less than or equal to y.



## 5.4.3 Logical operations

The utility library provides function object classes with operator() defined for the logical operations.

### 5.4.3.1 logical\_and

Returns true if the first and the second argument are true.

```
template <class T> struct logical_and :  
    binary_function<T,T,bool> {  
    bool operator()(const T& x, const T& y) const;  
};
```

#### Remarks

Returns true if x and y are true.

### 5.4.3.2 logical\_or

Returns true if the first or the second argument are true.

```
template <class T> struct logical_or :  
    binary_function<T,T,bool> {  
    bool operator()(const T& x, const T& y) const;  
};
```

#### Remarks

Returns true if the x or y are true.

### 5.4.3.3 logical\_not

Returns true if the argument is zero

```
template <class T> struct logical_not :  
    unary_function<T,bool> {  
    bool operator()(const T& x) const;  
};
```

#### Remarks

Returns true if x is equal to zero.

## 5.4.4 Negators

The utility library provides negators `not1` and `not2` that returns the complement of the unary or binary predicate.

A predicate is an object that takes one or two arguments and returns something convertible to `bool`.

### 5.4.4.1 Unary\_negate

In the template class `unary_negate` the `operator()` returns the compliment of the predicate argument.

#### **not1**

The template function `not1` returns the `unary_predicate` of the predicate argument.

```
template <class Predicate>
unary_negate<Predicate>
not1(const Predicate& pred);
```

#### **Remarks**

Returns true if `pred` is not true.

### 5.4.4.2 binary\_negate

In the template class `binary_negate` the `operator()` returns the compliment of the predicate arguments.

#### **not2**

The template function `not2` returns the `binary_predicate` of the predicate arguments.

```
template <class Predicate>
binary_negate<Predicate>
not2(const Predicate& pred);
```

#### **Remarks**

Returns the compliment of the argument.

## 5.4.5 Binders

The binders classes, `bind1st` and `bind2nd` take a function object and a value and return a function object constructed out of the function bound to the value.

### 5.4.5.1 Template class `binder1st`

The binders class `bind1st` takes a function object and a value and return a function object constructed out of the function bound to the value.

#### Remarks

The constructor initializes the operation.

### 5.4.5.2 `bind1st`

Binds the first.

```
template <class Operation, class T>
    binder1st<Operation> bind1st(const Operation& op, const T& x);
```

#### Remarks

Binds the operation to the first argument type.

### 5.4.5.3 Template class `binder2nd`

The binders class `bind1st` takes a function object and a value and return a function object constructed out of the function bound to the value.

#### Remarks

The constructor initializes the operation.

#### 5.4.5.4 bind2nd

```
template <class Operation, class T>
binder2nd<Operation> bind2nd
    (const Operation& op, const T& x);
```

#### Remarks

Binds the operation to the second argument type.

### 5.4.6 Adaptors for Pointers to Functions

Special adaptors for pointers to both unary and binary functions call them to work with function adaptors.

#### 5.4.6.1 pointer\_to\_unary\_function

```
template <class Arg, class Result>
pointer_to_unary_function<Arg, Result>
    ptr_fun(Result (* f)(Arg));
```

#### Remarks

Returns a pointer for a unary function.

#### 5.4.6.2 class pointer\_to\_binary\_function

A class for a pointer used for binary binding.

#### 5.4.6.3 pointer\_to\_binary\_function

```
template <class Arg1, class Arg2, class Result>
pointer_to_binary_function<Arg1,Arg2,Result
ptr_fun(Result (* f)(Arg1, Arg2));
```

## Remarks

Returns a pointer for a binary function.

## 5.4.7 Adaptors for Pointers to Members

Adaptors for pointers to members are adaptors that allow you to call member functions for elements within a collection.

### 5.4.7.1 mem\_fun\_t

An adaptor for pointers to member functions.

```
template<class S, class T>
mem_fun_t<S,T,A> : public unary_function<T*, S>
explicit mem_fun(S (T::*p)());
```

## Remarks

The constructor for `mem_fun_t` calls the member function that is initialized with using a given pointer argument and an appropriate additional argument.

### 5.4.7.2 mem\_fun1\_t

A class for binding a member function.

```
template<class S, class T, class A>
class mem_fun1_t : public binary_function<T*,A, S>
explicit mem_fun1_t(S (T::*p)(A));
```

## Remarks

The constructor for `mem_fun1_t` calls the member function that it is initialized with using a given a pointer argument and an appropriate additional argument.

### 5.4.7.3 mem\_fun

A function adapter for member functions

```
template<class S, class T> mem_fun_t<S,T>
mem_fun(S (T::*f)());

template<class S, class T, class A>
mem_fun(S (T::*f)(A));
```

#### Remarks

The function returns an object through which a function can be called.

### 5.4.7.4 mem\_fun\_ref\_t

A function adaptor for function reference objects.

```
template<class S, class T>
class mem_fun_ref_t : public unary_function<T, S>
explicit mem_fun_ref_t(S (T::*p)());
```

#### Remarks

The function `mem_fun_ref_t` calls the member function reference it is initialized with using a given a reference argument.

### 5.4.7.5 mem\_fun1\_ref\_t

A function adaptor for a member to function reference object.

```
template<class S, class T, class A>
class mem_fun1_ref_t : public binary_function<T,A, S>
explicit mem_fun1_ref_t(S (T::*p)(A));
```

#### Remarks

The constructor for `mem_fun1_ref_t` calls the member function that it is initialized with a given a reference argument and an additional argument of the appropriate type.

### 5.4.7.6 mem\_fun\_ref

A function adaptor for a template member references.

```
template<class S, class T> mem_fun_ref_t<S,T>
    mem_fun_ref(S (T::*f)(A));

template<class S, class T, class A> mem_fun1_ref_t<S, T, A>
    mem_fun_ref(S (T::*f)(A));
```

#### Remarks

The template function `mem_fun_ref` returns an object through which `X::f` can be called given a reference to an `x` followed by the argument required for `f`.

### 5.4.7.7 const\_mem\_fun\_t

A function adaptor for a constant member.

```
template<class S, class T> class const_mem_fun_t
    : public unary_function<T*, S>
    explicit const mem_fun(S (T::*p)() const);
```

#### Remarks

Provides a constant member to function object.

The constructor for `const_mem_fun_t` calls the member function that it is initialized with using a given pointer argument.

### 5.4.7.8 const\_mem\_fun1\_t

A const to member function object type.

```
template<class S, class T, class A> const_mem_fun1_t
    : public binary_function<T,A,S>
    explicit mem_fun_fun1_t(S (T::*p)(A) const);
```

#### Remarks

The constructor for `const_mem_fun1_t` calls the member function that it is initialized with using a given a pointer argument and an additional argument of the appropriate type.

### 5.4.7.9 const\_mem\_fun\_ref\_t

A function adaptor for a constant member reference.

```
template<class S, class T>
class const_mem_fun_ref_t<S,T> : public unary_function<T,S>
explicit const_mem_fun_ref_t( S (T::*p) () const);
```

#### Remarks

The template functions `mem_fun_ref` returns an object through which `x::f` can be called.

The constructor for `const_mem_fun_ref_t` calls the member function that it is initialized with using a given a reference argument.

### 5.4.7.10 const\_mem\_fun1\_ref\_t

A constant member to function reference adaptor object.

```
template<class S, class T, class A>
class const_mem_fun1_ref_t<S,T>: public
binary_function<T,A,S>
explicit const_mem_fun1_ref_t( S (T::*p) (A) const);
```

#### Remarks

The constructor for `const_mem_fun1_ref_t` calls the member function it is initialized with using a given a reference argument and an additional argument of the appropriate type.

The template functions `mem_fun_ref` returns an object through which `x::f` can be called

## 5.5 Memory

The header `<memory>` includes functions and classes for the allocation and deallocation of memory.



## 5.5.1 allocator members

Members of the allocator class.

### 5.5.1.1 address

Determine the address of the allocation.

```
pointer address(reference x) const;
const_pointer address(const_reference x) const;
```

#### Remarks

Returns the address of the allocation.

### 5.5.1.2 allocate

Create an allocation and return a pointer to it.

```
pointer allocate(size_type n, allocator<void>::const_pointer
hint=0);
```

#### Remarks

A pointer to the initial element of an array of storage.

Allocate throw a `bad_alloc` exception if the storage cannot be obtained.

### 5.5.1.3 deallocate

Remove an allocation from memory.

```
void deallocate(pointer p, size_type n);
```

Deallocates the storage referenced by `p`.

### 5.5.1.4 max\_size

Determines the Maximum size for an allocation.

```
size_type max_size() const throw();
```

#### Remarks

Returns the largest size of memory that may be.

### 5.5.1.5 construct

Allocates an object and initializes it with a value.

```
void construct(pointer p, const_reference val);
```

#### Remarks

A pointer to the allocated memory is returned.

### 5.5.1.6 destroy

Destroys the memory allocated

```
void destroy(pointer p);
```

## 5.5.2 allocator globals

Provides globals operators in memory allocation.

### 5.5.2.1 operator==

Equality operator.

```
template <class T1, class T2> bool operator==  
(const allocator<T1>&,   
const allocator<T2>&) throw();
```

### Remarks

Returns true if the arguments are equal.

### 5.5.2.2 operator!=

Inequality operator.

```
template <class T1, class T2> bool operator!=  
(const allocator<T1>&,   
const allocator<T2>&) throw();
```

### Remarks

Returns true if the arguments are not equal.

## 5.5.3 Raw storage iterator

A means of storing the results of un-initialized memory.

### NOTE

The formal template parameter `OutputIterator` is required to have its `operator*` return an object for which `operator&` is defined and returns a pointer to `T`, and is also required to satisfy the requirements of an output iterator.

### 5.5.3.1 Constructors

A constructor for the `raw_storage_iterator` class.

```
raw_storage_iterator(OutputIterator x);
```

### Remarks

Initializes the iterator.

### 5.5.3.2 operator \*

A dereference operator.

```
raw_storage_iterator<OutputIterator,T>&  
operator*();
```

#### Remarks

The dereference operator return `*this`.

### 5.5.3.3 operator=

The `raw_storage_iterator` assignment operator.

```
raw_storage_iterator<OutputIterator,T>&  
operator=(const T& element);
```

#### Remarks

Constructs a value from `element` at the location to which the iterator points.

A reference to the iterator.

### 5.5.3.4 operator++

Post and Pre-increment operators for `raw_storage_iterator`.

```
raw_storage_iterator<OutputIterator,T>&  
operator++(); // Pre-increment  
  
raw_storage_iterator<OutputIterator,T>  
operator++(int); //Post-increment
```

#### Remarks

Increments the iterator. The post-increment operator returns the old value of the iterator. The pre-increment operator returns the updated value.

## 5.5.4 Temporary buffers

Methods for storing and retrieving temporary allocations.

### 5.5.4.1 `get_temporary_buffer`

Retrieves a pointer to store temporary objects.

```
template <class T> pair<T*, ptrdiff_t>
  get_temporary_buffer(ptrdiff_t n);
```

#### Remarks

Returns an address for the buffer and its size or zero if unsuccessful.

### 5.5.4.2 `return_temporary_buffer`

Deallocation for the `get_temporary_buffer` procedure.

```
template <class T>
  void return_temporary_buffer(T* p);
```

#### Remarks

The buffer must have been previously allocated by `get_temporary_buffer`.

## 5.5.5 Specialized Algorithms

Algorithm necessary to fulfill iterator requirements.

### 5.5.5.1 `uninitialized_copy`

An uninitialized copy.

**template Class auto\_ptr**

```

template <class InputIterator,
class ForwardIterator>
ForwardIterator uninitialized_copy
    (InputIterator first, InputIterator last, ForwardIterator
result);

```

**Remarks**

Returns a `ForwardIterator` to the result argument.

**5.5.5.2 uninitialized\_fill**

An uninitialized fill.

```

template <class ForwardIterator, class T>
void uninitialized_fill
    (ForwardIterator first,
    ForwardIterator last, const T& x);

```

**5.5.5.3 uninitialized\_fill\_n**

An uninitialized fill with a size limit.

```

template <class ForwardIterator,
class Size, class T>
void uninitialized_fill_n
    (ForwardIterator first, Size n, const T& x);

```

**5.6 Template Class auto\_ptr**

The `auto_ptr` class stores a pointer to an object obtained using `new` and deletes that object when it is destroyed. For example when a local allocation goes out of scope.

The template `auto_ptr_ref` holds a reference to an `auto_ptr`, and is used by the `auto_ptr` conversions. This allows `auto_ptr` objects to be passed to and returned from functions.

**NOTE**

An `auto_ptr` owns the object it holds a pointer to. When copying an `auto_ptr` the pointer transfers ownership to the destination.

If more than one `auto_ptr` owns the same object at the same time the behavior of the program is undefined.

See the example of using `std::auto_ptr` and extension version for arrays in [Using Auto\\_ptr](#)

This extension can be turned on by uncommenting the statement,

```
#define _EWL_ARRAY_AUTO_PTR in <ewlconfig>. No recompile of the C++ lib is necessary, but do
rebuild any precompiled headers when making this change.
```

The functionality provided by the extended `std::auto_ptr` is very similar to that provided by the newer `Metrowerks::alloc_ptr` found in `<ewl_utility>`.

**Listing: Using Auto\_ptr**

```
#include <iostream>
#include <memory>

using std::auto_ptr;
using std::_Array;

struct A
{
    A() {std::cout << "construct A\n";}
    virtual ~A() {std::cout << "destruct A\n";}
};

struct B
    : A
{
    B() {std::cout << "construct B\n";}
    virtual ~B() {std::cout << "destruct B\n";}
};

auto_ptr<B> source();
void sink_b(auto_ptr<B>);
void sink_a(auto_ptr<A>);
auto_ptr<B, _Array<B> > array_source();
void array_sink(auto_ptr<B, _Array<B> >);
auto_ptr<B>
```

## template Class auto\_ptr

```

source()
{
    return auto_ptr<B>(new B);
}

void
sink_b(auto_ptr<B>)
{
}

void
sink_a(auto_ptr<A>)
{
}

auto_ptr<B, _Array<B> >
array_source()
{
    return auto_ptr<B, _Array<B> >(new B [2]);
}

void
array_sink(auto_ptr<B, _Array<B> >)
{
}

int main()
{
    {
        auto_ptr<B> b(new B);
        auto_ptr<B> b2(b);
        b = b2;
        auto_ptr<B> b3(source());
        auto_ptr<A> a(b);
        a = b3;
        b3 = source();
        sink_b(source());
        auto_ptr<A> a2(source());
        a2 = source();
    }
}

```



```

    sink_a(source());
}
{
    auto_ptr<B, _Array<B> > b(new B [2]);
    auto_ptr<B, _Array<B> > b2(b);
    b = b2;
    auto_ptr<B, _Array<B> > b3(array_source());
    b3 = array_source();
    array_sink(array_source());
//    auto_ptr<A, _Array<A> > a(b3);    // Should not compile
//    a = b3;                          // Should not
compile
}
}

```

## 5.6.1 auto\_ptr constructors

Constructs an `auto_ptr` object.

```

explicit auto_ptr(X* p =0) throw();
auto_ptr(auto_ptr& a) throw();
template<class Y> auto_ptr(auto_ptr<Y>& a) throw();

```

## 5.6.2 operator =

An `auto_ptr` assignment operator.

```

template<class Y> auto_ptr& operator=(
auto_ptr<Y>& a) throw();
auto_ptr& operator=
(auto_ptr& a) throw();

```

### Remarks

Returns the this pointer.

### 5.6.3 destructor

Destroys the auto\_ptr object.

```
~auto_ptr() throw();
```

### 5.6.4 auto\_ptr Members

Member of the auto\_ptr class.

### 5.6.5 operator\*

The de-reference operator.

```
X& operator*() const throw();
```

#### Remarks

Returns what the dereferenced pointer `*this` holds.

### 5.6.6 operator->()

The pointer dereference operator.

```
X* operator->() const throw();
```

#### Remarks

Returns what the pointer `*this` holds.

## 5.6.7 get

Gets the value that the pointer points to.

```
X* get() const throw();
```

### Remarks

Returns what the pointer `*this` holds.

## 5.6.8 release

Releases the `auto_ptr` object.

```
X* release() throw();
```

### Remarks

Returns what the pointer `*this` holds.

## 5.6.9 reset

Resets the `auto_ptr` to zero or another pointer.

```
void reset(X* p=0) throw();
```

## 5.6.10 auto\_ptr conversions

Conversion functionality for the `auto_ptr` class for copying and converting.

### 5.6.10.1 Conversion Constructor

A conversion constructor.

```
auto_ptr(auto_ptr_ref<X> r) throw();
```

### 5.6.10.2 operator auto\_ptr\_ref

Provides a convert to lvalue process.

```
template<class Y> operator auto_ptr_ref<Y>() throw();
```

#### Remarks

Returns a reference that holds the this pointer.

### 5.6.11 operator auto\_ptr

Releases the auto\_ptr and returns the pointer held.

```
template<class Y> operator auto_ptr<Y>() throw();
```

#### Remarks

Returns the pointer held.

## 5.7 C Library

The EWL C++ memory libraries use the C library memory functions. See the EWL C Reference for <stdlib.h> functions `calloc`, `malloc`, `free`, `realloc` for more information.

## 5.8 Date and Time

The header <ctime> has the same contents as the Standard C library header <time.h> but within namespace `std`.





## Chapter 6

# Strings Library

This chapter is a reference guide to the ANSI/ISO String class that describes components for manipulating sequences of characters, where characters may be of type `char`, `wchar_t`, or of a type defined in a C++ program.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Character traits](#) defines types and facilities for character manipulations
- [String Classes](#) lists string and character structures and classes
- [Class Basic\\_string](#) defines facilities for character sequence manipulations.
- [Null Terminated Sequence Utilities](#) lists facilities for Null terminated character sequence strings.

### 6.1 Character traits

This section defines a class template `char_traits<charT>` and two specializations for `char` and `wchar_t` types.

These types are required by string and stream classes and are passed to these classes as formal parameters `charT` and `traits`.

The topics in this section are:

- [Character Trait Definitions](#)
- [Character Trait Requirements](#)
- [Character Trait Type Definitions](#)
- `struct char_traits<T>`

## 6.1.1 Character Trait Definitions

This section defines character trait definitions.

### 6.1.1.1 character

Any object when treated sequentially can represent text. This term is not restricted to just `char` and `wchar_t` types

### 6.1.1.2 character container type

A class or type used to represent a character. This object must be POD (Plain Old Data).

### 6.1.1.3 traits

A class that defines types and functions necessary for handling characteristics.

### 6.1.1.4 NTCTS

A null character termination string is a character sequence that proceeds the null character value `charT(0)`.

## 6.1.2 Character Trait Requirements

These types are required by string and stream classes and are passed to these classes as formal parameters `charT` and `traits`.

### 6.1.2.1 assign

Used for character type assignment.



```
static void assign
(char_type, const char_type);
```

### 6.1.2.2 eq

Used for `bool` equality checking.

```
static bool eq
(const char_type&, const char_type&);
```

### 6.1.2.3 lt

Used for `bool` less than checking.

```
static bool lt(const char_type&, const char_type&);
```

### 6.1.2.4 compare

Used for `NTCTS` comparison.

```
static int compare
(const char_type*, const char_type*, size_t n);
```

### 6.1.2.5 length

Used when determining the length of a `NTCTS`.

```
static size_t length
(const char_type*);
```

### 6.1.2.6 find

## Character traits

Used to find a character type in an array

```
static const char_type* find
(const char_type*, int n, const char_type&);
```

### 6.1.2.7 move

Used to move one `NTCTS` to another even if the receiver contains the sting already.

```
static char_type* move
(char_type*, const char_type*, size_t);
```

### 6.1.2.8 copy

Used for copying a `NTCTS` that does not contain the `NTCTS` already.

```
static char_type* copy
(char_type*, const char_type*, size_t);
```

### 6.1.2.9 not\_eof

Used for `bool` inequality checking.

```
static int_type not_eof
(const int_type&);
```

### 6.1.2.10 to\_char\_type

Used to convert to a char type from an `int_type`

```
static char_type to_char_type
(const int_type&);
```

### 6.1.2.11 to\_int\_type

Used to convert from a char type to an int\_type.

```
static int_type to_int_type  
(const char_type&);
```

### 6.1.2.12 eq\_int\_type

Used to test for equality.

```
static bool eq_int_type  
(const int_type&, const int_type& );
```

### 6.1.2.13 get\_state

Used to store the state of the file buffer.

```
static state_type get_state  
(pos_type pos);
```

### 6.1.2.14 eof

Used to return end of file. The value returned from eof() can be used to test against the return value of basic\_istream functions such as get() to determine when another character can not be returned. It is also used to mean "not a character" on input to various functions such as basic\_ostream::overflow.

```
static int_type eof();
```

## 6.1.3 Character Trait Type Definitions

There are several types defined in the `char_traits` structure for both wide and conventional char types.

**Table 6-1. The functions are:**

Type	Defined	Use
<code>char</code>	<code>char_type</code>	char values
<code>int</code>	<code>int_type</code>	integral values of char types including eof
<code>streamoff</code>	<code>off_type</code>	stream offset values
<code>streampos</code>	<code>pos_type</code>	stream position values
<code>mbstate_t</code>	<code>state_type</code>	file state values

### 6.1.4 struct `char_traits<T>`

The template structure is overloaded for both the `wchar_t` type `struct char_traits<wchar_t>`. This specialization is used for string and stream usage.

**NOTE**

The `assign`, `eq` and `lt` are the same as the `=`, `==` and `<` operators.

## 6.2 String Classes

The header `<string>` define string and trait classes used to manipulate character and wide character like template arguments.

### 6.3 Class `basic_string`

The `class basic_string` is used to store and manipulate a sequence of character like types of varying length known as strings.

Memory for a string is allocated and deallocated as necessary by member functions.

The first element of the sequence is at position zero.

The iterators used by `basic_string` are random iterators and as such qualifies as a reversible container.

### NOTE

In general, the string size can be constrained by memory restrictions.

The topics in this section include:

- [Constructors and Assignments](#)
- [Iterator Support](#)
- [Capacity](#)
- [Element Access](#)
- [Modifiers](#)
- [String Operations](#)
- [Non-Member Functions and Operators](#)
- [Inserters and extractors](#)

The class `basic_string` can have either of two implementations:

- Refcounted.
- Non-refcounted.

The interface and functionality are identical with both implementations. The only difference is performance. Which performs best is dependent upon usage patterns in each application.

The refcounted implementation ships as the default.

### NOTE

To enable the non-refcounted implementation un-comment `#define _EWL_NO_REFCOUNT_STRING` in `<ewlconfig>`. The C++ library and precompiled headers must be rebuilt after making this change.

## 6.3.1 Constructors and Assignments

Constructor, destructor and assignment operators and functions.

### 6.3.1.1 Constructors

**class basic\_string**

The various `basic_string` constructors construct a string object for character sequence manipulations. All constructors include an `Allocator` argument that is used for memory allocation.

```
explicit basic_string
(const Allocator& a = Allocator());
```

This default constructor, constructs an empty string. A zero sized string that may be copied to is created.

```
basic_string
(const basic_string& str,
 size_type pos = 0,
 size_type n = npos,
 const Allocator& a = Allocator());
```

This constructor takes a string class argument and creates a copy of that string, with size of the length of that string and a capacity at least as large as that string.

An exception is thrown upon failure

```
basic_string
(const charT* s,
 size_type n,
 const Allocator& a = Allocator());
```

This constructor takes a `const char` array argument and creates a copy of that array with the size limited to the `size_type` argument.

The `charT*` argument shall not be a null pointer

An exception is thrown upon failure

```
basic_string
(const charT* s,
 const Allocator& a = Allocator());
```

This constructor takes an `const char` array argument. The size is determined by the size of the `char` array.

The `charT*` argument shall not be a null pointer

```
basic_string
(size_type n,
 charT c,
 const Allocator& a = Allocator());
```

This constructor creates a string of `size_type n` size repeating `charT c` as the filler.

A `length_error` is thrown if `n` is less than `npos`.

```
template<class InputIterator>
basic_string
(InputIterator begin,
InputIterator end,
const Allocator& a = Allocator());
```

This iterator string takes `InputIterator` arguments and creates a string with its first position starts with `begin` and its ending position is `end`. Size is the distance between `beginning` and `end`.

### 6.3.1.2 Destructor

Deallocates the memory referenced by the `basic_string` object.

```
~basic_string ();
```

### 6.3.1.3 Assignment Operator

Assigns the input string, char array or char type to the current string.

```
basic_string& operator= (const basic_string& str);
```

If `*this` and `str` are the same object has it has no effect.

```
basic_string& operator=(const charT* s);
```

Used to assign a NCTCS to a string.

```
basic_string& operator=(charT c);
```

Used to assign a single char type to a string.

### 6.3.1.4 Assignment & Addition Operator `basic_string`

Appends the string `rhs` to the current string.

**class basic\_string**

```
string& operator+= (const string& rhs);  
string& operator+= (const charT* s);  
string& operator+= (charT s);
```

**Remarks**

Both of the overloaded functions construct a string object from the input *s*, and append it to the current string.

The assignment operator returns the `this` pointer.

## 6.3.2 Iterator Support

Member functions for string iterator support.

### 6.3.2.1 begin

Returns an iterator to the first character in the string

```
iterator begin();  
const_iterator begin() const;
```

### 6.3.2.2 end

Returns an iterator that is past the end value.

```
iterator end();  
const_iterator end() const;
```

### 6.3.2.3 rbegin

Returns an iterator that is equivalent to

```
reverse_iterator(end()).  
reverse_iterator rbegin();  
const_reverse_iterator rbegin() const;
```



### 6.3.2.4 `rend`

Returns an iterator that is equivalent to

```
reverse_iterator(begin()).  
reverse_iterator rend();  
const_reverse_iterator rend() const;
```

## 6.3.3 Capacity

Member functions for determining a strings capacity.

### 6.3.3.1 `size`

Returns the size of the string.

```
size_type size() const;
```

### 6.3.3.2 `length`

Returns the length of the string

```
size_type length() const;
```

### 6.3.3.3 `max_size`

Returns the maximum size of the string.

```
size_type max_size() const;
```

### 6.3.3.4 resize

Resizes the string to size `n`.

```
void resize(size_type n);  
void resize(size_type n, charT c);
```

#### Remarks

If the size of the string is longer than `size_type n`, it shortens the string to `n`, if the size of the string is shorter than `n` it appends the string to size `n` with `charT c` or `charT()` if no filler is specified.

### 6.3.3.5 capacity

Returns the memory storage capacity.

```
size_type capacity() const;
```

### 6.3.3.6 reserve

A directive that indicates a planned change in memory size to allow for better memory management.

```
void reserve(size_type res_arg = 0);
```

### 6.3.3.7 clear

Erases from `begin()` to `end()`.

```
void clear();
```

### 6.3.3.8 empty

Empties the string stored.

```
bool empty() const;
```

## Remarks

Returns `true` if the size is equal to zero, otherwise `false`.

## 6.3.4 Element Access

Member functions and operators for accessing individual string elements.

### 6.3.4.1 operator[]

An operator used to access an indexed element of the string.

```
const_reference operator[](size_type pos) const;  
reference operator[](size_type pos);
```

### 6.3.4.2 at

A function used to access an indexed element of the string.

```
const_reference at(size_type n) const;  
reference at(size_type n);
```

## 6.3.5 Modifiers

Operators for appending a string.

### 6.3.5.1 operator+=

**class basic\_string**

An Operator used to append to the end of a string.

```
basic_string& operator+=(const basic_string& str);
basic_string& operator+=(const charT* s);
basic_string& operator+=(charT c);
```

**6.3.5.2 append**

A function used to append to the end of a string.

```
basic_string& append(const basic_string& str);
basic_string& append(
const basic_string& str,
size_type pos, size_type n);
basic_string& append(const charT* s, size_type n);
basic_string& append(const charT* s);
basic_string& append(size_type n, charT c);
template<class InputIterator>
basic_string& append(InputIterator first, InputIterator
last);
```

**6.3.5.3 assign**

Assigns a string, Null Terminated Character Type Sequence or char type to the string.

```
basic_string& assign(const basic_string&);
basic_string& assign
(const basic_string& str, size_type pos, size_type n);
basic_string& assign(const charT* s, size_type n);
basic_string& assign(const charT* s);
basic_string& assign(size_type n, charT c);
template<class InputIterator>
basic_string& assign(InputIterator first, InputIterator
last);
```

**Remarks**

If there is a size argument whichever is smaller the string size or argument value will be assigned.

### 6.3.5.4 insert

Inserts a string, Null Terminated Character Type Sequence or char type into the string.

```
basic_string& insert
(size_type pos1, const basic_string& str);
basic_string& insert
(size_type pos1, const basic_string& str,
size_type pos2, size_type n);
basic_string& insert
(size_type pos, const charT* s, size_type n);
basic_string& insert(size_type pos, const charT* s);
basic_string& insert
(size_type pos, size_type n, charT c);
iterator insert(iterator p, charT c = charT());
void insert(iterator p, size_type n, charT c);
template<class InputIterator>
void insert
(iterator p, InputIterator first,
InputIterator last);
```

#### Remarks

May throw an exception.

### 6.3.5.5 erase

Erases the string

```
basic_string& erase
(size_type pos = 0, size_type n = npos);
iterator erase(iterator position);
iterator erase(iterator first, iterator last);
```

#### Remarks

May throw an exception.

### 6.3.5.6 replace

Replaces the string with a string, Null Terminated Character Type Sequence **OR** char type.

```

basic_string replace(pos1, size_type n1,
const basic_string& str);
basic_string& replace(size_type pos1, size_type n1,
const basic_string& str, size_type pos2, size_type n2);
basic_string& replace(size_type pos, size_type n1,
const charT* s, size_type n2);
basic_string& replace
(size_type pos, size_type n1, const charT* s);
basic_string& replace(size_type pos, size_type n1,
size_type n2, charT c);
basic_string& replace(iterator i1, iterator i2,
const basic_string& str);
basic_string& replace(iterator i1, iterator i2,
const charT* s, size_type n);
basic_string& replace(iterator i1, iterator i2, const charT*
s);
basic_string& replace(iterator i1, iterator i2,
size_type n, charT c);
template<class InputIterator>
basic_string& replace
(iterator i1, iterator i2, InputIterator j1, InputIterator j2);

```

#### Remarks

May throw an exception,

### 6.3.5.7 copy

Copies a Null Terminated Character Type Sequence to a string up to the size designated.

```

size_type copy(charT* s, size_type n,
size_type pos = 0) const;

```

## Remarks

The function `copy` does not pad the string with Null characters.

### 6.3.5.8 `swap`

Swaps one string for another.

```
void swap(basic_string<charT,traits,Allocator>&);
```

## 6.3.6 String Operations

Member functions for sequences of character operations.

### 6.3.6.1 `c_str`

Returns the string as a Null terminated character type sequence.

```
const charT* c_str() const;
```

### 6.3.6.2 `data`

Returns the string as an array without a Null terminator.

```
const charT* data() const;
```

### 6.3.6.3 `get_allocator`

Returns a copy of the allocator object used to create the string.

## class basic\_string

```
allocator_type get_allocator() const;
```

### 6.3.6.4 find

Finds a string, Null Terminated Character Type Sequence OR char type in a string starting from the beginning.

```
size_type find
(const basic_string& str, size_type pos = 0) const;
size_type find
(const charT* s, size_type pos, size_type n) const;
size_type find (const charT* s, size_type pos = 0) const;
size_type find (charT c, size_type pos = 0) const;
```

#### Remarks

The found position or `npos` if not found.

### 6.3.6.5 rfind

Finds a string, Null Terminated Character Type Sequence OR char type in a string testing backwards from the end.

```
size_type rfind
(const basic_string& str, size_type pos = npos) const;
size_type rfind
(const charT* s, size_type pos, size_type n) const;
size_type rfind
(const charT* s, size_type pos = npos) const;
size_type rfind(charT c, size_type pos = npos) const;
```

#### Remarks

The found position or `npos` if not found.

### 6.3.6.6 find\_first\_of



Finds the first position of one of the elements in the function's argument starting from the beginning.

```
size_type find_first_of
(const basic_string& str, size_type pos = 0) const;
size_type find_first_of
(const charT* s, size_type pos, size_type n) const;
size_type find_first_of
(const charT* s, size_type pos = 0) const;
size_type find_first_of(charT c, size_type pos = 0) const;
```

### Remarks

The found position or `npos` if not found.

### 6.3.6.7 find\_last\_of

Finds the last position of one of the elements in the function's argument starting from the beginning.

```
size_type find_last_of
(const basic_string& str, size_type pos = npos) const;
size_type find_last_of
(const charT* s, size_type pos, size_type n) const;
size_type find_last_of
(const charT* s, size_type pos = npos) const;
size_type find_last_of (charT c, size_type pos = npos) const;
```

### Remarks

The found position or `npos` if not found is returned.

### 6.3.6.8 find\_first\_not\_of

Finds the first position that is not one of the elements in the function's argument starting from the beginning.

```
size_type find_first_not_of
(const basic_string& str, size_type pos = 0) const;
```

## Class `basic_string`

```

size_type find_first_not_of
(const charT* s, size_type pos, size_type n) const;

size_type find_first_not_of
(const charT* s, size_type pos = 0) const;

size_type find_first_not_of(charT c, size_type pos = 0)
const;

```

### Remarks

The found position or `npos` if not found.

### 6.3.6.9 `find_last_not_of`

Finds the last position that is not one of the elements in the function's argument starting from the beginning.

```

size_type find_last_not_of
(const basic_string& str, size_type pos = npos) const;

size_type find_last_not_of
(const charT* s, size_type pos, size_type n) const;

size_type find_last_not_of
(const charT* s, size_type pos = npos) const;

size_type find_last_not_of(charT c, size_type pos = npos)
const;

```

### Remarks

The found position or `npos` if not found.

### 6.3.6.10 `substr`

Returns a string if possible from beginning at the first arguments position to the last position.

```

basic_string substr
(size_type pos = 0, size_type n = npos) const;

```

### Remarks

May throw an exception,

### 6.3.6.11 compare

Compares a `string`, `substring` or Null Terminated Character Type Sequence with a lexicographical comparison.

```
int compare(const basic_string& str) const;
int compare(
size_type pos1, size_type n1, const basic_string& str) const;
int compare
(size_type pos1, size_type n1,
const basic_string& str, size_type pos2, size_type n2) const;
int compare(const charT* s) const;
int compare
(size_type pos1, size_type n1, const charT* s,
size_type n2 = npos) const;
```

#### Return

Less than zero if the string is smaller than the argument lexicographically, zero if the string is the same size as the argument lexicographically and greater than zero if the string is larger than the argument lexicographically.

## 6.3.7 Non-Member Functions and Operators

Non-member functions.

### 6.3.7.1 operator+

Appends one string to another.

```
template <class charT, class traits, class Allocator>
basic_string<charT,traits,Allocator>operator+
(const basic_string<charT,traits, Allocator>& lhs,
const basic_string<charT,traits,Allocator>& rhs);
```

## class basic\_string

```

template <class charT, class traits, class Allocator>
basic_string<charT,traits,Allocator> operator+
(const charT* lhs,
const basic_string<charT,traits,Allocator>& rhs);
template <class charT, class traits, class Allocator>
basic_string<charT,traits,Allocator> operator+
(charT lhs,const basic_string
    <charT,traits,Allocator>& rhs);
template <class charT, class traits, class Allocator>
basic_string<charT,traits,Allocator> operator+
(const basic_string<charT,traits,Allocator>& lhs,
const charT* rhs);
template <class charT, class traits, class Allocator>
basic_string<charT,traits,Allocator> operator+
(const basic_string <charT,traits,Allocator>& lhs, charT rhs);

```

## Remarks

The combined strings are returned.

### 6.3.7.2 operator==

Test for lexicographical equality.

```

template <class charT, class traits, class Allocator>
bool operator==
(const basic_string<charT,traits,Allocator>& lhs,
const basic_string<charT,traits,Allocator>& rhs);
template<class charT, class traits, class Allocator>
bool operator==
(const charT* lhs,const basic_string
    <charT,traits,Allocator>& rhs);
template<class charT, class traits, class Allocator>
bool operator==
(const basic_string<charT,traits,Allocator>& lhs,
const charT* rhs);

```

## Return

True if the strings match otherwise false.

### 6.3.7.3 operator!=

Test for lexicographical inequality.

```
template<class charT, class traits, class Allocator>
bool operator!=
(const basic_string<charT,traits,Allocator>& lhs,
const basic_string<charT,traits,Allocator>& rhs);
template<class charT, class traits, class Allocator>
bool operator!=
(const charT* lhs,const basic_string
<charT,traits,Allocator>& rhs);
template<class charT, class traits, class Allocator>
bool operator!=
(const basic_string<charT,traits,Allocator>& lhs,
const charT* rhs);
```

## Remarks

True if the strings do not match otherwise false.

### 6.3.7.4 operator<

Tests for a lexicographically less than condition.

```
template <class charT, class traits, class Allocator>
bool operator<
const basic_string<charT,traits,Allocator>& lhs,
const basic_string<charT,traits,Allocator>& rhs);
template <class charT, class traits, class Allocator>
bool operator<
(const charT* lhs, const basic_string
<charT,traits,Allocator>& rhs);
```

## class basic\_string

```
template <class charT, class traits, class Allocator>
bool operator<
(const basic_string <charT,traits,Allocator>& lhs,
const charT* rhs);
```

### Remarks

Returns `true` if the first argument is lexicographically less than the second argument otherwise `false`.

### 6.3.7.5 operator>

Tests for a lexicographically greater than condition.

```
template <class charT, class traits, class Allocator>
bool operator>
(const basic_string <charT,traits,Allocator>& lhs,
const basic_string <charT,traits,Allocator>& rhs);
template <class charT, class traits, class Allocator>
bool operator>
(const charT* lhs,const basic_string
<charT,traits,Allocator>& rhs);
template <class charT, class traits, class Allocator>
bool operator>
(const basic_string <charT,traits,Allocator>& lhs,
const charT* rhs);
```

### Remarks

Returns `True` if the first argument is lexicographically greater than the second argument otherwise `false`.

### 6.3.7.6 operator<=

Tests for a lexicographically less than or equal to condition.

```
template <class charT, class traits, class Allocator>
bool operator<=
```

```
(const basic_string <charT,traits,Allocator>& lhs,  
const basic_string <charT,traits,Allocator>& rhs);  
template <class charT, class traits, class Allocator>  
bool operator<=  
(const charT* lhs,  
const basic_string <charT,traits,Allocator>& rhs);  
template <class charT, class traits, class Allocator>  
bool operator<=  
(const basic_string <charT,traits,Allocator>& lhs, const charT* rhs);
```

## Remarks

Returns `true` if the first argument is lexicographically less than or equal to the second argument otherwise `false`.

### 6.3.7.7 operator>=

Tests for a lexicographically greater than or equal to condition.

```
template <class charT, class traits, class Allocator>  
bool operator>=  
(const basic_string <charT,traits,Allocator>& lhs,  
const basic_string <charT,traits,Allocator>& rhs);  
template <class charT, class traits, class Allocator>  
bool operator>=  
(const charT* lhs,  
const basic_string <charT,traits,Allocator>& rhs);  
template <class charT, class traits, class Allocator>  
bool operator>=  
(const basic_string <charT,traits,Allocator>& lhs,  
const charT* rhs);
```

## Remarks

Returns `true` if the first argument is lexicographically greater than or equal to the second argument otherwise `false`.

### 6.3.7.8 swap

This non member `swap` exchanges the first and second arguments.

```
template <class charT, class traits, class Allocator>
void swap
(basic_string<charT,traits,Allocator>& lhs,
basic_string <charT,traits,Allocator>& rhs);
```

## 6.3.8 Inserters and extractors

Overloaded inserters and extractors for `basic_string` types.

### 6.3.8.1 operator>>

Overloaded `extractor` for stream input operations.

```
template <class charT, class traits, class Allocator>
basic_istream<charT,traits>& operator>>
(basic_istream<charT,traits>& is,
basic_string<charT,traits,Allocator>& str);
```

#### Remarks

Characters are extracted and appended until `n` characters are stored or `end-of-file` occurs on the input sequence;

### 6.3.8.2 operator<<

Inserts characters from a string object from into a output stream.

```
template <class charT, class traits, class Allocator>
basic_ostream<charT, traits>& operator<<
(basic_ostream<charT, traits>& os,
const basic_string <charT,traits,Allocator>& str);
```



### 6.3.8.3 getline

Extracts characters from a `stream` and appends them to a `string`.

```
template <class charT, class traits, class Allocator>
basic_istream<charT,traits>& getline
(basic_istream<charT,traits>& is,
basic_string <charT,traits,Allocator>& str,charT delim);
template <class charT, class traits, class Allocator>
basic_istream<charT,traits>& getline
(basic_istream<charT,traits>& is,
basic_string<charT,traits,Allocator>& str)
```

#### Remarks

Extracts characters from a `stream` and appends them to the `string` until the `end-of-file` occurs on the input sequence (in which case, the `getline` function calls `setstate(eofbit)` or the delimiter is encountered in which case, the delimiter is extracted but not appended.

If the function extracts no characters, it calls `setstate(failbit)` in which case it may throw an exception.

## 6.4 Null Terminated Sequence Utilities

The standard requires C++ versions of the standard libraries for use with characters and Null Terminated Character Type Sequences.

### 6.4.1 Character Support

The standard provides for namespace and character type support.

**Table 6-2. Character support testing**

<cctype.h>	<cwctype.h>	<cwctype.h>	<cwctype.h>
isalnum	iswalnum	isprint	iswprint

*Table continues on the next page...*

**Table 6-2. Character support testing (continued)**

<cctype.h>	<cwctype.h>	<cwctype.h>	<cwctype.h>
isalpha	iswalpha	ispunct	iswpunct
isctrl	iswcntrl	isspace	iswspace
isdigit	iswdigit	isupper	iswupper
isgraph	iswgraph	isxdigit	iswxdigit
islower	iswlower	isprint	iswprint
isalnum	iswalnum	toupper	towupper
tolower	tolower		iswctype
	wctype		towctrans
	wctrans	EOF	WEOF

## 6.4.2 String Support

The standard provides for namespace and wide character type for Null Terminated Character Type Sequence functionality.

**Table 6-3. String support testing**

<cstring.h>	<wchar.h>	<cstring.h>	<wchar.h>
memchr	wmemchr	strerror	
memcmp	wmemcmp	strlen	wcslen
memcpy	wmemcpy	strncat	wcsncat
memmove	wmemmove	strncpy	wcsncpy
memset	wmemset	strpbrk	wcspbrk
strcat	wcscat	strchr	wcschr
strchr	wcschr	strrchr	wcsrchr
strcmp	wcscmp	strspn	wcsspn
strcoll	wcscoll	strstr	wcsstr
strcpy	wcscpy	strtok	wcstok
strcspn	wcscspn	strxfrm	wcsxfrm
mbstate_t	size_t	wint_t	
NULL		WCHAR_MAX	WCHAR_MIN

## 6.4.3 Input and Output Manipulations

The standard provides for namespace and wide character support for manipulation and conversions of input and output and character and character sequences.

**Table 6-4. Additional <wchar.h> and <stdlib.h> support**

wchar.h	wchar.h	wchar.h	<stdlib.h>
btowc	mbrtowc	wcrtomb	atol
fgetwc	mbsinit	wcscoll	atof
fgetws	mbsrtowcs	wcsftime	atoi
fputwc	putwc	wcstod	mblen
fputws	putwchar	wcstol	mbstowcs
fwide	swscanf	wcsrtombs	mbtowc
fwprintf	swprintf	wcstoul	strtod
fwscanf	ungetwc	wctob	strtol
getwc	vfwprintf	wprintf	strtoul
getwchar	vwprintf	wscanf	wctomb
mbrlen	vswprintf		wcstombs



## Chapter 7

# Localization Library

This chapter describes components that the C++ library that may use for porting to different cultures.

Much of named locales is implementation defined behavior and is not portable between vendors. This document specifies the behavior of EWL C++. Other vendors may not provide this functionality, or may provide it in a different manner.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Supported Locale Names](#)
- [Strings and Characters in Locale Data Files](#)
- [Locales](#)
- [Standard Locale Categories](#)
- [C Library Locales](#)

### 7.1 Supported Locale Names

EWL C++ predefines only two names: "c" and "".

However, other names sent to the locale constructor are interpreted as file names containing data to create a named locale. So localizing your program is as easy as creating a data file specifying the desired behavior. The format for this data file is outlined below for each different facet.

A `locale` is a collection of `facets`. And a `facet` is a class that provides a certain behavior. The "c" `locale` contains the following `facets`:

- `ctype<char>` & `ctype<wchar_t>`
- `codecvt<char, char, mbstate_t>` & `codecvt<wchar_t, char, mbstate_t>`
- `num_get<char>` & `num_get<wchar_t>`

## Strings and Characters in Locale Data Files

- `num_put<char>` & `num_put<wchar_t>`
- `numpunct<char>` & `numpunct<wchar_t>`
- `collate<char>` & `collate<wchar_t>`
- `time_get<char>` & `time_get<wchar_t>`
- `time_put<char>` & `time_put<wchar_t>`
- `money_get<char>` & `money_get<wchar_t>`
- `money_put<char>` & `money_put<wchar_t>`
- `moneypunct<char, bool>` & `moneypunct<wchar_t, bool>`
- `messages<char>` & `messages<wchar_t>`

A named locale replaces many of these facets with "`_byname`" versions, whose behavior can vary based on the name passed.

- `ctype_byname<char>` & `ctype_byname<wchar_t>`
- `codecvt_byname<char, char, mbstate_t>` & `codecvt_byname<wchar_t, char, mbstate_t>`
- `numpunct_byname<char>` & `numpunct_byname<wchar_t>`
- `collate_byname<char>` & `collate_byname<wchar_t>`
- `time_get_byname<char>` & `time_get_byname<wchar_t>`
- `time_put_byname<char>` & `time_put_byname<wchar_t>`
- `moneypunct_byname<char, bool>` & `moneypunct_byname<wchar_t, bool>`
- `messages_byname<char>` & `messages_byname<wchar_t>`

The behavior of each of these "`_byname`" facets can be specified with a data file. A single data file can contain data for all of the byname facets. That way, when you code:

```
locale myloc("MyLocale");
```

then the file "`MyLocale`" will be used for each "`_byname`" facet in `myloc`.

### NOTE

Unnamed namespaces are displayed using a compiler generated unique name that has the form: `__unnamed_<filename>` where `<filename>` is the source file name of the main translation unit that contains the unnamed namespace.

## 7.2 Strings and Characters in Locale Data Files

The named locale facility involves reading strings and characters from files. This document gives the details of the syntax used to enter strings and characters.

## 7.2.1 Character Syntax

Characters in a locale data file can in general appear quoted (') or not. For example:

```
thousands_sep = ,  
thousands_sep = ','
```

Both of the above statements set `thousands_sep` to a comma. Quotes might be necessary to disambiguate the intended character from ordinary whitespace. For example, to set the `thousands_sep` to a space character, quotes must be used:

```
thousands_sep = ' '
```

The whitespace appearing before and after the equal sign is not necessary and insignificant.

## 7.2.2 Escape sequences

The usual `c` escape sequences are recognized. For example, to set the `thousands_sep` to the single quote character, an escape sequence must be used:

```
thousands_sep = \'
```

The recognized escape sequences are:

- `\n` - newline
- `\t` - horizontal tab
- `\v` - vertical tab
- `\b` - backspace
- `\r` - carriage return
- `\f` - form feed
- `\a` - alert
- `\\` - `\`
- `\?` - `?`
- `\"` - `"`
- `\'` - `'`
- `\u \U` - universal character
- `\x` - hexadecimal character
- `\ooo` - octal character

The octal character may have from 1 to 3 octal digits (digits must be in the range [0, 7]. The parser will read as many digits as it can to interpret a valid octal number. For example:

```
\18
```

This is the character '\1' followed by the character '8'.

```
\17
```

But this is the single character '\17'.

The hexadecimal and universal character formats are all identical with each other, and have slightly relaxed syntax compared to the formats specified in the standard. The x (or u or U) is followed by zero to `sizeof(charT)*CHAR_BIT/4` hexadecimal digits. `charT` is `char` when reading narrow data, and `wchar_t` when reading wide data (even when reading wide data from a narrow file). On Macintosh and Windows this translates to 0 to 2 digits when reading a `char`, and from 0 to 4 digits when reading a `wchar_t`. Parsing the character is terminated when either the digit limit has been reached, or a non-hexadecimal digit has been reached. If there are 0 valid digits, then the character is read as '\0'. Example (assume a 8 bit `char` and 16 bit `wchar_t`):

```
\x01234
```

When reading narrow data this is the following sequence of 4 char's: '\1' '2' '3' '4'

The '\x01' is read as one character, but the following '2' is not included because a 8 bit char can only hold 2 hex digits.

When reading wide data the above example parses to the following two `wchar_t`'s:

```
L'\x123' L'4'
```

The '\x0123' is read as one `wchar_t`, but the following '4' is not included because a 16 bit `wchar_t` can only hold 4 hex digits.

### 7.2.3 Errors

If a character is expected, but an end of file occurs, then `failbit` is set. If a character is started with a single quote, and end of file occurs before the character within the quotes can be read, or if a closing quote is not found directly after the character, then `failbit` will be set. Depending on the context of when the character is being read, setting `failbit` may or may not cause a runtime error to be thrown.



## 7.2.4 String Syntax

Strings can be quoted or not (using `"`). If the string contains white space, then it must be quoted. For example:

```
Hi there!
```

This would be parsed as two strings: `"Hi"` and `"there!"`. But the following is one string:

```
"Hi there!"
```

If a string begins with quotes, but does not end with a quote (before end of file), then `failbit` will be set. This may or may not cause a runtime error to be thrown (depending on the context).

Any of the escape sequences described under character syntax are allowed within strings. But within strings, single quotes do not delimit characters. Instead single quotes are just another character in the string. Note that you can use `\` to place the string quote character within a string.

## 7.3 Locales

The header `<locale>` defines classes used to contain and manipulate information for a locale.

- [Class locale](#)
- [Locale Types](#)
- [Locale Members](#)
- [Locale Operators](#)
- [Locale Static Members](#)
- [Locale Globals](#)
- [Convenience Interfaces](#)
- [Character Classification](#)
- [Character Conversions](#)

### 7.3.1 Class locale

The class locale contains a set of facets for locale implementation. These facets are as if they were an index and an interface at the same time.

### 7.3.1.1 Combined Locale Names

Two locale constructors can result in a new locale whose name is a combination of the names of two other locales:

```
locale(const locale& other, const char* std_name, category);
locale(const locale& other, const locale& one, category);
```

If `other` has a name (and if `one` has a name in the case of the second constructor), then the resulting locale's name is composed from the two locales' names. A combined name locale has the format:

```
collate_name/ctype_name/monetary_name/numeric_name/ time_name/messages_name
```

Each name is the name of a locale from which that category of facets was copied.

The locale `loc` is created from two locales: `other` and `one`. The facets in the categories `collate` and `numeric` are taken from `one`. The rest of the facets are taken from `other`. The name of the resulting locale is:

```
one/other/other/one/other/other
```

The locale `loc2` is created from the "C" locale and from `loc` (which already has a combined name). It takes only the `monetary` and `collate` facets from `loc`, and the rest from "C":

```
one/C/other/C/C/C
```

Using this format, two locales can be compared by name, and if their names are equal, then they have the same facets.

#### Listing: Locale example usage:

```
#include <locale>
#include <iostream>

int main()
{
    using std::locale;

    locale loc(locale("other"), locale("one"),
               locale::collate | locale::numeric);
```

```

std::cout << loc.name() << '\n';

locale loc2(locale(), loc, locale::monetary |
            locale::collate);

std::cout << loc2.name() << '\n';
}
    
```

## 7.3.2 Locale Types

This library contains various types specific for locale implementation.

### 7.3.2.1 locale::Category

An integral type used as a mask for all types.

```
typedef int category;
```

Each `locale` member function takes a `locale::category` argument based on a corresponding facet.

**Table 7-1. Locale Category Facets**

Category	Includes Facets
collate	collate<char>, collate<wchar_t>
ctype	ctype<char>, ctype<wchar_t>, codecvt<char, char, mbstate_t>, codecvt<wchar_t, char, mbstate_t>
messages	messages<char>, messages<wchar_t>
monetary	moneypunct<char>, moneypunct<wchar_t> moneypunct<char, true>, moneypunct<wchar_t, true>, money_get<char>, money_get<wchar_t> money_put<char>, money_put<wchar_t>
numeric	numpunct<char>, numpunct<wchar_t>, num_get<char>, num_get<wchar_t> num_put<char>, num_put<wchar_t>
time	time_get<char>, time_get<wchar_t>, time_put<char>, time_put<wchar_t>

An implementation is included for each `facet` template member of a `category`.

**Table 7-2. Required Instantiations**

Category	Includes Facets
collate	collate_byname<char>, collate_byname<wchar_t>
ctype	ctype_byname<char>, ctype_byname<wchar_t>
messages	messages_byname<char>, messages_byname<wchar_t>
monetary	moneypunct_byname<char,International>, moneypunct_byname<wchar_t,International>, money_get<C,InputIterator>, money_put<C,OutputIterator>
numeric	numpunct_byname<char>, numpunct_byname<wchar_t> num_get<C,InputIterator>, num_put<C,OutputIterator>
time	time_get<char,InputIterator>, time_get_byname<char,InputIterator>, time_get<wchar_t,OutputIterator>, time_get_byname<wchar_t,OutputIterator>, time_put<char,OutputIterator>, time_put_byname<char,OutputIterator>, time_put<wchar_t,OutputIterator>, time_put_byname<wchar_t,OutputIterator>

### 7.3.2.2 locale::facet

The class `facet` is the base class for `locale` feature sets.

#### Listing: class `locale::facet` synopsis

```
namespace std {
class locale::facet {
protected:
explicit facet(size_t refs = 0);
virtual ~facet();
private:
facet(const facet&); // not defined
void operator=(const facet&); // not defined };
}
```

### 7.3.2.3 locale::id

The class `locale::id` is used for an index for locale facet identification.

## Listing: class locale::id synopsis

```
namespace std {
class locale::id {

public:
id();

private:

void operator=(const id&); // not defined
id(const id&); // not defined };
}
```

### 7.3.2.4 Constructors

Constructs an object of `locale`.

```
locale() throw();
locale(const locale& other) throw();
explicit locale(const char* std_name);
locale(const locale& other, const char* std_name, category);
template <class Facet> locale(const locale& other, Facet* f);
locale(const locale& other, const locale& one, category cats);
```

#### Remarks

`std::locale a_locale("");` is an example use of the constructor: `explicit locale(const char* std_name);`. The "" locale will attempt to read the environment variable `EWL_DEFAULT_LOCALE` and create a locale with the associated string. If `getenv("EWL_DEFAULT_LOCALE")` returns `null`, then "C" is used. There is no data file associated with the "C" locale. The "C" locale is coded directly into EWL C++.

### 7.3.2.5 destructor

Removes a `locale` object.

```
~locale() throw();
```

## 7.3.3 Locale Members

Member functions of the class `locale`.

### 7.3.3.1 `combine`

Creates a copy of the `locale` except for the type `Facet` of the argument.

```
template <class Facet> locale combine(const locale& other);
```

#### Remarks

The newly created locale is returned.

### 7.3.3.2 `name`

Returns the name of the `locale`.

```
basic_string<char> name() const;
```

#### Remarks

Returns the name of the locale or "\*" if there is none.

## 7.3.4 Locale Operators

The class `locale` has overloaded operators.

### 7.3.4.1 `operator ==`

The locale equality operator.

```
bool operator==(const locale& other) const;
```

## Remarks

The equality operator returns true if both arguments are the same locale.

### 7.3.4.2 operator !=

The locale non-equality operator

```
bool operator!=(const locale& other) const;
```

## Remarks

The non-equality operator returns true if the locales are not the same.

### 7.3.4.3 operator ()

Compares two strings using `use_facet<collate<>>`.

```
template <class charT,  
class Traits, class Allocator>  
bool operator()(  
const basic_string<charT,Traits,Allocator>& s1,  
const basic_string<charT,Traits,Allocator>& s2)  
const;
```

## Remarks

Returns true if the first argument is less than the second argument for ordering.

## 7.3.5 Locale Static Members

This section describes local static members.

### 7.3.5.1 global

Installs a new global locale.

```
static locale global(const locale& loc);
```

#### Remarks

Global returns the previous locale.

### 7.3.5.2 classic

Sets the locale to "C" locale equivalent to locale("C").

```
static const locale& classic();
```

#### Remarks

This function returns the "C" locale.

## 7.3.6 Locale Globals

Locale has two global functions.

### 7.3.6.1 use\_facet

Retrieves a reference to a facet of a locale.

```
template <class Facet> const Facet& use_facet  
(const locale& loc);
```

#### Remarks

Throws a `bad_cast` exception if `has_facet` is false.

The function returns a facet reference to corresponding to its argument.



### 7.3.6.2 has\_facet

Tests a locale to see if a facet is present

```
template <class Facet> bool has_facet
(const locale& loc) throw();
```

#### Remarks

If a facet requested is present `has_facet` returns true.

### 7.3.7 Convenience Interfaces

Character classification functionality is provided for in the `locale` class.

### 7.3.8 Character Classification

In the character classification functions true is returned if the function evaluates to true.

#### Listing: Character Classification

```
template <class charT> bool isspace (charT c, const locale& loc);
template <class charT> bool isprint (charT c, const locale& loc);

template <class charT> bool iscntrl (charT c, const locale& loc);
template <class charT> bool isupper (charT c, const locale& loc);
template <class charT> bool islower (charT c, const locale& loc);
template <class charT> bool isalpha (charT c, const locale& loc);
template <class charT> bool isdigit (charT c, const locale& loc);
template <class charT> bool ispunct (charT c, const locale& loc);
template <class charT> bool isxdigit(charT c, const locale& loc);
template <class charT> bool isalnum (charT c, const locale& loc);
template <class charT> bool isgraph (charT c, const locale& loc);
```

## 7.3.9 Character Conversions

Character conversion functionality is provided for in the `locale` class.

### 7.3.9.1 `toupper`

Converts to upper case character using the locale specified.

```
template <class charT> charT toupper  
(charT c, const locale& loc) const;
```

#### Remarks

Returns the upper case character.

### 7.3.9.2 `tolower`

Converts to a lower case character using the locale specified.

```
template <class charT> charT tolower  
(charT c, const locale& loc) const;
```

#### Remarks

Returns the lower case character.

## 7.4 Standard Locale Categories

The standard provides for various locale categories for providing formatting and manipulation of data and streams.

- [The Ctype Category](#)
- [The Numeric Category](#)
- [The Collate Category](#)
- [The Time Category](#)

- [The Monetary Category](#)
- [The Message Retrieval Category](#)
- [Program-defined Facets](#)

## 7.4.1 The Ctype Category

The type `ctype_base` provides for const enumerations.

### Listing: Ctype Category

```
namespace std {
class ctype_base
{
public:
    enum mask
    {
        alpha    = 0x0001,
        blank    = 0x0002,
        cntrl    = 0x0004,
        digit    = 0x0008,
        graph    = 0x0010,
        lower    = 0x0020,
        print    = 0x0040,
        punct    = 0x0080,
        space    = 0x0100,
        upper    = 0x0200,
        xdigit   = 0x0400,
        alnum    = alpha | digit
    };
};
}
```

### 7.4.1.1 Template Class Ctype

The class `ctype` provides for character classifications.

### 7.4.1.1.1 is

An overloaded function that tests for or places a mask.

```
bool is(mask m, charT c) const;
```

Test if *c* matches the mask *m*.

Returns true if the char *c* matches mask.

```
const charT* is  
(const charT* low, const charT* high,  
mask* vec) const;
```

Fills between the low and high with the mask argument.

Returns the second argument.

### 7.4.1.1.2 scan\_is

Scans the range for a mask value.

```
const charT* scan_is  
(mask m, const charT* low, const charT* high) const;
```

#### Remarks

Returns a pointer to the first character in the range that matches the mask, or the *high* argument if there is no match.

### 7.4.1.1.3 scan\_not

Scans the range for exclusion of the mask value.

```
const charT* scan_not(mask m,  
const charT* low, const charT* high) const;
```

#### Remarks

Returns a pointer to the first character in the range that does not match the mask, or the *high* argument if all characters match

#### 7.4.1.1.4 toupper

Converts to a character or a range of characters to uppercase.

```
charT toupper(charT) const;  
const charT* toupper (charT* low, const charT* high) const;
```

#### Remarks

Returns the converted char if it exists.

#### 7.4.1.1.5 tolower

Converts to a character or a range of characters to lowercase.

```
charT tolower(charT c) const;  
const charT* tolower(charT* low, const charT* high) const;
```

#### Remarks

Returns the converted char if it exists.

#### 7.4.1.1.6 widen

Converts a `char` or range of `char` type to the `charT` type.

```
charT widen(char c) const;  
const char* widen (const char* low, const char* high, charT* to) const;
```

#### Remarks

The converted `charT` is returned.

#### 7.4.1.1.7 narrow

Converts a `charT` or range of `charT` type to the `char` type.

```
char narrow(charT c, char default) const;  
const charT* narrow(const charT* low, const charT*, char default, char* to) const;
```

## Remarks

The converted `char` is returned.

### 7.4.1.2 ctype Virtual Functions

Virtual functions must be overloaded in the locale.

#### 7.4.1.2.1 do\_is

Implements the function `is`.

```
bool do_is (mask m, charT c) const;
const charT* do_is
(const charT* low, const charT* high, mask* vec) const;
```

#### 7.4.1.2.2 do\_scan\_is

Implements the function `scan_is`.

```
const charT* do_scan_is(mask m,
const charT* low, const charT* high) const;
```

#### 7.4.1.2.3 do\_scan\_not

Implements the function `scan_not`.

```
const charT* do_scan_not(mask m,
const charT* low, const charT* high) const;
```

#### 7.4.1.2.4 do\_toupper

Implements the function `toupper`.

```
charT do_toupper(charT c) const;
const charT* do_toupper(charT* low, const charT* high) const;
```

### 7.4.1.2.5 do\_tolower

Implements the function `tolower`.

```
charT do_tolower(charT c) const;
const charT* do_tolower(charT* low, const charT* high) const;
```

### 7.4.1.2.6 do\_widen

Implements the function `widen`.

```
charT do_widen(char c) const;
const char* do_widen(const char* low, const char* high,
charT* dest) const;
```

### 7.4.1.2.7 do\_narrow

Implements the function `narrow`.

```
char do_narrow(charT c, char dfaul) const;
const charT* do_narrow(const charT* low, const charT* high,
char dfaul, char* dest) const;
```

## 7.4.1.3 Template class `ctype_byname`

The template class `ctype_byname` has several responsibilities.

- character classification
- conversion to upper/lower case
- conversion to/from char

### 7.4.1.3.1 `ctype_byname` Constructor

```
explicit ctype_byname(const char*, size_t refs = 0);
```

The facet `ctype` has several responsibilities:

- character classification
- conversion to upper/lower case
- conversion to/from char

The first two of these items can be customized with `ctype_byname`. If you construct `ctype_byname` with a `const char*` that refers to a file, then that file is scanned by `ctype_byname`'s constructor for information to customize character classification, and case transformation tables.

```
ctype_byname<char> ct("en_US");
// looks for the file "en_US"
```

If the file "en\_US" exists, has `ctype` data in it, and there are no syntax errors in the data, then `ct` will behave as dictated by that data. If the file exists, but does not have `ctype` data in it, then the facet will behave as if it were constructed with "C". If the file has `ctype` data in it, but there is a syntax error in the data, or if the file does not exist, then a `std::runtime_error` is thrown.

For `ctype_byname<char>`, the `ctype` data section begins with:

```
$ctype_narrow
```

For `ctype_byname<wchar_t>`, the `ctype` data section begins with:

```
$ctype_wide
```

### 7.4.1.3.2 Classification

The classification table is created with one or more entries of the form:

```
ctype[character1 - character2] =
  ctype_classification |
  ctype_classification | ...
ctype[character] = ctype_classification |
  ctype_classification | ...
```

where `character`, `character1` and `character2` are characters represented according to the rules for [Strings and Characters in Locale Data Files](#). The characters may appear as normal characters:



```
ctype[a - z]
ctype['a' - 'z']
```

or as octal, hexadecimal or universal:

```
ctype['\101']
ctype['\x41']
ctype['\u41']
```

The usual escape sequences are also recognized: `\n`, `\t`, `\a`, `\\`, `\'` and so on.

On the right hand side of the equal sign, `ctype_classification` is one of:

- alpha
- blank
- cntrl
- digit
- graph
- lower
- print
- punct
- space
- upper
- xdigit

An `|` can be used to assign a character, or range of characters, more than one classification. These keywords correspond to the names of the enum `ctype_base::mask`, except that `alnum` is not present. To get `alnum` simply specify `"alpha | digit"`. The keyword `blank` is introduced, motivated by C99's `isblank` function.

Each of these keywords represent one bit in the `ctype_base::mask`. Thus for each entry into the `ctype` table, one must specify all attributes that apply. For example, in the "C" locale `a-z` are represented as:

```
ctype['a' - 'z'] =

    xdigit | lower | alpha | graph | print
```

### 7.4.1.3.3 Case Transformation

## Standard Locale Categories

Case transformation is usually handled by a table that maps each character to itself, except for those characters being transformed - which are mapped to their transformed counterpart. For example, a lower case map might look like:

```
lower['a'] == 'a'
lower['A'] == 'a'
```

This is represented in the ctype data as two tables: lower and upper. You can start a map by first specifying that all characters map to themselves:

```
lower['\0' - '\xFF'] = '\0' - '\xFF'
```

You can then override a subrange in this table to specify that 'A' - 'Z' maps to 'a' - 'z':

```
lower['A' - 'Z'] = 'a' - 'z'
```

These two statements have completely specified the lower case mapping for an 8 bit char. The upper case table is similar. For example, here is the specification for upper case mapping of a 16 bit wchar\_t in the "C" locale:

```
upper['\0' - '\xFFFF'] = '\0' - '\xFFFF'
upper['a' - 'z'] = 'A' - 'Z'
```

Below is the complete "C" locale specification for both ctype\_byname<char> and ctype\_byname<wchar\_t>. Note that a "C" data file does not actually exist. But if you provided a locale data file with this information in it, then the behavior would be the same as the "C" locale.

### Listing: Example of "C" Locale

```
$ctype_narrow
ctype['\x00' - '\x08'] = cntrl
ctype['\x09'] = cntrl | space | blank
ctype['\x0A' - '\x0D'] = cntrl | space
ctype['\x0E' - '\x1F'] = cntrl
ctype['\x20'] = space | blank | print
ctype['\x21' - '\x2F'] = punct | graph | print
ctype['\x30' - '\x39'] = digit | xdigit | graph | print
ctype['\x3A' - '\x40'] = punct | graph | print
ctype['\x41' - '\x46'] = xdigit | upper | alpha | graph | print
ctype['\x47' - '\x5A'] = upper | alpha | graph | print
```

```

ctype['\x5B' - '\x60'] = punct | graph | print
ctype['\x61' - '\x66'] = xdigit | lower | alpha | graph | print
ctype['\x67' - '\x7A'] = lower | alpha | graph | print
ctype['\x7B' - '\x7E'] = punct | graph | print
ctype['\x7F']          = cntrl

lower['\0' - '\xFF'] = '\0' - '\xFF'
lower['A' - 'Z']     = 'a' - 'z'

upper['\0' - '\xFF'] = '\0' - '\xFF'
upper['a' - 'z']     = 'A' - 'Z'

$type_wide
ctype['\x00' - '\x08'] = cntrl
ctype['\x09']          = cntrl | space | blank
ctype['\x0A' - '\x0D'] = cntrl | space
ctype['\x0E' - '\x1F'] = cntrl
ctype['\x20']          = space | blank | print
ctype['\x21' - '\x2F'] = punct | graph | print
ctype['\x30' - '\x39'] = digit | xdigit | graph | print
ctype['\x3A' - '\x40'] = punct | graph | print
ctype['\x41' - '\x46'] = xdigit | upper | alpha | graph | print
ctype['\x47' - '\x5A'] = upper | alpha | graph | print
ctype['\x5B' - '\x60'] = punct | graph | print
ctype['\x61' - '\x66'] = xdigit | lower | alpha | graph | print
ctype['\x67' - '\x7A'] = lower | alpha | graph | print
ctype['\x7B' - '\x7E'] = punct | graph | print
ctype['\x7F']          = cntrl

lower['\0' - '\xFFFF'] = '\0' - '\xFFFF'
lower['A' - 'Z']       = 'a' - 'z'

upper['\0' - '\xFFFF'] = '\0' - '\xFFFF'
upper['a' - 'z']       = 'A' - 'Z'

```

### 7.4.1.4 ctype Specializations

The category `ctype` has various specializations to help localization.

The class `ctype<char>` has four protected data members:

- `const mask* __table_;`
- `const unsigned char* __lower_map_;`
- `const unsigned char* __upper_map_;`
- `bool __owns_;`

Each of the pointers refers to an array of length `ctype<char>::table_size`. The destructor `~ctype<char>()` will delete `__table_` if `__owns_` is true, but it will not delete `__lower_map_` and `__upper_map_`. The derived class destructor must take care of deleting these pointers if they are allocated on the heap (`ctype<char>` will not allocate these pointers). A derived class can set these pointers however it sees fit, and have `ctype<char>` implement all of the rest of the functionality.

The class `ctype<wchar_t>` has three protected data members:

```
Metrowerks::range_map<charT, ctype_base::mask> __table_;

Metrowerks::range_map<charT, charT>          __lower_map_;

Metrowerks::range_map<charT, charT>          __upper_map_;
```

The class `range_map` works much like the tables in `ctype<char>` except that they are sparse tables. This avoids having tables of length `0xFFFF`. These tables map the first template parameter into the second.

#### Listing: The range\_map interface

```
template <class T, class U>
class range_map
{
public:
    U operator[] (const T& x) const;
    void insert(const T& x1, const T& x2, const U& y1, const U& y2);
```

```

void insert(const T& x1, const T& x2, const U& y1);

void insert(const T& x1, const U& y1);

void clear();

};

```

When constructed, the `range_map` implicitly holds a `map` of all `T` that `map` to `U()`. Use of the `insert` methods allows exceptions to that default mapping. For example, the first `insert` method maps the range `[x1 - x2]` into `[y1 - y2]`. The second `insert` method maps the `x`-range into a constant: `y1`. And the third `insert` method maps the single `T(x1)` into `U(y1)`. The method `clear()` brings the `range_map` back to the default setting: all `T` map into `U()`.

A class derived from `ctype<wchar_t>` can fill `__table_`, `__lower_map_` and `__upper_map_` as it sees fit, and allow the base class to query these tables. For an example see `ctype_byname<wchar_t>`.

### 7.4.1.5 Specialized Ctype Constructor and Destructor

Specialized `ctype<char>` and `ctype<wchar_t>` constructors and destructors.

#### 7.4.1.5.1 Constructor

Constructs a `ctype` object.

```

explicit ctype
(const mask* tbl = 0, bool del = false,
size_t refs = 0);

```

#### 7.4.1.5.2 destructor

Removes a `ctype` object.

```

~ctype();

```

#### 7.4.1.5.3 Specialized Ctype Members

**Listing: Several Ctype members are specialized in the standard library**

```

Specialized
ctype<char> and
ctype<wchar_t> member functions.

```

## Standard Locale Categories

```

bool is(mask m, char c) const;

const char* is(const char* low, const char* high,
mask* vec) const;

const char* scan_is(mask m,
const char* low, const char* high) const;

const char* scan_not(mask m,
const char* low, const char* high) const;

char toupper(char c) const;

const char* toupper(char* low, const char* high) const;

char tolower(char c) const;

const char* tolower(char* low, const char* high) const;

char widen(char c) const;

const char* widen(const char* low, const char* high,
char* to) const;

char narrow(char c, char /*dfault*/) const;

const char* narrow(const char* low, const char* high,
char /*dfault*/, char* to) const;

const mask* table() const throw();

```

### 7.4.1.6 ctype<Char> Static Members

Specialized ctype<char> static members. are provided.

#### 7.4.1.6.1 classic\_table

Determines the classification of characters in the "C" locale.

```

static const mask* classic_table() throw();

```

#### Remarks

Returns to a table that represents the classification in a "C" locale.

### 7.4.1.7 Class `ctype_byname<char>`

A specialization of `ctype_byname` of type `char`.

#### 7.4.1.7.1 `ctype_byname<char>` Constructor

```
explicit ctype_byname(const char*, size_t refs = 0);
```

The facet `ctype` has several responsibilities:

- character classification
- conversion to upper/lower case
- conversion to/from `char`

For a full and complete description of this facet specialization see [Ctype\\_byname Constructor](#) which list the process in greater detail.

### 7.4.1.8 Template Class `codecvt`

A class used for converting one character encoded types to another. For example, from wide character to multibyte character sets.

#### 7.4.1.8.1 `codecvt` Members

Member functions of the `codecvt` class.

##### 7.4.1.8.1.1 `out`

Convert internal representation to external.

```
result out(  
stateT& state, const internT* from,  
const internT* from_end, const internT*&  
from_next, externT* to, externT* to_limit,  
externT*& to_next) const;
```

### 7.4.1.8.1.2 unshift

Converts the shift state.

```
result unshift(stateT& state,
externT* to, externT* to_limit, externT*& to_next) const;
```

### 7.4.1.8.1.3 in

Converts external representation to internal.

```
result in(stateT& state, const externT* from,
const externT* from_end, const externT*&
from_next, internT* to, internT* to_limit,
internT*& to_next) const;
```

### 7.4.1.8.1.4 always\_noconv

Determines if no conversion is ever done.

```
bool always_noconv() const throw();
```

#### Remarks

Returns true if no conversion will be done.

### 7.4.1.8.1.5 length

Determines the length between two points.

```
int length(stateT& state, const externT* from,
const externT* from_end, size_t max) const;
```

#### Remarks

The distance between two points is returned.

### 7.4.1.8.1.6 max\_length

Determines the length necessary for conversion.



```
int max_length() const throw();
```

## Remarks

The number of elements to convert from `externT` to `internT` is returned.

### 7.4.1.8.1.7 `codecvt` Virtual Functions

Virtual functions for `codecvt` implementation.

```
result do_out(stateT& state, const internT* from,
const internT* from_end,
const internT*& from_next, externT* to,
externT* to_limit, externT*& to_next) const;
```

Implements `out`.

The result is returned as a value as in [Table 7-3](#).

```
result do_in(stateT& state, const externT* from,
const externT* from_end,
const externT*& from_next, internT* to,
internT* to_limit, internT*& to_next) const;
```

Implements `in`.

The result is returned as a value as in [Table 7-3](#).

```
result do_unshift(stateT& state,
externT* to, externT* to_limit, externT*& to_next) const;
Implements
unshift.
```

The result is returned as a value as in [Table 7-3](#).

```
int do_encoding() const throw();
```

Implements `encoding`.

```
bool do_always_noconv() const throw();
```

Implements `always_noconv`.

```
int do_length(stateT& state, const externT* from, const
externT* from_end, size_t max) const;
```

Implements `length`.

```
int do_max_length() const throw();
```

Implements `max_length`.

**Table 7-3. Convert Result Values**

Value	Meaning
error	Encountered a from_type character it could not convert
noconv	No conversion was needed
ok	Completed the conversion
partial	Not all source characters converted

### 7.4.1.9 Template Class `codecvt_byname`

The facet `codecvt` is responsible for translating internal characters (`wchar_t`) to/from external char's in a file.

There are several techniques for representing a series of `wchar_t`'s with a series of `char`'s. The `codecvt_byname` facet can be used to select among several of the encodings. If you construct `codecvt_byname` with a `const char*` that refers to a file, then that file is scanned by `codecvt_byname`'s constructor for information to customize the encoding.

```
codecvt_byname<wchar_t, char, std::mbstate_t>
cvt("en_US");
```

If the file "en\_US" exists, has `codecvt` data in it, and there are no syntax errors in the data, then `cvt` will behave as dictated by that data. If the file exists, but does not have `codecvt` data in it, then the facet will behave as if it were constructed with "C". If the file has `codecvt` data in it, but there is a syntax error in the data, or if the file does not exist, then a `std::runtime_error` is thrown.

For `codecvt_byname<char, char, mbstate_t>`, the `codecvt` data section begins with:

```
$codecvt_narrow
```

For `codecvt_byname<wchar_t, char, mbstate_t>`, the `codecvt` data section begins with:

```
$codecvt_wide
```

Although `$codecv_t_narrow` is a valid data section, it really does not do anything. The `codecv_t_byname<char, char, mbstate_t>` facet does not add any functionality beyond `codecv_t<char, char, mbstate_t>`. This facet is a degenerate case of `noconv` (no conversion). This can be represented in the locale data file as:

```
$codecv_t_narrow
noconv
```

The facet `codecv_t_byname<wchar_t, char, mbstate_t>` is much more interesting. After the data section introduction (`$codecv_t_wide`), one of these keywords can appear:

- `noconv`
- `UCS-2`
- `JIS`
- `Shift-JIS`
- `EUC`
- `UTF-8`

These keywords will be parsed as strings according to the rules for [Strings and Characters in Locale Data Files](#).

#### 7.4.1.10 Codecv\_t\_byname Keywords

These `Codecv_t_byname` keywords will be parsed as strings according to the rules for entering strings in locale data files.

##### 7.4.1.10.1 noconv

This conversion specifies that the base class should handle the conversion. The EWL C++ implementation of `codecv_t<wchar_t, char, mbstate_t>` will I/O all bytes of the `wchar_t` in native byte order.

##### 7.4.1.10.2 UCS-2

This encoding input and outputs the two lowest order bytes of the `wchar_t`, high byte first. For a big-endian, 16 bit `wchar_t` platform, this encoding is equivalent to `noconv`.

### 7.4.1.10.3 JIS

This is an early encoding used by the Japanese to represent a mixture of ASCII and a subset of Kanji.

### 7.4.1.10.4 Shift-JIS

Another early encoding used by the Japanese to represent a mixture of ASCII and a subset of Kanji.

### 7.4.1.10.5 EUC

Extended Unix Code.

### 7.4.1.10.6 UTF-8

A popular Unicode multibyte encoding. For example

```
$codecvt_wide
UTF-8
```

specifies that `codecvt_byname<wchar_t, char, mbstate_t>` will implement the UTF-8 encoding scheme. If this data is in a file called "en\_US", then the following program can be used to output a `wchar_t` string in UTF-8 to a file:

#### Listing: Example of Writing a `wchar_t` String in utf-8 to a File:

```
#include <locale>
#include <fstream>

int main()
{
    std::locale loc("en_US");
    std::wofstream out;
    out.imbue(loc);
    out.open("test.dat");
    out << L"This is a test \x00DF";
}
```

The binary contents of the file is (in hex):

```
54 68 69 73 20 69 73 20 61 20 74 65 73 74 20 C3 9F
```

Without the UTF-8 encoding, the default encoding will take over (all `wchar_t` bytes in native byte order):

```
#include <fstream>
int main()
{
    std::wofstream out("test.dat");
    out << L"This is a test \x00DF";
}
```

On a big-endian machine with a 2 byte `wchar_t` the resulting file in hex is:

```
00 54 00 68 00 69 00 73 00 20 00 69 00 73 00 20
```

```
00 61 00 20 00 74 00 65 00 73 00 74 00 20 00 DF
```

### 7.4.1.11 Extending codecvt by derivation

The facet `codecvt` can still be customized if you are on a platform that does not support a file system, or if you do not wish to use data files for other reasons.

Naturally, you can derive from `codecvt` and override each of the virtual methods in a portable manner as specified by the C++ standard. Additionally you can take advantage of the EWL C++ specific classes used to implement `codecvt_byname`. There are five implementation specific facets that you can use in place of `codecvt` or `codecvt_byname` to get the behavior of one of the five encodings:

- `__ucs_2`
- `__jis`
- `__shift_jis`
- `__euc`
- `__utf_8`

These classes are templated simply on the internal character type (and should be instantiated with `wchar_t`). The external character type is implicitly `char`, and the state type is implicitly `mbstate_t`.

Note in [An example use of `\_\_utf\_8` is](#): that this locale (and `wofstream`) will have all of the facets of the current global locale except that its `codecvt<wchar_t, char, mbstate_t>` will use the UTF-8 encoding scheme. Thus the binary contents of the file is (in hex):

**Listing: An example use of `__utf_8` is:**

```
#include <locale>
#include <fstream>

int main()
{
    std::locale loc(std::locale(), new std::__utf_8<wchar_t>);
    std::wofstream out;
    out.imbue(loc);
    out.open("test.dat");
    out << L"This is a test \x00DF";
}

```

**Result**

```
54 68 69 73 20 69 73 20 61 20 74 65 73 74 20 C3 9F
```

## 7.4.2 The Numeric Category

A class for numeric formatting and manipulation for locales.

### 7.4.2.1 Template Class `Num_get`

A class for formatted numeric input.

#### 7.4.2.2 `Num_get` Members

The class `num_get` includes specific functions for parsing and formatting of numbers.

##### 7.4.2.2.1 `get`

The function `get` is overloaded for un-formatted input.

```
iter_type get(iter_type in, iter_type end,
ios_base& str, ios_base::iostate& err, long& val) const;
iter_type get(iter_type in, iter_type end,
```

```

ios_base& str,ios_base::iostate& err,
unsigned short& val) const;
iter_type get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err,unsigned int& val)
const;
iter_type get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, unsigned long& val)
const;
iter_type get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, short& val) const;
iter_type get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, double& val) const;
iter_type get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err,long double& val) const;
iter_type get(iter_type in, iter_type end,
ios_base& str, ios_base::iostate& err, void*& val) const;

```

## Remarks

returns and iterator type.

### 7.4.2.2.2 Num\_get Virtual Functions

Implements the relative versions of the `get` function

```

iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, long& val) const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str, ios_base::iostate& err,
unsigned short& val) const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err,
unsigned int& val) const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err,
unsigned long& val) const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err,
float& val) const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, double& val) const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, long double& val)
const;
iter_type do_get(iter_type in, iter_type end,
ios_base& str,ios_base::iostate& err, void*& val) const;
iter_type do_get(iter_type in, iter_type end, ios_base& str,
ios_base::iostate& err, bool& val) const;

```

## Remarks

Implements the relative versions of `get`.

### TemplateClassNum\_put

A class for formatted numeric output.

### 7.4.2.3 Num\_put Members

The class `num_put` includes specific functions for parsing and formatting of numbers.

#### 7.4.2.3.1 put

The function `put` is overloaded for un-formatted output.

```
iter_type put(iter_type out, ios_base& str,
char_type fill, bool val) const;
iter_type put(iter_type out, ios_base& str,
char_type fill, long val) const;
iter_type put(iter_type out, ios_base& str,
char_type fill, unsigned long val) const;
iter_type put(iter_type out, ios_base& str,
char_type fill, double val) const;
iter_type put(iter_type out, ios_base& str,
char_type fill, long double val) const;
iter_type put(iter_type out, ios_base& str,
char_type fill, const void* val) const;
```

#### 7.4.2.3.2 Num\_put Virtual Functions

Implementation functions for `put`.

```
iter_type do_put(iter_type out, ios_base& str,
char_type fill, bool val) const;
iter_type do_put(iter_type out, ios_base& str,
char_type fill, long val) const;
iter_type do_put(iter_type out, ios_base& str,
char_type fill, unsigned long val) const;
iter_type do_put(iter_type out, ios_base& str,
char_type fill, double val) const;
iter_type do_put(iter_type out, ios_base& str,
char_type fill, long double val) const;
iter_type do_put(iter_type out, ios_base& str,
char_type fill, const void* val) const;
```

### 7.4.2.4 The Numeric Punctuation Facet

A facet for numeric punctuation in formatting and parsing.

#### TemplateClassNumpunct



A class for numeric punctuation conversion.

#### 7.4.2.4.1 Numpunct Members

The template class `numpunct` provides various functions for punctuation localizations.

##### 7.4.2.4.1.1 `decimal_point`

Determines the character used for a decimal point.

```
char_type decimal_point() const;
```

#### Remarks

Returns the character used for a decimal point.

##### 7.4.2.4.1.2 `thousands_sep`

Determines the character used for a thousand separator.

```
char_type thousands_sep() const;
```

#### Remarks

Returns the character used for the thousand separator.

##### 7.4.2.4.1.3 `grouping`

Describes the thousand separators.

```
string grouping() const;
```

#### Remarks

Returns a string describing the thousand separators.

##### 7.4.2.4.1.4 `truename`

Determines the localization for "true".

## Standard Locale Categories

```
string_type truename() const;
```

### Remarks

Returns a string describing the localization of the word "true".

#### 7.4.2.4.1.5 falsename

Determines the localization for "false".

```
string_type falsename() const;
```

### Remarks

Returns a string describing the localization of the word "false".

#### 7.4.2.4.1.6 numpunct virtual functions

Implementation of the public functions.

```
char_type do_decimal_point() const;
```

Implements `decimal_point`.

```
string_type do_thousands_sep() const;
```

Implements `thousands_sep`.

```
string do_grouping() const;
```

Implements `grouping`.

```
string_type do_truename() const;
```

Implements `truename`.

```
string_type do_falsename() const;
```

Implements `falsename`.

### 7.4.2.4.1.7 Template Class `num_punct_byname`

The facet `num_punct` specifies the punctuation used for parsing and formatting numeric quantities. You can specify the decimal point character, thousands separator, the grouping, and the spelling of true and false. If you construct `num_punct_byname` with a `const char*` that refers to a file, then that file is scanned by `num_punct_byname`'s constructor for information to customize the encoding.

```
num_punct_byname<char> np("en_US");
```

If the file "en\_US" exists, has `num_punct` data in it, and there are no syntax errors in the data, then `np` will behave as dictated by that data. If the file exists, but does not have `num_punct` data in it, then the facet will behave as if it were constructed with "C". If the file has `num_punct` data in it, but there is a syntax error in the data, or if the file does not exist, then a `std::runtime_error` is thrown.

For `num_punct_byname<char>`, the `num_punct` data section begins with:

```
$numeric_narrow
```

For `num_punct_byname<wchar_t>`, the `num_punct` data section begins with:

```
$numeric_wide
```

The syntax for both the narrow and wide data sections is the same. There are keywords that allow you to specify the different parts of the `num_punct` data:

- [decimal\\_point](#)
- [thousands\\_sep](#)
- [grouping](#)
- [false\\_name](#) and [true\\_name](#)

You enter data with one of these keywords, followed by an equal sign '=', and then the data. You can specify any or all of the keywords. Data not specified will default to that of the "C" locale. The first two keywords (`decimal_point` and `thousands_sep`) have character data associated with them. See the rules for [Character Syntax](#) for details. The last three keywords have string data associated with them. See the rules for [String Syntax](#).

#### Listing: Example usage of `num_punct_byname`

```
$numeric_narrow
decimal_point = ','
thousands_sep = '.'
grouping = 3|2
```

## Standard Locale Categories

```
false_name = nope
```

```
true_name = sure
```

Here is an example program using the above data for narrow streams:

```
#include <sstream>
#include <locale>
#include <iostream>
int main()
{
    std::locale loc("my_loc");
    std::cout.imbue(loc);
    std::istringstream in("1.23.456 nope 1.23.456,789");
    in.imbue(loc);
    in >> std::boolalpha;
    long i;
    bool b;
    double d;
    in >> i >> b >> d;
    std::cout << i << '
        << std::boolalpha << !b << '
        << std::fixed << d;
}
```

The output is:

```
1.23.456
sure
1.23.456,789000
```

### 7.4.2.4.1.7.1 *decimal\_point*

The decimal point data is a single character, as in:

```
decimal_point = '.'
```

### 7.4.2.4.1.7.2 *thousands\_sep*

The character to be used for the thousands separator is specified with `thousands_sep`, as in:

```
thousands_sep = ','
```

### 7.4.2.4.1.7.3 *grouping*

The grouping string specifies the number of digits to group, going from right to left. For example, the grouping: 321 means that the number 12345789 would be printed as in:

```
1,2,3,4,56,789
```

The above grouping string can be specified as:

```
grouping = 321
```

A grouping string of "0" or "" means: do not group.

#### 7.4.2.4.1.7.4 *false\_name and true\_name*

The names of false and true can be specified with `false_name` and `true_name`. For example:

```
false_name = "no way"
```

```
true_name = sure
```

#### 7.4.2.4.1.8 **Numeric\_wide**

For \$ `numeric_wide`, wide characters can be represented with the hex or universal format (e.g. "\u64D0").

### 7.4.2.5 **Extending numpunct by derivation**

It is easy enough to derive from `numpunct` and override the virtual functions in a portable manner. But `numpunct` also has a non-standard protected interface that you can take advantage of if you wish.

There are five protected data members:

```
char_type __decimal_point_;  
char_type __thousands_sep_;  
string __grouping_;
```

**Standard Locale Categories**

```
string_type __truename_;
string_type __falsename_;
```

A derived class could set these data members in its constructor to whatever is appropriate, and thus not need to override the virtual methods.

**Listing: Example of `numpunct<char>`**

```
struct mypunct: public std::numpunct<char>
{
    mypunct();
};

mypunct::mypunct()
{
    __decimal_point_ = ',';
    __thousands_sep_ = '.';
    __grouping_ = "\3\2";
    __falsename_ = "nope";
    __truename_ = "sure";
}

int main()
{
    std::locale loc(std::locale(), new mypunct);
    std::cout.imbue(loc);
    // ...
}
```

**7.4.3 The Collate Category**

The Template class `collate` used for the comparison and manipulation of strings.

**7.4.3.1 Collate Members**

Member functions used for comparison and hashing of strings.

**7.4.3.1.1 `compare`**

Lexicographical comparison of strings.

```
int compare(const charT* low1, const charT* high1,
            const charT* low2, const charT* high2) const;
```

## Remarks

A value of 1 is returned if the first is lexicographically greater than the second. A value of negative 1 is returned if the second is greater than the first. A value of zero is returned if the strings are the same.

### 7.4.3.1.2 transform

Provides a string object to be compared to other transformed strings.

```
string_type transform
(const charT* low, const charT* high) const;
```

## Remarks

The `transform` member function is used for comparison of a series of strings.

Returns a string for comparison.

### 7.4.3.1.3 hash

Determines the `hash` value for the string.

```
long hash(const charT* low, const charT* high) const;
```

## Remarks

Returns the hash value of the string

### 7.4.3.1.4 collate Virtual Functions

Localized implementation functions for public collate member functions.

```
int do_compare
(const charT* low1, const charT* high1,
 const charT* low2, const charT* high2) const;
```

Implements `compare`.

```
string_type do_transform(const charT* low, const charT* high)
const;
```

Implements `transform`

```
long do_hash(const charT* low, const charT* high) const;
```

Implements `hash`.

### 7.4.3.2 Template Class `Collate_byname`

The facet `collate` is responsible for specifying the sorting rules used for sorting strings.

The base class `collate` does a simple lexical comparison on the binary values in the string. `collate_byname` can perform much more complex comparisons that are based on the Unicode sorting algorithm. If you construct `collate_byname` with a `const char*` that refers to a file, then that file is scanned by `collate_byname`'s constructor for information to customize the collation rules.

```
collate_byname<char> col("en_US");
```

If the file `"en_US"` exists, has collate data in it, and there are no syntax errors in the data, then `col` will behave as dictated by that data. If the file exists, but does not have collate data in it, then the facet will behave as if it were constructed with `"C"`. If the file has collate data in it, but there is a syntax error in the data, or if the file does not exist, then a `std::runtime_error` is thrown.

#### 7.4.3.2.1 Collate Data Section

For `collate_byname<char>`, the collate data section begins with:

```
$collate_narrow
```

For `collate_byname<wchar_t>`, the collate data section begins with:

```
$collate_wide
```



The syntax for both the narrow and wide data sections is the same. The data consists of a single string that has a syntax very similar to Java's `RuleBasedCollator` class. This syntax is designed to provide a level three sorting key consistent with the sorting algorithm specified by the Unicode collation algorithm.

#### 7.4.3.2.2 Rule Format

The collation string rule is composed of a list of collation rules, where each rule is of three forms:

```
< modifier >  
< relation > < text-argument >  
< reset > < text-argument >
```

#### 7.4.3.2.3 Text-Argument:

A text-argument is any sequence of characters, excluding special characters (that is, common whitespace characters and rule syntax characters). If those characters are desired, you can put them in single quotes (e.g. ampersand => '&').

#### 7.4.3.2.4 Modifier:

There is a single modifier which is used to specify that all accents (secondary differences) are backwards.

```
'@': Indicates that accents are sorted backwards, as in French.
```

#### 7.4.3.2.5 Relation:

The relations are the following:

- '<': Greater, as a letter difference (primary)
- ',': Greater, as an accent difference (secondary)
- ', ': Greater, as a case difference (tertiary)
- '=': Equal

#### 7.4.3.2.6 Reset:

There is a single reset which is used primarily for expansions, but which can also be used to add a modification at the end of a set of rules.

- '&': Indicates that the next rule follows the position to where the reset text-argument would be sorted.

### 7.4.3.2.7 Relationals

The relationals allow you to specify the relative ordering of characters. For example, the following string expresses that 'a' is less than 'b' which is less than 'c':

```
"< a < b < c"
```

For the time being, just accept that a string should start with '<'. That rule will be both relaxed and explained later.

Many languages (including English) consider 'a' < 'A', but only as a tertiary difference. And such minor differences are not considered significant unless more important differences are found to be equal. For example consider the strings:

- aa
- Aa
- ab

Since 'a' < 'A', then "aa" < "Aa". But "Aa" < "ab" because the difference between the second characters 'a' and 'b' is more important the difference between the first characters 'A' and 'a'. This type of relationship can be expressed in the collation rule with:

```
"< a, A < b, B < c, C"
```

This says that 'a' is less 'A' by a tertiary difference, and then 'b' and 'B' are greater than 'a' and 'A' by a primary difference (similarly for 'c' and 'C').

Accents are usually considered secondary differences. For example, lower case e with an acute accent might be considered to be greater than lower case e, but only by a secondary difference. This can be represented with a semicolon like:

```
"... < e, E ; é, É < ..."
```

Note that characters can be entered in hexadecimal or universal format. They can also be quoted with single quotes (for example 'a'). If it is ambiguous whether a character is a command or a text argument, adding quotes specifies that it is a text argument.

Characters not present in a rule are implicitly ordered after all characters that do appear in a rule.

### 7.4.3.2.8 French collation

Normally primary, secondary and tertiary differences are considered left to right. But in French, secondary differences are considered right to left. This can be specified in the rule string by starting it with '@':

```
"@ ... < e, E ; é, É < ..."
```

### 7.4.3.2.9 Contraction

Some languages sort groups of letters as a single character. Consider the two strings: "acha" and "acia". In English they are sorted as just shown. But Spanish requires "ch" to be considered a single character that is sorted after 'c' and before 'd'. Thus the order in Spanish is reversed relative to English (that is "acia" < "acha"). This can be specified like:

```
"... < c < ch < d ..."
```

Taking case into account, you can expand this idea to:

```
"... < c, C < ch, cH, Ch, CH < d, D ..."
```

### 7.4.3.2.10 Expansion

Some languages expand a single character into multiple characters for sorting. For example in English the ligature 'æ' might be sorted as 'a' followed by 'e'. To represent this in a rule, the reset character (&) is used. The idea is to reset the current sorting key to an already entered value, and create multiple entries for the ligature. For example:

```
"... < a < b < c < d < e ... < z & a = æ & e = æ ..."
```

This rule resets the sort key to that of 'a', and then enters 'æ'. Then resets the sort key to that of 'e' and enters 'æ' again. This rule says that 'æ' is exactly equivalent to 'a' followed by 'e'. Alternatively ';' could have been used instead of '='. This would have made "ae" less than "æ" but only by a secondary difference.

### 7.4.3.2.11 Ignorable Characters

Characters in the rule before the first '<' are ignorable. They are not considered during the primary sorting. Accents and punctuation are often marked as ignorable, but given a non-ignorable secondary or tertiary weight. For example, the default Java rule starts out with:

```
"= '\u200B'=\u200C=\u200D=\u200E=\u200F ...
"; '\u0020'; '\u00A0'..."
```

This completely ignores the first five characters (formatting control), and ignores except for secondary differences the next two characters (spacing characters).

This is why all example rules up till now started with '<' (so that none of the characters would be ignorable).

In the [In the notice how the space character was entered using quotes to disambiguate it from insignificant white space. Example of locale sorting](#) notice how the space character was entered using quotes to disambiguate it from insignificant white space. Example of locale sorting

Assume the file "my\_loc" has the following data in it:

```
$collate_narrow
"; - = ' '
< a, A < b, B < c, C
< ch, cH, Ch, CH
< d, D < e, E < f, F
< g, G < h, H < i, I
< j, J < k, K < l, L
< ll, lL, Ll, LL
< m, M < n, N < o, O
< p, P < q, Q < r, R
< s, S < t, T < u, U
< v, V < w, W < x, X
< y, Y < z, Z"
```

The program below creates a vector of strings and sorts them both by "binary order" (just using string's operator <), and by the custom rule above using a locale as the sorting key.

```

#include <locale>

#include <algorithm>

#include <vector>

#include <string>

#include <iostream>

int main()
{
    std::vector<std::string> v;
    v.push_back("aaaaaaB");
    v.push_back("aaaaaaA");
    v.push_back("AaaaaaB");
    v.push_back("AaaaaaA");
    v.push_back("blackbird");
    v.push_back("black-bird");
    v.push_back("black bird");
    v.push_back("blackbirds");
    v.push_back("acia");
    v.push_back("acha");
    std::ostream_iterator<std::string> out(std::cout, "\n");
    std::cout << "Binary order:\n\n";
    std::sort(v.begin(), v.end());
    std::copy(v.begin(), v.end(), out);
    std::cout << '\n';
    std::locale loc("my_loc");
    std::sort(v.begin(), v.end(), loc);
    std::cout << "Customized order:\n\n";
    std::copy(v.begin(), v.end(), out);
    std::cout << '\n';
}

```

## The output is:

### Binary order:

```

AaaaaaA
AaaaaaB
aaaaaaA
aaaaaaB
acha
acia
black bird
black-bird
blackbird
blackbirds

```

### Customized order:

```

aaaaaaA
AaaaaaA
aaaaaaB
AaaaaaB
acia
acha
blackbird
black-bird
black bird
blackbirds

```

### 7.4.3.3 Extending collate by derivation

The behavior of collate can still be customized if you are on a platform that does not support a file system, or if you do not wish to use data files for other reasons.

Naturally, you can derive from collate and override each of the virtual methods in a portable manner as specified by the C++ standard. Additionally you can take advantage of the EWL C++ specific protected interface of collate\_byname if you wish (to make your job easier if portability is not a concern).

The class collate\_byname has one protected data member:

```
__collation_rule<charT> rule_;
```

#### Listing: The class std::\_\_collation\_rule interface:

```
template <class charT>
class __collation_rule
{
    struct value
    {
        charT primary;
        charT secondary;
        charT tertiary;
        ;
    public:
        struct entry
            : value
        {
            unsigned char length;
        };
        __collation_rule();
        explicit __collation_rule(const basic_string<charT>& rule);
        void set_rule(const basic_string<charT>& rule);
        entry operator()(const charT* low,
            const charT* high, int& state) const;
        bool is_french() const;
        bool empty() const;
```

```
};
```

Most of this interface is to support `collate_byname`. If you simply derive from `collate_byname`, set the rule with a string, and let `collate_byname` do all the work, then there is really very little you have to know about `__collation_rule`.

A `__collation_rule` can be empty (contain no rule). In that case `collate_byname` will use `collate`'s sorting rule. This is also the case if `collate_byname` is constructed with `"C"`. And once constructed, `__collation_rule`'s rule can be set or changed with `set_rule`. That is all you need to know to take advantage of all this horsepower!

### Listing: Example of a `__collation_rule`:

```
#include <iostream>
#include <locale>

#include <string>

struct my_collate
    : public std::collate_byname<char>
{
    my_collate();
};

my_collate::my_collate()
    : std::collate_byname<char>("C")
{
    rule_.set_rule("< a = A < b = B < c = C
                  < d = D < e = E < f = F"
                  < g = G < h = H < i = I"
                  < j = J < k = K < l = L"
                  < m = M < n = N < o = O"
                  < p = P < q = Q < r = R"
                  < s = S < t = T < u = U"
                  < v = V < w = W < x = X"
                  < y = Y < z = Z");
}

int main()
{
    std::locale loc(std::locale(), new my_collate);
```

## Standard Locale Categories

```

std::string s1("Arnold");
std::string s2("arnold");
if (loc(s1, s2))
    std::cout << s1 << " < " << s2 << '\n';
else if (loc(s2, s1))
    std::cout << s1 << " > " << s2 << '\n';
else
    std::cout << s1 << " == " << s2 << '\n';
}

```

The custom facet `my_collate` derives from `std::collate_byname<char>` and sets the rule in its constructor. That's all it has to do. For this example, a case-insensitive rule has been constructed. The output of this program is:

```
Arnold == arnold
```

Alternatively, you could use `my_collate` directly (this is exactly what EWL C++'s locale does):

### Listing: Example of custom facet `my_collate`:

```

int main()
{
    my_collate col;
    std::string s1("Arnold");
    std::string s2("arnold");
    switch (col.compare(s1.data(), s1.data()+s1.size(),
                      s2.data(), s2.data()+s2.size())
           )
    {
    case -1:
        std::cout << s1 << " < " << s2 << '\n';
        break;
    case 0:
        std::cout << s1 << " == " << s2 << '\n';
        break;
    case 1:
        std::cout << s1 << " > " << s2 << '\n';
    }
}

```



```
        break;
    }
}
```

The output of this program is also:

```
Arnold == arnold
```

## 7.4.4 The Time Category

The facets `time_get` and `time_put` are conceptually simple: they are used to parse and format dates and times in a culturally sensitive manner. But as is not uncommon, there can be a lot of details. And for the most part, the standard is quiet about the details, leaving much of the behavior of these facets in the "implementation defined" category. Therefore this document not only discusses how to extend and customize the time facets, but it also explains much of the default behavior as well.

### 7.4.4.1 Time\_get Members

The facet `time_get` has 6 member functions.

- `date_order`
- `get_time`
- `get_date`
- `get_weekday`
- `get_monthname`
- `get_year`

```
dateorder date_order() const;
```

Determines how the date, month and year are ordered.

Returns an enumeration representing the date, month, year order. Returns zero if it is unordered.

```
iter_type get_time
(iter_type s, iter_type end, ios_base& str,
 ios_base::iostate& err, tm* t) const;
```

**Standard Locale Categories**

Determines the localized time.

Returns an iterator immediately beyond the last character recognized as a valid time.

```
iter_type get_date
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

Determines the localized date.

Returns an iterator immediately beyond the last character recognized as a valid date.

```
iter_type get_weekday
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

Determines the localized weekday.

Returns an iterator immediately beyond the last character recognized as a valid weekday.

```
iter_type get_monthname
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

Determines the localized month name.

Returns an iterator immediately beyond the last character recognized as a valid month name.

```
iter_type get_year(iter_type s, iter_type end,
ios_base& str, ios_base::iostate& err,
tm* t) const;
```

Determines the localized year.

Returns an iterator immediately beyond the last character recognized as a valid year.

### 7.4.4.2 Time\_get Virtual Functions

The facet `time_get` has 6 protected virtual members.

- `do_date_order`
- `do_get_time`
- `do_get_date`
- `do_get_weekday`

- `do_get_monthname`
- `do_get_year`

```
dateorder
do_date_order() const;
```

The method `do_date_order` returns `no_order`. This result can be changed via derivation.

```
iter_type do_get_time(iter_type s, iter_type end,
ios_base& str, ios_base::iostate& err,
tm* t) const;
```

The method `do_get_time` parses time with the format:

```
"%H:%M:%S"
iter_type do_get_date
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

The method `do_get_date` parses a date with the format:

```
"%A %B %d %T %Y"
```

This format string can be changed via the named locale facility, or by derivation.

```
iter_type do_get_weekday
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

The method `do_get_weekday` parses with the format:

```
"%A"
```

Although the format string can only be changed by derivation, the names of the weekdays themselves can be changed via the named locale facility or by derivation.

```
iter_type do_get_monthname
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

The method `do_get_monthname` parses with the format:

```
"%B"
```

Although the format string can only be changed by derivation, the names of the months themselves can be changed via the named locale facility or by derivation.

```
iter_type do_get_year
(iter_type s, iter_type end, ios_base& str,
ios_base::iostate& err, tm* t) const;
```

The method `do_get_year` parses a year with the format:

```
"%Y"
```

This behavior can only be changed by derivation.

The details of what these formats mean can be found in the [Format/Parsing Table](#) .

In addition to the above mentioned protected methods, EWL C++ provides a non-standard, non-virtual protected method:

```
iter_type __do_parse(iter_type in, iter_type end,
ios_base& str, ios_base::iostate& err,
const basic_string<charT>& pattern, tm* t) const;
```

This method takes the parameters typical of the standard methods, but adds the pattern parameter of type `basic_string`. The pattern is a general string governed by the rules outlined in the section [Format Parsing](#) . Derived classes can make use of this method to parse patterns not offered by `time_get`.

### Listing: Derived classes example:

```
template <class charT, class InputIterator>
typename my_time_get<charT, InputIterator>::iter_type
my_time_get<charT, InputIterator>::do_get_date_time(
    iter_type in, iter_type end, std::ios_base& str,
    std::ios_base::iostate& err, std::tm* t) const
{
    const std::ctype<charT>& ct = std::use_facet<std::ctype<charT>>
        (str.getloc());
    return __do_parse(in, end, str, err, ct.widen("%c"), t);
}
```

## 7.4.4.3 Format Parsing

These commands follow largely from the C90 and C99 standards.

However a major difference here is that most of the commands have meaning for parsing as well as formatting, whereas the C standard only uses these commands for formatting. The pattern string consists of zero or more conversion specifiers and ordinary characters (`char` or `wchar_t`). A conversion specifier consists of a `%` character, possibly followed by an `E` or `O` modifier character (described below), followed by a character that determines the behavior of the conversion specifier. Ordinary characters (non-conversion specifiers) must appear in the source string during parsing in the appropriate place or failbit gets set. On formatting, ordinary characters are sent to the output stream unmodified.

The `E` modifier can appear on any conversion specifier. But it is ignored for both parsing and formatting.

The `O` modifier can appear on any conversion specifier. It is ignored for parsing, but effects the following conversion specifiers on output by not inserting leading zeroes: `%C`, `%d`, `%D`, `%F`, `%g`, `%H`, `%I`, `%j`, `%m`, `%M`, `%S`, `%U`, `%V`, `%W`, `%y`

**Table 7-4. Format/Parsing Table**

Modifier	Parse	Format
<code>%a</code>	Reads one of the locale's weekday names. The name can either be the full name, or the abbreviated name. Case is significant. On successful parsing of one of the weekday names, sets <code>tm_wday</code> , otherwise sets failbit. For parsing, this format is identical to <code>%A</code> .	Outputs the locale's abbreviated weekday name as specified by <code>tm_wday</code> . The "C" locale's abbreviated weekday names are: Sun, Mon, Tue, Wed, Thu, Fri, Sat.
<code>%A</code>	For parsing, this format is identical to <code>%a</code> .	Outputs the locale's full weekday name as specified by <code>tm_wday</code> . The "C" locale's full weekday names are: Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday.
<code>%b</code>	Reads one of the locale's month names. The name can either be the full name, or the abbreviated name. Case is significant. On successful parsing of one of the month names, sets <code>tm_mon</code> , otherwise sets failbit. For parsing, this format is identical to <code>%B</code> .	Outputs the locale's abbreviated month name as specified by <code>tm_mon</code> . The "C" locale's abbreviated month names are: Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec.
<code>%B</code>	For parsing, this format is identical to <code>%b</code> .	Outputs the locale's full month name as specified by <code>tm_mon</code> . The "C" locale's full month names are: January, February, March, April, May, June, July, August, September, October, November, December.
<code>%c</code>	Reads the date-and-time as specified by the current locale. The "C" locale specification is <code>"%A %B %d %T %Y"</code> . On successful parsing this sets <code>tm_wday</code> , <code>tm_mon</code> , <code>tm_mday</code> , <code>tm_sec</code> , <code>tm_min</code> ,	Outputs the locale's date-and-time. The "C" locale's date-and-time format is <code>"%A %B %d %T %Y"</code> . This information is specified by <code>tm_wday</code> , <code>tm_mon</code> , <code>tm_mday</code> , <code>tm_sec</code> , <code>tm_min</code> , <code>tm_hour</code> and <code>tm_year</code> .

*Table continues on the next page...*

**Table 7-4. Format/Parsing Table (continued)**

Modifier	Parse	Format
	tm_hour and tm_year. If the entire pattern is not successfully parsed, then no tm members are set and failbit is set.	
%C	This is not a valid parse format. If %C is used in a parse pattern, a runtime_error is thrown.	Outputs the current year divided by 100. Single digit results will be pre-appended with '0' unless the O modifier is used.
%d	Reads the day of the month. The result must be in the range [1, 31] else failbit will be set. Upon successful parsing tm_mday is set. For parsing, this format is identical to %e.	Outputs the day of the month as specified by tm_mday. Single digit results will be pre-appended with '0' unless the O modifier is used.
%D	Is equivalent to "%m/%d/%y".	Is equivalent to "%m/%d/%y". If the O modifier is used, is equivalent to "%Om/%Od/%y".
%e	Reads the day of the month. The result must be in the range [1, 31] else failbit will be set. Upon successful parsing tm_mday is set. For parsing, this format is identical to %d.	Outputs the day of the month as specified by tm_mday. Single digit results will be pre-appended with a space.
%F	Is equivalent to "%Y-%m-%d" (the ISO 8601 date format).	Is equivalent to "%Y-%m-%d". If the O modifier is used, is equivalent to "%Y-%Om-%Od".
%g	This is not a valid parse format. If %g is used in a parse pattern, a runtime_error is thrown.	Outputs the last 2 digits of the <a href="#">ISO 8601 week-based year</a> . Single digit results will be pre-appended with '0' unless the O modifier is used. Specified by tm_year, tm_wday and tm_yday.
%G	This is not a valid parse format. If %G is used in a parse pattern, a runtime_error is thrown.	Outputs the <a href="#">ISO 8601 week-based year</a> . Specified by tm_year, tm_wday and tm_yday.
%h	Is equivalent to %b.	Is equivalent to %b.
%H	Reads the hour (24-hour clock) as a decimal number. The result must be in the range [0, 23] else failbit will be set. Upon successful parsing tm_hour is set.	Outputs the hour (24-hour clock) as specified by tm_hour. Single digit results will be pre-appended with '0' unless the O modifier is used.
%I	Reads the hour (12-hour clock) as a decimal number. The result must be in the range [1, 12] else failbit will be set. Upon successful parsing tm_hour is set. This format is usually used with %p to specify am/pm. If a %p is not parsed with the %I, am is assumed.	Outputs the hour (12-hour clock) as specified by tm_hour. Single digit results will be pre-appended with '0' unless the O modifier is used.
%j	This is not a valid parse format. If %j is used in a parse pattern, a runtime_error is thrown.	Outputs the day of the year as specified by tm_yday in the range [001, 366]. If the O modifier is used, leading zeroes are suppressed.
%m	Reads the month as a decimal number. The result must be in the range [1, 12] else failbit will be set. Upon successful parsing tm_mon is set.	Outputs the month as specified by tm_mon as a decimal number in the range [1, 12]. Single digit results will be pre-appended with '0' unless the O modifier is used.

Table continues on the next page...

**Table 7-4. Format/Parsing Table (continued)**

Modifier	Parse	Format
%M	Reads the minute as a decimal number. The result must be in the range [0, 59] else failbit will be set. Upon successful parsing tm_min is set.	Outputs the minute as specified by tm_min as a decimal number in the range [0, 59]. Single digit results will be pre-appended with '0' unless the O modifier is used.
%n	Is equivalent to '\n'. A newline must appear in the source string at this position else failbit will be set.	Is equivalent to '\n'. A newline is output.
%p	Reads the locale's designation for am or pm. If neither of these strings are parsed then failbit will be set. A successful read will modify tm_hour, but only if %l is successfully parsed in the same parse pattern.	Outputs the locale's designation for am or pm, depending upon the value of tm_hour. The "C" locale's designations are am and pm.
%r	Reads the 12-hour time as specified by the current locale. The "C" locale specification is "%l:%M:%S %p". On successful parsing this sets tm_hour, tm_min, and tm_sec. If the entire pattern is not successfully parsed, then no tm members are set and failbit is set.	Outputs the locale's 12-hour time. The "C" locale's date-and-time format is "%l:%M:%S %p". This information is specified by tm_hour, tm_min, and tm_sec.
%R	Is equivalent to "%H:%M".	Is equivalent to "%H:%M". If the O modifier is used, is equivalent to "%OH:%M".
%S	: Reads the second as a decimal number. The result must be in the range [0, 60] else failbit will be set. Upon successful parsing tm_sec is set.	Outputs the second as specified by tm_sec as a decimal number in the range [0, 60]. Single digit results will be pre-appended with '0' unless the O modifier is used.
%t	Is equivalent to '\t'. A tab must appear in the source string at this position else failbit will be set.	Is equivalent to '\t'. A tab is output.
%T	Is equivalent to "%H:%M:%S".	Is equivalent to "%H:%M:%S". If the O modifier is used, is equivalent to "%OH:%M:%S".
%u	Reads the ISO 8601 weekday as a decimal number [1, 7], where Monday is 1. If the result is outside the range [1, 7] failbit will be set. Upon successful parsing tm_wday is set.	Outputs tm_wday as the ISO 8601 weekday in the range [1, 7] where Monday is 1.
%U	This is not a valid parse format. If %U is used in a parse pattern, a runtime_error is thrown.	Outputs the week number of the year (the first Sunday as the first day of week 1) as a decimal number in the range [00, 53] using tm_year, tm_wday and tm_yday. If the O modifier is used, any leading zero is suppressed.
%V	This is not a valid parse format. If %V is used in a parse pattern, a runtime_error is thrown.	Outputs the <a href="#">ISO 8601 week-based year</a> week number in the range [01, 53]. Specified by tm_year, tm_wday and tm_yday. If the O modifier is used, any leading zero is suppressed.

Table continues on the next page...

**Table 7-4. Format/Parsing Table (continued)**

Modifier	Parse	Format
%w	Reads the weekday as a decimal number [0, 6], where Sunday is 0. If the result is outside the range [0, 6] failbit will be set. Upon successful parsing tm_wday is set.	Outputs tm_wday as the weekday in the range [0, 6] where Sunday is 0.
%W	This is not a valid parse format. If %W is used in a parse pattern, a runtime_error is thrown.	Outputs the week number in the range [00, 53]. Specified by tm_year, tm_wday and tm_yday. The first Monday as the first day of week 1. If the O modifier is used, any leading zero is suppressed.
%x	Reads the date as specified by the current locale. The "C" locale specification is "%A %B %d %Y". On successful parsing this sets tm_wday, tm_mon, tm_mday, and tm_year. If the entire pattern is not successfully parsed, then no tm members are set and failbit is set.	Outputs the locale's date. The "C" locale's date format is "%A %B %d %Y". This information is specified by tm_wday, tm_mon, tm_mday, and tm_year.
%X	Reads the time as specified by the current locale. The "C" locale specification is "%H:%M:%S". On successful parsing this sets tm_hour, tm_min, and tm_sec. If the entire pattern is not successfully parsed, then no tm members are set and failbit is set.	Outputs the locale's time. The "C" locale's time format is "%H:%M:%S". This information is specified by tm_hour, tm_min, and tm_sec.
%y	Reads the year as a 2 digit number. The century is specified by the locale. The "C" locale specification is 20 (the 21st century). On successful parsing this sets tm_year. If the year is not successfully parsed, then tm_year is not set and failbit is set.	Outputs the last two digits of tm_year. Single digit results will be pre-appended with '0' unless the O modifier is used.
%Y	Reads the year. On successful parsing this sets tm_year. If the year is not successfully parsed, then tm_year is not set and failbit is set.	Outputs the year as specified by tm_year. (e.g. 2001)
%z	Reads the offset from UTC in the ISO 8601 format "-0430" (meaning 4 hours 30 minutes behind UTC, west of Greenwich). Two strings are accepted according to the current locale, one indicating Daylight Savings Time is not in effect, the other indicating it is in effect. Depending upon which string is read, tm_isdst will be set to 0 or 1. If the locale's designations for these strings are zero length, then no parsing is done and tm_isdst is set to -1. If the locale has non-empty strings for the UTC offset and neither is successfully parsed, failbit is set.	Outputs the UTC offset according to the current locale and the setting of tm_isdst (if non-negative). The "C" locale's designation for these strings is "" (an empty string).

*Table continues on the next page...*



**Table 7-4. Format/Parsing Table (continued)**

Modifier	Parse	Format
%Z	: Reads the time zone name. Two strings are accepted according to the current locale, one indicating Daylight Savings Time is not in effect, the other indicating it is in effect. Depending upon which string is read, tm_isdst will be set to 0 or 1. If the locale's designations for these strings are zero length, then no parsing is done and tm_isdst is set to -1. If the locale has non-empty strings for the time zone names and neither is successfully parsed, failbit is set.	Outputs the time zone according to the current locale and the setting of tm_isdst (if non-negative). The "C" locale's designation for these strings is "" (an empty string).
%%	A % must appear in the source string at this position else failbit will be set	A % is output.
% followed by a space	One or more white space characters are parsed in this position. White space is determined by the locale's ctype facet. If at least one white space character does not exist in this position, then failbit is set.	A space (' ') for output.

#### 7.4.4.4 ISO 8601 week-based year

The %g, %G, and %v give values according to the ISO 8601 week-based year.

In this system, weeks begin on a Monday and week 1 of the year is the week that includes January 4th, which is also the week that includes the first Thursday of the year, and is also the first week that contains at least four days in the year. If the first Monday of January is the 2nd, 3rd, or 4th, the preceding days are part of the last week of the preceding year; thus, for Saturday 2nd January 1999, %G is replaced by 1998 and %v is replaced by 53. If December 29th, 30th, or 31st is a Monday, it and any following days are part of week 1 of the following year. Thus, for Tuesday 30th December 1997, %G is replaced by 1998 and %v is replaced by 1.

#### 7.4.4.5 Template Class Time\_get\_byname

A class used for locale time manipulations.

##### Listing: Template class time\_get\_byname

```
namespace std {
template <class charT,
```

## Standard Locale Categories

```
class InputIterator = istreambuf_iterator<charT> >
class time_get_byname
    : public time_get<charT, InputIterator>
{
public:
    typedef time_base::dateorder dateorder;
    typedef InputIterator iter_type;
    explicit time_get_byname(const char* std_name, size_t refs = 0);
protected:
    virtual ~time_get_byname();
};
}
```

### 7.4.4.6 Time\_put Members

The class `time_put` has one member function.

```
iter_type put(iter_type s, ios_base& str,
char_type fill, const tm* t, const charT* pattern, const
charT* pat_end) const;
iter_type put(iter_type s, ios_base& str,
char_type fill, const tm* t, char format,
char modifier = 0) const;
```

#### Remarks

Formats a localized time.

Returns an iterator immediately beyond the last character.

### 7.4.4.7 Time\_put Virtual Functions

The class `time_put` has one virtual member function.

```
iter_type do_put(iter_type s, ios_base&,
char_type fill, const tm* t, char format,
char modifier) const;
```

#### Remarks

Implements the public member function `put`.

### 7.4.4.8 Template Class `time_put_byname` Synopsis

#### Template Class `time_put_byname` Synopsis

```
namespace std {
template <class charT, class OutputIterator =
ostreambuf_iterator<charT> >
class time_put_byname
: public time_put<charT, OutputIterator>
{
public:
typedef charT char_type;
typedef OutputIterator iter_type;
explicit time_put_byname(const char* std_name, size_t refs = 0);
protected:
virtual ~time_put_byname();
};
};
```

### 7.4.4.9 Extending The Behavior Of The Time Facets

The time facets can easily be extended and customized for many different cultures.

To stay portable one can derive from `time_get` and `time_put` and re-implement the behavior described above. Or one could take advantage of the EWL C++ implementation of these classes and build upon the existing functionality quite easily. Specifically you can easily alter the following data in the EWL time facets:

- The abbreviations of the weekday names
- The full weekday names
- The abbreviations of the month names
- The full month names
- The date-and-time format pattern (what `%c` will expand to)
- The date format pattern (what `%x` will expand to)
- The time format pattern (what `%X` will expand to)
- The 12 hour time format pattern (what `%r` will expand to)
- The strings used for AM/PM
- The strings used for the UTC offset
- The strings used for time zone names
- The default century to be used when parsing `%y`

### 7.4.4.10 Extending locale by using named locale facilities

The easiest way to specify the locale specific data is to use the named locale facilities.

When you create a named locale with a string that refers to a locale data file, the time facets parse that data file for time facet data.

```
locale loc("my_locale");
```

The narrow file "my\_locale" can hold time data for both narrow and wide time facets. Wide characters and strings can be represented in the narrow file using hexadecimal or universal format (e.g. '\u06BD'). Narrow time data starts with the keyword:

```
$time_narrow
```

And wide time data starts with the keyword:

```
$time_wide
```

Otherwise, the format for the time data is identical for the narrow and wide data.

There are twelve keywords that allow you to enter the time facet data:

1. `abbrev_weekday`
2. `weekday`
3. `abbrev_monthname`
4. `monthname`
5. `date_time`
6. `am_pm`
7. `time_12hour`
8. `date`
9. `time`
10. `time_zone`
11. `utc_offset`
12. `default_century`

You enter data with one of these keywords, followed by an equal sign '=', and then the data. You can specify any or all of the 12 keywords in any order. Data not specified will default to that of the "C" locale.

#### NOTE

See [String Syntax](#) for syntax details.

### 7.4.4.10.1 `abrev_weekday`

This keyword allows you to enter the abbreviations for the weekday names. There must be seven strings that follow this keyword, corresponding to Sun through Sat. The "C" designation is:

```
abrev_weekday = Sun Mon Tue Wed Thu Fri Sat
```

### 7.4.4.10.2 `weekday`

This keyword allows you to enter the full weekday names. There must be seven strings that follow this keyword, corresponding to Sunday through Saturday. The "C" designation is:

```
weekday = Sunday Monday Tuesday Wednesday Thursday Friday  
Saturday
```

### 7.4.4.10.3 `abrev_monthname`

This keyword allows you to enter the abbreviations for the month names. There must be twelve strings that follow this keyword, corresponding to Jan through Dec. The "C" designation is:

```
abrev_monthname = Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov  
Dec
```

### 7.4.4.10.4 `monthname`

This keyword allows you to enter the full month names. There must be twelve strings that follow this keyword, corresponding to January through December. The "C" designation is:

```
monthname =  
January February March April May June July  
August September October November December
```

### 7.4.4.10.5 date\_time

This keyword allows you to enter the parsing/formatting string to be used when `%c` is encountered. The "C" locale has:

```
date_time = "%A %B %d %T %Y"
```

The `date_time` string must not contain `%c`, else an infinite recursion will occur.

### 7.4.4.10.6 am\_pm

This keyword allows you to enter the two strings that designate AM and PM. The "C" locale specifies:

```
am_pm = am pm
```

### 7.4.4.10.7 time\_12hour

This keyword allows you to enter the parsing/formatting string to be used when `%r` is encountered. The "C" locale has:

```
time_12hour = "%I:%M:%S %p"
```

The `time_12hour` string must not contain `%r`, else an infinite recursion will occur.

### 7.4.4.10.8 date

This keyword allows you to enter the parsing/formatting string to be used when `%x` is encountered. The "C" locale has:

```
date = "%A %B %d %Y"
```

The `date` string must not contain `%x`, else an infinite recursion will occur.

### 7.4.4.10.9 time

This keyword allows you to enter the parsing/formatting string to be used when `%X` is encountered. The "C" locale has:

```
time = "%H:%M:%S"
```

The time string must not contain `%X`, else an infinite recursion will occur.

#### 7.4.4.10.10 time\_zone

This keyword allows you to enter two strings that designate the names of the locale's time zones: the first being the name for the time zone when Daylight Savings Time is not in effect, and the second name for when it is. The "C" locale has:

```
time_zone = "" ""
```

This means that time zone information is not available in the "C" locale.

#### 7.4.4.10.11 utc\_offset

This keyword allows you to enter two strings that designate the UTC offsets of the locale's time zones: the first being the offset for the time zone when Daylight Savings Time is not in effect, and the second string for when it is. The "C" locale has:

```
utc_offset = "" ""
```

This means that UTC offset information is not available in the "C" locale.

#### 7.4.4.10.12 default\_century

This keyword allows you to enter the default century which is used to create the correct year when parsing the `%y` format. This format parses a number and then computes the year by adding it to  $100 * \text{default\_century}$ . The "C" locale has:

```
default_century = 20
```

Assume a Date class. The I/O for the Date class can be written using `time_get` and `time_put` in a portable manner. The input operator might look like:

#### Listing: Date Class Example Use

## Standard Locale Categories

```

template<class charT, class traits>
std::basic_istream<charT, traits>&

operator >>(std::basic_istream<charT, traits>& is, Date& item)
{
    typename std::basic_istream<charT, traits>::sentry ok(is);
    if (ok)
    {
        std::ios_base::iostate err = std::ios_base::goodbit;
        try
        {
            const std::time_get<charT>& tg =
                std::use_facet<std::time_get<charT> >
                    (is.getloc());
            std::tm t;
            tg.get_date(is, 0, is, err, &t);
            if (!(err & std::ios_base::failbit))
                item = Date(t.tm_mon+1, t.tm_mday, t.tm_year+1900);
        }
        catch (...)
        {
            err |= std::ios_base::badbit | std::ios_base::failbit;
        }
        is.setstate(err);
    }
    return is;
}

```

The code extracts the `time_get` facet from the istream's locale and uses its `get_date` method to fill a `tm`. If the extraction was successful, then the data is transferred from the `tm` into the `Date` class.

### Listing: The output method

```

template<class charT, class traits>
std::basic_ostream<charT, traits>&

operator <<(std::basic_ostream<charT, traits>& os, const Date& item)
{
    std::basic_ostream<charT, traits>::sentry ok(os);

```



```
if (ok)
{
    bool failed;
    try
    {
        const std::time_put<charT>& tp =
            std::use_facet<std::time_put<charT>
>
            (os.getloc());
        std::tm t;
        t.tm_mday = item.day();
        t.tm_mon = item.month() - 1;
        t.tm_year = item.year() - 1900;
        t.tm_wday = item.dayOfWeek();
        charT pattern[2] = {'%', 'x'};
        failed = tp.put(os, os, os.fill(), &t, pattern,
            pattern+2).failed();
    }
    catch (...)
    {
        failed = true;
    }
    if (failed)
        os.setstate(std::ios_base::failbit |
            std::ios_base::badbit);
}
return os;
}
```

After extracting the `time_put` facet from the ostream's locale, you transfer data from your `Date` class into the `tm` (or the `Date` class could simply export a `tm`). Then the `put` method is called with the `tm` and using the pattern `"%x"`. There are several good things about the `Date`'s I/O methods:

- They are written in portable standard C++.
- They are culturally sensitive since they use the locale's time facets.
- They can handle narrow or wide streams.
- The streams can be in memory (e.g. `stringstream`) or file based streams (`fstream`)

## Standard Locale Categories

- For wide file streams, routing is automatically going through a codecvt that could (for example) be using something like UTF-8 to convert to/from the external file.
- They are relatively simple considering the tremendous flexibility involved.

With the Date's I/O done, the rest of the example is very easy. A French locale can be created with the following data in a file named "French":

```
$time_narrow
date = "%A, le %d %B %Y"
weekday =
    dimanche lundi mardi mercredi jeudi vendredi samedi
abrev_weekday =
    dim lun mar mer jeu ven sam
monthname = j
    janvier février mars avril mai juin juillet août
abrev_monthname =
    jan fév mar avr mai juin juil août sep oct nov déc
```

Now a program can read and write Date's in both English and French (and the Date class is completely ignorant of both languages).

### Listing: Example of dates in English and French

```
#include <locale>
#include <iostream>
#include <sstream>
#include "Date.h"

int
main()
{
    std::istringstream in("Saturday February 24 2001");

    Date today;

    in >> today;

    std::cout.imbue(std::locale("French"));

    std::cout << "En Paris, c'est " << today << '\n';

    std::cout.imbue(std::locale("US"));

    std::cout << "But in New York it is " << today << '\n';
}
```

This program reads in a Date using the "C" locale from an `istringstream`. Then `cout` is imbued with "French" and the same Date is written out. And finally the same stream is imbued again with a "US" locale and the same Date is written out again. The output is:

```
En Paris, c'est samedi, le 24 février 2001
But in New York it is Saturday February 24 2001
```

For this example the "US" locale was implemented with an empty file. This was possible since the relevant parts of the "US" locale coincide with the "C" locale.

### 7.4.4.11 Extending by derivation

The behavior of the time facets can still be customized if you are on a platform that does not support a file system, or if you do not wish to use data files for other reasons.

Naturally, you can derive from `time_get` and `time_put` and override each of the virtual methods in a portable manner as specified by the C++ standard. Additionally you can take advantage of the EWL C++ implementation if you wish (to make your job easier if portability is not a concern).

The central theme of the EWL time facets design is a non-standard facet class called `std::timepunct`:

#### Listing: Template Class Timepunct Synopsis

```
template <class charT>
class timepunct
    : public locale::facet
{
public:
    typedef charT          char_type;
    typedef basic_string<charT> string_type;

    explicit timepunct(size_t refs = 0);

    const string_type& abbrev_weekday(int wday) const
        {return __weekday_names_[7+wday];}
    const string_type& weekday(int wday) const
        {return __weekday_names_[wday];}
    const string_type& abbrev_monthname(int mon) const
        {return __month_names_[12+mon];}
    const string_type& monthname(int mon) const {
        return __month_names_[mon];}
    const string_type& date_time() const
        {return __date_time_;}
    const string_type& am_pm(int hour) const
        {return __am_pm_[hour/12];}
```

**Standard Locale Categories**

```

    const string_type& time_12hour() const
{
    return __12hr_time_;
}
    const string_type& date() const
    {return __date_;}
    const string_type& time() const
    {return __time_;}
    const string_type& time_zone(int isdst) const
    {return __time_zone_[isdst];}
    const string_type& utc_offset(int isdst) const
    {return __utc_offset_[bool(isdst)];}
    int
        default_century() const
    {return __default_century_;}

    static locale::id id;

protected:
    virtual ~timepunct() {}

    string_type __weekday_names_[14];
    string_type __month_names_[24];
    string_type __am_pm_[2];
    string_type __date_time_;
    string_type __date_;
    string_type __time_;
    string_type __12hr_time_;
    string_type __time_zone_[2];
    string_type __utc_offset_[2];
    int
        __default_century_;
};

```

This class is analogous to `numpunct` and `moneypunct`. It holds all of the configurable data. The facets `time_get` and `time_put` refer to `timepunct` for the data and then behave accordingly. All of the data in `timepunct` is protected so that the constructor of a derived facet can set this data however it sees fit. The `timepunct` facet will set this data according to the "C" locale.

Both the full weekday names and the abbreviated weekday names are stored in `__weekday_names_`. The full names occupy the first seven elements of the array, and the abbreviated names get the last seven slots. Similarly for `__month_names_`.

The `__am_pm_` member holds the strings that represent AM and PM, in that order.

The `__date_time_` member holds the formatting/parsing string for the date-and-time. This is the member that gets queried when `%c` comes up. Do not put `%c` in this string or an infinite recursion will occur. The default for this string is `"%A %B %d %T %Y"`.

The `__date_` member holds the formatting/parsing string for the date. This is the member that gets queried when `%x` comes up. Do not put `%x` in this string or an infinite recursion will occur. The default for this string is `"%A %B %d %Y"`.

The `__time_` member holds the formatting/parsing string for the time. This is the member that gets queried when `%X` comes up. Do not put `%X` in this string or an infinite recursion will occur. The default for this string is `"%H:%M:%S"`.

The `__12hr_time_` member holds the formatting/parsing string for the 12-hour-time. This is the member that gets queried when `%r` comes up. Do not put `%r` in this string or an infinite recursion will occur. The default for this string is `"%I:%M:%S %p"`.

The `__time_zone_` member contains two strings. The first is the name of the time zone when Daylight Savings Time is not in effect. The second string is the name of the time zone when Daylight Savings Time is in effect. These can be used to parse or format the `tm_isdst` member of a `tm`. These strings may be empty (as they are in the `"C"` locale) which means that time zone information is not available.

The `__utc_offset_` member contains two strings. The first represents the UTC offset when Daylight Savings Time is not in effect. The second string is the offset when Daylight Savings Time is in effect. These can be used to parse or format the `tm_isdst` member of a `tm`. These strings may be empty (as they are in the `"C"` locale) which means that UTC offset information is not available.

The final member, `__default_century_` is an `int` representing the default century to assume when parsing a two digit year with `%y`. The value 19 represents the 1900's, 20 represent's the 2000's, etc. The default is 20.

It is a simple matter to derive from `timepunct` and set these data members to whatever you see fit.

#### 7.4.4.12 Timepunct\_byname

## Standard Locale Categories

You can use `timepunct_byname` to get the effects of a named locale for time facets instead of using a named locale.

The `time_get_byname` and `time_put_byname` facets do not add any functionality over `time_get` and `time_put`.

### Listing: Using Timepunct\_byname

```
#include <locale>
#include <iostream>

#include <sstream>

#include "Date.h"

int
main()
{
    std::istringstream in("Saturday February 24 2001");
    Date today;
    in >> today;
    std::cout.imbue(std::locale(std::locale(),
        new std::timepunct_byname<char>("French")));
    std::cout << "En Paris, c'est " << today << '\n';
    std::cout.imbue(std::locale(std::locale(),
        new std::timepunct_byname<char>("US")));
    std::cout << "But in New York it is " << today << '\n';
}
```

This has the exact same effect as the named locale example.

But the `timepunct_byname` example still uses the files "French" and "US". Below is an example `timepunct` derived class that avoids files but still captures the functionality of the above examples.

### Listing: Example Timepunct Facet Use

```
// The first job is to create a facet derived from timepunct
// that stores the desired data in the timepunct:

class FrenchTimepunct
    : public std::timepunct<char>
{
public:
    FrenchTimepunct();
```

```
};  
  
FrenchTimepunct::FrenchTimepunct()  
{  
    __date_ = "%A, le %d %B %Y";  
    __weekday_names_[0] = "dimanche";  
    __weekday_names_[1] = "lundi";  
    __weekday_names_[2] = "mardi";  
    __weekday_names_[3] = "mercredi";  
    __weekday_names_[4] = "jeudi";  
    __weekday_names_[5] = "vendredi";  
    __weekday_names_[6] = "samedi";  
    __weekday_names_[7] = "dim";  
    __weekday_names_[8] = "lun";  
    __weekday_names_[9] = "mar";  
    __weekday_names_[10] = "mer";  
    __weekday_names_[11] = "jeu";  
    __weekday_names_[12] = "ven";  
    __weekday_names_[13] = "sam";  
    __month_names_[0] = "janvier";  
    __month_names_[1] = "février";  
    __month_names_[2] = "mars";  
    __month_names_[3] = "avril";  
    __month_names_[4] = "mai";  
    __month_names_[5] = "juin";  
    __month_names_[6] = "juillet";  
    __month_names_[7] = "août";  
    __month_names_[8] = "septembre";  
    __month_names_[9] = "octobre";  
    __month_names_[10] = "novembre";  
    __month_names_[11] = "décembre";  
    __month_names_[12] = "jan";  
    __month_names_[13] = "fév";  
    __month_names_[14] = "mar";  
    __month_names_[15] = "avr";  
    __month_names_[16] = "mai";  
}
```

**Standard Locale Categories**

```

__month_names_[17] = "juin";
__month_names_[18] = "juil";
__month_names_[19] = "août";
__month_names_[20] = "sep";
__month_names_[21] = "oct";
__month_names_[22] = "nov";
__month_names_[23] = "déc";
}

//Though tedious, the job is quite simple.
//Next simply use your facet:
int main()
{
    std::istringstream in("Saturday February 24 2001");
    Date today;
    in >> today;
    std::cout.imbue(std::locale(std::locale(),
    new FrenchTimepunct));
    std::cout << "En Paris, c'est " << today << '\n';
    std::cout.imbue(std::locale::classic());
    std::cout << "But in New York it is " << today << '\n';
}

```

Here we have explicitly asked for the classic locale, instead of the "US" locale since the two are the same (but executing `classic()` does not involve file I/O). Using the global locale (`locale()`) instead of `classic()` would have been equally fine in this example.

## 7.4.5 The Monetary Category

There are five standard money classes.

- `class money_base;`
- `template <class charT, class InputIterator = istreambuf_iterator<charT> > class money_get;`
- `template <class charT, class OutputIterator = ostreambuf_iterator<charT> > class money_put;`
- `template <class charT, bool International = false> class moneypunct;`
- `template <class charT, bool International = false> class moneypunct_byname;`



The first of these (`money_base`) is not a facet, but the remaining four are. The `money_base` class is responsible only for specifying pattern components that will be used to specify how monetary values are parsed and formatted (currency symbol first or last, etc.).

The facets `money_get` and `money_put` are responsible for parsing and formatting respectively. Though their behavior is made up of virtual methods, and thus can be overridden via derivation, it will be exceedingly rare for you to feel the need to do so. Like the numeric facets, the real customization capability comes with the "punct" classes: `moneypunct` and `moneypunct_byname`.

A user-defined `Money` class (there will be an example later on) can use `money_get` and `money_put` in defining its I/O, and remain completely ignorant of whether it is dealing with francs or pounds. Instead clients of `Money` will imbue a stream with a locale that specifies this information. On I/O the facets `money_get` and `money_put` query `moneypunct` (or `moneypunct_byname`) for the appropriate locale-specific data. The `Money` class can remain blissfully ignorant of cultural specifics, and at the same time, serve all cultures!

### 7.4.5.1 A sample `Money` class

The very reason that we can design a `Money` class before we know the details of `moneypunct` customization is because the `Money` class can remain completely ignorant of this customization.

This `Money` class is meant only to demonstrate I/O. Therefore it is as simple as possible. We begin with a simple struct:

#### **Listing: A example demonstration of input and output**

```
struct Money
{
    long double amount_;
};

// The I/O methods for this class follow a fairly standard formula,
// but reference the money facets to do the real work:
template<class charT, class traits>
std::basic_istream<charT,traits>&
operator >>(std::basic_istream<charT,traits>& is, Money& item)
{
    typename std::basic_istream<charT,traits>::sentry ok(is);
```

```

if (ok)
{
std::ios_base::iostate err = std::ios_base::goodbit;
    try
    {
        const std::money_get<charT>& mg =
            std::use_facet<std::money_get<charT> > (is.getloc());
        mg.get(is, 0, false, is, err, item.amount_);
    }
    catch (...)
    {
        err |= std::ios_base::badbit | std::ios_base::failbit;
    }
    is.setstate(err);
}
return is;
}

template<class charT, class traits>
std::basic_ostream<charT, traits>&
operator <<(std::basic_ostream<charT, traits>& os,
           const Money& item)
{
    std::basic_ostream<charT, traits>::sentry ok(os);
    if (ok)
    {
        bool failed;
        try
        {
            const std::money_put<charT>& mp =
                std::use_facet<std::money_put<charT> >(os.getloc());
            failed = mp.put(os, false, os, os.fill(),
                           item.amount_).failed();
        }
        catch (...)
        {

```

```

        failed = true;
    }
    if (failed)
        os.setstate(std::ios_base::failbit |
                    std::ios_base::badbit);
    }
    return os;
}

```

The extraction operator ( >> ) obtains a reference to `money_get` from the stream's locale, and then simply uses its `get` method to parse directly into Money's `amount_`. The insertion operator ( << ) does the same thing with `money_put` and its `put` method. These methods are extremely flexible, as all of the formatting details (save one) are saved in the stream's locale. That one detail is whether we are dealing a local currency format, or an international currency format. The above methods hard wire this decision to "local" by specifying false in the `get` and `put` calls. The `money_punct` facet can store data for both of these formats. An example difference between an international format and a local format is the currency symbol. The US local currency symbol is "\$", but the international US currency symbol is "USD ".

For completeness, we extend this example to allow client code to choose between local and international formats via a stream manipulator. See Matt Austern's excellent C/C++ Users Journal article: [The Standard Librarian: User-Defined Format Flags](#) for a complete discussion of the technique used here.

To support the manipulators, our simplistic Money struct is expanded in the following code example.

### Listing: Example of manipulator support.

```

struct Money
{
    enum format {local, international};
    static void set_format(std::ios_base& s, format f)
        {flag(s) = f;}
    static format get_format(std::ios_base& s)
        {return static_cast<format>(flag(s));}
    static long& flag(std::ios_base& s);
    long double amount_;
};

```

## Standard Locale Categories

An `enum` has been added to specify local or international format. But this `enum` is only defined within the `Money` class. There is no format data member within `Money`. That information will be stored in a stream by clients of `Money`. To aid in this effort, three static methods have been added: `set_format`, `get_format` and `flag`. The first two methods simply call `flag` which has the job of reading and writing the format information to the stream. Although `flag` is where the real work is going on, its definition is surprisingly simple.

### Listing: Money class flag

```
long&
Money::flag(std::ios_base& s)
{
    static int n = std::ios_base::xalloc();
    return s.iword(n);
}
```

As described in Austern's C/C++ User Journal article, `flag` uses the stream's `xalloc` facility to reserve an area of storage which will be the same location in all streams. And then it uses `iword` to obtain a reference to that storage for a particular stream. Now it is easier to see how `set_format` and `get_format` are simply writing and reading a long associated with the stream `s`.

To round out this manipulator facility we need the manipulators themselves to allow client code to write statements like:

```
in >> international >> money;
out << local << money << '\n';
```

These are easily accomplished with a pair of namespace scope methods:

### Listing: Money class manipulators

```
template<class charT, class traits>
std::basic_ios<charT, traits>&
local(std::basic_ios<charT, traits>& s)
{
    Money::set_format(s, Money::local);
    return s;
}

template<class charT, class traits>
std::basic_ios<charT, traits>&
international(std::basic_ios<charT, traits>& s)
{
    Money::set_format(s, Money::international);
    return s;
}
```

And finally, we need to modify the `Money inserter` and `extractor` methods to read this information out of the stream, instead of just blindly specifying `false (local)` in the `get` and `put` methods.

### Listing: Money class inserters and extractors

```
template<class charT, class traits>
std::basic_istream<charT,traits>&
operator >>(std::basic_istream<charT,traits>& is, Money& item)
{
    typename std::basic_istream<charT,traits>::sentry ok(is);
    if (ok)
    {
        std::ios_base::iostate err = std::ios_base::goodbit;
        try
        {
            const std::money_get<charT>& mg =
                std::use_facet<std::money_get<charT> > (is.getloc());

            mg.get(is, 0, Money::get_format(is) ==
                Money::international, is, err, item.amount_);
        } catch (...)
        {
            err |= std::ios_base::badbit |
                std::ios_base::failbit;
        }

        is.setstate(err);
    }
    return is;
}
template<class charT, class traits>
std::basic_ostream<charT, traits>&
operator <<(std::basic_ostream<charT, traits>& os,
    const Money& item)
{
    std::basic_ostream<charT, traits>::sentry ok(os);
    if (ok)
    {
        bool failed;
        try
        {
            const std::money_put<charT>& mp =
                std::use_facet<std::money_put<charT> >(os.getloc());

            failed = mp.put(os, Money::get_format(os) ==
                Money::international, os, os.fill(),
                item.amount_).failed();
        }
        catch (...)
    }
```

**Standard Locale Categories**

```

    {
        failed = true;
    }

    if (failed)
        os.setstate(std::ios_base::failbit |
                    std::ios_base::badbit);
}
return os;
}

```

Because we gave the enum `Money::local` the value 0, this has the effect of making local the default format for a stream.

We now have a simple `Money` class that is capable of culturally sensitive input and output, complete with local and international manipulators! To motivate the following sections on how to customize moneypunct data. Below is sample code that uses our `Money` class, along with the named locale facility:

**Listing: Example of using a money class**

```

int main()
{
    std::istringstream in("USD (1,234,567.89)");

    Money money;

    in >> international >> money;

    std::cout << std::showbase << local << money << '\n';

    std::cout << international << money << '\n';

    std::cout.imbue(std::locale("Norwegian"));

    std::cout << local << money << '\n';

    std::cout << international << money << '\n';

}

```

And the output is:

```

$-1,234,567.89
USD (1,234,567.89)
-1 234 567,89 kr
NOK (1 234 567,89)

```

**7.4.5.2 Template Class Money\_get**

The template class `money_get` is used for `locale` monetary input routines.

**Listing: Template Class Money\_get Synopsis**

```
namespace std {
template <class charT,

class InputIterator = istreambuf_iterator<charT> >
class money_get : public locale::facet {
public:
typedef charT char_type;
typedef InputIterator iter_type;
typedef basic_string<charT> string_type;
explicit money_get(size_t refs = 0);
iter_type get(iter_type s, iter_type end, bool intl,
ios_base& f, ios_base::iostate& err,
long double& units) const;
iter_type get(iter_type s, iter_type end, bool intl,
ios_base& f, ios_base::iostate& err,
string_type& digits) const;
static locale::id id;
protected:
~money_get(); //virtual
virtual iter_type do_get(iter_type, iter_type, bool, ios_base&,
ios_base::iostate& err, long double& units) const;
virtual iter_type do_get(iter_type, iter_type, bool, ios_base&,
ios_base::iostate& err, string_type& digits) const;
};
}
```

### 7.4.5.2.1 Money\_get Members

Localized member functions for inputting monetary values.

#### 7.4.5.2.1.1 get

Inputs a localized monetary value.

```
iter_type get(iter_type s, iter_type end,
bool intl, ios_base& f, ios_base::iostate& err,
long double& quant) const;
iter_type get( s, iter_type end, bool intl,
```

**Standard Locale Categories**

```
ios_base& f, ios_base::iostate& err, string_type& quant)
const;
```

**Remarks**

Returns an iterator immediately beyond the last character recognized as a valid monetary quantity.

**7.4.5.2.1.2 Money\_get Virtual Functions**

Implementation functions for localization of the `money_get` public member functions.

```
iter_type do_get(iter_type s, iter_type end,
bool intl, ios_base& str, ios_base::iostate& err,
long double& units) const;
iter_type do_get(iter_type s, iter_type end,
bool intl, ios_base& str, ios_base::iostate& err
string_type& digits) const;
```

**Remarks**

Implements a localized monetary `get` function.

**7.4.5.3 Template Class Money\_put**

The template class `money_put` is used for `locale` monetary output routines.

**Listing: Template Class Money\_put Synopsis**

```
namespace std {
template <class charT,

class OutputIterator = ostreambuf_iterator<charT> >

class money_put : public locale::facet {
public:

typedef charT char_type;

typedef OutputIterator iter_type;

typedef basic_string<charT> string_type;

explicit money_put(size_t refs = 0);

iter_type put(iter_type s, bool intl, ios_base& f,
char_type fill, long double units) const;

iter_type put(iter_type s, bool intl, ios_base& f,
```



```
char_type fill, const string_type& digits) const;
static locale::id id;
protected:
~money_put(); //virtual
virtual iter_type
do_put(iter_type, bool, ios_base&, char_type fill,
long double units) const;
virtual iter_type
do_put(iter_type, bool, ios_base&, char_type fill,
const string_type& digits) const;
};
}
```

### 7.4.5.3.1 Money\_put Members

Localized member functions for outputting monetary values.

#### 7.4.5.3.1.1 put

Outputs a localized monetary value.

```
iter_type put(iter_type s, bool intl, ios_base& f,
char_type fill, long double quant) const;
iter_type put(iter_type s, bool intl, ios_base& f,
char_type fill, const string_type& quant) const;
```

#### Remarks

Returns an iterator immediately beyond the last character recognized as a valid monetary quantity.

#### 7.4.5.3.1.2 Money\_put Virtual Functions

Implementation functions for localization of the `money_put` public member functions.

```
iter_type do_put(iter_type s, bool intl,
ios_base& str, char_type fill,
long double units) const;
iter_type do_put(iter_type s, bool intl,
```

**Standard Locale Categories**

```
ios_base& str, char_type fill,
const string_type& digits) const;
```

**Remarks**

Implements a localized put function.

**7.4.5.4 Class Moneypunct**

An object used for localization of monetary punctuation.

**Listing: Template Class Moneypunct Synopsis**

```
namespace std {
class money_base {

public:

enum part { none, space, symbol, sign, value };

struct pattern { char field[4]; };

};

template <class charT, bool International = false>
class moneypunct : public locale::facet, public money_base {

public:

typedef charT char_type;

typedef basic_string<charT> string_type;

explicit moneypunct(size_t refs = 0);

charT decimal_point() const;

charT thousands_sep() const;

string grouping() const;

string_type curr_symbol() const;

string_type positive_sign() const;

string_type negative_sign() const;

int frac_digits() const;

pattern pos_format() const;

pattern neg_format() const;

static locale::id id;

static const bool intl = International;

protected:
```

```
~moneypunct(); //virtual
virtual charT do_decimal_point() const;
virtual charT do_thousands_sep() const;
virtual string do_grouping() const;
virtual string_type do_curr_symbol() const;
virtual string_type do_positive_sign() const;
virtual string_type do_negative_sign() const;
virtual int do_frac_digits() const;
virtual pattern do_pos_format() const;
virtual pattern do_neg_format() const;
};
}
```

#### 7.4.5.4.1 Moneypunct Members

Member functions to determine the punctuation used for monetary formatting.

##### 7.4.5.4.1.1 decimal\_point

Determines what character to use as a decimal point.

```
charT decimal_point() const;
```

#### Remarks

Returns a char to be used as a decimal point.

##### 7.4.5.4.1.2 thousands\_sep

Determines which character to use for a thousandths separator.

```
charT thousands_sep() const;
```

#### Remarks

The character to be used for the thousands separator is specified with `thousands_sep`.

Returns the character to use for a thousandths separator.

### 7.4.5.4.1.3 grouping

Determines a string that determines the grouping of thousands.

```
string grouping() const;
```

#### Remarks

The grouping string specifies the number of digits to group, going from right to left.

Returns the string that determines the grouping of thousands.

### 7.4.5.4.1.4 curr\_symbol

Determines a string of the localized currency symbol.

```
string_type curr_symbol() const;
```

#### Remarks

Returns the string of the localized currency symbol.

### 7.4.5.4.1.5 positive\_sign

Determines a string of the localized positive sign.

```
string_type positive_sign() const;
```

#### Remarks

Returns the string of the localized positive sign.

### 7.4.5.4.1.6 negative\_sign

Determines a string of the localized negative sign.

```
string_type negative_sign() const;
```

#### Remarks

Returns the string of the localized negative sign.

#### 7.4.5.4.1.7 `frac_digits`

Determines a string of the localized fractional digits.

```
int frac_digits() const;
```

#### Remarks

Returns the string of the localized fractional digits.

#### 7.4.5.4.1.8 `pos_format`

Determines the format of the localized non-negative values.

```
pattern pos_format() const;
```

#### Remarks

These keywords allow you to enter the format for both positive and negative values. There are 5 keywords to specify a format:

`none`

`space`

`symbol`

`sign`

`value`

A monetary format is a sequence of four of these keywords. Each value : `symbol`, `sign`, `value`, and either `space` or `none` appears exactly once. The value `none`, if present, is not first; the value `space`, if present, is neither first nor last. The behavior of breaking any of these rules is undefined. The default pattern for positive values, and for local and international formats is:

```
pos_format = symbol sign none value
```

Returns the pattern initialized to a positive value.

### 7.4.5.4.1.9 neg\_format

Determines the format of the localized non-negative values.

```
pattern neg_format() const;
```

#### Remarks

These keywords allow you to enter the format for both positive and negative values. There are 5 keywords to specify a format:

none

space

symbol

sign

value

A monetary format is a sequence of four of these keywords. Each value : `symbol`, `sign`, `value`, and either `space` or `none` appears exactly once. The value `none`, if present, is not first; the value `space`, if present, is neither first nor last. The behavior of breaking any of these rules is undefined. The default pattern for negative values, and for local and international formats is:

```
neg_format = symbol sign none value
```

Returns the pattern initialized to a negative value.

### 7.4.5.4.1.10 Moneypunct Virtual Functions

Virtual functions that implement the localized public member functions.

```
charT do_decimal_point() const;
```

Implements `decimal_point`.

```
charT do_thousands_sep() const;
```

Implements `thousands_sep`.

```
string do_grouping() const;
```

Implements `grouping`.

```
string_type do_curr_symbol() const;
```

Implements `cur_symbol`.

```
string_type do_positive_sign() const;
```

Implements `positive_sign`.

```
string_type do_negative_sign() const;
```

Returns the string to use to indicate a negative value.

```
int do_frac_digits() const;
```

Implements `frac_digits`.

```
pattern do_pos_format() const;
```

Implements `pos_format`.

```
pattern do_neg_format() const;
```

Implements `neg_format`.

### 7.4.5.5 Extending `moneypunct` by derivation

It is easy enough to derive from `moneypunct` and override the virtual functions in a portable manner.

But `moneypunct` also has a non-standard protected interface that you can take advantage of if you wish. There are nine protected data members:

```
charT    __decimal_point_;  
charT    __thousands_sep_;  
string    __grouping_;  
string_type __cur_symbol_;  
string_type __positive_sign_;  
string_type __negative_sign_;  
int       __frac_digits_;  
pattern    __pos_format_;  
pattern    __neg_format_;
```

A derived class could set these data members in its constructor to whatever is appropriate, and thus not need to override the virtual methods.

### Listing: Extending Moneypunct by derivation

```
struct mypunct
    : public std::moneypunct<char, false>
{
    mypunct();
};

mypunct::mypunct()
{
    __decimal_point_ = ',';
    __thousands_sep_ = ' ';
    __cur_symbol_ = "kr";
    __pos_format_.field[0] = __neg_format_.field[0] = char(sign);
    __pos_format_.field[1] = __neg_format_.field[1] = char(value);
    __pos_format_.field[2] = __neg_format_.field[2] = char(space);
    __pos_format_.field[3] = __neg_format_.field[3] = char(symbol);
}

int
main()
{
    std::locale loc(std::locale(), new mypunct);
    std::cout.imbue(loc);
    // ...
}
```

Indeed, this is just what `moneypunct_byname` does after reading the appropriate data from a locale data file.

### 7.4.5.6 Template Class `Moneypunct_byname`

A template class for implementation of the `moneypunct` template class.

#### Listing: Template Class `Moneypunct_byname` Synopsis

```
namespace std {
template <class charT, bool Intl = false>

class moneypunct_byname : public moneypunct<charT, Intl> {
public:
```



```
typedef money_base::pattern pattern;
typedef basic_string<charT> string_type;
explicit moneypunct_byname(const char*, size_t refs = 0);
protected:
~moneypunct_byname(); // virtual
virtual charT do_decimal_point() const;
virtual charT do_thousands_sep() const;
virtual string do_grouping() const;
virtual string_type do_curr_symbol() const;
virtual string_type do_positive_sign() const;
virtual string_type do_negative_sign() const;
virtual int do_frac_digits() const;
virtual pattern do_pos_format() const;
virtual pattern do_neg_format() const;
};
}
```

When a named locale is created:

```
std::locale my_loc("MyLocale");
```

this places the facet `moneypunct_byname("MyLocale")` in the locale. The `moneypunct_byname` constructor considers the name it is constructed with as the name of a data file which may or may not contain moneypunct data. There are 4 keywords that mark the beginning of moneypunct data in a locale data file.

- `$money_local_narrow`
- `$money_international_narrow`
- `$money_local_wide`
- `$money_international_wide`

These data sections can appear in any order in the locale data file. And they are all optional. Any data not specified defaults to that of the "C" locale. Wide characters and strings can be represented in the narrow locale data file using hexadecimal or universal format (for example, `'\u06BD'`). See the rules for [Strings and Characters in Locale Data Files](#) for more syntax details.

## 7.4.5.7 Data file syntax

The syntax for entering `money_punct` data is the same under all four keywords.

There are 9 keywords that can be used within a `$money_XXX` data section to specify `money_punct` data. The keywords can appear in any order and they are all optional.

- `decimal_point`
- `thousands_sep`
- `grouping`
- `curr_symbol`
- `positive_sign`
- `negative_sign`
- `frac_digits`
- `pos_format`
- `neg_format`

Each of these keywords is followed by an equal sign (=) and then the appropriate data (described below).

### 7.4.5.7.1 decimal\_point

The decimal point data is a single character, as in:

```
decimal_point = '.'
```

#### Remarks

The default decimal point is '.'

### 7.4.5.7.2 thousands\_sep

The character to be used for the thousands separator is specified with `thousands_sep`, as in:

```
thousands_sep = ','
```

#### Remarks

The default thousands separator is ','

### 7.4.5.7.3 grouping

The grouping string specifies the number of digits to group, going from right to left.

#### Remarks

For example, the grouping: 321 means that the number 12345789 would be printed as in:

```
1,2,3,4,56,789
```

The above grouping string can be specified as:

```
grouping = 321
```

A grouping string of "0" or "" means: don't group. The default grouping string is "3".

### 7.4.5.7.4 curr\_symbol

The currency symbol is specified as a string by `curr_symbol`, as in:

```
curr_symbol = $
```

It is customary for international currency symbols to be four characters long, but this is not enforced by the `locale` facility. The default local currency symbols is "\$". The default international currency symbol is "USD".

### 7.4.5.7.5 positive\_sign

The string to be used for the positive sign is specified by `positive_sign`. Many locales set this as the empty string, as in:

```
positive_sign = ""
```

#### Remarks

The default positive sign is the empty string.

### 7.4.5.7.6 negative\_sign

The negative sign data is a string specified by `negative_sign`, as in:

```
negative_sign = ()
```

## Remarks

The precise rules for how to treat signs that are longer than one character are laid out in the standard. Suffice it to say that this will typically enclose a negative value in parentheses.

The default negative sign for local formats is "-", and for international formats is "()".

### 7.4.5.7.7 `frac_digits`

The number of digits to appear after the decimal point is specified by `frac_digits`, as in:

```
frac_digits = 2
```

## Remarks

The default value is 2.

### 7.4.5.7.8 `pos_format / neg_format`

These keywords allow you to enter the format for both positive and negative values.

## Remarks

There are 5 keywords to specify a format:

none

space

symbol

sign

value

A `monetary` format is a sequence of four of these keywords. Each value: `symbol`, `sign`, `value`, and either `space` or `none` appears exactly once. The value `none`, if present, is not first; the value `space`, if present, is neither first nor last. The behavior of breaking any of these rules is undefined.

The default pattern for positive and negative values, and for local and international formats is:

```
pos_format = symbol sign none value
```

```
neg_format = symbol sign none value
```

Notice that in the following listing not all of the fields have been specified because the default values for these fields were already correct. On the other hand, it does not hurt to specify default data to improve (human) readability in the data file.

### Listing: Example Data file

To have the example code run correctly, we need a file named "Norwegian" containing the following data:

```
$money_local_narrow
```

```
decimal_point = ','
```

```
thousands_sep = ' '
```

```
curr_symbol = kr
```

```
pos_format = sign value space symbol
```

```
neg_format = sign value space symbol
```

```
$money_international_narrow
```

```
decimal_point = ','
```

```
thousands_sep = ' '
```

```
curr_symbol = "NOK "
```

## 7.4.6 The Message Retrieval Category

The messages facet is the least specified facet in the C++ standard. Just about everything having to do with messages is implementation defined.

### Listing: Template Class Messages Synopsis

```
namespace std {  
class messages_base  
{  
public:  
    typedef int catalog;  
};  
template <class charT>  
class messages  
    : public locale::facet,  
    public messages_base
```

**Standard Locale Categories**

```

{
public:
    typedef charT char_type;
    typedef basic_string<charT> string_type;
    explicit messages(size_t refs = 0);
    catalog open(const basic_string<char>& fn,
                const locale& loc) const;
    string_type get(catalog c, int set, int msgid,
                  const string_type& ddefault) const;
    void close(catalog c) const;
    static locale::id id;
protected:
    virtual ~messages();
    virtual catalog do_open(const basic_string<char>& fn,
                           const locale& loc) const;
    virtual string_type do_get(catalog c, int set, int msgid,
                              const string_type& ddefault) const;
    virtual void do_close(catalog c) const;
};
}

```

The intent is that you can use this class to read messages from a catalog. There may be multiple sets of messages in a catalog. And each message set can have any number of `int/string` pairs. But beyond that, the standard is quiet.

Does the string `fn` in `open` refer to a file? If so, what is the format of the `set/msgid/string` data to be read in from the file? There is also a `messages_byname` class that derives from `messages`. What functionality does `messages_byname` add over `messages`?

Unfortunately the answers to all of these questions are implementation defined. This document seeks to answer those questions. Please remember that applications depending on these answers will probably not be portable to other implementations of the standard C++ library.

### 7.4.6.1 Messages Members

Public member functions for catalog message retrieval.

### 7.4.6.1.1 open

Opens a message catalog for reading

```
catalog open(const basic_string<char>& name,  
const locale& loc) const;
```

#### Remarks

Returns a value that may be passed to `get` to retrieve a message from a message catalog.

### 7.4.6.1.2 get

Retrieves a message from a message catalog.

```
string_type get(catalog cat, int set, int msgid,  
const string_type& default) const;
```

#### Remarks

Returns the message in the form of a string.

### 7.4.6.1.3 close

Closes a message catalog.

```
void close(catalog cat) const;
```

### 7.4.6.1.4 Messages Virtual Functions

Virtual functions used to localize the public member functions.

```
catalog do_open(const basic_string<char>& name,  
const locale& loc) const;
```

Implements `open`.

```
string_type do_get(catalog cat, int set, int msgid,  
const string_type& default) const;
```

Implements `get`.

```
void do_close(catalog cat) const;
```

Implements `close`.

## 7.4.6.2 EWL C++ implementation of messages

The Embedded Warrior Library for C++ has a custom implementation of messages.

```
Example code to open a catalog:
typedef std::messages<char> Msg;
const Msg& ct = std::use_facet<Msg>(std::locale::classic());
Msg::catalog cat = ct.open("my_messages",
std::locale::classic());
if (cat < 0)
{
    std::cout << "Can't open message file\n";
    std::exit(1);
}
```

The first line simply type defines `messages<char>` for easier reading or typing. The second line extracts the messages facet from the "C" locale. The third line instructs the messages facet to look for a file named "my\_messages" and read message set data out of it using the classic ("C") locale (one could specify a locale with a specialized codecvt facet for reading the data file). If the file is not found, the open method returns -1. The facet `messages<char>` reads data from a narrow file (`ifstream`). The facet `messages<wchar_t>` reads data from a wide file (`wifstream`).

The messages data file can contain zero or more message data sets of the format:

- \$set setid
- msgid message
- msgid message
- msgid message
- ...

The keyword `$set` begins a `message` data set. The `setid` is the set number. It can be any int. Set `id`'s do not need to be contiguous. But the set `id` must be unique among the sets in this catalog.

The `msgid` is the message `id` number. It can be any int. Message `id`'s do not need to be contiguous. But the message `id` must be unique among the messages in this set.



The message is an optionally quoted (") string that is the message for this `setid` and `msgid`. If the message contains white space, it must be quoted. The message can have characters represented escape sequences using the hexadecimal or universal format. For example (see also [String Syntax](#)):

```
"\u0048\u0069\u0020\u0054\u0068\u0065\u0072\u0065\u0021"
```

The message data set terminates when the data is not of the form

```
msgid message
```

Thus, there are no syntax errors in this data. Instead, a syntax error is simply interpreted as the end of the data set. The catalog file can contain data other than message data sets. The messages facet will scan the file until it encounters `$set setid`.

### Listing: Example of message facet

An example message data file might contain:

```
$set 1
1 "First Message"
2 "Error in foo"
3 Baboo
4 "\u0048\u0069\u0020\u0054\u0068\u0065\u0072\u0065\u0021"
$set 2
1 Ok
2 Cancel
```

A program that uses messages to read and output this file follows:

```
#include <locale>
#include <iostream>
int main()
{
    typedef std::messages<char> Msg;
    const Msg& ct = std::use_facet<Msg>(std::locale::classic());
    Msg::catalog cat = ct.open("my_messages",
        std::locale::classic());
    if (cat < 0)
    {
        std::cout << "Can't open message file\n";
        return 1;
    }
    std::string eof("no more messages");
    for (int set = 1; set <= 2; ++set)
    {
        std::cout << "set " << set << "\n\n";
        for (int msgid = 1; msgid < 10; ++msgid)
        {
            std::string msg = ct.get(cat, set, msgid, eof);
            if (msg == eof)
```

## Standard Locale Categories

```

        break;
        std::cout << msgid << "\t" << msg << '\n';
    }
    std::cout << '\n';
}
ct.close(cat);
}

```

The output of this program is:

### set 1

```

1  First Message
2  Error in foo
3  Baboo
4  Hi There!

```

### set 2

```

1  Ok
2  Cancel

```

## 7.4.6.3 Template Class Messages\_byname Synopsis

The class `messages_byname` adds no functionality over `messages`.

The `const char*` that it is constructed with is ignored. To localize `messages` for a specific culture, either open a different catalog (file), or have different sets in a catalog represent `messages` for different cultures.

### Listing: Template Class Messages\_byname Synopsis

```

namespace std {
template <class charT>

class messages_byname : public messages<charT> {
public:

typedef messages_base::catalog catalog;
typedef basic_string<charT> string_type;

explicit messages_byname(const char*, size_t refs = 0);

protected:

~messages_byname(); // virtual

virtual catalog do_open(const basic_string<char>&, const locale&)
const;

virtual string_type do_get(catalog, int set, int msgid,

```

```

const string_type& default) const;
virtual void do_close(catalog) const;
};
}

```

#### 7.4.6.4 Extending messages by derivation

If you are on a platform without file support, or you do not want to use files for messages for other reasons, you may derive from messages and override the virtual methods as described by the standard.

Additionally you can take advantage of the EWL C++ specific protected interface of messages if you wish (to make your job easier if portability is not a concern).

The messages facet has the non-virtual protected member:

```
string_type& __set(catalog c, int set, int msgid);
```

You can use this to place the quadruple ( *c*, *set*, *msgid*, *string*) into messages' database. The constructor of the derived facet can fill the database using multiple calls to `__set`. Below is an example of such a class. This example also overrides `do_open` to double check that the catalog name is a valid name, and then return the proper catalog number. And `do_close` is also overridden to do nothing. The messages destructor will reclaim all of the memory used by its database:

The main program (client code) in the [Example of extending message by derivation](#) is nearly identical to the previous example. Here we simply create and use the customized messages facet. Alternatively we could have created a locale and installed this facet into it. And then extracted the facet back out of the locale using `use_facet` as in the first example.

#### Listing: Example of extending message by derivation

```

#include <locale>
#include <iostream>

#include <string>

#include <map>

class MyMessages
    : public std::messages<char>
{
public:
    MyMessages();

```

## Standard Locale Categories

protected:

```
virtual catalog do_open(const std::string& fn,
    const std::locale&) const;
virtual void do_close(catalog) const {}
```

private:

```
std::map<std::string, catalog> catalogs_;
};
```

MyMessages::MyMessages()

```
{
    catalogs_["my_messages"] = 1;
    __set(1, 1, 1) = "set 1: first message";
    __set(1, 1, 2) = "set 1: second message";
    __set(1, 1, 3) = "set 1: third message";
    __set(1, 2, 1) = "set 2: first message";
    __set(1, 2, 2) = "set 2: second message";
    __set(1, 2, 3) = "set 2: third message";
}
```

MyMessages::catalog

MyMessages::do\_open(const std::string& fn, const std::locale&) const

```
{
    std::map<std::string, catalog>::const_iterator i =
        catalogs_.find(fn);
    if (i == catalogs_.end())
        return -1;
    return i->second;
}
```

int main()

```
{
    typedef MyMessages Msg;
    Msg ct;
    Msg::catalog cat = ct.open("my_messages",
        std::locale::classic());
    if (cat < 0)
    {
        std::cout << "Can't open message file\n";
    }
}
```

```
    return 1;
}
std::string eof("no more messages");
for (int set = 1; set <= 2; ++set)
{
    std::cout << "set " << set << "\n\n";
    for (int msgid = 1; msgid < 10; ++msgid)
    {
        std::string msg = ct.get(cat, set, msgid, eof);
        if (msg == eof)
            break;
        std::cout << msgid << "\t" << msg << '\n';
    }
    std::cout << '\n';
}
ct.close(cat);
}
```

The output of this program is:

### set 1

```
1 set 1: first message
2 set 1: second message
3 set 1: third message
```

### set 2

```
1 set 2: first message
2 set 2: second message
3 set 2: third message
```

## 7.4.7 Program-defined Facets

A C++ program may add its own locales to be added to and used the same as the built in facets.

To do this derive a class from `locale::facet` with the static member `static locale::id id`.

## 7.5 C Library Locales

The C++ header `<locale>` are the same as the C header `locale` but in standard namespace.

**Table 7-5. Header `<locale>` Synopsis**

Type	Name(s)	Name(s)
Macro	LC_ALL	LC_COLLATE
Macro	LC_CTYPE	LC_MONETARY
Macro	LC_NUMERIC	LC_TIME
Macro	NULL	
Struct	lconv	
Function	localeconv	setlocale

## Chapter 8

# Containers Library

Containers are used to store and manipulate collections of information.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Container Requirements](#)
- [Sequences](#)
- [Associative Containers](#)
- [Template Class Bitset](#)

### 8.1 Container Requirements

Container objects store other objects and control the allocation and de-allocation of those objects.

#### 8.1.1 All containers must meet basic requirements.

The `swap()`, `equal()` and `lexicographical_compare()` algorithms are defined in the algorithm library for more information see [Algorithms Library](#) .

The member function `size()` returns the number of elements in a container.

The member function `begin()` returns an iterator to the first element and `end` returns an iterator to the last element.

If `begin()` equals `end()` the container is empty.

Copy constructors for container types copy and allocator argument from their first parameter. All other constructors take an Allocator reference argument.

The member function `get_allocator()` returns a copy of the Allocator object used in construction of the container.

If an iterator type of the container is bi-directional or a random access iterator the container is reversible.

### 8.1.2 Unless specified containers meet these requirements.

If an exception is thrown by an `insert()` function while inserting a single element, that function has no effects.

If an exception is thrown by a `push_back()` or `push_front()` function, that function has no effects.

The member functions `erase()`, `pop_back()` or `pop_front()` do not throw an exception.

None of the copy constructors or assignment operators of a returned iterator throw an exception.

The member function `swap()` does not throw an exception, Except if an exception is thrown by the copy constructor or assignment operator of the container's compare object.

The member function `swap()` does not invalidate any references, pointers, or iterators referring to the elements of the containers being swapped.

### 8.1.3 Sequences Requirements

A sequence is a kind of container that organizes a finite set of objects, all of the same type, into a strictly linear arrangement.

The Library includes three kinds of sequence containers `vector`, `lists`, `deque` and `adaptors` classes.

#### 8.1.3.1 Additional Requirements

The iterator returned from `a.erase(q)` points to the element immediately following `q` prior to the element being erased.

If no prior element exists for `a.erase` then `a.end()` is returned.

- The previous conditions are true for `a.erase(q1, q2)` as well.



For every sequence defined in this clause the constructor

```
template <class InputIterator>
X(InputIterator f, InputIterator l,
  const Allocator& a = Allocator())
```

- shall have the same effect as:

```
X(static_cast<typename X::size_type>(f),
  static_cast<typename X::value_type>(l), a)
```

- if `InputIterator` is an integral type.

Member functions in the forms:

```
template <class InputIterator>
rt fx1(iterator p, InputIterator f, InputIterator l);
template <class InputIterator>
rt fx2(InputIterator f, InputIterator l);
template <class InputIterator>
rt fx3(iterator i1, iterator i2, InputIterator f, InputIterator l);
```

- shall have the same effect, respectively, as:

```
fx1(p, static_cast<typename X::size_type>(f),
  static_cast<typename X::value_type>(l));
fx2(static_cast<typename X::size_type>(f),
  static_cast<typename X::value_type>(l));
fx3(i1, i2, static_cast<typename X::size_type>(f),
  static_cast<typename X::value_type>(l));
```

- if `InputIterator` is an integral type.

The member function `at()` provides bounds-checked access to container elements.

The member function `at()` throws `out_of_range` if `n >= a.size()`.

### 8.1.4 Associative Containers Requirements

Associative containers provide an ability for optimized retrieval of data based on keys.

Associative container are parameterized on `Key` and an ordering relation. Furthermore, `map` and `multimap` associate an arbitrary type `T` with the key.

The phrase "equivalence of keys" means the equivalence relation imposed by the comparison and not the `operator ==` on keys.

An associative container supports both unique keys as well as support fir equivalent keys.

- The classes set and map support unique keys.
- The classes multiset and multimap support equivalent keys.

An iterator of an associative container must be of the bidirectional iterator category.

The insert members shall not affect the validity of iterators.

Iterators of associative containers iterate through the containers in the non-descending order of keys where non-descending is defined by the comparison that was used to construct them.

## 8.2 Sequences

The sequence libraries consist of several headers.

- [Template Class Deque](#)
- [Template Class List](#)
- [Container Adaptors](#)
- [Template Class Queue](#)
- [Template Class Priority\\_queue](#)
- [Template Class Stack](#)
- [Template Class Vector](#)
- [Class Vector<bool>](#)

### 8.2.1 Template Class Deque

A deque is a kind of sequence that supports random access iterators.

The deque class also supports insert and erase operations at the beginning middle or the end. However, deque is especially optimized for pushing and popping elements at the beginning and end.

A deque satisfies all of the requirements of a container and of a reversible container as well as of a sequence.

#### 8.2.1.1 Constructors

The deque constructor creates an object of the class deque.

```
explicit deque(const Allocator& = Allocator());
explicit deque(size_type n, const T& value = T(),
const Allocator& = Allocator());
template <class InputIterator>
deque(InputIterator first, InputIterator last,
const Allocator& = Allocator());
```

### 8.2.1.2 assign

The assign function is overloaded to allow various types to be assigned to a deque.

```
template <class InputIterator>
void assign (InputIterator first, InputIterator last);
void assign(size_type n, const T& t);
```

### DequeCapacity

The class deque has one member function to resize the deque.

### 8.2.1.3 resize

This function resizes the deque.

```
void resize(size_type sz, T c = T());
```

### DequeModifiers

The deque class has member functions to modify the deque.

### 8.2.1.4 insert

The insert function is overloaded to insert a value into deque.

```
iterator insert(iterator position, const T& x);
void insert
(iterator position, size_type n, const T& x);
template <class InputIterator>
void insert
```

```
(iterator position, InputIterator first,  
InputIterator last);
```

### 8.2.1.5 erase

An overloaded function that allows the removal of a value at a position.

```
iterator erase(iterator position);  
iterator erase(iterator first, iterator last);
```

#### Remarks

An iterator to the position erased.

#### DequeSpecializedAlgorithms

Deque has one specialize swap function.

### 8.2.1.6 swap

Swaps the element at one position with another.

```
template <class T, class Allocator>  
void swap (deque<T,Allocator>& x, deque<T,Allocator>& y);
```

## 8.2.2 Template Class List

A list is a sequence that supports bidirectional iterators and allows insert and erase operations anywhere within the sequence.

In a list fast random access to list elements is not supported.

A list satisfies all of the requirements of a container as well as those of a reversible container and of a sequence except for `operator[]` and the member function `at` which are not included.

### 8.2.2.1 Constructors

The overloaded list constructors create objects of type list.

```
explicit list(const Allocator& = Allocator());
explicit list(size_type n, const T& value = T(),
             const Allocator& = Allocator());
template <class InputIterator>
list(InputIterator first, InputIterator last,
     const Allocator& = Allocator());
```

### 8.2.2.2 assign

The overloaded assign function allows values to be assigned to a list after construction.

```
template <class InputIterator>
void assign(InputIterator first, InputIterator last);
void assign(size_type n, const T& t);
```

### ListCapacity

The list class provides for one member function to resize the list.

### 8.2.2.3 resize

Resizes the list.

```
void resize(size_type sz, T c = T());
```

### ListModifiers

The list class has several overloaded functions to allow modification of the list object.

### 8.2.2.4 insert

The insert member function insert a value at a position.

```
iterator insert(iterator position, const T& x);
void insert(iterator position, size_type n, const T& x);
template <class InputIterator>
```

**Sequences**

```
void insert  
(iterator position, InputIterator first, InputIterator last);
```

### 8.2.2.5 push\_front

The `push_front` member function pushes a value at the front of the list.

```
void push_front(const T& x);
```

### 8.2.2.6 push\_back

The `push_back` member function pushes a value onto the end of the list.

```
void push_back(const T& x);
```

### 8.2.2.7 erase

The `erase` member function removes a value at a position or range.

```
iterator erase(iterator position);  
iterator erase(iterator first, iterator last);
```

### Remarks

Returns an iterator to the last position.

### 8.2.2.8 pop\_front

The `pop_front` member function removes a value from the top of the list.

```
void pop_front();
```

### 8.2.2.9 pop\_back

The `pop_back` member function removes a value from the end of the list.

```
void pop_back();
```

### 8.2.2.10 clear

Clears a list by removing all elements.

```
void clear();
```

## ListOperations

The list class provides for operations to manipulate the list.

### 8.2.2.11 splice

Moves an element or a range of elements in front of a position specified.

```
void splice  
(iterator position, list<T,Allocator>& x);  
void splice  
(iterator position, list<T,Allocator>& x,iterator i);  
void splice  
(iterator position, list<T,Allocator>& x,  
iterator first, iterator last);
```

### 8.2.2.12 remove

Removes all element with a value.

```
void remove(const T& value);
```

### 8.2.2.13 remove\_if

Removes all element for which the predicate is true.

```
template <class Predicate>
void remove_if(Predicate pred);
```

### 8.2.2.14 unique

Removes duplicates of consecutive elements.

```
void unique();
template <class BinaryPredicate>
void unique(BinaryPredicate binary_pred);
```

### 8.2.2.15 merge

Moves sorted elements into a list according to the compare argument.

```
void merge(list<T,Allocator>& x);
template <class Compare>
void merge(list<T,Allocator>& x, Compare comp);
```

### 8.2.2.16 reverse

Reverses the order of the list.

```
void reverse();
```

### 8.2.2.17 sort

Sorts a list according to the Compare function or by less than value for the parameterless version.



```
void sort();  
template <class Compare> void sort(Compare comp);
```

## ListSpecializedAlgorithms

The list class provides a swapping function.

### 8.2.2.18 swap

Changes the position of the first argument with the second argument.

```
template <class T, class Allocator>  
void swap (list<T,Allocator>& x, list<T,Allocator>& y);
```

## 8.2.3 Container Adaptors

Container adaptors take a Container template parameter so that the container is copied into the Container member of each adaptor.

## 8.2.4 Template Class Queue

Any of the sequence types supporting operations `front()`, `back()`, `push_back()` and `pop_front()` can be used to instantiate queue.

### 8.2.4.1 operator ==

A user supplied operator for the queue class that compares the queue's data member.

```
bool operator ==
```

#### Remarks

Returns true if the data members are equal.

### 8.2.4.2 operator <

A user supplied operator for the queue class that compares the queue's data member.

```
bool operator <
```

#### Remarks

Returns true if the data member is less than the compared queue.

## 8.2.5 Template Class Priority\_queue

You can instantiate any `priority_queue` with any sequence that has random access iterator and supporting operations `front()`, `push_back()` and `pop_back()`.

Instantiation of a `priority_queue` requires supplying a function or function object for making the priority comparisons.

### 8.2.5.1 Constructors

Creates an object of type `priority_queue`.

```
priority_queue(const Compare& x = Compare(),
               const Container& y = Container());
template <class InputIterator>
priority_queue
(InputIterator first, InputIterator last,
 const Compare& x = Compare(),
 const Container& y = Container());
```

#### priority\_queue members

The class `priority_queue` provides public member functions for manipulation the `priority_queue`.

### 8.2.5.2 push

Inserts an element into the `priority_queue`.

```
void push(const value_type& x);
```

### 8.2.5.3 pop

Removes an element from a `priority_queue`.

```
void pop();
```

## 8.2.6 Template Class Stack

A stack class may be instantiated by any sequence supporting operations `back()`, `push_back()` and `pop_back()`.

### 8.2.6.1 Public Member Functions

This section describes public member functions.

#### 8.2.6.1.1 Constructors

Creates an object of type `stack` with a container object.

```
explicit stack(const Container& = Container());
```

#### 8.2.6.1.2 empty

Signifies when the stack is empty

```
bool empty() const;
```

#### Remarks

Returns true if there are no elements in the stack.

### 8.2.6.1.3 size

Gives the number of elements in a stack.

```
size_type size() const;
```

#### Remarks

Returns the number of elements in a stack.

### 8.2.6.1.4 top

Gives the top element in the stack.

```
value_type& top(){return c.back();}  
const value_type& top() const{return c.back();}
```

#### Remarks

Returns the value at the top of the stack.

### 8.2.6.1.5 push

Puts a value onto a stack.

```
void push(const value_type& x) { c.push_back(x); }
```

### 8.2.6.1.6 pop

Removes an element from a stack.

```
void pop();
```

## 8.2.7 Template Class Vector

A vector is a kind of sequence container that supports random access iterators.

You can use insert and erase operations at the end and in the middle but at the end is faster.

A vector satisfies all of the requirements of a container and of a reversible container and of a sequence. It also satisfies most of the optional sequence requirements with the exceptions being `push_front` and `pop_front` member functions.

### 8.2.7.1 Constructors

The vector class provides overloaded constructors for creation of a vector object.

```
vector(const Allocator& = Allocator());
explicit vector (size_type n, const T& value = T(),
const Allocator& = Allocator());
template <class InputIterator>
vector(InputIterator first, InputIterator last,
const Allocator& = Allocator());
vector(const vector<T,Allocator>& x);
```

### 8.2.7.2 assign

The member function assign allows you to assign values to an already created object.

```
template <class InputIterator>
void assign
(InputIterator first, InputIterator last);
void assign(size_type n, const T& t);
```

### 8.2.7.3 capacity

Tells the maximum number of elements the vector can hold.

```
size_type capacity() const;
```

#### Remarks

Returns the maximum number of elements the vector can hold.

### 8.2.7.4 **resize**

Resizes a vector if a second argument is give the elements are filled with that value.

```
void resize(size_type sz, T c = T());
```

## **VectorModifiers**

The vector class provides various member functions for vector data manipulation.

### 8.2.7.5 **insert**

The member function insert inserts a value or a range of values at a set position.

```
iterator insert(iterator position, const T& x);  
void insert(iterator position, size_type n, const T& x);  
template <class InputIterator> void insert  
(iterator position, InputIterator first, InputIterator last);
```

### 8.2.7.6 **erase**

Removes elements at a position or for a range.

```
iterator erase(iterator position);  
iterator erase(iterator first, iterator last);
```

## **VectorSpecializedAlgorithms**

The vector class provides for a specialized swap function.

### 8.2.7.7 **swap**

Swaps the data of one argument with the other argument.

```
template <class T, class Allocator> void swap  
(vector<T,Allocator>& x, vector<T,Allocator>& y);
```

## 8.2.8 Class Vector<bool>

A specialized vector for `bool` elements is provided to optimize allocated space.

A EWL bitvector class is available for efficient `bool` vector manipulations. Refer to [Bitvector Class Library](#) for more information.

## 8.3 Associative Containers

The associative container library consists of four template container classes.

- [Template Class Map](#)
- [Template Class Multimap](#)
- [Template Class Set](#)
- [Template Class Multiset](#)

### 8.3.1 Template Class Map

The map class is an associative container that supports unique keys and provides for retrieval of values of another type `T` based on the keys.

The map template class supports bidirectional iterators.

The template class map satisfies all of the requirements of a normal container and those of a reversible container, as well as an associative container.

A map also provides operations for unique keys.

#### 8.3.1.1 Constructors

The map class provides an overloaded constructor for creating an object of type map.

```
explicit map(const Compare& comp = Compare(),
            const Allocator& = Allocator());
template <class InputIterator> map (InputIterator first,
```

```
InputIterator last, const Compare& comp = Compare(),  
const Allocator& = Allocator());
```

### 8.3.1.2 Map Element Access

The map class includes an element access operator.

#### 8.3.1.2.1 operator []

Access an indexed element.

```
T& operator[] (const key_type& x);
```

#### Remarks

Returns the value at the position indicated.

### 8.3.1.3 Map Operations

The map class includes member functions for map operations.

#### 8.3.1.3.1 find

Finds an element based upon a key.

```
iterator find(const key_type& x);  
const_iterator find(const key_type& x) const;
```

#### Remarks

Returns the position where the element is found.

#### 8.3.1.3.2 lower\_bound

Finds the first position where an element based upon a key would be inserted.



```
iterator lower_bound(const key_type& x);  
const_iterator lower_bound(const key_type& x) const;
```

## Remarks

Returns the first position where an element would be inserted.

### 8.3.1.3.3 upper\_bound

Finds the last position where an element based upon a key would be inserted.

```
iterator upper_bound(const key_type& x);  
const_iterator upper_bound(const key_type &x) const;
```

## Remarks

Returns the last position where an element would be inserted.

### 8.3.1.3.4 equal\_range

Finds both the first and last position in a range where an element based upon a key would be inserted.

```
pair<iterator, iterator> equal_range (const_key_type &x);  
pair<const_iterator, const_iterator> equal_range  
(const key_type& x) const;
```

## Remarks

Returns a pair of elements representing a range for insertion.

## 8.3.1.4 Map Specialized Algorithms

The map class provides for a method to swap elements.

### 8.3.1.4.1 swap

Swaps the first argument with the second argument.

```
template <class Key, class T, class Compare, class Allocator>  
void swap
```

```
(map<Key, T, Compare, Allocator>& x,
map<Key, T, Compare, Allocator>& y);
```

## 8.3.2 Template Class Multimap

A `multimap` container supports equivalent keys that may contain multiple copies of the same key value. Multimap provides for fast retrieval of values of another type based on the keys.

Multimap supports bidirectional iterators.

The `multimap` satisfies all of the requirements of a container, reversible container and associative containers.

Multimap supports the `a_eq` operations but not the `a_uniq` operations.

For a `multimap<Key, T>` the `key_type` is `Key` and the `value_type` is `pair<const Key, T>`

### 8.3.2.1 Constructors

The `multimap` constructor is overloaded for creation of a `multimap` object.

```
explicit multimap
(const Compare& comp = Compare(),
const Allocator& = Allocator());
template <class InputIterator> multimap
(InputIterator first, InputIterator last,
const Compare& comp = Compare(),
const Allocator& = Allocator());
```

### 8.3.2.2 Multimap Operations

The `multimap` class includes member functions for manipulation of `multimap` data.

#### 8.3.2.2.1 find

Finds a value based upon a key argument.

```
iterator find(const key_type &x);  
const_iterator find(const key_type& x) const;
```

## Remarks

Returns the position where the element is at.

### 8.3.2.2.2 lower\_bound

Finds the first position where an element based upon a key would be inserted.

```
iterator lower_bound (const key_type& x);  
const_iterator lower_bound (const key_type& x) const;
```

## Remarks

Returns the position where an element was found.

### 8.3.2.2.3 equal\_range

Finds the first and last positions where a range of elements based upon a key would be inserted.

```
pair<iterator, iterator> equal_range  
(const key_type& x);  
pair<const_iterator, const_iterator> equal_range  
(const_key_type& x) const;
```

## Remarks

Returns a pair object that represents the first and last position where a range is found.

## 8.3.2.3 Multimap Specialized Algorithms

The multimap class provides a specialized function for swapping elements.

### 8.3.2.3.1 swap

Swaps the first argument for the last argument.

```
template <class Key, class T, class Compare, class Allocator>
void swap
(multimap<Key,T,Compare,Allocator>& x,
multimap<Key,T,Compare,Allocator>& y);
```

### 8.3.3 Template Class Set

The template class `set` is a container that supports unique keys and provides for fast retrieval of the keys themselves.

Set supports bidirectional iterators.

The class `set` satisfies all of the requirements of a container, a reversible container and an associative container.

A set supports the `a_uniq` operations but not the `a_eq` operations.

#### 8.3.3.1 Constructors

The `set` class includes overloaded constructors for creation of a set object.

```
explicit set
(const Compare& comp = Compare(),
const Allocator& = Allocator());
template <class InputIterator> set
(InputIterator first, last,
const Compare& comp = Compare(),
const Allocator& = Allocator());
```

#### 8.3.3.2 Set Specialized Algorithms

The `set` class specializes the swap function.

##### 8.3.3.2.1 swap

Swaps the first argument with the second argument.

```
template <class Key, class Compare, class Allocator>
void swap
(set<Key,Compare,Allocator>& x,
set<Key,Compare,Allocator>& y);
```

## 8.3.4 Template Class Multiset

The template class multiset is an associative container that supports equivalent keys and retrieval of the keys themselves.

Multiset supports bidirectional iterators.

The multiset satisfies all of the requirements of a container, reversible container and an associative container.

A multiset supports the `a_eq` operations but not the `a_uniq` operations.

### 8.3.4.1 Constructors

The multiset class includes overloaded constructors for creation of a multiset object.

```
explicit multiset
(const Compare& comp = Compare(),
 const Allocator& = Allocator());
template <class InputIterator> multiset
(InputIterator first, last, const Compare& comp = Compare(),
 const Allocator& = Allocator());
```

### 8.3.4.2 Multiset Specialized Algorithms

The multiset class provides a specialized swap function.

#### 8.3.4.2.1 swap

Swaps the first argument with the second argument.

```
template <class Key, class Compare, class Allocator>
void swap
(multiset<Key, Compare, Allocator>& x,
 multiset<Key, Compare, Allocator>& y);
```

## 8.3.5 Template Class Bitset

The `bitset` header defines a template class and related procedures for representing and manipulating fixed-size sequences of bits.

The template class `bitset` can store a sequence consisting of a fixed number of bits.

In the `bitset` class each bit represents either the value zero (`reset`) or one (`set`), there is no negative position. You can `toggle` a bit to change the value.

When converting between an object of class `bitset` and an integral value, the integral value corresponding to two or more bits is the sum of their bit values.

The `bitset` functions can report three kinds of errors as exceptions.

- An `invalid_argument` exception
- An `out_of_range` error exception
- An `overflow_error` exceptions

See [Exception Classes](#), for more information on exception classes.

### 8.3.5.1 Constructors

The `bitset` class includes overloaded constructors for creation of a `bitset` object.

```
bitset();  
bitset(unsigned long val);  
template <class charT, class traits, class Allocator>  
explicit bitset  
(const basic_string<charT, traits, Allocator>& str,  
typename basic_string  
<charT, traits, Allocator>::size_type pos = 0,  
typename basic_string<charT, traits,  
Allocator>::size_type n = basic_string  
<charT, traits, Allocator>::npos);
```

### 8.3.5.2 Bitset Members

The `bitset` class provides various member operators.

#### 8.3.5.2.1 operator &=

A bitwise "and equal" operator.

```
bitset<N>& operator&=(const bitset<N>& rhs);
```

### Remarks

Returns the result of the "and equals" operation.

#### 8.3.5.2.2 operator |=

An "Assignment by bitwise OR" operator.

```
bitset<N>& operator|=(const bitset<N>& rhs);
```

### Remarks

Assigns the result of the "bitwise OR" of the left and right operands to the left operand.

#### 8.3.5.2.3 operator ^=

A bitwise "exclusive or equals" operator.

```
bitset<N>& operator^=(const bitset<N>& rhs);
```

### Remarks

Returns the result of the "exclusive or equals" operation.

#### 8.3.5.2.4 operator <<=

A bitwise "left shift equals" operator.

```
bitset<N>& operator <<=(size_t pos);
```

### Remarks

Returns the result of the "left shift equals" operation.

#### 8.3.5.2.5 operator >>=

A bitwise "right shift equals" operator.

```
bitset<N>& operator>>=(size_t pos);
```

### Remarks

Returns the result of the "right shifts equals" operation.

### 8.3.5.2.6 Set

Sets all the bits or a single bit to a value.

```
bitset<N>& set();  
bitset<N>& set(size_t pos, int val = 1);
```

### Remarks

For the function with no parameters sets all the bits to true. For the overloaded function with just a position argument sets that bit to true. For the function with both a position and a value sets the bit at that position to the value.

Returns the altered bitset.

### 8.3.5.2.7 reset

Sets the bits to false.

```
bitset<N>& reset();  
bitset<N>& reset(size_t pos);
```

### Remarks

The reset function without any arguments sets all the bits to false. The reset function with an argument sets the bit at that position to false.

Returns the modified bitset.

### 8.3.5.2.8 operator ~

Toggles all bits in the bitset.



```
bitset<N> operator~() const;
```

## Remarks

Returns the modified bitset.

### 8.3.5.2.9 flip

Toggles all the bits in the bitset.

```
bitset<N>& flip();  
bitset<N>& flip(size_t pos);
```

## Remarks

Returns the modified bitset.

### 8.3.5.2.10 to\_ulong

Gives the value as an unsigned long.

```
unsigned long to_ulong() const;
```

## Remarks

Returns the unsigned long value that the bitset represents.

### 8.3.5.2.11 to\_string

Gives the string as zero and ones that the bitset represents.

```
template <class charT, class traits, class Allocator>  
basic_string<charT, traits, Allocator> to_string() const;
```

## Remarks

Returns a string that the bitset represents.

### 8.3.5.2.12 count

Tells the number of bits that are true.

```
size_t count() const;
```

### Remarks

Returns the number of set bits.

#### 8.3.5.2.13 size

Tells the size of the bitset as the number of bits.

```
size_t size() const;
```

### Remarks

Returns the size of the bitset.

#### 8.3.5.2.14 operator ==

The equality operator.

```
bool operator==(const bitset<N>& rhs) const;
```

### Remarks

Returns true if the argument is equal to the right side bitset.

#### 8.3.5.2.15 operator !=

The inequality operator.

```
bool operator!=(const bitset<N>& rhs) const;
```

### Remarks

Returns true if the argument is not equal to the right side bitset.

#### 8.3.5.2.16 test

Test if a bit at a position is set.

```
bool test(size_t pos) const;
```

### Remarks

Returns true if the bit at the position is true.

### 8.3.5.2.17 any

Tests if all bits are set to true.

```
bool any() const;
```

### Remarks

Returns true if any bits in the bitset are true.

### 8.3.5.2.18 none

Tests if all bits are set to false.

```
bool none() const;
```

### Remarks

Returns true if all bits are false.

### 8.3.5.2.19 operator <<

Shifts the bitset to the left a number of positions.

```
bitset<N> operator<<(size_t pos) const;
```

### Remarks

Returns the modified bitset.

### 8.3.5.2.20 operator >>

Shifts the bitset to the right a number of positions.

```
bitset<N> operator>>(size_t pos) const;
```

### Remarks

Returns the modified bitset.

## 8.3.5.3 Bitset Operators

Bitwise operators are included in the bitset class.

### 8.3.5.3.1 operator &

A bitwise `and` operator.

```
bitset<N> operator&(const bitset<N>& lhs, const bitset<N>& rhs);
```

### Remarks

Returns the modified bitset.

### 8.3.5.3.2 operator |

A bitwise `or` operator.

```
bitset<N> operator|(const bitset<N>& lhs, const bitset<N>& rhs);
```

### Remarks

Returns the modified bitset.

### 8.3.5.3.3 operator ^

A bitwise `exclusive or` operator.

```
bitset<N> operator^(const bitset<N>& lhs, const bitset<N>&
rhs);
```

## Remarks

Returns the modified bitset.

### 8.3.5.3.4 operator >>

An extractor operator for a bitset input.

```
template <class charT, class traits, size_t N>
basic_istream<charT, traits>& operator>>
(basic_istream<charT, traits>& is, bitset<N>& x);
```

## Remarks

Returns the bitset.

### 8.3.5.3.5 operator <<

An inserter operator for a bitset output.

```
template <class charT, class traits, size_t N>
basic_ostream<charT, traits>& operator<<
(basic_ostream<charT, traits>& os, const bitset<N>& x);
```

## Remarks

Returns the bitset.



## Chapter 9

# Iterators Library

This chapter presents the concept of iterators in detail, defining and illustrating the five iterator categories of input iterators, output iterators, forward iterators, bidirectional iterators and random access iterators.

This chapter describes the components used in C++ programs to perform iterations for container classes, streams and stream buffers.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Requirements](#)
- [Header iterator](#)
- [Iterator Primitives](#)
- [Predefined Iterators](#)
- [Stream Iterators](#)
- [\\_EWL\\_RAW\\_ITERATORS](#)

### 9.1 Requirements

Iterators are a generalized pointer that allow the C++ program to work with various containers in a unified manner.

All iterators allow the dereference into a value type.

Since iterators are an abstraction of a pointer all functions that work with regular pointers work equally with regular pointers.

#### 9.1.1 Input Iterators

There are requirements for input iterators, this manual, does not attempt to list them all.

Algorithms on input iterators should never attempt to pass through the same iterator more than once.

## 9.1.2 Output Iterators

There are requirements for output iterators, this manual, does not attempt to list them all.

An output iterator is assignable.

## 9.1.3 Forward Iterators

Forward iterators meet all the requirements of input and output iterators.

There are requirements for forward iterators, this manual, does not attempt to list them all.

## 9.1.4 Bidirectional Iterators

Bidirectional iterators meet the requirements of forward iterators.

There are requirements for forward iterators, this manual, does not attempt to list them all.

## 9.1.5 Random Access Iterators

Random access iterators meet the requirements of bidirectional iterators.

There are requirements for forward iterators, this manual, does not attempt to list them all.



## 9.2 Header iterator

The header iterator includes classes, types and functions used to allow the C++ program to work with various containers in a unified manner.

## 9.3 Iterator Primitives

The library provides several classes and functions to simplify the task of defining iterators.

### 9.3.1 Iterator Traits

To implement algorithms only in terms of iterators, it is often necessary to determine the value and difference types for a particular iterator type. Therefore, it is required that if `iterator` is the type of an iterator, then the types

```
iterator_traits<Iterator>::difference_type  
iterator_traits<Iterator>::value_type  
iterator_traits<Iterator>::iterator_category
```

are defined as the iterator's difference type, value type and iterator category, respectively.

In the case of an output iterator, the types

```
iterator_traits<Iterator>::difference_type
```

```
iterator_traits<Iterator>::value_type
```

defined as `void`.

The template `iterator_traits<Iterator>` is specialized for pointers and for pointers to `const`

### 9.3.2 Basic Iterator

The iterator template may be used as a base class for new iterators.

### 9.3.3 Standard Iterator Tags

The standard library includes category tag classes which are used as compile time tags for algorithm selection. These tags are used to determine the best iterator argument at compile time. These tags are:

- `input_iterator_tag`
- `output_iterator_tag`
- `forward_iterator_tag`,
- `bidirectional_iterator_tag`
- `random_access_iterator_tag`

### 9.3.4 Iterator Operations

Since only random access iterators provide plus and minus operators, the library provides two template functions for this functionality.

#### 9.3.4.1 `advance`

Increments or decrements iterators.

```
template <class InputIterator, class Distance>
void advance(InputIterator& i, Distance n);
```

#### 9.3.4.2 `distance`

Provides a means to determine the number of increments or decrements necessary to get from the beginning to the end.

```
template<class InputIterator>
typename iterator_traits<InputIterator>::
difference_type distance
(InputIterator first, InputIterator last);
```

#### Remarks

The distance from last must be reachable from first.

The number of increments from first to last.

## 9.4 Predefined Iterators

The standard provides for two basic predefined iterators.

- [Reverse iterators](#)
- [Insert Iterators](#)

### 9.4.1 Reverse iterators

Both bidirectional and random access iterators have corresponding reverse iterator adaptors that they iterate through.

#### 9.4.1.1 Template Class `Reverse_iterator`

A `reverse_iterator` must meet the requirements of a bidirectional iterator.

#### 9.4.1.2 `Reverse_iterator` Requirements

Additional requirements may be necessary if random access operators are referenced in a way that requires instantiation.

#### 9.4.1.3 Constructors

Creates an instance of a `reverse_iterator` object.

```
explicit reverse_iterator(Iterator x);  
template <class U> reverse_iterator  
(const reverse_iterator<U> &u);
```

#### 9.4.1.4 `base`

The base operator is used for conversion.

```
Iterator base() const; // explicit
```

## Remarks

The current iterator is returned.

### 9.4.1.5 Reverse\_iterator operators

The common operators are provided for `reverse_iterator`.

#### Operator\*

```
reference operator*() const;
```

A reference iterator is returned.

A pointer to the dereferenced iterator is returned.

#### Operator->

```
pointer operator ->() const;
```

#### Operator++

```
reverse_iterator& operator++();  
reverse_iterator operator++(int);
```

The this pointer is returned.

#### Operator--

```
reverse_iterator& operator--();  
reverse_iterator operator--(int);
```

The this pointer is returned.

#### Operator+

```
reverse_iterator operator+  
(typename reverse_iterator<Iterator>::difference_type n)  
const;
```

The `reverse_iterator` representing the result of the operation is returned.

## Operator+=

```
reverse_iterator& operator+=  
(typename reverse_iterator<Iterator>::difference_type n);
```

The `reverse_iterator` representing the result of the operation is returned.

## Operator-

```
iterator operator-  
(typename reverse_iterator<Iterator>::difference_type n)  
const;
```

The `reverse_iterator` representing the result of the operation is returned.

## Operator-=

```
reverse_iterator& operator-=  
(typename reverse_iterator<Iterator>  
::difference_type n);
```

The `reverse_iterator` representing the result of the operation is returned.

## Operator[]

```
reference operator[]  
(typename reverse_iterator<Iterator>::difference_type n)  
const;
```

An element access reference is returned.

## Operator==

```
template <class Iterator> bool operator==  
(const reverse_iterator<Iterator>& x,  
const reverse_iterator<Iterator>& y);
```

A `bool` true value is returned if the iterators are equal.

## Operator<

```
template <class Iterator> bool operator<  
(const reverse_iterator<Iterator>& x,  
const reverse_iterator<Iterator>& y);
```

A `bool` true value is returned if the first iterator is less than the second.

## Operator!=

```
template <class Iterator> bool operator!=
(const reverse_iterator<Iterator>& x,
const reverse_iterator<Iterator>& y);
```

A bool true value is returned if the first iterator is not equal to the second.

### Operator>

```
template <class Iterator> bool operator>
(const reverse_iterator<Iterator>& x,
const reverse_iterator<Iterator>& y);
```

A bool true value is returned if the first iterator is greater than the second.

### Operator>=

```
template <class Iterator> bool operator>=
(const reverse_iterator<Iterator>& x,
const reverse_iterator<Iterator>& y);
```

The reverse\_iterator representing the result of the operation is returned.

### Operator<=

```
template <class Iterator> bool operator<=
(const reverse_iterator<Iterator>& x,
const reverse_iterator<Iterator>& y);
```

The reverse\_iterator representing the result of the operation is returned.

### Operator-

```
template <class Iterator>
typename reverse_iterator<Iterator>
::difference_type operator-
(const reverse_iterator<Iterator>& x,
const reverse_iterator<Iterator>& y);
```

The reverse\_iterator representing the result of the operation is returned.

### Operator+

```
template <class Iterator>
reverse_iterator<Iterator> operator+
(typename reverse_iterator<Iterator>
::difference_type n,
const reverse_iterator<Iterator>& x);
```

The reverse\_iterator representing the result of the operation is returned.

## 9.4.2 Insert Iterators

Insert iterators, are provided to make it possible to deal with insertion in the same way as writing into an array.

### 9.4.2.1 Class `back_insert_iterator`

A `back_insert_iterator` inserts at the back.

### 9.4.2.2 Constructors

Constructs a `back_insert_iterator` object.

```
explicit back_insert_iterator(Container& x);
```

#### 9.4.2.2.1 operator =

An operator is provided for copying a `const_reference` value.

```
back_insert_iterator<Container>& operator=  
(typename Container::const_reference value);
```

### Remarks

A reference to the copied `back_insert_iterator` is returned.

### 9.4.2.3 Back\_insert\_iterator Operators

Several standard operators are provided for `Back_insert_iterator`.

### 9.4.2.3.1 Operator \*

```
back_insert_iterator<Container>& operator* ();
```

The dereferenced iterator is returned.

### 9.4.2.3.2 Operator ++

```
back_insert_iterator<Container>& operator++ ();  
back_insert_iterator<Container> operator++ (int);
```

The incremented iterator is returned.

### 9.4.2.4 back\_inserter

Provides a means to get the back iterator.

```
template <class Container> back_insert_iterator<Container>  
back_inserter  
(Container& x);
```

#### Remarks

The `back_insert_iterator` is returned.

## 9.4.3 Template Class `front_insert_iterator`

A `front_insert_iterator` inserts at the front.

### 9.4.3.1 Constructors

Creates a `front_insert_iterator` object.

```
explicit front_insert_iterator(Container& x);
```



## Operator=

Assigns a value to a `front_insert_iterator` object.

```
front_insert_iterator<Container>& operator=  
  
(typename Container::const_reference value);
```

## Remarks

A `front_insert_iterator` copy of the `const_reference` value is returned.

### 9.4.3.2 `front_insert_iterator` operators

Several common operators are provided for the `front_insert_iterator` class.

## Operator\*

```
front_insert_iterator<Container>& operator* ();
```

A `this` pointer is returned.

## Operator++

```
front_insert_iterator<Container>& operator++ ();  
  
front_insert_iterator<Container> operator++ (int);
```

## Remarks

A post or pre increment operator.

The `this` pointer is returned.

### 9.4.3.3 `front_inserter`

Provides a means to get the front iterator.

```
template <class Container>
front_insert_iterator<Container>
front_inserter(Container& x);
```

## Remarks

The `front_insert_iterator` is returned.

## 9.4.4 Template Class `Insert_iterator`

A bidirectional insertion iterator.

### 9.4.4.1 Constructors

Creates an instance of an `insert_iterator` object.

```
insert_iterator
(Container& x, typename Container::iterator i);
```

### `operator=`

An operator for assignment of a `const_reference` value.

```
insert_iterator<Container>& operator=
(typename Container::const_reference value);
```

## Remarks

Returns a copy of the `insert_iterator`.

### 9.4.4.2 `Insert_iterator` Operators

Various operators are provided for an `insert_iterator`.

### `Operator*`

```
insert_iterator<Container>& operator*();
```

The dereferenced iterator is returned.

## Operator++

```
insert_iterator<Container>& operator++();  
insert_iterator<Container>& operator++(int);
```

The this pointer is returned.

### 9.4.4.3 inserter

Provides a means to get the iterator.

```
template <class Container, class Inserter>  
insert_iterator<Container> inserter  
(Container& x, Inserter i);
```

#### Remarks

The inserter iterator is returned.

## 9.5 Stream Iterators

Input and output iterators are provided to make it possible for algorithmic templates to work directly with input and output streams.

### 9.5.1 Template Class Istream\_iterator

An `istream_iterator` reads (using `operator>>`) successive elements from the input stream. It reads after it is constructed, and every time the increment operator is used.

If an end of stream is reached the iterator returns false.

Since `istream` iterators are not assignable `istream` iterators can only be used for one pass algorithms.

### 9.5.1.1 Constructors

Creates and object of an `istream_iterator` object.

```
istream_iterator();  
istream_iterator(istream_type& s);  
istream_iterator  
(const istream_iterator<T, charT,traits,Distance>& x);
```

The parameterless iterator is the only legal constructor for an `end` condition.

### 9.5.1.2 destructor

Removes an instance of an `istream_iterator`.

```
~istream_iterator();
```

### 9.5.1.3 `istream_iterator` Operations

Various operators are provided for an `istream_iterator`.

#### Operator\*

```
const T& operator*() const;
```

A dereferenced iterator is returned.

#### Operator->

```
const T* operator->() const;
```

The address of a dereferenced iterator is returned.

#### Operator++

```
istream_iterator <T,charT,traits,Distance>& operator++();  
istream_iterator <T,charT,traits,Distance>& operator++(int);
```

The this pointer is returned.

## Operator==

```
template <class T, class charT,  
class traits, class Distance> bool operator==  
(const istream_iterator<T,charT, traits,  
Distance> & x, const istream_iterator  
<T,charT,traits,Distance> & y);
```

A bool true value is returned if the arguments are the same.

## 9.5.2 Template Class Ostream\_iterator

The `ostream_iterator` writes (using `operator<<`) successive elements onto the output stream.

### 9.5.2.1 Constructors

Creates an instance of an `ostream_iterator` object.

```
ostream_iterator(ostream_type& s);  
ostream_iterator(ostream_type& s, const charT* delimiter);  
ostream_iterator(const ostream_iterator& x);
```

### Operator=

```
ostream_iterator& operator=(const T& value);
```

Returns a value to an ostream iterator.

### 9.5.2.2 destructor

Removes an instance of an `ostream_iterator` object.

```
~ostream_iterator();
```

### 9.5.2.3 Ostream\_iterator Operators

Various operators are provided in the `ostream_iterator` class.

## Operator\*

```
ostream_iterator& operator*();
```

The dereference iterator is returned.

## Operator++

```
ostream_iterator& operator++();
ostream_iterator& operator++(int);
```

The this pointer is returned.

## 9.5.3 Template Class Istreambuf\_iterator

The `istreambuf_iterator` reads successive characters from the `istreambuf` object for which it was constructed.

An `istreambuf_iterator` can only be used for a one pass algorithm.

### 9.5.3.1 Constructors

An overloaded constructor is provided for creation of an `istreambuf_iterator` object.

```
istreambuf_iterator() throw();
istreambuf_iterator(basic_istream<charT,traits>& s) throw();
istreambuf_iterator(basic_streambuf<charT,traits>* s)
throw();
istreambuf_iterator(const proxy& p) throw();
```

### 9.5.3.2 Istreambuf\_iterator Operators

Various operators are provided for the `istreambuf_iterator` class.

## Operator\*

```
charT operator*() const
```

A dereferenced character type is returned.

## Operator++

```
istreambuf_iterator<charT,traits>&  
istreambuf_iterator<charT,traits>::operator++();
```

The this pointer is returned.

## Operator==

```
template <class charT, class traits>  
bool operator==  
(const istreambuf_iterator<charT,traits>& a,  
const istreambuf_iterator<charT,traits>& b);
```

True is returned if the arguments are equal.

## Operator!=

```
template <class charT, class traits>  
bool operator!=  
(const istreambuf_iterator<charT,traits>& a,  
const istreambuf_iterator<charT,traits>& b);
```

True is returned if the arguments are not equal.

### 9.5.3.3 equal

An equality comparison.

```
bool equal(istreambuf_iterator<charT,traits>& b);
```

## Remarks

True is returned if the arguments are equal.

## 9.5.4 Template Class Ostreambuf\_iterator

The `ostreambuf_iterator` writes successive characters to the `ostreambuf` object for which it was constructed.

### 9.5.4.1 Constructors

The constructor is overloaded for creation of an `ostreambuf_iterator` object.

```
ostreambuf_iterator(ostream_type& s) throw();  
ostreambuf_iterator(streambuf_type* s) throw();
```

#### Operator=

```
ostreambuf_iterator<charT,traits>& operator=(charT c);
```

The result of the assignment is returned.

### 9.5.4.2 Ostreambuf\_iterator Operators

#### Operator\*

```
ostreambuf_iterator<charT,traits>& operator*();
```

The dereferenced `ostreambuf_iterator` is returned.

#### Operator++

```
ostreambuf_iterator<charT,traits>& operator++();  
ostreambuf_iterator<charT,traits>& operator++(int);
```

The this pointer is returned.

### 9.5.4.3 failed

Reports a failure in writing.

```
bool failed() const throw();
```

#### Remarks

The `bool` false value is returned if a write failure occurs.



## 9.6 `_EWL_RAW_ITERATORS`

If `_EWL_RAW_ITERATORS` is defined, vector and string will use pointers for their iterators, otherwise they will use classes.

The difference can effect argument dependent (Koenig) lookup in some cases. For example:

```
#include <vector>
#include <algorithm>
int main()
{
    std::vector<int> v1(10), v2(10);
    copy(v1.begin(), v1.end(), v2.begin());
}
```

This compiles if the iterators are classes (`_EWL_RAW_ITERATORS` undefined). But if the iterators are simply pointers, a compile time error results:

```
Error : undefined identifier 'copy'
```

To fix this code so that it works with either setting, add a `std` qualifier to `copy`:

```
std::copy(v1.begin(), v1.end(), v2.begin());
```

The default configuration is for `_EWL_RAW_ITERATORS` to be undefined. There is no code size or run time overhead for this configuration (with inlining turned on). If you use `_EWL_DEBUG` (a configuration that does extensive run time checking when using the STL), then behavior is consistent with a `_EWL_RAW_ITERATORS` undefined setting, since the use of `_EWL_DEBUG` also forces vector and string iterators to be classes. Therefore the behavior of your application is less likely to change when switching between debug and release builds.

### NOTE

Recompile EWL C++ when switching this flag.



## Chapter 10

# Algorithms Library

This chapter discusses the algorithms library. These algorithms cover sequences, sorting, and numerics.

The standard provides for various algorithms that a C++ program may use to perform algorithmic operations on containers and other sequences.

This chapter uses the ISO (International Organization for Standardization) C++ Standard as a guide.

### 10.1 Header algorithm

The header algorithm provides classes, types and functions for use with the standard C++ libraries.

The standard algorithms can work with program defined data structures, as long as these data structures have iterator types satisfying the assumptions on the algorithms.

The names of the parameters used in this chapter reflect their usage.

A predicate parameter is used for a function object that returns a value testable as true. The binary predicate parameter takes two arguments.

#### 10.1.1 Non-modifying Sequence Operations

Various algorithms are provided which do not modify the original object.

##### 10.1.1.1 `for_each`

The function `for_each` is used to perform an operation for each element.

```
template<class InputIterator, class Function>
Function for_each
(InputIterator first, InputIterator last, Function f);
```

## Remarks

The function `f` is returned.

### 10.1.1.2 find

The function `find` searches for the first element that contains the value passed.

```
template<class InputIterator, class T>
InputIterator find
(InputIterator first, InputIterator last, const T& value);
```

## Remarks

Returns the type passed.

### 10.1.1.3 find\_if

The function `find_if` searches for the first element that matches the criteria passed by the predicate.

```
template<class InputIterator, class Predicate>
InputIterator find_if
(InputIterator first, InputIterator last, Predicate pred);
```

## Remarks

Returns the iterator of the matched value.

### 10.1.1.4 find\_end

The function `find_end` searches for the last occurrence of a value.

```
template<class ForwardIterator1,
class ForwardIterator2>
ForwardIterator1 find_end
(ForwardIterator1 first1, ForwardIterator1 last1,
ForwardIterator2 first2, ForwardIterator2 last2);
template<class ForwardIterator1,
class ForwardIterator2, class BinaryPredicate>
ForwardIterator1 find_end
(ForwardIterator1 first1, ForwardIterator1 last1,
ForwardIterator2 first2, ForwardIterator2 last2,
BinaryPredicate pred);
```

## Remarks

Returns the iterator to the last value or the `last1` argument if none is found.

### 10.1.1.5 `find_first_of`

The function `find_first_of` searches for the first occurrence of a value.

```
template<class ForwardIterator1,
class ForwardIterator2>
ForwardIterator1 find_first_of
(ForwardIterator1 first1, ForwardIterator1 last1,
ForwardIterator2 first2, ForwardIterator2 last2);
template<class ForwardIterator1,
class ForwardIterator2, class BinaryPredicate>
ForwardIterator1 find_first_of
(ForwardIterator1 first1, ForwardIterator1 last1,
ForwardIterator2 first2,
ForwardIterator2 last2, BinaryPredicate pred);
```

## Remarks

Returns the iterator to the first value or the `last1` argument if none is found.

### 10.1.1.6 `adjacent_find`

The function `adjacent_find` is used to search for two adjacent elements that are equal or equal according to the predicate argument.

```
template<class ForwardIterator>
ForwardIterator adjacent_find
(ForwardIterator first, ForwardIterator last);
template<class ForwardIterator, class BinaryPredicate>
ForwardIterator adjacent_find
(ForwardIterator first, ForwardIterator last,
BinaryPredicate pred);
```

## Remarks

Returns the iterator to the first occurrence found or to `last` if no occurrence is found.

### 10.1.1.7 `count`

The function `count` is used to find the number of elements.

```
template <class InputIterator, class T>
typename iterator_traits
<InputIterator>::difference_type count
(InputIterator first, InputIterator last, const T& value);
```

## Remarks

Returns the number of elements (iterators) as an

`iterator_traits<InputIterator>::difference_type`

### 10.1.1.8 `count_if`

The function `count_if` is used to find the number of elements that match the criteria.

```
template <class InputIterator, class Predicate>
typename iterator_traits
<InputIterator>::difference_type count_if
(InputIterator first, InputIterator last, Predicate pred);
```

## Remarks

Returns the number of elements (iterators) as an

`iterator_traits<InputIterator>::difference_type`

### 10.1.1.9 `mismatch`

The function `mismatch` is used to find sequences that are not the same or differ according to the predicate criteria.

```
template<class InputIterator1, class InputIterator2>
pair<InputIterator1, InputIterator2> mismatch
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2);
```

```
template<class InputIterator1,
class InputIterator2, class BinaryPredicate>
pair<InputIterator1, InputIterator2> mismatch
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, BinaryPredicate pred);
```

## Remarks

Returns a `pair<iterator>` that represent the beginning element and the range. If no mismatch is found the end and the corresponding range element is returned.

### 10.1.1.10 equal

The function `equal` is used to determine if two ranges are equal.

```
template<class InputIterator1, class InputIterator2>
bool equal
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2);
template<class InputIterator1,
class InputIterator2, class BinaryPredicate>
bool equal
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, BinaryPredicate pred);
```

## Remarks

A `bool true` is returned if the values are equal or meet the criteria of the predicate.

### 10.1.1.11 search

The function `search` is used to search for the first occurrence of a sub-range that meets the criteria.

```
template<class ForwardIterator1, class ForwardIterator2>
ForwardIterator1 search
(ForwardIterator1 first1, ForwardIterator1 last1,
ForwardIterator2 first2, ForwardIterator2 last2);
template<class ForwardIterator1,
class ForwardIterator2, class BinaryPredicate>
ForwardIterator1 search
(ForwardIterator1 first1, ForwardIterator1 last1,
ForwardIterator2 first2, ForwardIterator2 last2,
BinaryPredicate pred);
```

## Remarks

An iterator to the first occurrence is returned or `last1` is returned if no criteria is met.

### 10.1.1.12 search\_n

The function `search_n` is used to search for a number of consecutive elements with the same properties.

```
template<class ForwardIterator, class Size, class T>
ForwardIterator search_n
(ForwardIterator first, ForwardIterator last,
Size count, const T& value);
template<class ForwardIterator,
class Size, class T, class BinaryPredicate>
ForwardIterator search_n
(ForwardIterator first, ForwardIterator last, Size count,
const T& value, BinaryPredicate pred);
```

#### Remarks

An iterator to the first occurrence is returned or `last-1` is returned if no criteria is met.

## 10.1.2 Mutating Sequence Operators

Various algorithms are provided that are used to modify the original object.

### 10.1.2.1 copy

The function `copy` is used to copy a range.

```
template<class InputIterator, class OutputIterator>
OutputIterator copy(InputIterator first,
InputIterator last, OutputIterator result);
```

#### Remarks

The position of the last copied element is returned.

### 10.1.2.2 copy\_backward

The function `copy_backwards` is used to copy a range starting with the last element.



```
template<class BidirectionalIterator1,  
class BidirectionalIterator2>  
BidirectionalIterator2 copy_backward  
(BidirectionalIterator1 first, BidirectionalIterator1 last,  
BidirectionalIterator2 result);
```

## Remarks

The position of the last copied element is returned.

### 10.1.2.3 swap

The function `swap` is used to exchange values from two locations.

```
template<class T> void swap(T& a, T& b);
```

## Remarks

There is no return.

### 10.1.2.4 swap\_ranges

The function `swap_ranges` is used swap elements of two ranges.

```
template<class ForwardIterator1, class ForwardIterator2>  
ForwardIterator2 swap_ranges  
(ForwardIterator1 first1, ForwardIterator1 last1,  
ForwardIterator2 first2);
```

## Remarks

The position of the last swapped element is returned.

### 10.1.2.5 iter\_swap

The function `iter_swap` is used to exchange two values pointed to by iterators.

```
template<class ForwardIterator1, class ForwardIterator2>  
void iter_swap(ForwardIterator1 a, ForwardIterator2 b);
```

## Remarks

There is no return.

### 10.1.2.6 transform

The function `transform` is used to modify and copy elements of two ranges.

```
template<class InputIterator,
class OutputIterator, class UnaryOperation>
OutputIterator transform
(InputIterator first, InputIterator last,
OutputIterator result, UnaryOperation op);
template<class InputIterator1,
class InputIterator2, class OutputIterator,
class BinaryOperation>
OutputIterator transform
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, OutputIterator result,
BinaryOperation binary_op);
```

## Remarks

The position of the last transformed element is returned.

### 10.1.2.7 replace

The function `replace` is used to replace an element with another element of different value.

```
template<class ForwardIterator, class T>
void replace
(ForwardIterator first, ForwardIterator last,
const T& old_value, const T& new_value);
template<class ForwardIterator, class Predicate, class T>
void replace_if
(ForwardIterator first, ForwardIterator last,
Predicate pred, const T& new_value);
```

## Remarks

There is no return.

### 10.1.2.8 replace\_copy

The function `replace_copy` is used to replace specific elements while copying an entire range.

```
template<class InputIterator, class OutputIterator, class T>
OutputIterator replace_copy
(InputIterator first, InputIterator last,
OutputIterator result,
const T& old_value, const T& new_value);
```

### Remarks

The position of the last copied element is returned.

#### 10.1.2.9 `replace_copy_if`

The function `replace_copy_if` is used to replace specific elements that match certain criteria while copying the entire range.

```
template<class Iterator,
class OutputIterator, class Predicate, class T>
OutputIterator replace_copy_if
(Iterator first, Iterator last,
OutputIterator result, Predicate pred, const T& new_value);
```

### Remarks

The position of the last copied element is returned.

#### 10.1.2.10 `fill`

The function `fill` is used to fill a range with values.

```
template<class ForwardIterator, class T>
void fill
(ForwardIterator first, ForwardIterator last, const T&
value);
```

### Remarks

There is no return value.

### 10.1.2.11 fill\_n

The function `fill_n` is used to fill a number of elements with a specified value.

```
template<class OutputIterator,
class Size, class T>
void fill_n
(OutputIterator first, Size n, const T& value);
```

#### Remarks

There is no return value.

### 10.1.2.12 generate

The function `generate` is used to replace elements with the result of an operation.

```
template<class ForwardIterator, class Generator>
void generate
(ForwardIterator first, ForwardIterator last, Generator gen);
```

#### Remarks

There is no return value.

### 10.1.2.13 generate\_n

The function `generate_n` is used to replace a number of elements with the result of an operation.

```
template<class OutputIterator, class Size, class Generator>
void generate_n
(OutputIterator first, Size n, Generator gen);
```

#### Remarks

There is no return value.

### 10.1.2.14 remove

The function `remove` is used to remove elements with a specified value.

```
template<class ForwardIterator, class T>
ForwardIterator remove
(ForwardIterator first, ForwardIterator last, const T& value);
```

### Remarks

The end of the resulting range is returned.

#### 10.1.2.15 `remove_if`

The function `remove_if` is used to remove elements using a specified criteria.

```
template<class ForwardIterator, class Predicate>
ForwardIterator remove_if
(ForwardIterator first, ForwardIterator last, Predicate pred);
```

### Remarks

The end of the resulting range is returned.

#### 10.1.2.16 `remove_copy`

The function `remove_copy` is used to remove elements that do not match a value during a copy.

```
template<class InputIterator, class OutputIterator, class T>
OutputIterator remove_copy
(InputIterator first, InputIterator last,
OutputIterator result, const T& value);
```

### Remarks

The end of the resulting range is returned.

#### 10.1.2.17 `remove_copy_if`

The function `remove_copy_if` is used to remove elements that do not match a criteria while doing a copy.

```
template<class InputIterator,
class OutputIterator, class Predicate>
OutputIterator remove_copy_if
(InputIterator first, InputIterator last,
OutputIterator result, Predicate pred);
```

## Remarks

The end of the resulting range is returned.

### 10.1.2.18 unique

The function `unique` is used to remove all adjacent duplicates.

```
template<class ForwardIterator>
ForwardIterator unique
(ForwardIterator first, ForwardIterator last);
template<class ForwardIterator, class BinaryPredicate>
ForwardIterator unique (ForwardIterator first,
ForwardIterator last, BinaryPredicate pred);
```

## Remarks

The end of the resulting range is returned.

### 10.1.2.19 unique\_copy

The function `unique_copy` is used to remove adjacent duplicates while copying.

```
template<class InputIterator, class OutputIterator>
OutputIterator unique_copy
(InputIterator first, InputIterator last,
OutputIterator result);
template<class InputIterator,
class OutputIterator, class BinaryPredicate>
OutputIterator unique_copy
(InputIterator first, InputIterator last,
OutputIterator result, BinaryPredicate pred);
```

## Remarks

The end of the resulting range is returned.

### 10.1.2.20 reverse

The function `reverse` is used to reverse a sequence.

```
template<class BidirectionalIterator>
void reverse
(BidirectionalIterator first, BidirectionalIterator last);
```

#### Remarks

No value is returned.

### 10.1.2.21 reverse\_copy

The function `reverse_copy` is used to copy the elements while reversing their order.

```
template<class BidirectionalIterator, class OutputIterator>
OutputIterator reverse_copy
(BidirectionalIterator first, BidirectionalIterator last,
OutputIterator result);
```

#### Remarks

The position of the last copied element is returned.

### 10.1.2.22 rotate

The function `rotate` is used to rotate the elements within a sequence.

```
template<class ForwardIterator>
void rotate
(ForwardIterator first, ForwardIterator middle,
ForwardIterator last);
```

#### Remarks

There is no return value.

### 10.1.2.23 rotate\_copy

The function `rotate_copy` is used to copy a sequence with a rotated order.

```
template<class ForwardIterator, class OutputIterator>
OutputIterator rotate_copy
(ForwardIterator first, ForwardIterator middle,
ForwardIterator last, OutputIterator result);
```

## Remarks

The position of the last copied element is returned.

### 10.1.2.24 `random_shuffle`

The function `random_shuffle` is used to exchange the order of the elements in a random fashion.

```
template<class RandomAccessIterator>
void random_shuffle
(RandomAccessIterator first, RandomAccessIterator last);
template<class RandomAccessIterator,
class RandomNumberGenerator>
void random_shuffle
(RandomAccessIterator first, RandomAccessIterator last,
RandomNumberGenerator& rand);
```

## Remarks

No value is returned.

### 10.1.2.25 `partition`

The function `partition` is used to change the order of the elements so that the elements that meet the criteria are first in order.

```
template<class BidirectionalIterator, class Predicate>
BidirectionalIterator partition
(BidirectionalIterator first,
BidirectionalIterator last, Predicate pred);
```

## Remarks

Returns an iterator to the first position where the predicate argument is false.



### 10.1.2.26 `stable_partition`

The function `stable_partition` is used to change the order of the elements so that the elements meet the criteria are first in order. The relative original order is preserved.

```
template<class BidirectionalIterator, class Predicate>
BidirectionalIterator stable_partition
(BidirectionalIterator first,
BidirectionalIterator last, Predicate pred);
```

#### Remarks

Returns an iterator to the first position where the predicate argument is false.

## 10.1.3 Sorting And Related Operations

All of the sorting functions have two versions:, one that takes a function object for comparison and one that uses the less than operator.

### 10.1.3.1 `sort`

The function `sort` is used sorts the range according to the criteria.

```
template<class RandomAccessIterator>
void sort
(RandomAccessIterator first,RandomAccessIterator last);
template<class RandomAccessIterator,
class Compare>
void sort(RandomAccessIterator first,
RandomAccessIterator last, Compare comp);
```

#### Remarks

There is no return value.

### 10.1.3.2 `stable_sort`

The function `stable_sort` is used to sort the range but preserves the original order for equal elements.

```

template<class RandomAccessIterator>
void stable_sort
(RandomAccessIterator first, RandomAccessIterator last);
template<class RandomAccessIterator, class Compare>
void stable_sort
(RandomAccessIterator first,
RandomAccessIterator last, Compare comp);

```

## Remarks

There is no return value.

### 10.1.3.3 partial\_sort

The function `partial_sort` is used to sort a sub-range leaving the rest unsorted.

```

template<class RandomAccessIterator>
void partial_sort
(RandomAccessIterator first, RandomAccessIterator middle,
RandomAccessIterator last);
template<class RandomAccessIterator, class Compare>
void partial_sort
(RandomAccessIterator first, RandomAccessIterator middle,
RandomAccessIterator last, Compare comp);

```

## Remarks

There is no return value.

### 10.1.3.4 partial\_sort\_copy

The function `partial_sort_copy` is used to copy a partially sorted sequence.

```

template<class InputIterator, class RandomAccessIterator>
RandomAccessIterator partial_sort_copy
(InputIterator first, InputIterator last,
RandomAccessIterator result_first,
RandomAccessIterator result_last);
template<class InputIterator,
class RandomAccessIterator, class Compare>
RandomAccessIterator partial_sort_copy
(InputIterator first, InputIterator last,
RandomAccessIterator result_first,
RandomAccessIterator result_last, Compare comp);

```

## Remarks

The position at the end of the copied elements is returned.

### 10.1.3.5 nth\_element

The function `nth_element` is used to sort based upon a specified position.

```
template<class RandomAccessIterator>
void nth_element
(RandomAccessIterator first, RandomAccessIterator nth,
 RandomAccessIterator last);
template<class RandomAccessIterator, class Compare>
void nth_element
(RandomAccessIterator first, RandomAccessIterator nth,
 RandomAccessIterator last, Compare comp);
```

#### Remarks

There is no value returned.

### 10.1.3.6 lower\_bound

The function `lower_bound` is used to find the first position that an element may be inserted without changing the order.

```
template<class ForwardIterator, class T>
ForwardIterator lower_bound
(ForwardIterator first, ForwardIterator last, const T&
 value);
template<class ForwardIterator, class T, class Compare>
ForwardIterator lower_bound
(ForwardIterator first, ForwardIterator last,
 const T& value, Compare comp);
```

#### Remarks

The position where the element can be inserted is returned.

### 10.1.3.7 upper\_bound

The function `upper_bound` is used to find the last position that an element may be inserted without changing the order.

```
template<class ForwardIterator, class T>
ForwardIterator upper_bound
(ForwardIterator first, ForwardIterator last, const T&
```

**header algorithm**

```
value);
template<class ForwardIterator, class T, class Compare>
ForwardIterator upper_bound
(ForwardIterator first, ForwardIterator last,
const T& value, Compare comp);
```

**Remarks**

The position where the element can be inserted is returned.

**10.1.3.8 equal\_range**

The function `equal_range` is used to find the range as a pair where an element can be inserted without altering the order.

```
template<class ForwardIterator, class T>
pair<ForwardIterator, ForwardIterator> equal_range
(ForwardIterator first, ForwardIterator last, const T&
value);
template<class ForwardIterator, class T, class Compare>
pair<ForwardIterator, ForwardIterator> equal_range
(ForwardIterator first, ForwardIterator last,
const T& value, Compare comp);
```

**Remarks**

The range as a `pair<>` where the element can be inserted is returned.

**10.1.3.9 binary\_search**

The function `binary_search` is used to see if a value is present in a range or that a value meets a criteria within that range.

```
template<class ForwardIterator, class T>
bool binary_search
(ForwardIterator first, ForwardIterator last, const T& value);
template<class ForwardIterator, class T, class Compare>
bool binary_search
(ForwardIterator first, ForwardIterator last,
const T& value, Compare comp);
```

**Remarks**

The bool value true is met if any element meets the criteria.

### 10.1.3.10 merge

The function `merge` is used to combine two sorted ranges.

```
template<class InputIterator1,
class InputIterator2, class OutputIterator>
OutputIterator merge
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, InputIterator2 last2,
OutputIterator result);
template<class InputIterator1, class InputIterator2,
class OutputIterator, class Compare>
OutputIterator merge
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, InputIterator2 last2,
OutputIterator result, Compare comp);
```

#### Return

The position of the first element not overwritten is returned.

### 10.1.3.11 inplace\_merge

The function `inplace_merge` is used to merge consecutive sequences to the first for a concatenation.

```
template<class BidirectionalIterator>
void inplace_merge
(BidirectionalIterator first, BidirectionalIterator middle,
BidirectionalIterator last);
template<class BidirectionalIterator, class Compare>
void inplace_merge
(BidirectionalIterator first, BidirectionalIterator middle,
BidirectionalIterator last, Compare comp);
```

#### Remarks

There is no value returned.

### 10.1.3.12 includes

The function `includes` is used to determine if every element meets a specified criteria.

```
template<class InputIterator1, class InputIterator2>
bool includes
(InputIterator1 first1, InputIterator1 last1,
```

**header algorithm**

```

InputIterator2 first2, InputIterator2 last2);
template<class InputIterator1,
class InputIterator2, class Compare>
bool includes
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, InputIterator2 last2,
Compare comp);

```

**Remarks**

The bool value true is returned if all values match or false if one or more does not meet the criteria.

**10.1.3.13 set\_union**

The function `set_union` is used to process the sorted union of two ranges.

```

template<class InputIterator1,
class InputIterator2, class OutputIterator>
OutputIterator set_union
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, InputIterator2 last2,
OutputIterator result);
template<class InputIterator1, class InputIterator2,
class OutputIterator, class Compare>
OutputIterator set_union
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, InputIterator2 last2,
OutputIterator result, Compare comp);

```

**Remarks**

The end of the constructed range is returned.

**10.1.3.14 set\_intersection**

The function `set_intersection` is used to process the intersection of two ranges.

```

template<class InputIterator1,
class InputIterator2, class OutputIterator>
OutputIterator set_intersection
(InputIterator1 first1, InputIterator1 last1,
InputIterator2 first2, InputIterator2 last2,
OutputIterator result);
template<class InputIterator1,
class InputIterator2, class OutputIterator,
class Compare>
OutputIterator set_intersection
(InputIterator1 first1, InputIterator1 last1,

```

```
InputIterator2 first2, InputIterator2 last2,  
OutputIterator result, Compare comp);
```

## Remarks

The end of the constructed range is returned.

### 10.1.3.15 set\_difference

The function `set_difference` is used to process all of the elements of one range that are not part of another range.

```
template<class InputIterator1,  
class InputIterator2, class OutputIterator>  
OutputIterator set_difference  
(InputIterator1 first1, InputIterator1 last1,  
InputIterator2 first2, InputIterator2 last2,  
OutputIterator result);  
template<class InputIterator1,  
class InputIterator2,  
class OutputIterator, class Compare>  
OutputIterator set_difference  
(InputIterator1 first1, InputIterator1 last1,  
InputIterator2 first2, InputIterator2 last2,  
OutputIterator result, Compare comp);
```

## Remarks

The end of the constructed range is returned.

### 10.1.3.16 set\_symetric\_difference

The function `set_symetric_difference` is used to process all of the elements that are in only one of two ranges.

```
template<class InputIterator1,  
class InputIterator2, class OutputIterator>  
OutputIterator set_symmetric_difference  
(InputIterator1 first1, InputIterator1 last1,  
InputIterator2 first2, InputIterator2 last2,  
OutputIterator result);  
template<class InputIterator1,  
class InputIterator2,  
class OutputIterator, class Compare>  
OutputIterator set_symmetric_difference  
(InputIterator1 first1, InputIterator1 last1,  
InputIterator2 first2, InputIterator2 last2,  
OutputIterator result, Compare comp);
```

## Remarks

The end of the constructed range is returned.

### 10.1.3.17 push\_heap

The function `push_heap` is used to add an element to a heap.

```
template<class RandomAccessIterator>
void push_heap
(RandomAccessIterator first, RandomAccessIterator last);
template<class RandomAccessIterator, class Compare>
void push_heap
(RandomAccessIterator first,
 RandomAccessIterator last, Compare comp);
```

## Remarks

There is no value returned.

### 10.1.3.18 pop\_heap

The function `pop_heap` is used to remove an element from a heap.

```
template<class RandomAccessIterator>
void pop_heap
(RandomAccessIterator first, RandomAccessIterator last);
template<class RandomAccessIterator, class Compare>
void pop_heap
(RandomAccessIterator first, RandomAccessIterator last,
 Compare comp);
```

## Remarks

There is no value returned.

### 10.1.3.19 make\_heap

The function `make_heap` is used to convert a range into a heap.

```
template<class RandomAccessIterator>
void make_heap
(RandomAccessIterator first, RandomAccessIterator last);
```



```
template<class RandomAccessIterator, class Compare>
void make_heap(
RandomAccessIterator first,RandomAccessIterator last,
Compare comp);
```

## Remarks

There is no value returned.

### 10.1.3.20 sort\_heap

The function `sort_heap` is used to sort a heap.

```
template<class RandomAccessIterator>
void sort_heap
(RandomAccessIterator first,RandomAccessIterator last);
template<class RandomAccessIterator, class Compare>
void sort_heap
(RandomAccessIterator first, RandomAccessIterator last,
Compare comp);
```

## Remarks

Note that this result is not stable

There is no value returned.

### 10.1.3.21 min

The function `min` is used to determine the lesser of two objects by value or based upon a comparison.

```
template<class T>
const T& min (const T& a, const T& b);
template<class T, class Compare>
const T& min(const T& a, const T& b, Compare comp);
```

## Remarks

The lesser of the two objects is returned.

### 10.1.3.22 max

The function `max` is used to determine the greater of two objects by value or based upon a comparison.

```
template<class T>
const T& max (const T& a, const T& b);
template<class T, class Compare>
const T& max(const T& a, const T& b, Compare comp);
```

## Remarks

The greater of the two objects is returned.

### 10.1.3.23 min\_element

The function `min_element` is used to determine the lesser element within a range based upon a value or a comparison.

```
template<class ForwardIterator>
ForwardIterator min_element
(ForwardIterator first, ForwardIterator last);
template<class ForwardIterator, class Compare>
ForwardIterator min_element
(ForwardIterator first, ForwardIterator last,
Compare comp);
```

## Remarks

The position of the element is returned.

### 10.1.3.24 max\_element

The function `max_element` is used to determine the greater element within a range based upon a value or a comparison.

```
template<class ForwardIterator>
ForwardIterator max_element
(ForwardIterator first, ForwardIterator last);
template<class ForwardIterator, class Compare>
ForwardIterator max_element
(ForwardIterator first, ForwardIterator last,
Compare comp);
```

## Remarks

The position of the element is returned.

### 10.1.3.25 lexicographical\_compare

The function `lexicographical_compare` is used to determine if a range is lexicographically less than another.

```
template<class InputIterator1, class InputIterator2>
bool lexicographical_compare
(InputIterator1 first1, InputIterator1 last1,
 InputIterator2 first2, InputIterator2 last2);
template<class InputIterator1,
class InputIterator2, class Compare>
bool lexicographical_compare
(InputIterator1 first1, InputIterator1 last1,
 InputIterator2 first2, InputIterator2 last2,
 Compare comp);
```

#### Remarks

Returns true if the first argument is less than the second and false for all other conditions.

### 10.1.3.26 next\_permutation

The function `next_permutation` is used to sort in an ascending order based upon lexicographical criteria.

```
template<class BidirectionalIterator>
bool next_permutation
(BidirectionalIterator first, BidirectionalIterator last);
template<class BidirectionalIterator, class Compare>
bool next_permutation
(BidirectionalIterator first,
 BidirectionalIterator last, Compare comp);
```

#### Remarks

Returns true if all elements have been sorted.

### 10.1.3.27 prev\_permutation

The function `prev_permutation` is used to sort in an descending order based upon lexicographical criteria.

```

template<class BidirectionalIterator>
bool prev_permutation
(BidirectionalIterator first, BidirectionalIterator last);
template<class BidirectionalIterator, class Compare>
bool prev_permutation
(BidirectionalIterator first,
BidirectionalIterator last, Compare comp);

```

## Remarks

Returns true if all elements have been sorted.

## 10.1.4 C library algorithms

The C++ header `<cstdlib>` provides two variations from the standard C header `stdlib.h` for searching and sorting.

### 10.1.4.1 bsearch

The function signature of `bsearch`

```

bsearch(const void *, const void *, size_t,
size_t, int (*)(const void *, const void *));

```

is replaced by

```

extern "C" void *bsearch
(const void * key, const void * base,
size_t nmemb, size_t size,
int (* compar)(const void *, const void *));

```

and

```

extern "C++" void *bsearch
(const void * key, const void * base,
size_t nmemb, size_t size,
int (* compar)(const void *, const void *));

```

### 10.1.4.2 qsort

The function signature of `qsort`

```
qsort(void *, size_t, size_t,  
int (*)(const void *, const void *));
```

is replaced by

```
extern "C" void qsort  
void* base, size_t nmemb, size_t size,  
int (* compar)(const void*, const void*));
```

and

```
extern "C++" void qsort  
(void* base, size_t nmemb, size_t size,  
int (* compar)(const void*, const void*));
```



# Chapter 11

## Numerics Library

This chapter is a reference guide to the ANSI/ISO standard Numeric classes which are used to perform the semi-numerical operations. This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide.

- [Numeric type requirements](#)
- [Numeric arrays](#)
- [Generalized Numeric Operations](#)
- [C Library](#)

### 11.1 Numeric type requirements

The complex and valarray components are parameterized by the type of information they contain and manipulate.

A C++ program shall instantiate these components only with a type `TYPE` that satisfies the following requirements:

This is not an abstract class (it has no pure virtual member functions);

- `TYPE` is not a reference type;
- `TYPE` is not cv-qualified;
- If `TYPE` is a class, it has a public default constructor;
- If `TYPE` is a class, it has a public copy constructor with the signature `TYPE::TYPE(const TYPE&)`
- If `TYPE` is a class, it has a public destructor;
- If `TYPE` is a class, it has a public assignment operator whose signature is either

```
TYPE& TYPE::operator=(const TYPE&)
```

or

```
TYPE&    TYPE::operator=(TYPE)
```

- If `TYPE` is a class, the assignment operator, copy and default constructors, and destructor shall correspond to each other as far as an initialization of raw storage using the default constructor, followed by assignment, is the equivalent to initialization of raw storage using the copy constructor.
- Destruction of an object, followed by initialization of its raw storage using the copy constructor, is semantically equivalent to assignment to the original object.
- If `TYPE` is a class, it shall not overload unary `operator&`.

If an operation on `TYPE` throws an exception then the effects are undefined.

Specific classes member functions or general functions may have other restrictions.

## 11.2 Numeric arrays

The numeric array library consists of several classes and non member operators for the manipulation of array objects.

- [Template Class Valarray](#)
- [Valarray Non-member Operations](#)
- [Class slice](#)
- [Template Class Slice\\_array](#)
- [Class Gslice](#)
- [Template Class Gslice\\_array](#)
- [Template Class Mask\\_array](#)
- [Template Class Indirect\\_array](#)

### 11.2.1 Template Class Valarray

The template class `valarray` is a single direction smart array with element indexing beginning with the zero element.



### 11.2.1.1 Constructors

The class `valarray` provides overloaded constructors to create an object of `valarray` in several manners.

```
valarray();  
explicit valarray(size_t);  
valarray(const T&, size_t);  
valarray(const T*, size_t);  
valarray(const valarray<T>&);  
valarray(const slice_array<T>&);  
valarray(const gslice_array<T>&);  
valarray(const mask_array<T>&);  
valarray(const indirect_array<T>&);
```

### 11.2.1.2 Destructor

Removes a `valarray` object from memory.

```
~valarray();
```

### 11.2.1.3 Assignment Operator

The `valarray` class provides for various means of assignment to an already created object.

```
valarray<T>& operator=(const valarray<T>&);  
valarray<T>& operator=(const T&);  
valarray<T>& operator=(const slice_array<T>&);  
valarray<T>& operator=(const gslice_array<T>&);  
valarray<T>& operator=(const mask_array<T>&);  
valarray<T>& operator=(const indirect_array<T>&);
```

#### Remarks

A `valarray` object is returned.

#### `valarray` element access

An index operator is provided for single element access of `valarray` objects.

### 11.2.1.4 operator[]

This operator provides element access for read and write operations.

```
T operator[] (size_t) const;  
T& operator[] (size_t);
```

#### Remarks

A value is returned.

#### valarray subset operations

An index operator is provided for subset array access.

### 11.2.1.5 operator[]

The index operator is specialized for subset access to allow both read and write operations.

```
valarray<T> operator[] (slice) const;  
slice_array<T> operator[] (slice);  
valarray<T> operator[] (const gslice&) const;  
gslice_array<T> operator[] (const gslice&);  
valarray<T> operator[] (const valarray<bool>&) const;  
mask_array<T> operator[] (const valarray<bool>&);  
valarray<T> operator[] (const valarray<size_t>&) const;  
indirect_array<T> operator[] (const valarray<size_t>&);
```

#### Remarks

These operators return subset of the array. Const-qualified operators return the subset as a new valarray object, and non-const operators return a class template object which has reference semantics to the original array.

### 11.2.1.6 valarray unary operators

The `valarray` class provides operators for array manipulation.

**Operator+**

```
valarray<T> operator+() const;
```

Returns a `valarray` sum of  $x+y$ ;

**Operator-**

```
valarray<T> operator-() const;
```

Returns a `valarray` result of  $x-y$ ;

**Operator~**

```
valarray<T> operator~() const;
```

Returns a `valarray` result of  $x\sim y$ ;

**Operator!**

```
valarray<bool> operator!() const;
```

Returns a `bool` `valarray` of  $!x$ ;

**11.2.1.7 Valarray Computed Assignment**

The `valarray` class provides for a means of compound assignment and math operation. A `valarray` object is returned.

**Operator\*=  
Operator\*=**

```
valarray<T>& operator*= (const valarray<T>&);  
valarray<T>& operator*= (const T&);
```

Returns a `valarray` result of  $x*=y$ ;

**Operator/=**

```
valarray<T>& operator/= (const valarray<T>&);  
valarray<T>& operator/= (const T&);
```

Returns a `valarray` result of  $x/=y$ ;

**Operator%=**

```
valarray<T>& operator%= (const valarray<T>&);  
valarray<T>& operator%= (const T&);
```

Returns a `valarray` result of  $x\%=y$ ;

**Operator+=**

```
valarray<T>& operator+= (const valarray<T>&);  
valarray<T>& operator+= (const T&);
```

## numeric arrays

Returns a `valarray` result of `x+=y`;

### Operator -=

```
valarray<T>& operator-= (const valarray<T>&);
valarray<T>& operator-= (const T&);
```

Returns a `valarray` result of `x-=y`;

### Operator ^=

```
valarray<T>& operator^= (const valarray<T>&);
valarray<T>& operator^= (const T&);
```

Returns a `valarray` result of `x^=y`;

### Operator &=

```
valarray<T>& operator&= (const T&);
valarray<T>& operator&= (const valarray<T>&);
```

Returns a `valarray` result of `x&=y`;

### Operator |=

```
valarray<T>& operator|= (const valarray<T>&);
valarray<T>& operator|= (const T&);
```

Returns a `valarray` result of `x|=y`;

### Operator <<=

```
valarray<T>& operator<<= (const valarray<T>&);
valarray<T>& operator<<= (const T&);
```

Returns a `valarray` result of `x<<=y`;

### Operator >>=

```
valarray<T>& operator>>= (const valarray<T>&);
valarray<T>& operator>>= (const T&);
```

Returns a `valarray` result of `x>>=y`;

## 11.2.2 Valarray Member Functions

The `valarray` class provides member functions for array information.

### 11.2.2.1 size

Tells the size of the array.

```
size_t size() const;
```

### Remarks

Returns the size of the array.

### 11.2.2.2 sum

Tells the sum of the array elements.

```
T sum() const;
```

### Remarks

Returns the sum of the array elements.

### 11.2.2.3 min

Tells the smallest element of an array.

```
T min() const;
```

### Remarks

Returns the smallest element in an array.

### 11.2.2.4 max

Tells the largest element in an array.

```
T max() const;
```

### Remarks

Returns the largest element in an array.

### 11.2.2.5 shift

Returns a new array where the elements have been shifted a set amount.

```
valarray<T> shift(int n) const;
```

#### Remarks

Returns the modified array.

### 11.2.2.6 cshift

A cyclical shift of an array.

```
valarray<T> cshift(int n) const;
```

#### Remarks

Returns the modified array.

### 11.2.2.7 apply

Processes the elements of an array.

```
valarray<T> apply(T func(T)) const;  
valarray<T> apply(T func(const T&)) const;
```

#### Remarks

This function "applies" the function specified to all the elements of an array.

Return the modified array.

### 11.2.2.8 resize

Resizes an array and initializes the elements

```
void resize(size_t sz, T c = T());
```

## Remarks

If no object is provided the array is initialized with the default constructor.

## 11.2.3 Valarray Non-member Operations

Non-member operators are provided for manipulation or arrays.

### 11.2.3.1 Valarray Binary Operators

Non-member `valarray` operators are provided for the manipulation of arrays.

```
template<class T> valarray<T> operator*
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator/
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator%
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator+
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator-
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator^
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator&
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator|
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator<<
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator>>
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> operator*
(const valarray<T>&, const T&);
template<class T> valarray<T> operator*
(const T&, const valarray<T>&);
template<class T> valarray<T> operator/
(const valarray<T>&, const T&);
template<class T> valarray<T> operator/
(const T&, const valarray<T>&);
template<class T> valarray<T> operator%
(const valarray<T>&, const T&);
template<class T> valarray<T> operator%
(const T&, const valarray<T>&);
template<class T> valarray<T> operator+
(const valarray<T>&, const T&);
template<class T> valarray<T> operator+
(const T&, const valarray<T>&);
template<class T> valarray<T> operator-
(const valarray<T>&, const T&);
template<class T> valarray<T> operator-
(const T&, const valarray<T>&);
```

## numeric arrays

```

template<class T> valarray<T> operator^
(const valarray<T>&, const T&);
template<class T> valarray<T> operator^
(const T&, const valarray<T>&);
template<class T> valarray<T> operator&
(const valarray<T>&, const T&);
template<class T> valarray<T> operator&
(const T&, const valarray<T>&);
template<class T> valarray<T> operator|
(const valarray<T>&, const T&);
template<class T> valarray<T> operator|
(const T&, const valarray<T>&);
template<class T> valarray<T> operator<<
(const valarray<T>&, const T&);
template<class T> valarray<T> operator<<
(const T&, const valarray<T>&);
template<class T> valarray<T> operator>>
(const valarray<T>&, const T&);
template<class T> valarray<T> operator>>
(const T&, const valarray<T>&);

```

### Remarks

Each operator returns an array whose length is equal to the lengths of the argument arrays and initialized with the result of applying the operator.

## 11.2.3.2 Valarray Logical Operators

The `valarray` class provides logical operators for the comparison of like arrays.

```

template<class T> valarray<bool> operator==
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator!=
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator<
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator>
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator<=
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator>=
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator&&
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<bool> operator||
(const valarray<T>&, const valarray<T>&);

```

### Remarks

All of the logical operators returns a bool array whose length is equal to the length of the array arguments. The elements of the returned array are initialized with a boolean result of the match.



## 11.2.4 Non-member logical operations

Non-member logical operators are provided to allow for variations of order of the operation.

```

template<class T> valarray<bool> operator==(
    (const valarray&, const T&);
template<class T> valarray<bool> operator==(
    (const T&, const valarray&);
template<class T> valarray<bool> operator!=(
    (const valarray&, const T&);
template<class T> valarray<bool> operator!=(
    (const T&, const valarray&);
template<class T> valarray<bool> operator<
    (const valarray&, const T&);
template<class T> valarray<bool> operator<
    (const T&, const valarray&);
template<class T> valarray<bool> operator>
    (const valarray&, const T&);
template<class T> valarray<bool> operator>
    (const T&, const valarray&);
template<class T> valarray<bool> operator<=
    (const valarray&, const T&);
template<class T> valarray<bool> operator<=
    (const T&, const valarray&);
template<class T> valarray<bool> operator>=
    (const valarray&, const T&);
template<class T> valarray<bool> operator>=
    (const T&, const valarray&);
template<class T> valarray<bool> operator&&
    (const valarray<T>&, const T&);
template<class T> valarray<bool> operator&&
    (const T&, const valarray<T>&);
template<class T> valarray<bool> operator||
    (const valarray<T>&, const T&);
template<class T> valarray<bool> operator||
    (const T&, const valarray<T>&);

```

### Remarks

The result of these operations is a bool array whose length is equal to the length of the array argument. Each element of the returned array is the result of a logical match.

### 11.2.4.1 valarray transcendentals

Trigonometric and exponential functions are provided for the `valarray` classes.

```

template<class T> valarray<T> abs
    (const valarray<T>&);
template<class T> valarray<T> acos
    (const valarray<T>&);
template<class T> valarray<T> asin
    (const valarray<T>&);
template<class T> valarray<T> atan
    (const valarray<T>&);

```

## numeric arrays

```

template<class T> valarray<T> atan2
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> atan2
(const valarray<T>&, const T&);
template<class T> valarray<T> atan2
(const T&, const valarray<T>&);
template<class T> valarray<T> cos
(const valarray<T>&);
template<class T> valarray<T> cosh
(const valarray<T>&);
template<class T> valarray<T> exp
(const valarray<T>&);
template<class T> valarray<T> log
(const valarray<T>&);
template<class T> valarray<T> log10
(const valarray<T>&);
template<class T> valarray<T> pow
(const valarray<T>&, const valarray<T>&);
template<class T> valarray<T> pow
(const valarray<T>&, const T&);
template<class T> valarray<T> pow
(const T&, const valarray<T>&);
template<class T> valarray<T> sin
(const valarray<T>&);
template<class T> valarray<T> sinh
(const valarray<T>&);
template<class T> valarray<T> sqrt
(const valarray<T>&);
template<class T> valarray<T> tan
(const valarray<T>&);
template<class T> valarray<T> tanh
(const valarray<T>&);

```

## Remarks

A `valarray` object is returned with the individual elements initialized with the result of the corresponding operation.

## 11.2.5 Class slice

A `slice` is a set of indices that have three properties, a starting index, the number of elements and the distance between the elements.

### 11.2.5.1 Constructors

A constructor is overloaded to initialize an object with values or without values.

```

slice();
slice(size_t start, size_t length, size_t stride);
slice(const slice&);

```

## 11.2.5.2 slice access functions

The slice class has three member functions.

### 11.2.5.2.1 start

`start` indicates the position where the slice starts.

```
size_t start() const;
```

#### Remarks

The starting position is returned.

### 11.2.5.2.2 size

Size indicates the size of the slice.

```
size_t size() const;
```

#### Remarks

The size of the slice is returned by the `size` member function.

### 11.2.5.2.3 stride

The distance between elements is given by the `stride` function.

```
size_t stride() const;
```

#### Remarks

The distance between each element is returned by `stride`.

## 11.2.6 Template Class `Slice_array`

The `slice_array` class is a helper class used by the slice subscript operator.

### 11.2.6.1 Constructors

Constructs a `slice_array` object.

```
private:
slice_array();
slice_array(const slice_array&);
```

### 11.2.6.2 Assignment Operator

The assignment operator allows for the initialization of a `slice_array` after construction.

```
void operator=(const valarray<T>&) const;
slice_array& operator=(const slice_array&);
```

### 11.2.6.3 `slice_array` computed assignment

Several compound assignment operators are provided.

```
void operator*=(const valarray<T>&) const;
void operator/=(const valarray<T>&) const;
void operator%=(const valarray<T>&) const;
void operator+=(const valarray<T>&) const;
void operator-=(const valarray<T>&) const;
void operator^=(const valarray<T>&) const;
void operator&=(const valarray<T>&) const;
void operator|=(const valarray<T>&) const;
void operator<<=(const valarray<T>&) const;
void operator>>=(const valarray<T>&) const;
```

#### Remarks

There is no return for the compound operators.

### 11.2.6.4 `Slice_array` Fill Function

An assignment operation is provided to fill individual elements of the array.

```
void operator=(const T&);
```

## Remarks

No value is returned.

## 11.2.7 Class Gslice

A general slice class is provided for multidimensional arrays.

### 11.2.7.1 Constructors

An overloaded constructor is provided for the creation of a `gslice` object.

```
gslice();  
gslice(size_t start, const valarray<size_t>& lengths,  
const valarray<size_t>& strides);  
gslice(const gslice&);
```

### 11.2.7.2 Gslice Access Functions

The `gslice` class provides for access to the start, size and stride of the slice class.

#### 11.2.7.2.1 start

The start function gives the starting position.

```
size_t start() const;
```

## Remarks

The starting position of the `gslice` is returned.

#### 11.2.7.2.2 size

The size function returns the number of elements.

**numeric arrays**

```
valarray<size_t> size() const;
```

**Remarks**

The number of elements as a valarray is returned.

**11.2.7.2.3 stride**

The stride function tells the size of each element.

```
valarray<size_t> stride() const;
```

**Remarks**

The size of the element as a valarray is returned.

**11.2.8 Template Class Gslice\_array**

The `gslice_array` class is a helper class used by the `gslice` subscript operator.

**11.2.8.1 Constructors**

An overloaded constructor is provided for the creation of a `gslice_array` object.

```
gslice_array();  
gslice_array(const gslice_array&);
```

**11.2.8.2 Assignment Operators**

An assignment operator is provided for initializing a `gslice_array` after it has been created.

```
void operator=(const valarray<T>&) const;  
gslice_array& operator=(const gslice_array&);
```

**Remarks**

A copy of the modified `gslice_array` is returned for the second assignment operator.

### 11.2.8.3 Gslice\_array Computed Assignment

Several compound assignment operators are provided.

```
void operator*= (const valarray<T>&) const;
void operator/= (const valarray<T>&) const;
void operator%= (const valarray<T>&) const;
void operator+= (const valarray<T>&) const;
void operator-= (const valarray<T>&) const;
void operator^= (const valarray<T>&) const;
void operator&= (const valarray<T>&) const;
void operator|= (const valarray<T>&) const;
void operator<<= (const valarray<T>&) const;
void operator>>= (const valarray<T>&) const;
```

#### Remarks

No return is given for the compound operators.

### 11.2.8.4 Fill Function

An assignment operation is provided to fill individual elements of the array.

```
void operator=(const T&);
```

#### Remarks

There is no return for the fill function.

## 11.2.9 Template Class Mask\_array

The `mask_array` class is a helper class used by the mask subscript operator.

### 11.2.9.1 Constructors

An overloaded constructor is provided for creating a `mask_array` object.

```
private:
mask_array();
mask_array(const mask_array&);
```

### 11.2.9.2 Assignment Operators

An overloaded assignment operator is provided for assigning values to a `mask_array` after construction.

```
void operator=(const valarray<T>&) const;
mask_array& operator=(const mask_array&);
```

#### Remarks

The copy assignment operator returns a `mask_array` reference.

### 11.2.9.3 Mask\_array Computed Assignment

Several compound assignment operators are provided.

```
void operator*=(const valarray<T>&) const;
void operator/=(const valarray<T>&) const;
void operator%=(const valarray<T>&) const;
void operator+=(const valarray<T>&) const;
void operator-=(const valarray<T>&) const;
void operator^=(const valarray<T>&) const;
void operator&=(const valarray<T>&) const;
void operator|=(const valarray<T>&) const;
void operator<<=(const valarray<T>&) const;
void operator>>=(const valarray<T>&) const;
```

#### Remarks

There is no return value for the compound assignment operators.

### 11.2.9.4 Mask\_array Fill Function

An assignment operation is provided to fill individual elements of the array.

```
void operator =(const T&);
```

#### Remarks



There is no return for the fill function.

## 11.2.10 Template Class `Indirect_array`

The `indirect_array` class is a helper class used by the indirect subscript operator.

This template is a helper template used by the indirect subscript operator `indirect_array<T> valarray<T>::operator[](const valarray<size_t>&)`.

It has reference semantics to a subset of an array specified by an `indirect_array`.

### 11.2.10.1 Constructors

An overloaded constructor is provided for creating a `indirect_array` object.

```
indirect_array();  
indirect_array(const indirect_array&);
```

### 11.2.10.2 Assignment Operators

An overloaded assignment operator is provided for assigning values to a `indirect_array` after construction.

```
void operator=(const valarray<T>&) const;  
indirect_array& operator=(const indirect_array&);
```

#### Remarks

The copy assignment operator returns a `indirect_array` reference.

### 11.2.10.3 `Indirect_array` Computed Assignment

Several compound assignment operators are provided.

```
void operator*=(const valarray<T>&) const;  
void operator/=(const valarray<T>&) const;  
void operator%=(const valarray<T>&) const;  
void operator+=(const valarray<T>&) const;
```

## Generalized Numeric Operations

```
void operator-= (const valarray<T>&) const;
void operator^= (const valarray<T>&) const;
void operator&= (const valarray<T>&) const;
void operator|= (const valarray<T>&) const;
void operator<<= (const valarray<T>&) const;
void operator>>= (const valarray<T>&) const;
```

### Remarks

There is no return value for the compound assignment operators.

### 11.2.10.4 indirect\_array fill function

An assignment operation is provided to fill individual elements of the array.

```
void operator=(const T&);
```

### Remarks

There is no return for the fill function.

## 11.3 Generalized Numeric Operations

The standard library provides general algorithms for numeric processing.

### 11.3.1 Header <numeric>

The header <numeric> includes template functions for generalized numeric processing.

#### 11.3.1.1 accumulate

Accumulate the sum of a sequence.

```
template <class InputIterator, class T>
T accumulate(InputIterator first, InputIterator last, T init);
template <class InputIterator, class T, class BinaryOperation>
T accumulate(InputIterator first, InputIterator last, T init, BinaryOperation binary_op);
```

### Remarks

The sum of the values in a range or the sum of the values after being processed by an operation is returned.

### 11.3.1.2 inner\_product

Computes and returns the value of a product of the values in a range.

```
template <class InputIterator1, class InputIterator2, class T>
T inner_product(InputIterator1 first1, InputIterator1 last1, InputIterator2 first2, T init);
template <class InputIterator1, class InputIterator2, class T, class BinaryOperation1, class
BinaryOperation2>
T inner_product(InputIterator1 first1, InputIterator1 last1, InputIterator2 first2, T
init, BinaryOperation1 binary_op1, BinaryOperation2 binary_op2);
```

#### Remarks

The value of the product starting with an initial value in a range is returned. In the function with the operation argument it is the product after the operation is performed.

### 11.3.1.3 partial\_sum

Computes the partial sum of a sequence of numbers.

```
template <class InputIterator, class OutputIterator>
OutputIterator partial_sum
(InputIterator first, InputIterator last,
OutputIterator result);
template <class InputIterator, class OutputIterator, class BinaryOperation>
OutputIterator partial_sum
(InputIterator first, InputIterator last,
OutputIterator result, BinaryOperation binary_op);
```

The first computes the partial sum and sends it to the output iterator argument.

$x, y, z$

$x, x+y, y+z.$

The second form computes according to the operational argument and sends it to the output iterator argument. For example if the operational argument was a multiplication operation

$x, y, z$

$x, x*y, y*z$

## Remarks

The range as the result plus the last minus the first.

### 11.3.1.4 adjacent\_difference

Computed the adjacent difference in a sequence of numbers.

```

template <class InputIterator,
class OutputIterator>
OutputIterator adjacent_difference
(InputIterator first, InputIterator last,
OutputIterator result);
template <class InputIterator,
class OutputIterator, class BinaryOperation>
OutputIterator adjacent_difference
(InputIterator first, InputIterator last,
OutputIterator result,
BinaryOperation binary_op);

```

The first computes the adjacent difference and sends it to the output iterator argument.

$x, y, z$

$x, y-x, z-y$ .

The second form computes according to the operational argument and sends it to the output iterator argument. For example if the operational argument was a division operation

$x, y, z$

$x, y/x, z/y$

## Remarks

The range as the result plus the last minus the first.

## 11.4 C Library

The standard provides for the math functions included in the standard C library with some overloading for various types.

## 11.4.1 <cmath>

The contents of the <cmath> headers is the same as the Standard C library headers <math.h> with the addition to the double versions of the math functions in <cmath>, C++ adds float and long double overloaded versions of some functions, with the same semantics.

## 11.4.2 <cstdlib>

The contents of the <cstdlib> headers is the same as the Standard C library headers <stdlib.h>. In addition to the int versions of certain math functions in <cstdlib>, C++ adds long overloaded versions of some functions, with the same semantics.

### Listing: The Added C++ Signatures in Cstdlib and Cmath

```
long double abs (long double);
long double acos (long double);
long double asin (long double);
long double atan (long double);
long double atan2(long double, long double);
long double ceil (long double);
long double cos (long double);
long double cosh (long double);
long double exp (long double);
long double fabs (long double);
long double floor(long double);
long double fmod (long double, long double);
long double frexp(long double, int*);
long double ldexp(long double, int);
long double log (long double);
long double log10(long double);
long double modf (long double, long double*);
long double pow (long double, long double);
long double pow (long double, int);
long double sin (long double);
long double sinh (long double);
long double sqrt (long double);
long double tan (long double);
long double tanh (long double);
float abs (float);
float acos (float);
float asin (float);
float atan (float);
float atan2(float, float);
float ceil (float);
float cos (float);
float cosh (float);
float exp (float);
float fabs (float);
float floor(float);
float fmod (float, float);
float frexp(float, int*);
float ldexp(float, int);
float log (float);
float log10(float);
```

## C Library

```
float modf (float, float*);  
float pow (float, float);  
float pow (float, int);  
float sin (float);  
float sinh (float);  
float sqrt (float);  
float tan (float);  
float tanh (float);  
double abs(double);  
double pow(double, int);
```

## Chapter 12

# Complex Class

The header `<complex>` defines a template class, and facilities for representing and manipulating complex numbers.

The header `<complex>` defines classes, operators, and functions for representing and manipulating complex numbers

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Header complex](#) shows the complex header class declarations
- [Complex Specializations](#) lists the float, double and long double specializations
- [Complex Template Class](#) is a template class for complex numbers.

### 12.1 Header complex

The header `<complex>` defines classes, operators, and functions for representing and manipulating complex numbers.

#### 12.1.1 `_EWL_CX_LIMITED_RANGE`

This flag effects the `*` and `/` operators of `complex`.

When defined, the "normal" formulas for multiplication and division are used. They may execute faster on some machines. However, infinities will not be properly calculated, and there is more roundoff error potential.

If the flag is undefined (default), then more complicated algorithms (from the C standard) are used which have better overflow and underflow characteristics and properly propagate infinity. Flipping this switch requires recompilation of the C++ library.

### NOTE

It is recommended that `ansi_prefix.xxx.h` is the place to define this flag if you want the simpler and faster multiplication and division algorithms.

## 12.1.2 Header `<complex>` forward declarations

The complex class has forward declarations.

- `template<class T> class complex;`
- `template<> class complex<float>;`
- `template<> class complex<double>;`
- `template<> class complex<long double>;`

## 12.2 Complex Specializations

The standard specializes the template complex class for float, double and long double types.

## 12.3 Complex Template Class

The `template class complex` contains Cartesian components `real` and `imag` for a complex number.

### Remarks

The effect of instantiating the template complex for any type other than float, double or long double is unspecified. If the result of a function is not mathematically defined or not in the range of representable values for its type, the behavior is undefined.

The complex class consists of:

- [Constructors and Assignments](#)
- [Complex Member Functions](#)



- [Complex Class Operators](#)
- [Overloaded Operators and Functions](#)
- [Complex Value Operations](#)
- [Complex Transcendentals](#)

## 12.3.1 Constructors and Assignments

Constructor, destructor and assignment operators and functions.

### 12.3.1.1 Constructors

Construct an object of a complex class.

```
complex(const T& re = T(), const T& im = T());  
complex(const complex&);  
template<class X> complex(const complex<X>&);
```

#### Remarks

After construction real equal re and imag equals im.

#### AssignmentOperator

An assignment operator for complex classes.

```
complex<T>& operator= (const T&);  
complex& operator= (const complex&);  
  
template<class X> complex<T>& operator= (const complex<X>&);
```

#### Remarks

Assigns a floating point type to the Cartesian complex class.

## 12.3.2 Complex Member Functions

There are two public member functions, `real` and `imag`.

There are two public member functions.

## Complex Template Class

- [real](#)
- [imag](#)

### 12.3.2.1 real

Retrieves the real component.

```
T real() const;
```

### 12.3.2.2 imag

Retrieves the imag component.

```
T imag() const;
```

## 12.3.3 Complex Class Operators

Several assignment operators are overloaded for the complex class manipulations.

### **operator+=**

Adds and assigns to a complex class.

```
complex<T>& operator+=(const T&);  
template<class X> complex<T>& operator+=  
(const complex<X>&);
```

### **Remarks**

The first operator with a scalar argument adds the scalar value of the right hand side to the real component and stores the result in the object. The imaginary component is left alone.

The second operator with a complex type, adds the complex value of the right hand side to the object and stores the result in the object.

The `this` pointer is returned.

**operator-=**

Subtracts and assigns from a complex class.

```
complex<T>& operator-=(const T&);  
template<class X> complex<T>& operator-=  
(const complex<X>&);
```

**Remarks**

The first operator with a scalar argument subtracts the scalar value of the right hand side from the real component and stores the result in the object. The imaginary component is left alone.

The second operator with a complex type, subtracts the complex value of the right hand side from the object and stores the result in the object.

The `this` pointer is returned.

**operator\*=  
operator\*=**

Multiplies by and assigns to a complex class.

```
complex<T>& operator*=(const T&);  
template<class X> complex<T>& operator*=  
(const complex<X>&);
```

**Remarks**

The first operator with a scalar argument multiplies the scalar value of the right hand side to class object and stores result in the object.

The second operator with a complex type, multiplies the complex value of the right hand side to the object and stores the result in the object.

The `this` pointer is returned.

**operator/=**

Divides by and assigns to a complex class.

```
complex<T>& operator/=(const T&);  
template<class X> complex<T>& operator/=  
(const complex<X>&);
```

**Remarks**

The first operator with a scalar argument divides the scalar value of the right hand side to class object and stores result in the object.

The second operator with a complex type, divides the complex value of the right hand side into the object and stores the result in the object.

The `this` pointer is returned.

## 12.3.4 Overloaded Operators and Functions

There are several non member functions and overloaded operators in the complex class library.

- [Overloaded Complex Operators](#)
- [Complex Value Operations](#)
- [Complex Transcendentals](#)

### 12.3.4.1 Overloaded Complex Operators

The overloaded complex operators consists of:

#### **operator+**

Adds to the complex class.

```
template<class T> complex<T> operator+
(const complex<T>&, const complex<T>&);
template<class T> complex<T> operator+
(const complex<T>&, const T&);
template<class T> complex<T> operator+
(const T&, const complex<T>&);
template<class T> complex<T> operator+
(const complex<T>&);
```

#### **Remarks**

The addition performs a += operation.

Returns the complex class after the addition.

#### **operator-**

Subtracts from the complex class.

```
template<class T> complex<T> operator-
(const complex<T>&, const complex<T>&);
template<class T> complex<T> operator-
(const complex<T>&, const T&);
template<class T> complex<T> operator-
(const T&, const complex<T>&);
```

```
template<class T> complex<T> operator-  
(const complex<T>&);
```

## Remarks

The subtraction performs a -= operation.

Returns the complex class after the Subtraction.

## operator\*

Multiplies the complex class.

```
template<class T> complex<T> operator*  
(const complex<T>&, const complex<T>&);  
template<class T> complex<T> operator*  
(const complex<T>&, const T&);  
template<class T> complex<T> operator*  
(const T&, const complex<T>&);
```

## Remarks

The multiplication performs a \*= operation.

Returns the complex class after the multiplication.

## operator/

Divides from the complex class.

```
template<class T> complex<T> operator/  
(const complex<T>&, const complex<T>&);  
template<class T> complex<T> operator/  
(const complex<T>&, const T&);  
template<class T> complex<T> operator/  
(const T&, const complex<T>&);
```

## Remarks

The division performs a /= operation.

Returns the complex class after the division.

## operator==

A boolean equality comparison.

```
template<class T> bool operator==  
(const complex<T>&, const complex<T>&);  
template<class T> bool operator==  
(const complex<T>&, const T&);  
template<class T> bool operator==  
(const T&, const complex<T>&);
```

**Remarks**

Returns true if the real and imaginary components are equal.

**operator!=**

A boolean non equality comparison.

```
template<class T> bool operator!=
(const complex<T>&, const complex<T>&);
template<class T> bool operator!=
(const complex<T>&, const T&);
template<class T> bool operator!=
(const T&, const complex<T>&);
```

**Remarks**

Returns true if the real or the imaginary components are not equal.

**operator>>**

Extracts a complex type from a stream.

```
template<class T, class charT, class traits>
basic_istream<charT, traits>& operator>>
(basic_istream<charT, traits>&, complex<T>&);
```

**Remarks**

Extracts in the form of u, (u), or (u,v) where u is the real part and v is the imaginary part.

Any failure in extraction will set the failbit and result in undefined behavior.

**operator<<**

Inserts a complex number into a stream.

```
template<class T, class charT, class traits>
basic_ostream<charT, traits>& operator<<
(basic_ostream<charT, traits>&, const complex<T>&);
```

## 12.3.5 Complex Value Operations

This section lists the complex value operations.

- [real](#)
- [imag](#)
- [abs](#)

- [arg](#)
- [norm](#)
- [conj](#)
- [polar](#)

### 12.3.5.1 real

Retrieves the real component of a complex class.

```
template<class T> T real(const complex<T>&);
```

#### Remarks

Returns the real component of the argument.

### 12.3.5.2 imag

Retrieves the imaginary component of a complex class.

```
template<class T> T imag(const complex<T>&);
```

#### Remarks

Returns the imaginary component of the argument.

### 12.3.5.3 abs

Determines the absolute value of a complex class.

```
template<class T> T abs(const complex<T>&);
```

#### Remarks

Returns the absolute value of the complex class argument.

### 12.3.5.4 arg

Determines the phase angle.

```
template<class T> T arg(const complex<T>&);
```

#### Remarks

Returns the phase angle of the complex class argument or `atan2(imag(x), real(x))`.

### 12.3.5.5 norm

Determines the squared magnitude.

```
template<class T> T norm(const complex<T>&);
```

#### Remarks

The squared magnitude of the complex class.

### 12.3.5.6 conj

Determines the complex conjugate.

```
template<class T> complex<T> conj(const complex<T>&);
```

#### Remarks

Returns the complex conjugate of the complex class argument.

### 12.3.5.7 polar

Determines the polar coordinates.

```
template<class T>  
complex<T> polar(const T&, const T&);
```



## Remarks

Returns the complex value corresponding to a complex number whose magnitude is the first argument and whose phase angle is the second argument.

## 12.3.6 Complex Transcendentals

This section lists the complex transcendentals.

- [cos](#)
- [cosh](#)
- [exp](#)
- [log](#)
- [log10](#)
- [pow](#)
- [sin](#)
- [sinh](#)
- [sqrt](#)
- [tan](#)
- [tanh](#)

### 12.3.6.1 `cos`

Determines the cosine.

```
template<class T> complex<T> cos (const complex<T>&);
```

## Remarks

Returns the cosine of the complex class argument.

### 12.3.6.2 `cosh`

Determines the hyperbolic cosine.

```
template<class T> complex<T> cosh (const complex<T>&);
```

## Remarks

Returns the hyperbolic cosine of the complex class argument.

### 12.3.6.3 exp

Determines the exponential.

```
template<class T> complex<T> exp (const complex<T>&);
```

## Remarks

Returns the base exponential of the complex class argument.

### 12.3.6.4 log

Determines the natural base logarithm.

```
template<class T>  
complex<T> log (const complex<T>&);
```

## Remarks

Returns the natural base logarithm of the complex class argument, in the range of a strip mathematically unbounded along the real axis and in the interval of  $[i\pi, i\pi]$  along the imaginary axis. The argument is a negative real number,  $\text{imag}(\log(\text{cpx}))$ , is  $\pi$ .

### 12.3.6.5 log10

Determines the logarithm to base ten.

```
template<class T>  
complex<T> log10(const complex<T>&);
```

## Remarks

Returns the logarithm base(10) of the argument  $\text{cpx}$  defined as  $\log(\text{cpx}) / \log(10)$ .

### 12.3.6.6 pow

Raises the complex class to a set power.

```
template<class T> complex<T> pow(const complex<T>&, int);  
template<class T> complex<T> pow(const complex<T>&, const T&);  
template<class T> complex<T> pow(const complex<T>&, const complex<T>&);  
template<class T> complex<T> pow(const T&, const complex<T>&);
```

#### Remarks

Returns the complex class raised to the power of second argument defined as the exponent of the second argument times the log of the first argument.

The value for `pow(0,0)` will return (nan, nan).

### 12.3.6.7 sin

Determines the sine.

```
template<class T>  
complex<T> sin (const complex<T>&);
```

#### Remarks

Returns the sine of the complex class argument.

### 12.3.6.8 sinh

Determines the hyperbolic sine.

```
template<class T>  
complex<T> sinh (const complex<T>&);
```

#### Remarks

Returns the hyperbolic sine of the complex class argument.

### 12.3.6.9 sqrt

Determines the square root.

```
template<class T>
complex<T> sqrt (const complex<T>&);
```

#### Remarks

Returns the square root of the complex class argument in the range of right half plane. If the argument is a negative real number, the value returned lies on the positive imaginary axis.

### 12.3.6.10 tan

Determines the tangent.

```
template<class T>
complex<T> tan (const complex<T>&);
```

#### Remarks

Returns the tangent of the complex class argument.

### 12.3.6.11 tanh

Determines the hyperbolic tangent.

```
template<class T>
complex<T> tanh (const complex<T>&);
```

#### Remarks

Returns the hyperbolic tangent of the complex class argument.

# Chapter 13

## Input and Output Library

A set of components that C++ programs may use to perform input/output operations.

This chapter is constructed in the following subsections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Input and Output Library Summary](#)
- [Iostreams requirements](#)

### 13.1 Input and Output Library Summary

This section lists the headers available in the Input/Output Library.

**Table 13-1. Input/Output Library Summary**

Include	Purpose
<iosfwd>	Forward declarations
<iostream>	Standard iostream objects
<ios>	Iostream base classes
<streambuf>	Stream buffers
<istream>	Formatting and manipulators
<ostream>	Output streams
<iomanip>	Input and output manipulators
<sstream>	String streams
<cstdlib>	Standard C utilities
<fstream>	File Streams
<cstdio>	Standard C input and output support
<cwchar>	Standard C wide characters support

## 13.2 iostreams requirements

The EWL C Library is not specifically required for EWL C++ input and output operations.

Topics in this section are:

- [Definitions](#)
- [Type requirements](#)
- [Type SZ\\_T](#)

### 13.2.1 Definitions

Additional definitions are:

- `character` - A unit that can represent text
- `character container type` - A class or type used to represent a `character`.
- `iostream class templates` - Templates that take two arguments: `charT` and `traits`. The argument `charT` is a character container type. The argument `traits` is a structure which defines characteristics and functions of the `charT` type.
- `narrow-oriented iostream classes` - These classes are template instantiation classes. The traditional `iostream` classes are `narrow-oriented iostream classes`.
- `wide-oriented iostream classes` - These classes are template instantiation classes. They are used for the character container class `wchar_t`.
- `repositional streams and arbitrary-positional streams` - A `repositional stream` can seek to only a previously encountered position. An `arbitrary-positional stream` can seek to an integral position within the length of the stream.

### 13.2.2 Type requirements

Several types are required by the standards, they are consolidated in the strings library.

### 13.2.3 Type SZ\_T

A type that represents one of the signed basic integral types. It is used to represent the number of characters transferred in an input/output operation or the size of the input/output buffers.

## Chapter 14

# Forward Declarations

The header `<iosfwd>` is used for forward declarations of template classes.

The non-standard header `<stringfwd>` is used for forward declarations of string class objects.

### 14.1 The Streams and String Forward Declarations

The ANSI/ISO standard calls for forward declarations of input and output streams for basic input and output.

This is for both normal and wide character formats.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

### 14.2 Header `iosfwd`

The header `<iosfwd>` is used for forward declarations of template classes.

The template class `basic_ios<charT, traits>` serves as a base class for class `basic_istream` and `basic_ostream`.

The class `ios` is an instantiation of `basic_ios` specialized by the type `char`.

The class `wios` is an instantiation of `basic_ios` specialized by the type `wchar_t`.

### 14.3 Header `stringfwd`

This non-standard header can be used to forward declare `basic_string` (much like `<iosfwd>` forward declares streams). There is also a `<stringfwd.h>` that forward declares `basic_string` and places it into the global namespace.

## NOTE

The header `<stringfwd>` is a non-standard header.

### Listing: Header `<stringfwd>` Synopsis

```
namespace std { // Optional
template <class T>    class allocator;

template<class charT>    struct char_traits;

template <class charT, class traits, class Allocator>

class basic_string;

typedef basic_string <char, char_traits<char>, allocator<char> >
string;

typedef basic_string
<wchar_t, char_traits<wchar_t>, allocator<wchar_t> > wstring;
}
```

Including `<stringfwd>` allows you to use a string object.

### Listing: Example of `<stringfwd>` Inclusion of `std::string`

```
#include <stringfwd>
class MyClass
{
....
    std::string* my_string_ptr;
};
```

The headers `<stringfwd.h>` and `<string>` can be used in combination to place `string` into the global namespace, much like is done with other `<name.h>` headers. The header `<string.h>` does not work because that is a standard C header.

### Listing: Example of Stringfwd usage

```
#include <stringfwd.h>
#include <string>

int main()
{
    string a("Hi");    // no std:: required

    return 0;
}
```







## Chapter 15

# iostream Objects

The include header `<iostream>` declares input and output stream objects. The declared objects are associated with the standard C streams provided for by the functions in `<stdio.h>`. This chapter uses the ISO (International Organization for Standardization) C++ Standard as a guide.

### 15.1 Header `iostream`

The header `<iostream>` declares standard input and output objects in namespace `std`.

#### Listing: `iostream` input and output objects

```
extern istream cin;
extern ostream cout;
extern ostream cerr;
extern ostream clog;
extern wistream wcin;
extern wostream wcout;
extern wostream cerr;
extern wostream wclog;
```

#### 15.1.1 Stream Buffering

All streams are buffered (by default) except `cerr` and `wcerr`.

**NOTE**

You can change the buffering characteristic of a stream with:

```
cout.setf(ios_base::unitbuf);
```

or

```
cerr.unsetf(ios_base::unitbuf);
```

**Tip**

Do not include `<iostream>` unless needed. Including and not using `<iostream>` will add code size. If you really need it, consider including only `<niostream>` instead. This will instantiate only the narrow console streams, not the wide ones.

## 15.2 The Standard Input and Output Stream Library

The ANSI/ISO standard calls for predetermined objects for standard input, output, logging and error reporting.

This is initialized for normal and wide character formats.

- [Narrow stream objects](#)
- [Wide stream objects](#)

### 15.2.1 Narrow stream objects

Narrow stream objects provide unbuffered input and output associated with standard input and output declared in `<cstdio>`.

#### 15.2.1.1 `istream cin`

An unbuffered input stream.

```
istream cin;
```

## Remarks

The object `cin` controls input from an unbuffered stream buffer associated with `stdin` declared in `<cstdio>`. After `cin` is initialized `cin.tie()` returns `cout`.

Returns an ostream object.

### 15.2.1.2 ostream cout

An unbuffered output stream.

```
ostream cout;
```

## Remarks

The object `cout` controls output to an unbuffered stream buffer associated with `stdout` declared in `<cstdio>`.

### 15.2.1.3 ostream cerr

Controls output to an unbuffered stream.

```
ostream cerr;
```

## Remarks

The object `cerr` controls output to an unbuffered stream buffer associated with `stderr` declared in `<cstdio>`. After `err` is initialized, `err.flags()` and `unitbuf` is nonzero.

### 15.2.1.4 ostream clog

Controls output to a stream buffer.

```
ostream clog;
```

## Remarks

The object `clog` controls output to a stream buffer associated with `cerr` declared in `<cstdio>`.

## 15.2.2 Wide stream objects

Wide stream objects provide unbuffered input and output associated with standard input and output declared in `<cstdio>`.

### 15.2.2.1 `wistream wcin`

An unbuffered wide input stream.

```
wistream wcin;
```

#### Remarks

The object `wcin` controls input from an unbuffered wide stream buffer associated with `stdin` declared in `<cstdio>`. After `wcin` is initialized `wcin.tie()` returns `wout`.

### 15.2.2.2 `wostream wcout`

An unbuffered wide output stream.

```
wostream wcout;
```

#### Remarks

The object `wcout` controls output to an unbuffered wide stream buffer associated with `stdout` declared in `<cstdio>`.

### 15.2.2.3 `wostream wcerr`

Controls output to an unbuffered wide stream.

```
wostream wcerr;
```

## Remarks

The object `wcerr` controls output to an unbuffered wide stream buffer associated with `stderr` declared in `<cstdio>`. After `wcerr` is initialized, `wcerr.flags()` and `unitbuf` is nonzero.

### 15.2.2.4 wostream wlog

Controls output to a wide stream buffer.

```
wostream wlog;
```

## Remarks

The object `wlog` controls output to a wide stream buffer associated with `cerr` declared in `<cstdio>`.





## Chapter 16

# iostreams Base Classes

The include header `<ios>` contains the basic class definitions, types, and enumerations necessary for input and output stream reading, writing, and other manipulations.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Header ios](#)
- [Typedef Declarations](#)
- [Class ios\\_base](#)
- [Template class basic\\_ios](#)
- [ios\\_base manipulators](#)

### 16.1 Header ios

The header file `<ios>` provides for implementation of stream objects for standard input and output.

#### 16.1.1 Template Class fpos

The template class `fpos<stateT>` is a class used for specifying file position information. The template parameter corresponds to the type needed to hold state information in a multi-byte sequence (typically `mbstate_t` from `<wchar>`). `fpos` is essentially a wrapper for whatever mechanisms are necessary to hold a stream position (and multi-byte state). In fact the standard stream position typedefs are defined in terms of `fpos`:

```
typedef fpos<mbstate_t> streampos;  
typedef fpos<mbstate_t> wstreampos;
```

The `template class fpos` is typically used in the `istream` and `ostream` classes in calls involving file position such as `tellg`, `tellp`, `seekg` and `seekp`. Though in these classes the `fpos` is typedef'd to `pos_type`, and can be changed to a custom implementation by specifying a traits class in the stream's template parameters.

## 16.2 Typedef Declarations

The following typedef's are defined in the class `ios_base`.

```
typedef long streamoff;  
typedef long streamsize;
```

## 16.3 Class `ios_base`

A base class for input and output stream mechanisms.

The prototype is listed below. Additional topics in this section are:

- [Typedef Declarations](#)
- [Class `ios\_base::failure`](#)
- [Type `fmtflags`](#)
- [Type `iostate`](#)
- [Type `openmode`](#)
- [Type `seekdir`](#)
- [Class `Init`](#)
- [Class `Init` Constructor](#)
- [`ios\_base` `fmtflags` state functions](#)
- [`ios\_base` locale functions](#)
- [`ios\_base` storage function](#)
- [`ios\_base`](#)

The `ios_base` class is a base class and includes many enumerations and mechanisms necessary for input and output operations.

### 16.3.1 Typedef Declarations

No types are specified in the current standards.

### 16.3.2 Class `ios_base::failure`

Defines a base class for types of objects thrown as exceptions.

#### 16.3.2.1 `failure`

Construct a class `failure`.

```
explicit failure(const string& msg);
```

#### Remarks

The function `failure()` constructs a class `failure` initializing with `exception(msg)`.

#### 16.3.2.2 `failure::what`

To return the exception message.

```
const char *what() const;
```

#### Remarks

The function `what()` is used to deliver the `msg.str()`.

Returns the message with which the exception was created.

### 16.3.3 Type `fmtflags`

An enumeration used to set various formatting flags for reading and writing of streams.

**Table 16-1. Format Flags Enumerations**

Flag	Effects when set
boolalpha	insert or extract bool type in alphabetic form
dec	decimal output
fixed	when set shows floating point numbers in normal manner, six decimal places is default
hex	hexadecimal output
oct	octal output
left	left justified
right	right justified
internal	pad a field between signs or base characters
scientific	show scientific notation for floating point numbers
showbase	shows the bases numeric values
showpoint	shows the decimal point and trailing zeros
showpos	shows the leading plus sign for positive numbers
skipws	skip leading white spaces with input
unitbuf	buffer the output and flush after insertion operation
uppercase	show the scientific notation, x or o in uppercase

**Table 16-2. Format flag field constants**

Constants	Allowable values
adjustfield	left   right   internal
basefield	dec   oct   hex
floatfield	scientific   fixed

**Listing: Example of ios format flags usage**

see `basic_ios::setf()` and `basic_ios::unsetf()`

**16.3.4 Type iostate**

An enumeration that is used to define the various states of a stream.

**Table 16-3. Enumeration iostate**

Flags	Usage
goodbit	True when all of badbit, eofbit and failbit are false.

*Table continues on the next page...*

**Table 16-3. Enumeration iostate (continued)**

Flags	Usage
badbit	True when the stream is in an irrecoverable error state (such as failure due to lack of memory)
failbit	True when a read or write has failed for any reason (This can happen for example when the input reads a character while attempting to read an integer.)
eofbit	True when the end of the stream has been detected. Note that eofbit can be set during a read, and yet the read may still succeed (failbit not set). (This can happen for example when an integer is the last character in a file.)  <b>Note:</b> see variance from AT&T standard.

For an example of ios iostate flags usage refer to `basic_ios::setstate()` and `basic_ios::rdstate()`

### 16.3.5 Type openmode

An enumeration that is used to specify various file opening modes.

**Table 16-4. Enumeration openmode**

Mode	Definition
app	Start the read or write at end of the file
ate	Start the read or write immediately at the end
binary	binary file
in	Start the read at end of the stream
out	Start the write at the beginning of the stream
trunc	Start the read or write at the beginning of the stream

### 16.3.6 Type seekdir

An enumeration to position a pointer to a specific place in a file stream.

Table 16-5. Enumeration seekdir

Enumeration	Position
beg	Beginning of stream
cur	Current position of stream
end	End of stream

For an example of ios seekdir usage refer to streambuf::pubseekoff

## 16.3.7 Class Init

An object that associates `<iostream>` object buffers with standard stream declared in `<cstdio>`.

### 16.3.7.1 Class Init Constructor

To construct an object of class Init;

```
Init();
```

#### Remarks

The default constructor `Init()` constructs an object of class `Init`. If `init_cnt` is zero the function stores the value one and constructs `cin`, `cout`, `cerr`, `clog`, `wcin`, `wout`, `werr` and `wlog`. In any case the constructor then adds one to `init_cnt`.

### 16.3.7.2 Destructor

```
~Init();
```

#### Remarks

The destructor subtracts one from `init_cnt` and if the result is one calls `cout.flush()`, `cerr.flush()` and `clog.flush()`.

## 16.3.8 ios\_base fmtflags state functions

To set the state of the ios\_base format flags.

### 16.3.8.1 flags

To alter formatting flags using a mask.

```
fmtflags flags() const  
fmtflags flags(fmtflags)
```

#### Remarks

Use `flags()` when you would like to use a mask of several flags, or would like to save the current format configuration. The return value of `flags()` returns the current `fmtflags`. The overloaded `flags(fmtflags)` alters the format flags but will return the value prior to the flags being changed.

The `fmtflags` type before alterations.

See `ios` enumerators for a list of `fmtflags`.

#### SeeAlso:

`setiosflags()` and `resetiosflags()`

#### Listing: Example of flags() usage:

```
#include <iostream>  
// showf() displays flag settings  
  
void showf();  
  
int main()  
{  
    using namespace std;  
    showf(); // show format flags  
    cout << "press enter to continue" << endl;  
    cin.get();  
    cout.setf(ios::right|ios::showpoint|ios::fixed);  
    showf();  
    return 0;  
}
```

```

class ios_base
}

// showf() displays flag settings
void showf()
{
using namespace std;

    char fflags[][12] = {
        "boolalpha",
        "dec",
        "fixed",
        "hex",
        "internal",
        "left",
        "oct",
        "right",
        "scientific",
        "showbase",
        "showpoint",
        "showpos",
        "skipws",
        "unitbuf",
        "uppercase"
    };

    long f = cout.flags();    // get flag settings
    cout.width(9); // for demonstration

        // check each flag
    for(long i=1, j =0; i<=0x4000; i = i<<1, j++)
    {
        cout.width(10); // for demonstration
        if(i & f)
            cout << fflags[j] << " is on \n";
        else
            cout << fflags[j] << " is off \n";
    }
    cout << "\n";
}

```



Result:

```

boolalpha    is off
dec          is on
fixed        is off
hex          is off
internal     is off
left         is off
oct          is off
right        is off
scientific  is off
showbase     is off
showpoint    is off
showpos      is off
skipws       is on
unitbuf      is off
uppercase    is off
press enter to continue
boolalpha is off
    dec is on
        hex is off
    internal is off
        left is off
            oct is off
                right is on
scientific is off
    showbase is off
        showpoint is on
            showpos is off
                skipws is on
                    unitbuf is off
                        uppercase is off

```

### 16.3.8.2 setf

Set the stream format flags.

```

fmtflags setf(fmtflags)
fmtflags setf(fmtflags, fmtflags)

```

#### Remarks

You should use the function `setf()` to set the formatting flags for input/output. It is overloaded. The single argument form of `setf()` sets the flags in the mask. The two argument form of `setf()` clears the flags in the first argument before setting the flags with the second argument.

type `basic_ios::fmtflags` is returned.

#### Listing: Example of `setf()` usage:

```

#include <iostream>
int main()

```

**class ios\_base**

```
{
using namespace std;
    double d = 10.01;
    cout.setf(ios::showpos | ios::showpoint);
    cout << d << endl;
    cout.setf(ios::showpoint, ios::showpos | ios::showpoint);
    cout << d << endl;
    return 0;
}
```

**Result:**

```
+10.01
10.01
```

### 16.3.8.3 unsetf

To un-set previously set formatting flags.

```
void unsetf(fmtflags)
```

**Remarks**

Use the `unsetf()` function to reset any format flags to a previous condition. You would normally store the return value of `setf()` in order to achieve this task.

There is no return.

**Listing: Example of unsetf() usage:**

```
#include <iostream>
int main()
{
using namespace std;
    double d = 10.01;
    cout.setf(ios::showpos | ios::showpoint);
    cout << d << endl;
    cout.unsetf(ios::showpoint);
    cout << d << endl;
    return 0;
}
```

```
}
```

Result:

```
+10.01  
+10.01
```

### 16.3.8.4 precision

Set and return the current format precision.

```
streamsize precision() const  
streamsize precision(streamsize prec)
```

#### Remarks

Use the `precision()` function with floating point numbers to limit the number of digits in the output. You may use `precision()` with scientific or non-scientific floating point numbers. You may use the overloaded `precision()` to retrieve the current precision that is set.

With the flag `ios::floatfield` set, the number in `precision` refers to the total number of significant digits generated. If the settings are for either `ios::scientific` or `ios::fixed` then the precision refers to the number of digits after the decimal place.

This means that `ios::scientific` will have one more significant digit than `ios::floatfield`, and `ios::fixed` will have a varying number of digits.

#### SeeAlso

```
setprecision()
```

#### Listing: Example of `precision()` usage:

```
#include <iostream>  
#include <cmath>  
  
const double pi = 4 * std::atan(1.0);  
  
int main()  
{  
    using namespace std;  
    double TenPi = 10*pi;  
  
    cout.precision(5);  
}
```

**class ios\_base**

```

    cout.unsetf(ios::floatfield);

    cout << "floatfield:\t" << TenPi << endl;

    cout.setf(ios::scientific, ios::floatfield);

    cout << "scientific:\t" << TenPi << endl;

    cout.setf(ios::fixed, ios::floatfield);

    cout << "fixed:\t\t" << TenPi << endl;

    return 0;
}

```

**Result:**

```

floatfield: 31.416
scientific: 3.14159e+01
fixed:      31.41593

```

## 16.3.8.5 width

To set the width of the output field.

```

streamsize width() const
streamsize width(streamsize wide)

```

**Remarks**

Use the `width()` function to set the field size for output. The function is overloaded to return just the current width setting if there is no parameter or to store and then return the previous setting before changing the fields width to the new parameter.

`width` is the one and only modifier that is not sticky and needs to be reset with each use. `width` is reset to `width(0)` after each use.

The previous width setting is returned.

**Listing: Example of width() usage:**

```

#include <iostream>
int main()
{
    using namespace std;

    int width;

    cout.width(8);
}

```

```
width = cout.width();
cout.fill('*');
cout << "Hi!" << '\n';
// reset to left justified blank filler
cout<< "Hi!" << '\n';
cout.width(width);
cout<< "Hi!" << endl;
return 0;
}
```

Result:

```
Hi!*****
Hi!
Hi!*****
```

## 16.3.9 ios\_base locale functions

Sets the locale for input output operations.

### 16.3.9.1 imbue

Stores a value representing the locale.

```
locale imbue(const locale loc);
```

#### Remarks

The precondition of the argument `loc` is equal to `getloc()`.

The previous value of `getloc()`.

### 16.3.9.2 getloc

Determines the imbued locale for input output operations.

```
locale getloc() const;
```

## Remarks

Returns the global C++ locale if no locale has been imbued. Otherwise it returns the locale of the input and output operations.

## 16.3.10 ios\_base storage function

To allocate storage pointers.

### 16.3.10.1 xalloc

Allocation function.

```
static int xalloc()
```

## Remarks

Returns `index++`.

### 16.3.10.2 iword

Allocates an array of `int` and stores a pointer.

```
long& iword(int idx);
```

## Remarks

If `iarray` is a null pointer, allocate an array and store a pointer to the first element. The function extends the array as necessary to include `iarray[idx]`. Each newly allocated element of the array is initialized to zero.

The reference returned is invalid after any other operation on the object.

Returns `iarray[idx]`

### 16.3.10.3 pword

Allocate an array of pointers.

```
void*& pword(int idx);
```

#### Remarks

If `parray` is a null pointer, allocates an array of void pointers. Then extends `parray` as necessary to include the element `parray[idx]`.

The reference returned is invalid after any other operation on the object.

Returns `parray[idx]`.

### 16.3.10.4 register\_callback

Registers functions when an event occurs.

```
void register_callback  
    (event_callback fn,  
     int index);
```

#### Remarks

Registers the pair `(fn, index)` such that during calls to `imbue()`, `copyfmt()` or `~ios_base()` the function `fn` is called with argument `index`. Registered functions are called when an event occurs, in opposite order of registration. Functions registered while a callback function is active are not called until the next event.

Identical pairs are not merged and a function registered twice will be called twice.

### 16.3.10.5 sync\_with\_stdio

Synchronizes stream input output with 'C' input and output functions.

```
static bool sync_with_stdio(bool sync = true);
```

#### Remarks

Is not supported in the EWL.

```
template class basic_ios
```

Always returns `true` indicating that the EWL streams are always synchronized with the C streams.

## 16.3.11 ios\_base

ios\_base

### 16.3.11.1 ios\_base Constructor

Construct an object of class ios\_base

```
protected:  
    ios_base();
```

#### Remarks

The `ios_base` constructor is protected so it may only be derived from. The values of the `ios_base` members are undermined.

### 16.3.11.2 ios\_base Destructor

Destruct an object of class ios\_base

```
~ios_base();
```

#### Remarks

Calls registered callbacks and destroys an object of class `ios_base`.

## 16.4 Template class basic\_ios

A template class for input and output streams.



The `basic_ios` template class is a base class and includes many enumerations and mechanisms necessary for input and output operations.

## 16.4.1 `basic_ios` Constructor

Construct an object of class `basic_ios` and assign values.

```
public:
    explicit basic_ios
        (basic_streambuf<charT,traits>* sb);
protected:
    basic_ios();
```

### Remarks

The `basic_ios` constructor creates an object to class `basic_ios` and assigns values to its member functions by calling `init()`.

## 16.4.2 Destructor

The conditions of the member functions after `init()` are shown in the following table.

```
virtual ~basic_ios();
```

### Remarks

Destroys an object of type `basic_ios`.

**Table 16-6. Conditions after `init()`**

Member	Postcondition Value
<code>rdbuf()</code>	<code>sb</code>
<code>tie()</code>	zero
<code>rdstate()</code>	goodbit if stream buffer is not a null pointer otherwise badbit.
<code>exceptions()</code>	goodbit
<code>flags()</code>	<code>skipws   dec</code>
<code>width()</code>	zero
<code>precision()</code>	six
<code>fill()</code>	the space character
<code>getloc()</code>	<code>locale::classic()</code>

*Table continues on the next page...*

**Table 16-6. Conditions after `init()` (continued)**

Member	Postcondition Value
<code>iarray</code>	a null pointer
<code>parray</code>	a null pointer

## 16.4.3 Basic\_ios Member Functions

Member functions of the class `basic_ios`.

### 16.4.3.1 tie

To tie an ostream to the calling stream.

```
basic_ostream<charT, traits>* tie() const;
basic_ostream<charT, traits>* tie
    (basic_ostream<charT, traits>* tiestr);
```

#### Remarks

Any stream can have an `ostream` tied to it to ensure that the `ostream` is flushed before any operation. The standard input and output objects `cin` and `cout` are tied to ensure that `cout` is flushed before any `cin` operation. The function `tie()` is overloaded. The parameterless version returns the current ostream that is tied, if any. The `tie()` function with an argument ties the new object to the ostream and returns a pointer, if any, from the first. The post-condition of `tie()` function that takes the argument `tiestr` is that `tiestr` is equal to `tie()`;

A pointer to type `ostream` that is or previously tied, or zero if there was none.

#### Listing: Example of `tie()` usage:

```
// The file EWL-test contains
// CodeWarrior "Software at Work"

#include <iostream>

#include <fstream>

#include <cstdlib>

char inFile[] = "EWL-test";
```

```
int main()
{
using namespace std;

    ifstream inOut(inFile, ios::in | ios::out);
    if(!inOut.is_open())
        { cout << "file is not open"; exit(1);}
    ostream Out(inOut.rdbuf());
    if(inOut.tie())
        cout << "The streams are tied\n";
    else cout << "The streams are not tied\n";
    inOut.tie(&Out);
    inOut.rdbuf()->pubseekoff(0, ios::end);
    char str[] = "\nRegistered Trademark";
    Out << str;

    if(inOut.tie())
        cout << "The streams are tied\n";
    else cout << "The streams are not tied\n";
    inOut.close();
    return 0;
}
```

## Result:

```
The streams are not tied
The streams are tied
The file EWL-test now contains
CodeWarrior "Software at Work"
Registered Trademark
```

### 16.4.3.2 rdbuf

To retrieve a pointer to the stream buffer.

```
basic_streambuf<charT, traits>* rdbuf() const;
basic_streambuf<charT, traits>* rdbuf
    (basic_streambuf<charT, traits>* sb);
```

## Remarks

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer. The `rdbuf()` function that takes an argument has the post-condition of `sb` is equal to `rdbuf()`.

Returns a pointer to `basic_streambuf` object.

### Listing: Example of `rdbuf()` usage:

```
#include <iostream>
struct address {
    int number;
    char street[40];
} addbook;
int main()
{
    using namespace std;

    cout << "Enter your street number: ";
    cin >> addbook.number;

    cin.rdbuf()->pubsync(); // buffer flush
    cout << "Enter your street name: ";
    cin.get(addbook.street, 40);
    cout << "Your address is: "
         << addbook.number << " " << addbook.street;

    return 0;
}
```

### Result:

```
Enter your street number: 1313
Enter your street name: Mockingbird Lane
Your address is: 1313 Mockingbird Lane
```

## 16.4.3.3 imbue

Stores a value representing the locale.

```
locale imbue(const locale& rhs);
```

## Remarks

The function `imbue()` calls `ios_base::imbue()` and

```
rdbuf->pubimbue().
```

Returns the current locale.

### 16.4.3.4 fill

To insert characters into the stream's unused spaces.

```
char_type fill() const  
char_type fill(char_type)
```

## Remarks

Use `fill(char_type)` in output to fill blank spaces with a character. The function `fill()` is overloaded to return the current filler without altering it.

Returns the current character being used as a filler.

## SeeAlso

```
manipulator setfill()
```

### Listing: Example of fill() usage:

```
#include <iostream>  
int main()  
{  
using namespace std;  
    char fill;  
    cout.width(8);  
    cout.fill('*');  
    fill = cout.fill();  
    cout<< "Hi!" << "\n";  
    cout << "The filler is a " << fill << endl;  
  
    return 0;  
}
```

## Result:

```
template class basic_ios
```

```
    Hi!*****  
    The filler is a *
```

### 16.4.3.5 copyfmt

Copies a `basic_ios` object.

```
basic_ios& copyfmt(const basic_ios& rhs);
```

#### Remarks

Assigns members of `*this` object the corresponding objects of the `rhs` argument with certain exceptions. The exceptions are `rdstate()` is unchanged, `exceptions()` is altered last, and the contents of `pword` and `iword` arrays are copied not the pointers themselves.

Returns the `this` pointer .

## 16.4.4 basic\_ios iostate flags functions

To set flags pertaining to the state of the input and output streams.

### 16.4.4.1 operator bool

A `bool` operator.

```
operator bool() const;
```

#### Remarks

Returns `!fail()`.

### 16.4.4.2 operator !

A `bool not` operator.

```
bool operator ! ();
```

## Remarks

Returns `fail()`.

### 16.4.4.3 `rdstate`

To retrieve the state of the current formatting flags.

```
iostate rdstate() const
```

## Remarks

This member function allows you to read and check the current status of the input and output formatting flags. The returned value may be stored for use in the function `ios::setstate()` to reset the flags at a later date.

Returns type `iostate` used in `ios::setstate()`

## SeeAlso

```
ios::setstate()
```

### Listing: Example of `rdstate()` usage:

```
// The file ewl-test contains:  
// ABCDEFGHIJKLMNOPQRSTUVWXYZ  
  
#include <iostream>  
#include <fstream>  
#include <cstdlib>  
  
char * inFile = "ewl-test";  
using namespace std;  
void status(ifstream &in);  
  
int main()  
{  
    ifstream in(inFile);  
    if(!in.is_open())  
    {  
        cout << "could not open file for input";  
        exit(1);  
    }  
    int count = 0;
```

## template class basic\_ios

```

int c;

while((c = in.get()) != EOF)
{
    // simulate a bad bit
    if(count++ == 12) in.setstate(ios::badbit);
    status(in);
}
status(in);
in.close();
return 0;
}

void status(istream &in)
{
    int i = in.rdstate();
    switch (i) {
        case ios::eofbit : cout << "EOF encountered \n";
                           break;

        case ios::failbit : cout << "Non-Fatal I/O Error n";
                           break;

        case ios::goodbit : cout << "GoodBit set \n";
                           break;

        case ios::badbit : cout << "Fatal I/O Error \n";
                           break;
    }
}

```

### Result:

```

GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
Fatal I/O Error

```



### 16.4.4.4 clear

Clears `iostate` field.

```
void clear
    (iostate state = goodbit) throw failure;
```

#### Remarks

Use `clear()` to reset the `failbit`, `eofbit` or a `badbit` that may have been set inadvertently when you wish to override for continuation of your processing. Post-condition of `clear` is the argument and is equal to `rdstate()`.

If `rdstate()` and `exceptions() != 0` an exception is thrown.

No value is returned.

#### Listing: Example of `clear()` usage:

```
// The file ewl-test contains:
// ABCDEFGH

#include <iostream>
#include <fstream>
#include <cstdlib>

char * inFile = "ewl-test";
using namespace std;
void status(ifstream &in);

int main()
{
    ifstream in(inFile);
    if(!in.is_open())
    {
        cout << "could not open file for input";
        exit(1);
    }

    int count = 0;

    int c;
    while((c = in.get()) != EOF) {
        if(count++ == 4)
```

## template class basic\_ios

```

{
    // simulate a failed state
    in.setstate(ios::failbit);
    in.clear();
}
status(in);
}
status(in);
in.close();
return 0;
}
void status(istream &in)
{
    // note: eof() is not needed in this example
    // if(in.eof()) cout << "EOF encountered \n"
    if(in.fail()) cout << "Non-Fatal I/O Error \n";
    if(in.good()) cout << "GoodBit set \n";
    if(in.bad()) cout << "Fatal I/O Error \n";
}

```

### Result:

```

GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
GoodBit set
Non-Fatal I/O Error

```

## 16.4.4.5 setstate

To set the state of the format flags.

```
void setstate(iostate state) throw(failure);
```

### Remarks

Calls `clear(rdstate() | state)` and may throw an exception.

There is no return value.

For an example of `setstate()` usage refer to `ios::rdstate()`

#### 16.4.4.6 good

To test for the lack of error bits being set.

```
bool good() const;
```

#### Remarks

Use the function `good()` to test for the lack of error bits being set.

Returns true if `rdstate() == 0`.

For an example of `good()` usage refer to `basic_ios::bad()`

#### 16.4.4.7 eof

To test for the eofbit setting.

```
bool eof() const;
```

#### Remarks

Use the `eof()` function to test for an eofbit setting in a stream being processed under some conditions. This end of file bit is not set by stream opening or closing, but only for operations that detect an end of file condition.

If eofbit is set in `rdstate()` true is returned.

#### Listing: Example of eof() usage

```
// ewl-test is simply a one line text document
ABCDEFGHIJKLMNPOQRSTUVWXYZabcdefghijklmnopqrstuvwxyz

#include <iostream>
#include <fstream>
#include <cstdlib>

const char* TheText = "ewl-test";
```

**template class basic\_ios**

```

int main()
{
using namespace std;

    ifstream in(TheText);
    if(!in.is_open())
    {
        cout << "Couldn't open file for input";
        exit(1);
    }
    int i = 0;
    char c;
    cout.setf(ios::uppercase);
        //eofbit is not set under normal file opening
    while(!in.eof())
    {
        c = in.get();
        cout << c << " " << hex << int(c) << "\n";
        // simulate an end of file state
        if(++i == 5) in.setstate(ios::eofbit);
    }
    return 0;
}

```

**Result:**

```

A 41
B 42
C 43
D 44
E 45

```

**16.4.4.8 fail**

To test for stream reading failure from any cause.

```

bool fail() const

```

## Remarks

The member function `fail()` will test for `failbit` and `badbit`.

Returns true if `failbit` or `badbit` is set in `rdstate()`.

## Listing: Example of `fail()` usage

```
// ewl-test file for input contains.
// float 33.33 double 3.16e+10 Integer 789 character C

#include <iostream>
#include <fstream>
#include <cstdlib>

int main()
{
using namespace std;

    char inFile[] = "ewl-test";
    ifstream in(inFile);
    if(!in.is_open())
    {cout << "Cannot open input file"; exit(1);}

    char ch = 0;
    while(!in.fail())
    {
        if(ch)cout.put(ch);
        in.get(ch);
    }

    return 0;
}
```

## Result:

```
float 33.33 double 3.16e+10 integer 789 character C
```

### 16.4.4.9 bad

To test for fatal I/O error.

**template class basic\_ios**

```
bool bad() const
```

**Remarks**

Use the member function `bad()` to test if a fatal input or output error occurred which sets the `badbit` flag in the stream.

Returns true if `badbit` is set in `rdstate()`.

**SeeAlso**

```
basic_ios::fail()
```

**Listing: Example of bad() usage:**

```
// The file ewl-test contains:
// abcdefghijklmnopqrstuvwxyz

#include <iostream>
#include <fstream>
#include <cstdlib>

char * inFile = "ewl-test";
using namespace std;
void status(istream &in);

int main()
{
    ifstream in(inFile);
    if(!in.is_open())
    {
        cout << "could not open file for input";
        exit(1);
    }
    int count = 0;
    int c;
    while((c = in.get()) != EOF)
    {
        // simulate a failed state
        if(count++ == 4) in.setstate(ios::failbit);
        status(in);
    }
    status(in);
}
```

```
    in.close();
    return 0;
}
void status(istream &in)
{
    // note: eof() is not needed in this example
    // if(in.eof()) cout << "EOF encountered \n";
    if(in.fail()) cout << "Non-Fatal I/O Error \n";
    if(in.good()) cout << "GoodBit set \n";
    if(in.bad()) cout << "Fatal I/O Error \n";
}
```

### Result:

```
GoodBit set
GoodBit set
GoodBit set
GoodBit set
Non-Fatal I/O Error
Non-Fatal I/O Error
```

#### 16.4.4.10 exceptions

To handle `basic_ios` exceptions.

```
iostate exceptions() const;
void exceptions(iostate except);
```

### Remarks

The function `exceptions()` determines what elements in `rdstate()` cause exceptions to be thrown. The overloaded `exceptions(iostate)` calls `clear(rdstate())` and leaves the argument `except` equal to `exceptions()`.

Returns a mask that determines what elements are set in `rdstate()`.

## 16.5 ios\_base manipulators

To provide an inline input and output formatting mechanism.

The topics in this section are:

- [fmtflags manipulators](#)
- [adjustfield manipulators](#)
- [basefield manipulators](#)
- [floatfield manipulators](#)
- [Overloading Manipulators](#)

## 16.5.1 fmtflags manipulators

To provide an inline input and output numerical formatting mechanism.

### Remarks

Manipulators are used in the stream to alter the formatting of the stream.

A reference to an object of type `ios_base` is returned to the stream. (The `this` pointer.)

**Table 16-7. Prototype of ios\_base manipulators**

Manipulator	Definition
<code>ios_base&amp; boolalpha(ios_base&amp;)</code>	insert and extract bool type in alphabetic format
<code>ios_base&amp; noboolalpha (ios_base&amp;)</code>	unsets insert and extract bool type in alphabetic format
<code>ios_base&amp; showbase(ios_base&amp; b)</code>	set the number base to parameter b
<code>ios_base&amp; noshowbase (ios_base&amp;)</code>	remove show base
<code>ios_base&amp; showpoint(ios_base&amp;)</code>	show decimal point
<code>ios_base&amp; noshowpoint(ios_base&amp;)</code>	do not show decimal point
<code>ios_base&amp; showpos(ios_base&amp;)</code>	show the positive sign
<code>ios_base&amp; noshowpos(ios_base&amp;)</code>	do not show positive sign
<code>ios_base&amp; skipws(ios_base&amp;)</code>	input only skip white spaces
<code>ios_base&amp; noskipws(ios_base&amp;)</code>	input only no skip white spaces
<code>ios_base&amp; uppercase(ios_base&amp;)</code>	show scientific in uppercase
<code>ios_base&amp; nouppercase (ios_base&amp;)</code>	do not show scientific in uppercase
<code>ios_base&amp; unitbuf (ios_base::unitbuf)</code>	set the unitbuf flag
<code>ios_base&amp; nounitbuf (ios_base::unitbuf)</code>	unset the unitbuf flag

## 16.5.2 adjustfield manipulators

To provide an inline input and output orientation formatting mechanism.

### Remarks



Manipulators are used in the stream to alter the formatting of the stream.

A reference to an object of type `ios_base` is returned to the stream. (The `this` pointer.)

**Table 16-8. Adjustfield manipulators**

Manipulator	Definition
<code>ios_base&amp; internal(ios_base&amp;)</code>	fill between indicator and value
<code>ios_base&amp; left(ios_base&amp;)</code>	left justify in a field
<code>ios_base&amp; right(ios_base&amp;)</code>	right justify in a field

### 16.5.3 basefield manipulators

To provide an inline input and output numerical formatting mechanism.

#### Remarks

Manipulators are used in the stream to alter the formatting of the stream.

A reference to an object of type `ios_base` is returned to the stream. (The `this` pointer.)

**Table 16-9. Basefield manipulators**

Manipulator	Definition
<code>ios_base&amp; dec(ios_base&amp;)</code>	format output data as a decimal
<code>ios_base&amp; oct(ios_base&amp;)</code>	format output data as octal
<code>ios_base&amp; hex(ios_base&amp;)</code>	format output data as hexadecimal

### 16.5.4 floatfield manipulators

To provide an inline input and output numerical formatting mechanism.

#### Remarks

Manipulators are used in the stream to alter the formatting of the stream.

A reference to an object of type `ios_base` is returned to the stream. (The `this` pointer.)

**Table 16-10. Floatfield manipulators**

Manipulator	Definition
<code>ios_base&amp; fixed(ios_base&amp;)</code>	format in fixed point notation
<code>ios_base&amp; scientific(ios_base&amp;)</code>	use scientific notation

**Listing: Example of manipulator usage:**

```

#include <iostream>
#include <iomanip>

int main()
{
using namespace std;

    long number = 64;

    cout << "Original Number is "
         << number << "\n\n";

    cout << showbase;

    cout << setw(30) << "Hexadecimal :"
         << hex << setw(10) << right
         << number <<'\n';

    cout << setw(30) << "Octal :" << oct
         << setw(10) << left
         << number <<'\n';

    cout << setw(30) << "Decimal :" << dec
         << setw(10) << right
         << number << endl;

    return 0;
}

```

**Result:**

```

Original Number is 64
Hexadecimal :                               0x40
Decimal :                                     Octal :0100                               64

```

**16.5.5 Overloading Manipulators**

To provide an inline formatting mechanism. The basic template for parameterless manipulators is shown in the listing below.

**Listing: Basic parameterless manipulator**

```

ostream &manip-name(ostream &stream)
{
    // coding
    return stream;
}

```

## Remarks

Use overloaded manipulators to provide specific and unique formatting methods relative to one class.

A reference to `ostream`. (Usually the `this` pointer.)

## See Also

<iomanip> for manipulators with parameters

## Listing: Example of overloaded manipulator usage:

```
#include <iostream>
using namespace std;
ostream &rJus(ostream &stream);

int main()
{
    cout << "align right " << rJus << "for column";
    return 0;
}

ostream &rJus(ostream &stream)
{
    stream.width(30);
    stream.setf(ios::right);
    return stream;
}
```

## Result:

```
align right                for column
```



## Chapter 17

# Stream Buffers

The header `<streambuf>` defines types that control input and output to character sequences.

### Listing: Header `<streambuf>`

```
namespace std {
template <class charT, class traits = char_traits<charT> >

    class basic_streambuf;

typedef basic_streambuf<char> streambuf;
typedef basic_streambuf<wchar_t> wstreambuf;
}
```

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Stream buffer requirements](#)
- [Class `basic\_streambuf`](#)

## 17.1 Stream buffer requirements

This section explains the constraints Stream buffers can impose.

The constraints include:

- The input sequence can be not readable
- The output sequence can be not writable
- The sequences can be associated with other presentations such as external files
- The sequences can support operations to or from associated sequences.
- The sequences can impose limitations on how the program can read and write characters to and from a sequence or alter the stream position.

There are three pointers that control the operations performed on a sequence or associated sequences. These are used for read, writes and stream position alteration. If not `null` all pointers point to the same `charT` array object.

- The beginning pointer or lowest element in an array. - (`beg`)
- The next pointer of next element addressed for read or write. - (`next`)
- The end pointer of first element addressed beyond the end of the array. - (`end`)

## 17.2 Class `basic_streambuf`

The template class `basic_streambuf` is an abstract class for deriving various stream buffers whose objects control input and output sequences.

The type `streambuf` is an instantiation of `char` type. the type `wstreambuf` is an instantiation of `wchar_t` type.

The prototype is listed below. Additional topics in this section are:

- [basic\\_streambuf Constructor](#)
- [basic\\_streambuf Public Member Functions](#)
- [Locales](#)
- [Buffer Management and Positioning](#)
- [Get Area](#)
- [Putback](#)
- [Put Area](#)
- [basic\\_streambuf Protected Member Functions](#)
- [Get Area Access](#)
- [Put Area Access](#)
- [basic\\_streambuf Virtual Functions](#)
- [Buffer Management and Positioning](#)
- [Get Area](#)
- [Putback](#)
- [Put Area](#)

### 17.2.1 `basic_streambuf` Constructor

The default constructor constructs an object of type `basic_streambuf`.

```
protected:  
    basic_streambuf();
```

## Remarks

The constructor sets all pointer member objects to null pointers and calls `getloc()` to copy the global locale at the time of construction.

### 17.2.1.1 Destructor

```
virtual ~basic_streambuf();
```

## Remarks

Removes the object from memory.

## 17.2.2 `basic_streambuf` Public Member Functions

The public member functions allow access to member functions from derived classes.

### 17.2.2.1 Locales

Locales are used for encapsulation and manipulation of information to a particular locale.

### 17.2.2.2 `basic_streambuf::pubimbue`

To set the locale.

```
locale pubimbue(const locale &loc);
```

## Remarks

The function `pubimbue` calls `imbue(loc)`.

Returns the previous value of `getloc()`.

### 17.2.2.3 basic\_streambuf::getloc

To get the locale.

```
locale getloc() const;
```

#### Remarks

If `pubimbue` has already been called, it returns the last value of `loc` supplied; otherwise the current one. If `pubimbue` has been called but has not returned a value from `imbue`, it then returns the previous value.

## 17.2.3 Buffer Management and Positioning

Functions used to manipulate the buffer and the input and output positioning pointers.

### 17.2.3.1 basic\_streambuf::pubsetbuf

To set an allocation after construction.

```
basic_streambuf<char_type, traits> *pubsetbuf  
(char_type* s, streamsize n);
```

#### Remarks

The first argument is used in an another function by a `filebuf` derived class. See `setbuf()`. The second argument is used to set the size of a dynamic allocated buffer.

Returns a pointer to `basic_streambuf<char_type, traits>` via `setbuf(s, n)`.

#### Listing: Example of `basic_streambuf::pubsetbuf()` usage:

```
#include <iostream>  
#include <sstream>  
  
const int size = 100;  
char temp[size] = "\\0";  
  
int main()  
{
```



```
using namespace std;

    stringbuf strbuf;
    strbuf.pubsetbuf('\0', size);
    strbuf.sputn("CodeWarrior",50);
    strbuf.sgetn(temp, 50);
    cout << temp;
    return 0;
}
```

### Result:

```
CodeWarrior
```

## 17.2.3.2 basic\_streambuf::pubseekoff

Determines the position of the get pointer.

```
pos_type pubseekoff
    (off_type off,
     ios_base::seekdir way, ios_base::openmode
     which = ios_base::in | ios_base::out);
```

### Remarks

The member function `pubseekoff()` is used to find the difference in bytes of the get pointer from a known position (such as the beginning or end of a stream). The function `pubseekoff()` returns a type `pos_type` which holds all the necessary information.

Returns a `pos_type` via `seekoff(off, way, which)`

### See Also

```
pubseekpos()
```

### Listing: Example of `basic_streambuf::pubseekoff()` usage:

```
// The ewl-test file contains originally
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <stdlib.h>
char inFile[] = "ewl-test";
```

## Class `basic_streambuf`

```
int main()
{
using namespace std;
    ifstream inOut(inFile, ios::in | ios::out);
    if(!inOut.is_open())
        {cout << "Could not open file"; exit(1);}

    ostream Out(inOut.rdbuf());
    char str[] = "\nRegistered Trademark";
    inOut.rdbuf()->pubseekoff(0, ios::end);
    Out << str;
    inOut.close();
    return 0;
}
```

### Result:

```
The File now reads:
CodeWarrior "Software at Work"
Registered Trademark
```

## 17.2.3.3 `basic_streambuf::pubseekpos`

Determine and move to a desired offset.

```
pos_type pubseekpos
(
    pos_type sp,
    ios_base::openmode which = ios::in | ios::out);
```

### Remarks

The function `pubseekpos()` is use to move to a desired offset using a type `pos_type`, which holds all necessary information.

Returns a `pos_type` via `seekpos(sb, which)`

### See Also

`pubseekoff()`, `seekoff()`

### Listing: Example of `streambuf::pubseekpos()` usage:

```
// The file ewl-test contains:
// ABCDEFGHIJKLMNOPQRSTUVWXYZ

#include <iostream>
#include <fstream>
#include <cstdlib>

int main()
{
using namespace std;
    ifstream in("ewl-test");
    if(!in.is_open())
        {cout << "could not open file"; exit(1);}
    streampos spEnd(0), spStart(0), aCheck(0);
    spEnd = spStart = 5;
```

```

aCheck = in.rdbuf()->pubseekpos(spStart, ios::in);

cout << "The offset at the start of the reading"
      << " in bytes is "
      << static_cast<streamoff>(aCheck) << endl;

char ch;
while(spEnd != spStart+10)
{
    in.get(ch);
    cout << ch;
    spEnd = in.rdbuf()->pubseekoff(0, ios::cur);
}

aCheck = in.rdbuf()->pubseekoff(0, ios::cur);
cout << "\nThe final position's offset"
      << " in bytes now is "
      << static_cast<streamoff>(aCheck) << endl;

in.close();
return 0;
}

```

**Result:**

```

The offset for the start of the reading in bytes is 5
FGHIJKLMNO
The final position's offset in bytes now is 15

```

**17.2.3.4 basic\_streambuf::pubsync**

To synchronize the `streambuf` object with its input/output.

```
int pubsync();
```

**Remarks**

The function `pubsync()` will attempt to synchronize the `streambuf` input and output.

Returns zero if successful or `EOF` if not via `sync()`.

**Listing: Example of `streambuf::pubsync()` usage:**

```

#include <iostream>
struct address {
    int number;
    char street[40];
}addbook;

int main()
{
using namespace std;

    cout << "Enter your street number: ";

```

**class basic\_streambuf**

```
cin >> addbook.number;

cin.rdbuf()->pubsync(); // buffer flush

cout << "Enter your street name: ";

cin.get(addbook.street, 40);

cout << "Your address is: "
      << addbook.number << " " << addbook.street;

return 0;
}
```

**Result:**

```
Enter your street number: 2201
Enter your street name: Donley Drive
Your address is: 2201 Donley Drive
```

## 17.2.4 Get Area

Public functions for retrieving input from a buffer.

### 17.2.4.1 basic\_streambuf::in\_avail

To test for availability of input stream.

```
streamsize in_avail();
```

**Remarks**

If a read is permitted returns size of stream as a type `streamsize`.

### 17.2.4.2 basic\_streambuf::snextc

To retrieve the next character in a stream.

```
int_type snextc();
```

**Remarks**

The function `snextc()` calls `sbumpc()` to extract the next character in a stream. After the operation, the get pointer references the character following the last character extracted.

If `sbumpc` returns `traits::eof`, otherwise returns `sgetc()`.

### Listing: Example of `streambuf::snextc()` usage:

```
#include <iostream>
#include <sstream>

const int size = 100;

int main()
{
    using namespace std;

    stringbuf strbuf;
    strbuf.pubsetbuf('\0', size);
    strbuf.sputn("ABCDE", 50);

    char ch;

        // look ahead at the next character
    ch =strbuf.snextc();

    cout << ch;

    // get pointer was not returned after peeking
    ch = strbuf.snextc();

    cout << ch;

    return 0;
}
```

### Result:

```
BC
```

### 17.2.4.3 `basic_streambuf::sbumpc`

To move the get pointer.

```
int_type sbumpc();
```

### Remarks

The function `sbumpc()` moves the get pointer one element when called.

## Return

The value of the character at the `get` pointer. It returns `uflow()` if it fails to move the pointer.

## See Also

`sgetc()`

## Listing: Example of `streambuf::sbumpc()` usage:

```
#include <iostream>
#include <sstream>

const int size = 100;
std::string buf = "CodeWarrior --Software at Work--";

int main()
{
    using namespace std;
    stringbuf strbuf(buf);
    int ch;
    for (int i = 0; i < 23; i++)
    {
        ch = strbuf.sgetc();
        strbuf.sbumpc();
        cout.put(ch);
    }

    cout << endl;
    cout << strbuf.str() << endl;
    return 0;
}
```

## Result:

```
CodeWarrior
CodeWarrior --Software at Work--
```

## 17.2.4.4 `basic_streambuf::sgetc`

To extract a character from the stream.

```
int_type sgetc();
```

## Remarks

The function `sgetc()` extracts a single character, without moving the `get` pointer.

A `int_type` type at the `get` pointer if available, otherwise returns `underflow()`.

For an example of `streambuf::sgetc()` usage refer to `streambuf::sbumpc()`

### 17.2.4.5 basic\_streambuf::sgetn

To extract a series of characters from the stream.

```
streamsize sgetn(char_type *s, streamsize n);
```

#### Remarks

The public member function `sgetn()` is used to extract a series of characters from the stream buffer. After the operation, the `get` pointer references the character following the last character extracted.

Returns a `streamsize` type as returned from the function `xsgetn(s,n)`.

For an example of `streambuf::sgetn()` usage refer to `pubsetbuf()`

## 17.2.5 Putback

Public functions to return a value to a stream.

### 17.2.5.1 basic\_streambuf::sputbackc

To put a character back into the stream.

```
int_type sputbackc(char_type c);
```

#### Remarks

The function `sputbackc()` will replace a character extracted from the stream with another character. The results are not assured if the putback is not immediately done or a different character is used.

If successful, returns a pointer to the `get` pointer as an `int_type` otherwise returns `pbackfail(c)`.

**Listing: Example of `streambuf::sputbackc()` usage:**

**Class basic\_streambuf**

```
#include <iostream>
#include <sstream>

std::string buffer = "ABCDEF";

int main()
{
using namespace std;

    stringbuf strbuf(buffer);

    char ch;

    ch = strbuf.sgetc(); // extract first character
    cout << ch;         // show it
        //get the next character
    ch = strbuf.snextc();
    // if second char is B replace first char with x
    if(ch == 'B') strbuf.sputbackc('x');
        // read the first character now x
    cout << (char)strbuf.sgetc();
    strbuf.sbumpc();      // increment get pointer
        // read second character
    cout << (char)strbuf.sgetc();
    strbuf.sbumpc();      // increment get pointer
        // read third character
    cout << (char)strbuf.sgetc();

        // show the new stream after alteration
    strbuf.pubseekoff(0, ios::beg);
    cout << endl;

    cout << (char)strbuf.sgetc();

    while( (ch = strbuf.snextc()) != EOF)
        cout << ch;

    return 0;
}
```



Result:

```
AxBC
```

```
xBCDEF
```

### 17.2.5.2 basic\_streambuf::sungetc

To restore a character extracted.

```
int_type sungetc();
```

#### Remarks

The function `sungetc()` restores the previously extracted character. After the operation, the `get` pointer references the last character extracted.

If successful, returns a pointer to the `get` pointer as an `int_type` otherwise returns `pbackfail(c)`.

For an example of `streambuf::sungetc()` usage refer to `streambuf::sputbackc()`

## 17.2.6 Put Area

Public functions for inputting characters into a buffer.

### 17.2.6.1 basic\_streambuf::sputc

To insert a character in the stream.

```
int_type sputc(char_type c);
```

#### Remarks

## class `basic_streambuf`

The function `sputc()` inserts a character into the stream. After the operation, the `get` pointer references the character following the last character inserted.

If successful, returns `c` as an `int_type` otherwise returns `overflow(c)`.

### Listing: Example of `streambuf::sputc()` usage:

```
#include <iostream>
#include <sstream>

int main()
{
    using namespace std;
    stringbuf strbuf;
    strbuf.sputc('A');
    char ch;
    ch = strbuf.sgetc();
    cout << ch;
    return 0;
}
```

### Result:

A

## 17.2.6.2 `basic_streambuf::sputn`

To insert a series of characters into a stream.

```
int_type sputn(char_type *s, streamsize n);
```

### Remarks

The function `sputn()` inserts a series of characters into a stream. After the operation, the `get` pointer references the character following the last character inserted.

Returns a `streamsize` type returned from a call to `xputn(s,n)`.

## 17.2.6.3 `basic_streambuf` Protected Member Functions

Protected member functions that are used for stream buffer manipulations by the `basic_streambuf` class and derived classes from it.

## 17.2.7 Get Area Access

Member functions for extracting information from a stream.

### 17.2.7.1 `basic_streambuf::eback`

Retrieve the beginning pointer for stream input.

```
char_type* eback() const;
```

#### Remarks

Returns the beginning pointer.

### 17.2.7.2 `basic_streambuf::gptr`

Retrieve the next pointer for stream input.

```
char_type* gptr() const;
```

#### Remarks

Returns the next pointer.

### 17.2.7.3 `basic_streambuf::egptr`

Retrieve the end pointer for stream input.

```
char_type* egptr() const;
```

#### Remarks

Returns the end pointer.

### 17.2.7.4 basic\_streambuf::gbump

Advances the next pointer for stream input.

```
void gbump(int n);
```

#### Remarks

The function `gbump()` advances the input pointer by the value of the `int n` argument.

### 17.2.7.5 basic\_streambuf::setg

To set the beginning, next and end pointers.

```
void setg  
(char_type *gbeg,  
 char_type *gnext,  
 char_type *gend);
```

#### Remarks

After the call to `setg()` the `gbeg` pointer equals `eback()`, the `gnext` pointer equals `gptr()`, and the `gend` pointer equals `egptr()`.

## 17.2.8 Put Area Access

Protected member functions for stream output sequences.

### 17.2.8.1 basic\_streambuf::pbase

To retrieve the beginning pointer for stream output.

```
char_type* pbase() const;
```

#### Remarks

Returns the `beginning` pointer.

### 17.2.8.2 `basic_streambuf::pptr`

To retrieve the next pointer for stream output.

```
char_type* pptr() const;
```

#### Remarks

Returns the `next` pointer.

### 17.2.8.3 `basic_streambuf::epptr`

To retrieve the end pointer for stream output.

```
char_type* epptr() const;
```

#### Remarks

Returns the `end` pointer.

### 17.2.8.4 `basic_streambuf::pbump`

To advance the next pointer for stream output.

```
void pbump(int n);
```

#### Remarks

The function `pbump()` advances the `next` pointer by the value of the `int` argument `n`.

### 17.2.8.5 `basic_streambuf::setp`

To set the values for the beginning, next and end pointers.

**class basic\_streambuf**

```
void setp  
    (char_type* pbeg,  
     char_type* pend);
```

**Remarks**

After the call to `setp()`, `pbeg` equals `pbase()`, `pbeg` equals `pptr()` and `pend` equals `epptr()`.

## 17.2.9 basic\_streambuf Virtual Functions

The virtual functions in `basic_streambuf` class are to be overloaded in any derived class.

### 17.2.9.1 Locales

To get and set the stream locale. These functions should be overridden in derived classes.

### 17.2.9.2 basic\_streambuf::imbue

To change any translations base on locale.

```
virtual void imbue(const locale &loc);
```

**Remarks**

The `imbue()` function allows the derived class to be informed in changes of locale and to cache results of calls to locale functions.

## 17.2.10 Buffer Management and Positioning

Virtual functions for positioning and manipulating the stream buffer. These functions should be overridden in derived classes.

### 17.2.10.1 `basic_streambuf::setbuf`

To set a buffer for stream input and output sequences.

```
virtual basic_streambuf<char_type, traits> *setbuf  
    (char_type* s, streamsize n);
```

#### Remarks

The function `setbuf()` is overridden in `basic_stringbuf` and `basic_filebuf` classes.

Returns the `this` pointer.

### 17.2.10.2 `basic_streambuf::seekoff`

To return an offset of the current pointer in an input or output stream.

```
virtual pos_type seekoff  
    (off_type off,  
     ios_base::seekdir way,  
     ios_base::openmode which = ios::in | ios::out);
```

#### Remarks

The function `seekoff()` is overridden in `basic_stringbuf` and `basic_filebuf` classes.

Returns a `pos_type` value, which is an invalid stream position.

### 17.2.10.3 `basic_streambuf::seekpos`

To alter an input or output stream position.

```
virtual pos_type seekpos  
    (pos_type sp,  
     ios_base::openmode which = ios::in | ios::out);
```

#### Remarks

The function `seekpos()` is overridden in `basic_stringbuf` and `basic_filebuf` classes.

Returns a `pos_type` value, which is an invalid stream position.

### 17.2.10.4 basic\_streambuf::sync

To synchronize the controlled sequences in arrays.

```
virtual int sync();
```

#### Remarks

If `pbase()` is non null the characters between `pbase()` and `pptr()` are written to the control sequence. The function `setbuf()` overrides the `basic_filebuf` class.

Returns zero if successful and -1 if failure occurs.

## 17.2.11 Get Area

Virtual functions for extracting information from an input stream buffer. These functions should be overridden in derived classes.

### 17.2.11.1 basic\_streambuf::showmanyc

Shows how many characters in an input stream

```
virtual int showmanyc();
```

#### Remarks

The function returns zero for the default behavior. Derived classes may return a negative one or a non-negative value. A positive value estimates the number of characters available in the sequence. If a positive value is returned, then successive calls to `underflow()` will not return `traits::eof()` until at least that number of characters have been extracted from the stream. If `showmanyc()` returns -1, then calls to `underflow()` or `uflow()` will fail.

Note that `underflow` or `uflow` might fail by throwing an exception prematurely. The intention is that the calls will not return `eof()` and will return immediately.



### 17.2.11.2 `basic_streambuf::xsgetn`

To read a number of characters from an input stream buffer.

```
virtual streamsize xsgetn  
    (char_type *s, streamsize n);
```

#### Remarks

The characters are read by repeated calls to `sbumpc()` until either `n` characters have been assigned or `EOF` is encountered.

Returns the number of characters read.

### 17.2.11.3 `basic_streambuf::underflow`

To show an underflow condition and not increment the get pointer.

```
virtual int_type underflow();
```

#### Remarks

The function `underflow()` is called when a character is not available for `sgetc()`.

There are many constraints for `underflow()`.

The pending sequence of characters is a concatenation of end pointer minus the get pointer plus some sequence of characters to be read from input.

The result character if the sequence is not empty, the first character in the sequence or the next character in the sequence.

The backup sequence if the beginning pointer is `null`, the sequence is empty, otherwise the sequence is the `get pointer` minus the beginning pointer.

Returns the first character of the pending sequence and does not increment the get pointer. If the position is `null` returns `traits::eof()` to indicate failure.

### 17.2.11.4 `basic_streambuf::uflow`

To show a underflow condition for a single character and increment the get pointer.

```
class basic_streambuf
```

```
    virtual int_type uflow();
```

## Remarks

The function `uflow()` is called when a character is not available for `sbumpc()`.

The constraints are the same as `underflow()`, with the exceptions that the resultant character is transferred from the pending sequence to the back up sequence and the pending sequence may not be empty.

Calls `underflow()` and if `traits::eof` is not returned returns the integer value of the `get` pointer and increments the `next` pointer for input.

## 17.2.12 Putback

Virtual functions for replacing data to a stream. These functions should be overridden in derived classes.

### 17.2.12.1 basic\_streambuf::pbackfail

To show a failure in a put back operation.

```
    virtual int_type pbackfail  
        (int_type c = traits::eof());
```

## Remarks

The resulting conditions are the same as the function `underflow()`.

The function `pbackfail()` is only called when a put back operation really has failed and returns `traits::eof`. If success occurs the return is undefined.

## 17.2.13 Put Area

Virtual function for inserting data into an output stream buffer.

These functions should be overridden in derived classes.

### 17.2.13.1 `basic_streambuf::xspn`

Write a number of characters to an output buffer.

```
virtual streamsize xspn  
(const char_type *s, streamsize n);
```

#### Remarks

The function `xspn()` writes to the output character by using repeated calls to `sputc(c)`. Write stops when `n` characters have been written or `EOF` is encountered.

Returns the number of characters written in a type `streamsize`.

### 17.2.13.2 `basic_streambuf::overflow`

Consumes the pending characters of an output sequence.

```
virtual int_type overflow  
(int_type c = traits::eof());
```

#### Remarks

The pending sequence is defined as the concatenation of the `put pointer` minus the `beginning pointer` plus either the sequence of characters or an empty sequence, unless the `beginning pointer` is null in which case the pending sequence is an empty sequence.

This function is called by `sputc()` and `sputn()` when the buffer is not large enough to hold the output sequence.

Overriding this function requires that:

When overridden by a derived class how characters are consumed must be specified.

After the overflow either the `beginning pointer` must be null or the `beginning` and `put pointer` must both be set to the same non-null value.

The function may fail if appending characters to an output stream fails or failure to set the previous requirement occurs.

The function returns `traits::eof()` for failure or some unspecified result to indicate success.



## Chapter 18

# Formatting and Manipulators

This chapter discusses formatting and manipulators in the input/output library.

There are three headers- `<istream>`, `<ostream>`, and `<iomanip>`-that contain stream formatting and manipulator routines and implementations.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Headers](#)
- [Input Streams](#)
- [Output streams](#)
- [Standard manipulators](#)

### 18.1 Headers

This section lists the header for `istream`, `ostream`, and `iomanip`.

- Header `<istream>` for input streams
- Header `<ostream>` for output streams
- Header `<iomanip>` for input and output manipulation

### 18.2 Input Streams

The header `<istream>` controls input from a stream buffer.

The topics in this section are:

- [Template class `basic\_istream`](#)
- [Class `basic\_istream::sentry`](#)
- [Formatted input functions](#)

- [Unformatted input functions](#)
- [Standard basic\\_istream manipulators](#)

## 18.2.1 Template class basic\_istream

A class that defines several functions for stream input mechanisms from a controlled stream buffer.

The `basic_istream` class is derived from the `basic_ios` class and provides many functions for input operations.

### 18.2.1.1 basic\_istream Constructors

Creates a `basic_istream` object.

```
explicit basic_istream  
(basic_streambuf<charT, traits>* sb);
```

#### Remarks

The `basic_istream` constructor is overloaded. It can be created as a base class with no arguments. It may be a simple input class initialized to a previous object's stream buffer.

### 18.2.1.2 Destructor

Destroy the `basic_istream` object.

```
virtual ~basic_istream()
```

#### Remarks

The `basic_istream` destructor removes from memory the `basic_istream` object.

#### Listing: Example of basic\_istream() usage:

```
// ewl-test file contains  
// Ask the teacher anything you want to know  
  
#include <iostream>
```

```
#include <fstream>
#include <cstdlib>

int main()
{
using namespace std;

    ofstream out("ewl-test", ios::out | ios::in);
    if(!out.is_open())
        {cout << "file did not open"; exit(1);}

    istream inOut(out.rdbuf());

    char c;
    while(inOut.get(c)) cout.put(c);
    return 0;
}
```

## Result:

Ask the teacher anything you want to know

## 18.2.2 Class `basic_istream::sentry`

A class for exception safe prefix and suffix operations.

### 18.2.2.1 Class `basic_istream::sentry` Constructor

Prepare for formatted or unformatted input

```
explicit sentry
(basic_istream<charT, traits>& is, bool noskipws = false);
```

## Remarks

If after the operation `is.good()` is `true` `ok_equals` `true` otherwise `ok_equals` `false`. The constructor may call `setstate(failbit)` which may throw an exception.

### 18.2.2.2 Destructor

Destroys a sentry object.

```
~sentry();
```

#### Remarks

The destructor has no effects.

### 18.2.2.3 `sentry::Operator bool`

To return the value of the data member `ok_`.

```
operator bool();
```

#### Remarks

Operator `bool` returns the value of `ok_`

## 18.2.3 Formatted input functions

Formatted functions provide mechanisms for input operations of specific types.

### 18.2.3.1 Common requirements

Each formatted input function begins by calling `ipfx()` and if the scan fails for any reason, then calls `setstate(failbit)`. The behavior of the scan functions are "as if" it was `fscanf()`.

### 18.2.3.2 Arithmetic Extractors Operator >>



Extractors that provide formatted arithmetic input operations. Each signature extracts the specified type and stores it in `n`.

```

basic_istream<charT, traits>& operator >>(bool & n);
basic_istream<charT, traits>& operator >>(short &n);
basic_istream<charT, traits>& operator >>(unsigned short &
n);
basic_istream<charT, traits>& operator >>(int & n);
basic_istream<charT, traits>& operator >>(unsigned int &n);
basic_istream<charT, traits>& operator >>(long & n);
basic_istream<charT, traits>& operator >>(unsigned long & n);
basic_istream<charT, traits>& operator >>(float & f);
basic_istream<charT, traits>& operator >>(double& f);
basic_istream<charT, traits>& operator >>long double& f);
    
```

## Remarks

The Arithmetic extractors extract a specific type from the input stream and store it in the address provided.

**Table 18-1. States and stdio equivalents**

state	stdio equivalent
(flags() & basefield) == oct	%o
(flags() & basefield) == hex	%x
(flags() & basefield) != 0	%X
(flags() & basefield) == 0	%i
Otherwise	
signed integral type	%d
unsigned integral type	%u

### 18.2.3.3 basic\_istream extractor operator >>

Extracts characters or sequences of characters and converts if necessary to numerical data.

```

basic_istream<charT, traits>& operator >>
(basic_istream<charT, traits>& (*pf)
(basic_istream<charT, traits>&))
    
```

Returns `pf(*this)`.

```

basic_istream<charT, traits>& operator >>
(basic_ios<charT, traits>& (*pf)(basic_ios<charT, traits>&))
    
```

Calls `pf(*this)` then returns `*this`.

```
basic_istream<charT, traits>& operator >>(char_type *s);
```

Extracts a char array and stores it in `s` if possible otherwise calls `setstate(failbit)`. If `width()` is set greater than zero `width()-1`, elements are extracted; otherwise up to size of `s-1` elements are extracted. Scan stops with a whitespace "as if" in `fscanf()`.

```
basic_istream<charT, traits>& operator >>(char_type& c);
```

Extracts a single character and stores it in `c` if possible, otherwise calls `setstate(failbit)`.

```
basic_istream<charT, traits>& operator >>(void*& p);
```

Converts a pointer to void and stores it in `p`.

```
basic_istream<charT, traits>& operator >>
(basic_streambuf<char_type, traits>* sb);
```

Extracts a `basic_streambuf` type and stores it in `sb` if possible, otherwise calls `setstate(failbit)`.

## Remarks

The various overloaded `extractors` are used to obtain formatted input dependent upon the type of argument. Since they return a reference to the calling stream they may be chained in a series of extractions. The overloaded extractors work "as if" like `fscanf()` in standard C and read until a white space character or EOF is encountered.

The white space character is not extracted and is not discarded, but simply ignored. Be careful when mixing unformatted input operations with the formatted extractor operators, such as when using console input.

The `this` pointer is returned.

## See Also

[basic\\_ostream::operator](#)

## Listing: Example of `basic_istream::` extractor usage:

```
// The ewl-test input file contains
// float 33.33 double 3.16e+10 Integer 789 character C

#include <iostream>
#include <fstream>
#include <cstdlib>

char ioFile[81] = "ewl-test";

int main()
{
    using namespace std;
    ifstream in(ioFile);
    if(!in.is_open())
        {cout << "cannot open file for input"; exit(1);}
}
```

```

char type[20];
double d;
int i;
char ch;

in  >> type >> d;
cout << type << " " << d << endl;

in  >> type >> d;
cout << type << " " << d << endl;

in  >> type >> i;
cout << type << " " << i << endl;

in  >> type >> ch;
cout << type << " " << ch << endl;
cout << "\nEnter an integer: ";

cin >> i;
cout << "Enter a word: ";

cin >> type;
cout << "Enter a character \ "
    << "then a space then a double: ";

cin >> ch >> d;
cout << i << " " << type << " "
    << ch << " " << d << endl;

in.close();
return 0;
}

```

**Result:**

```

float 33.33

double 3.16e+10

Integer 789

character C

Enter an integer: 123 <enter>

Enter a word: CodeWarrior <enter>

Enter a character then a space then a double: a 12.34 <enter>

123 CodeWarrior a 12.34

```

**18.2.3.4 Overloading Extractors**

To provide custom formatted data retrieval.

```

extractor prototype
Basic_istream &operator >>(basic_istream &s, const imanip<T>&)
{
    // procedures

    return s;
}

```

## Remarks

You may overload the `extractor` operator to tailor the specific needs of a particular class.

The `this` pointer is returned.

### Listing: Example of `basic_istream` overloaded extractor usage:

```
#include <iostream>
#include <iomanip>
#include <cstdlib>
#include <cstring>

class phonebook {
    friend std::ostream &operator<<(std::ostream &stream,
        phonebook o);
    friend std::istream &operator>>(std::istream &stream,
        phonebook &o);
private:
    char name[80];
    int areacode;
    int exchange;
    int num;
public:
    void putname() {std::cout << num;}
    phonebook() {}; // default constructor
    phonebook(char *n, int a, int p, int nm)
        {std::strcpy(name, n); areacode = a;
         exchange = p; num = nm;}
};

int main()
{
    using namespace std;
    phonebook a;
    cin >> a;
    cout << a;
    return 0;
}

std::ostream &operator<<(std::ostream &stream, phonebook o)
```

```

{
using namespace std;

    stream << o.name << " ";
    stream << "(" << o.areacode << ") ";
    stream << o.exchange << "-";
    cout << setfill('0') << setw(4) << o.num << "\n";
    return stream;
}

std::istream &operator>>(std::istream &stream, phonebook &o)
{
using namespace std;

    char buf[5];
    cout << "Enter the name: ";
    stream >> o.name;
    cout << "Enter the area code: ";
    stream >> o.areacode;
    cout << "Enter exchange: ";
    stream >> o.exchange;
    cout << "Enter number: ";
    stream >> buf;
    o.num = atoi(buf);
    cout << "\n";
    return stream;
}

```

**Result:**

```

Enter the name: CodeWarrior
Enter the area code: 512
Enter exchange: 996
Enter number: 5300
CodeWarrior (512) 996-5300

```

**18.2.4 Unformatted input functions**

The various unformatted input functions all begin by constructing an object of type `basic_istream::sentry` and ends by destroying the `sentry` object.

**NOTE**

Older versions of the library may begin by calling `ipfx()` and end by calling `isfx()` and returning the value specified.

**18.2.4.1 basic\_istream::gcount**

To obtain the number of bytes read.

```
streamsize gcount() const;
```

**Remarks**

Use the function `gcount()` to obtain the number of bytes read by the last unformatted input function called by that object.

Returns an `int` type count of the bytes read.

**Listing: Example of basic\_istream::gcount() usage:**

```
#include <iostream>
#include <fstream>

const SIZE = 4;

struct stArray {
    int index;
    double dNum;
};

int main()
{
    using namespace std;

    ofstream fOut("test");

    if(!fOut.is_open())
        {cout << "can't open out file"; return 1;}

    stArray arr;

    short i;

    for(i = 1; i < SIZE+1; i++)
    {
        arr.index = i;

        arr.dNum = i *3.14;

        fOut.write((char *) &arr, sizeof(stArray));
    }
}
```

```
}
fOut.close();
stArray aIn[SIZE];
ifstream fIn("test");
if(!fIn.is_open())
    {cout << "can't open in file"; return 2;}
long count =0;
for(i = 0; i < SIZE; i++)
{
    fIn.read((char *) &aIn[i], sizeof(stArray));
count+=fIn.gcount();
}
cout << count << " bytes read " << endl;
cout << "The size of the structure is "
    << sizeof(stArray) << endl;
for(i = 0; i < SIZE; i++)
cout << aIn[i].index << " " << aIn[i].dNum
    << endl;
fIn.close();
return 0;
}
```

### Result:

```
48 bytes read
The size of the structure is 12
1 3.14
2 6.28
3 9.42
4 12.56
```

#### 18.2.4.2 basic\_istream::get

Overloaded functions to retrieve a `char` or a `char` sequence from an input stream.

```
int_type get();
```

Extracts a character if available and returns that value, otherwise calls `setstate(failbit)` and returns `eof()`.

```
basic_istream<charT, traits>& get(char_type& c);
```

Extracts a character and assigns it to `c` if possible, else calls `setstate(failbit)`.

```
basic_istream<charT, traits>& get(char_type* s,
streamsize n, char_type delim = traits::newline());
```

### 18.2.4.2.1 Remarks

Extracts characters and stores them in a `char` array at an address pointed to by `s`, until:

- a limit (the second argument minus one) or the number of characters to be stored is reached
- a `delimiter` (the default value is the `newline` character) is met. In which case, the delimiter is not extracted.

If `end_of_file` is encountered, `setstate eofbit` is called.

If no characters are extracted `setstate(failbit)` is called. In any case, it stores a `null` character in the next available location of array `s`.

```
basic_istream<charT, traits>& get(basic_streambuf<char_type,
traits>& sb, char_type delim = traits::newline());
```

Extracts characters and assigns them to the `basic_streambuf` object `sb` if possible or else it calls `setstate(failbit)`. Extraction stops if:

- an insertion fails
- `end-of-file` is encountered
- an exception is thrown

Returns an integer when used with no argument. When used with an argument, if a character is extracted, the `get()` function returns the `this` pointer. If no character is extracted `setstate(failbit)` is called. In any case a `null char` is appended to the array.

### See Also

[basic\\_istream::getline](#)

### Listing: Examples of `basic_istream::get()` usage:

```
// READ ONE CHARACTER:
// ewl-test file for input

// float 33.33 double 3.16e+10 Integer 789 character C

#include <iostream>

#include <fstream>
```



```
#include <cstdlib>

int main()
{
using namespace std;

    char inFile[] = "ewl-test";
    ifstream in(inFile);
    if(!in.is_open())
    {cout << "Cannot open input file"; exit(1);}

    char ch;
    while(in.get(ch)) cout << ch;

    return 0;
}

//float 33.33 double 3.16e+10 Integer 789 character C
// READ ONE LINE:

#include <iostream>
const int size = 100;
char buf[size];
int main()
{
using namespace std;
    cout << " Enter your name: ";
    cin.get(buf, size);
    cout << buf;
    return 0;
}
```

## Result:

```
Enter your name: Johnny Socksorter<enter>
Johnny Socksorter
```

### 18.2.4.3 basic\_istream::getline

To obtain a delimiter terminated character sequence from an input stream.

```
basic_istream<charT, traits>& getline(char_type* s,
streamsize n, char_type delim = traits::newline());
```

## Remarks

The unformatted `getline()` function retrieves character input, and stores it in a character array buffer `s` if possible until the following conditions evaluated in this order occur. If no characters are extracted `setstate(failbit)` is called.

end-of-file occurs in which case `setstate eofbit)` is called.

A delimiter (default value is the newline character) is encountered. In which case the delimiter is read and extracted but not stored.

A limit (the second argument minus one) is read.

If `n-1` chars are read, that failbit gets set.

In any case it stores a null char into the next successive location of the array.

The `this` pointer is returned.

## See Also

[basic\\_ostream::flush](#)

## Listing: Example of `basic_istream::getline()` usage:

```
#include <iostream>
const int size = 120;

int main()
{
using namespace std;
    char compiler[size];
    cout << "Enter your compiler: ";
    cin.getline(compiler, size);
    cout << "You use " << compiler;
    return 0;
}
```

## Result:

```
Enter your compiler:CodeWarrior <enter>
You use CodeWarrior
```

```
#include <iostream>
const int size = 120;

#define TAB '\t'

int main()
{
using namespace std;
    cout << "What kind of Compiler do you use: ";
    char compiler[size];
    cin.getline(compiler, size,TAB);
    cout << compiler;
    cout << "\nsecond input not needed\n";
    cin >> compiler;
    cout << compiler;
    return 0;
}
```

**Result:**

What kind of Compiler do you use:

CodeWarrior<tab>Why?

CodeWarrior

second input not needed

Why?

**18.2.4.4 basic\_istream::ignore**

To extract and discard a number of characters.

```
basic_istream<charT, traits>& ignore
(steamsize n = 1, int_type delim = traits::eof());
```

**Remarks**

The function `ignore()` will extract and discard characters until:

- a limit is met (the first argument)
- end-of-file is encountered (in which case `setstate(eofbit)` is called)

The next character `c` is equal to the delimiter `delim`, in which case it is extracted except when `c` is equal to `traits::eof()`;

The `this` pointer is returned.

**Listing: Example of `basic_istream::ignore()` usage:**

```
// The file ewl-test contains:
// char ch; // to save char

//          /*This C comment will remain */

// while((ch = in.get())!= EOF) cout.put(ch);
// // read until failure
// /* the C++ comments won't */

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";
char bslash = '/';

int main()
```

**input Streams**

```

{
using namespace std;

    ifstream in(inFile);
    if(!in.is_open())
        {cout << "file not opened"; exit(1);}

    char ch;
    while((ch = in.get()) != EOF)
    {
        if(ch == bslash && in.peek() == bslash)
        {
            in.ignore(100, '\n');
            cout << '\n';
        }
        else
            cout << ch;
    }
    return 0;
}

```

**Result:**

```

char ch;
    /*This C comment will remain */
while((ch = in.get()) != EOF) cout.put(ch);
/* the C++ comments won't */

```

**18.2.4.5 basic\_istream::peek**

To view the next character to be extracted.

```
int_type peek();
```

**Remarks**

The function `peek()` allows you to look ahead at the next character in a stream to be extracted without extracting it.

If `good()` is false returns `traits::eof()` else returns the value of the next character in the stream.

**See Also**

Example of `basic_istream::peek()` usage see [basic\\_istream::ignore](#)

### 18.2.4.6 `basic_istream::read`

To obtain a block of binary data from an input stream.

```
basic_istream<charT, traits>& read
(char_type* s, streamsize n);
```

#### Remarks

The function `read()` will attempt to extract a block of binary data until the following conditions are met.

A limit of `n` number of characters are stored.

end-of-file is encountered on the input (in which case `setstate(failbit)` is called.

#### Return

The `this` pointer is returned.

#### SeeAlso

[basic\\_ostream::write](#)

#### Listing: Example of `basic_istream::read()` usage:

```
#include <iostream>
#include <fstream>

#include <iomanip>
#include <cstdlib>
#include <cstring>

struct stock {
    char name[80];
    double price;
    long trades;
};

char *Exchange = "BBSE";
char *Company = "Big Bucks Inc.";

int main()
{
```

**input Streams**

```

using namespace std;

    stock Opening, Closing;

    strcpy(Opening.name, Company);

    Opening.price = 180.25;

    Opening.trades = 581300;

    // open file for output
ofstream Market(Exchange, ios::out | ios::trunc | ios::binary);
if(!Market.is_open())
{cout << "can't open file for output"; exit(1);}
Market.write((char*) &Opening, sizeof(stock));

    Market.close();

    // open file for input
ifstream Market2(Exchange, ios::in | ios::binary);
if(!Market2.is_open())
{cout << "can't open file for input"; exit(2);}
Market2.read((char*) &Closing, sizeof(stock));

    cout << Closing.name << "\n"
    << "The number of trades was: " << Closing.trades << '\n';
cout << fixed << setprecision(2)
    << "The closing price is: $" << Closing.price << endl;
Market2.close();

return 0;

}

```

**Result:**

```

Big Bucks Inc.
The number of trades was: 581300
The closing price is: $180.25

```

**18.2.4.7 basic\_istream::readsome**

Extracts characters and stores them in an array.

```
streamsize readsome  
(charT_type* s, streamsize n);
```

## Remarks

The function `readsome` extracts and stores characters in the buffer pointed to by `s` until the following conditions are met.

- end-of-file is encountered (in which case `setstate(eofbit)` is called.)
- no characters are extracted
- a limit of characters is extracted; either `n` or the size of the buffer.

## Return

The number of characters extracted.

### Listing: Example of `basic_istream::readsome()` usage.

The file `ewl-test` contains:

CodeWarrior

Software at Work

Registered Trademark

```
#include <iostream>  
#include <fstream>  
#include <sstream>  
#include <cstdlib>  
const short SIZE = 81;  
int main()  
{  
using namespace std;  
    ifstream in("ewl-test");  
    if(!in.is_open())  
        {cout << "can't open file for input"; exit(1);}  
    char Buffer[SIZE] = "\0";  
    ostringstream Paragraph;  
    while(in.good() && (in.peek() != EOF))  
    {  
        in.readsome(Buffer, 5);  
        Paragraph << Buffer;  
    }  
    cout << Paragraph.str();  
    in.close();  
    return 0;  
}
```

## Result:

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## 18.2.4.8 basic\_istream::putback

To replace a previously extracted character.

```
basic_istream<charT, traits>& putback
(char_type c);
```

### Remarks

The function `putback()` allows you to replace the last character extracted by calling `rdbuf()->sungetc()`. If the buffer is empty, or if `sungetc()` returns `eof`, `setstate(failbit)` may be called.

### Return

The `this` pointer is returned.

### See Also

[basic\\_istream::unget](#)

### Listing: Example of basic\_istream::putback usage:

```
// The file ewl-test contains.
char ch; // to save char
        /* comment will remain */
while((ch = in.get()) != EOF) cout.put(ch);
// read until failure

#include <iostream>
#include <fstream>
#include <stdlib.h>

char inFile[] = "ewl-test";
char bslash = '/';

int main()
{
    using namespace std;

    ifstream in(inFile);

    if(!in.is_open())
        {cout << "file not opened"; exit(1);}

    char ch, tmp;
    while((ch = in.get()) != EOF)
    {
        if(ch == bslash)
        {
            in.get(tmp);
            if(tmp != bslash)
                in.putback(tmp);
            else continue;
        }
        cout << ch;
    }
    return 0;
}
```



**Result:**

```
char ch; // to save char
        /* comment will remain */
while((ch = in.get()) != EOF) cout.put(ch);
    read until failure
```

**18.2.4.9 basic\_istream::unget**

To replace a previously extracted character.

```
basic_istream<charT, traits>&unget();
```

**Remarks**

Use the function `unget()` to return the previously extracted character. If `rdbuf()` is `null` or if end-of-file is encountered `setstate(badbit)` is called.

The `this` pointer is returned.

**See Also**

[basic\\_istream::putback](#) , [basic\\_istream::ignore](#)

**Listing: Example of basic\_istream::unget() usage:**

```
// The file ewl-test contains:
// char ch; // to save char
//          /* comment will remain */
//          // read until failure
// while((ch = in.get()) != EOF) cout.put(ch);

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";
char bslash = '/';

int main()
{
using namespace std;
    ifstream in(inFile);
    if(!in.is_open())
        {cout << "file not opened"; exit(1);}
    char ch, tmp;
    while((ch = in.get()) != EOF)
        {
        if(ch == bslash)
            {
            in.get(tmp);
            if(tmp != bslash)
                in.unget();
            else continue;
            }
        cout << ch;
        }
}
```

**input Streams**

```
    return 0;
}
```

**Result:**

```
char ch; // to save char
        /* comment will remain */
        // read until failure
while((ch = in.get()) != EOF) cout.put(ch);
```

**18.2.4.10 basic\_istream::sync**

Synchronizes input and output

```
int sync();
```

**Remarks**

This function attempts to make the input source consistent with the stream being extracted.

If `rdbuf() ->pubsync()` returns `-1` `setstate(badbit)` is called and `traits::eof` is returned.

**Return**

If `rdbuf()` is `Null` returns `-1` otherwise returns zero.

**Listing: Example of basic\_istream::sync() usage:**

```
// The file ewl-test contains:
// This functions attempts to make the input source
// consistent with the stream being extracted.
// --
// CodeWarrior "Software at Work"
#include <iostream>
#include <fstream>
#include <cstdlib>
char inFile[] = "ewl-test";
int main()
{
using namespace std;
    ifstream in(inFile);
    if(!in.is_open())
        {cout << "could not open file"; exit(1);}
}
```

```
char str[10];

if(in.sync()          // return 0 if successful
   { cout << "cannot sync"; exit(1); }
while (in.good())
{
    in.get(str, 10, EOF);
    cout <<str;
}
return 0;
}
```

### Result:

```
This functions attempts to make the input source
consistent with the stream being extracted.
--
CodeWarrior "Software at Work"
```

#### 18.2.4.11 `basic_istream::tellg`

Determines the offset of the get pointer in a stream

```
pos_type tellg();
```

#### Remarks

The function `tellg` calls `rdbuf()->pubseekoff(0, cur, in)`.

The current offset is a `pos_type` if successful, else returns `-1`.

#### See Also

`basic_streambuf::pubseekoff()`

Example of `basic_istream::tellg()` usage see [basic\\_istream::seekg](#)

#### 18.2.4.12 `basic_istream::seekg`

Moves to a variable position in a stream.

**Input Streams**

```
basic_istream<charT, traits>& seekg(pos_type);
basic_istream<charT, traits>& seekg
(off_type, ios_base::seekdir dir);
```

**Remarks**

The function `seekg` is overloaded to take a `pos_type` object, or an `off_type` object (defined in `basic_ios` class.) The function is used to set the position of the `get` pointer of a stream to a random location for character extraction.

The `this` pointer is returned.

**See Also**

`basic_streambuf::pubseekoff()` and `pubseekpos()`.

**Listing: Example of `basic_istream::seekg()` usage:**

```
// The file ewl-test contains:
// ABCDEFGHIJKLMNOPQRSTUVWXYZ

#include <iostream>
#include <fstream>
#include <cstdlib>

int main()
{
using namespace std;
    ifstream in("ewl-test");
    if(!in.is_open())
        {cout << "could not open file"; exit(1);}

// note streampos is typedef in iosfwd
    streampos spEnd(5), spStart(5);
    in.seekg(spStart);
    streampos aCheck = in.tellg();
    cout << "The offset at the start of the reading in bytes is "
         << aCheck << endl;

    char ch;
    while(spEnd != spStart+10)
    {
        in.get(ch);
        cout << ch;
        spEnd = in.tellg();
    }

    aCheck = in.tellg();
    cout << "\nThe current position's offset in bytes now is "
         << aCheck << endl;

    streamoff gSet = 0;
    in.seekg(gSet, ios::beg);
    aCheck = in.tellg();
    cout << "The final position's offset in bytes now is "
         << aCheck << endl;

    in.close();
    return 0;
}
```

**Result:**

```
The offset at the start of the reading in bytes is 5
FGHIJKLMNO
The current position's offset in bytes now is 15
The final position's offset in bytes now is 0
```

## 18.2.5 Standard basic\_istream manipulators

The istream class provides several manipulators for input streams.

### 18.2.5.1 basic\_ifstream::ws

Provides inline style formatting.

```
template<class charT, class traits>
basic_istream<charT, traits> &ws
(basic_istream<charT,traits>& is);
```

#### Remarks

The ws manipulator skips whitespace characters in input.

The `this` pointer is returned.

#### Listing: Example of basic\_istream:: manipulator ws usage:

```
// The file ewl-test (where the number of blanks (and/or tabs)
// is unknown) contains:
//      a      b      c

#include <iostream>
#include <fstream>
#include <cstdlib>

int main()
{
    char * inFileName = "ewl-test";
    ifstream in(inFileName);
    if (!in.is_open())
    {cout << "Couldn't open for input\n"; exit(1);}
    char ch;
    in.unsetf(ios::skipws);
```

## Input Streams

```

cout << "Does not skip whitespace\n|";
while (1)
{
    in >> ch; // does not skip white spaces
    if (in.good())
        cout << ch;
    else break;
}
cout << "|\n\n";

//reset file position
in.clear();
in.seekg(0, ios::beg);

cout << "Does skip whitespace\n|";
while (1)
{
    in >> ws >> ch; // ignore white spaces

    if (in.good())
        cout << ch;
    else break;
}
cout << "|" << endl;

in.close();
return(0);
}

```

### Result:

```

Does not skip whitespace
|      a      b      c|
Does skip whitespace
|abc|

```

### 18.2.5.2 `basic_istream` Constructor

Constructs and destroys an object of the class `basic_istream`.

```
explicit basic_istream(basic_streambuf<charT, traits>* sb);
```

#### Remarks

Calls `basic_istream(<charT, traits>(sb)` and `basic_ostream(charT, traits>(sb)`. After it is constructed `rdbuf()` equals `sb` and `gcount()` equals zero.

#### 18.2.5.2.1 Destructor

```
virtual ~basic_istream();
```

#### Remarks

Destroys an object of type `basic_istream`.

## 18.3 Output streams

The include file `<ostream>` includes classes and types that provide output stream mechanisms.

The topics in this section are:

- [Template class `basic\_ostream`](#)
- [Class `basic\_ostream::sentry`](#)
- [Formatted output functions](#)
- [Unformatted output functions](#)
- [Standard `basic\_ostream` manipulators](#)

### 18.3.1 Template class `basic_ostream`

A class for stream output mechanisms.

The `basic_ostream` class provides for output stream mechanisms for output stream classes. The `basic_ostream` class may be used as an independent class, as a base class for the `basic_ofstream` class or a user derived class.

### 18.3.1.1 `basic_ostream` Constructor

Creates `basic_ostream` object for stream output.

```
explicit basic_ostream(basic_streambuf<char_type,
traits>*sb);
```

#### Remarks

The `basic_ostream` constructor constructs and initializes the base class object.

### 18.3.1.2 Destructor

Destroys an object of class `basic_ostream`.

```
virtual ~basic_ostream();
```

#### Remarks

Removes a `basic_ostream` object from memory.

#### Listing: Example of `basic_ostream()` usage:

```
// The ewl-test file contains originally
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";

int main()
{
using namespace std;

    ifstream inOut(inFile, ios::in | ios::out);

    if(!inOut.is_open())
        {cout << "Could not open file"; exit(1);}
}
```



```
ostream Out(inOut.rdbuf());  
  
char str[] = "\nRegistered Trademark";  
inOut.rdbuf()->pubseekoff(0, ios::end);  
Out << str;  
inOut.close();  
  
return 0;  
}
```

### Result:

```
The File now reads:  
CodeWarrior "Software at Work"  
Registered Trademark
```

## 18.3.2 Class `basic_ostream::sentry`

A class for exception safe prefix and suffix operations.

### 18.3.2.1 Class `basic_ostream::sentry` Constructor

Prepare for formatted or unformatted output.

```
explicit sentry(basic_ostream<charT, traits>& os);
```

#### Remarks

If after the operation `os.good()` is `true` `ok_ equals true` otherwise `ok_ equals false`. The constructor may call `setstate(failbit)` which may throw an exception.

### 18.3.2.2 Destructor

```
~sentry();
```

#### Remarks

The destructor under normal circumstances will call `os.flush()`.

### 18.3.2.3 `sentry::Operator bool`

Returns the value of the data member `ok_`.

```
operator bool();
```

#### Remarks

Operator `bool` returns the value of `ok_`.

## 18.3.3 Formatted output functions

Formatted output functions provide a manner of inserting for output specific data types.

### 18.3.3.1 Common requirements

The operations begin by calling `opfx()` and end by calling `osfx()` then returning the value specified for the formatted output.

Some output maybe generated by converting the scalar data type to a `NTBS` (null terminated byte string) text.

If the function fails for any reason the function calls `set state(failbit)`.

### 18.3.3.2 Arithmetic Inserter Operator `<<`

Provides formatted insertion of types into a stream.

```
basic_ostream<charT, traits>& operator<<(short n)
basic_ostream<charT, traits>& operator<<(unsigned short n)
basic_ostream<charT, traits>& operator<<(int n)
basic_ostream<charT, traits>& operator<<(unsigned int n)
basic_ostream<charT, traits>& operator<<(long n)
basic_ostream<charT, traits>& operator<<(unsigned long n)
basic_ostream<charT, traits>& operator<<(float f)
basic_ostream<charT, traits>& operator<<(double f)
basic_ostream<charT, traits>& operator<<(long double f)
```

#### Remarks

Converts an arithmetic value. The formatted values are converted as if they had the same behavior of the `fprintf()` function.

In most cases `*this` is returned unless failure, in which case `set_state(failbit)` is called.

**Table 18-2. Output states and stdio equivalents.**

Output State	stdio equivalent
Integers	
(flags() & basefield) == oct	%o
(flags() & basefield) == hex	%x
(flags() & basefield) != 0	%X
Otherwise	
signed integral type	%d
unsigned integral type	%u
Floating Point Numbers	
(flags() & floatfield) == fixed	%f
(flags() & floatfield) == scientific (flags() & uppercase) != 0	%e %E
Otherwise	
(flags() & uppercase) != 0	%g %G
An integral type other than a char type	
(flags() & showpos) != 0 (flags() & showbase) != 0	+ #
A floating point type	
(flags() & showpos) != 0 (flags() & showpoint) != 0	+ #

For any conversion, if `width()` is non-zero then a field with a conversion specification has the value of `width()`.

For any conversion, if `(flags() & fixed) != 0` or if `precision() > 0` the conversion specification is the value of `precision()`.

For any conversion, padding behaves in the following manner.

**Table 18-3. Conversion state and stdio equivalents**

State	Justification	stdio equivalent
(flags() & adjustfield) == left	left	space padding
(flags() & adjustfield) == internal	Internal	zero padding
Otherwise	right	space padding

The `ostream` insertion operators are overloaded to provide for insertion of most predefined types into an output stream. They return a reference to the `basic stream` object so they may be used in a chain of statements to input various types to the same stream.

### 18.3.3.3 basic\_ostream::operator<<

```
basic_ostream<charT, traits>& operator<<
(basic_ostream<charT, traits>&
(*pf)(basic_ostream<charT, traits>&));
```

Returns `pf(*this)`.

```
basic_ostream<charT, traits>& operator<<
(basic_ostream<charT, traits>&
(*pf)(basic_ios<charT, traits>&));
```

Calls `pf(*this)` return `*this`.

```
basic_ostream<charT, traits>& operator<<
(const char_type *s)basic_ostream<charT, traits>& operator<<
(char_type c)basic_ostream<charT, traits>& operator<<(bool n)
```

Behaves depending on how the `boolalpha` flag is set.

```
basic_ostream<charT, traits>& operator<<(void p)
```

Converts the pointer to `void p` as if the specifier was `%p` and returns `*this`.

```
basic_ostream<charT, traits>& operator<<
(basic_streambuf<char_type, traits>* sb);
```

If `sb` is null calls `setstate(failbit)` otherwise gets characters from `sb` and inserts them into `*this` until:

- end-of-file occurs
- inserting into the stream fails
- an exception is thrown.

If the operation fails, it calls `setstate(failbit)` or re-throws the exception, otherwise returns `*this`.

#### Remarks

The formatted output functions insert the values into the appropriate argument type.

Most `inserters` (unless noted otherwise) return the `this` pointer.

**Listing: Example of `basic_ostream` inserter usage:**

```

#include <iostream>
#include <fstream>

#include <cstdlib>

char oFile[81] = "ewl-test";

int main()
{
using namespace std;

    ofstream out(oFile);

    out << "float " << 33.33;

    out << " double " << 3.16e+10;

    out << " Integer " << 789;

    out << " character " << 'C' << endl;

    out.close();

    cout << "float " << 33.33;

    cout << "\ndouble " << 3.16e+10;

    cout << "\nInteger " << 789;

    cout << "\ncharacter " << 'C' << endl;

    return 0;
}

```

**Result:**

```

Output: to ewl-test
float 33.33 double 3.16e+10 Integer 789 character C
Output to console
float 33.33
double 3.16e+10
Integer 789
character C

```

**18.3.3.4 Overloading Inserters**

Provides specialized output mechanisms for an object.

```

Overloading
inserter prototype
basic_ostream &operator<<
(basic_ostream &stream, const omanip<T>&){
    // procedures;
    return stream;
}

```

**Remarks**

**Output streams**

You may overload the inserter operator to tailor it to the specific needs of a particular class.

The `this` pointer is returned.

**Listing: Example of overloaded inserter usage:**

```
#include <iostream>
#include <string.h>

#include <iomanip>

class phonebook {
    friend ostream &operator<<
        (ostream &stream, phonebook o);
protected:
    char *name;
    int areacode;
    int exchange;
    int num;
public:
    phonebook(char *n, int a, int p, int nm) :
        areacode(a),
        exchange(p),
        num(nm),
        name(n) {}
};

int main()
{
using namespace std;

    phonebook a("Sales", 800, 377, 5416);
    phonebook b("Voice", 512, 873, 4700);
    phonebook c("Fax", 512, 873, 4900);
    cout << a << b << c;
    return 0;
}

std::ostream &operator<<(std::ostream &stream, phonebook o)
{
    stream << o.name << " ";
}
```

```
stream << "(" << o.areacode << ") ";
stream << o.exchange << "-";
stream << setfill('0') << setw(4)
    << o.num << "\n";
return stream;
}
```

Result:

```
Sales (800) 377-5416
Voice (512) 873-4700
Fax (512) 873-4900
```

## 18.3.4 Unformatted output functions

Each unformatted output function begins by creating an object of the class `sentry`.

The unformatted output functions are ended by destroying the `sentry` object and may return a value specified.

### 18.3.4.1 `basic_ostream::tellp`

Returns the offset of the `put` pointer in an output stream.

```
pos_type tellp();
```

#### Return

If `fail()` returns `-1` else returns `rdbuf()->pubseekoff(0, cur, out)`.

#### See Also

[basic\\_istream::tellg](#), [basic\\_ostream::seekp](#)

Example of `basic_ostream::tellp()` usage see [basic\\_ostream::seekp](#)

### 18.3.4.2 `basic_ostream::seekp`

Randomly move to a position in an output stream.

## Output streams

```
basic_ostream<charT, traits>& seekp(pos_type);

basic_ostream<charT, traits>& seekp
    (off_type, iosbase::seekdir);
```

## Remarks

The function `seekp` is overloaded to take a single argument of a `pos_type` `pos` that calls `rdbuf()->pubseekpos(pos)`. It is also overloaded to take two arguments: an `off_type` `off` and an `ios_base::seekdir` `dir` that calls `rdbuf()->pubseekoff(off, dir)`.

Returns the `this` pointer.

## See Also

[basic\\_istream::seekg](#) , [basic\\_ostream::tellp](#)

## Listing: Example of `basic_ostream::seekp()` usage.

```
#include <iostream>
#include <sstream>
#include <string>

std::string motto = "CodeWarrior - Software at Work";

int main()
{
    using namespace std;
    ostringstream ostr(motto);
    streampos cur_pos, start_pos;
    cout << "The original array was :\n"
         << motto << "\n\n";
    // associate buffer

    stringbuf *strbuf(ostr.rdbuf());
    streamoff str_off = 10;
    cur_pos = ostr.tellp();
    cout << "The current position is "
         << cur_pos.offset()
         << " from the beginning\n";

    ostr.seekp(str_off);
    cur_pos = ostr.tellp();
    cout << "The current position is "
         << cur_pos.offset()
         << " from the beginning\n";

    strbuf->sputc('\0');
    cout << "The stringbuf array is\n"
         << strbuf->str() << "\n\n";
    cout << "The ostringstream array is still\n"
         << motto;

    return 0;
}
```

## Results:

```
The original array was :
CodeWarrior - Software at Work

The current position is 0 from the beginning
```



```
The current position is 10 from the beginning
The stringbuf array is
CodeWarrior
The ostream array is still
CodeWarrior - Software at Work
```

### 18.3.4.3 basic\_ostream::put

Places a single character in the output stream.

```
basic_ostream<charT, traits>& put(char_type c);
```

#### Remarks

The unformatted function `put()` inserts one character in the output stream. If the operation fails, it calls `setstate(badbit)`.

The `this` pointer is returned.

#### Listing: Example of `basic_ostream::put()` usage:

```
#include <iostream>
int main()
{
    using namespace std;

    char *str = "CodeWarrior \"Software at Work\"";
    while(*str)
    {
        cout.put(*str++);
    }

    return 0;
}
```

#### Result:

```
CodeWarrior "Software at Work"
```

### 18.3.4.4 basic\_ostream::write

Inserts a block of binary data into an output stream.

```
basic_ostream<charT, traits>& write
(const char_type* s, streamsize n);
```

#### Remarks

The overloaded function `write()` is used to insert a block of binary data into a stream. This function can be used to write an object by casting that object as a unsigned char pointer. If the operation fails, `setstate(badbit)` is called.

A reference to `ostream`. The `this` pointer is returned.

#### SeeAlso

[basic\\_istream::read](#)

#### Listing: Example of basic\_ostream::write() usage:

```
#include <iostream>
#include <fstream>
#include <iomanip>
#include <cstdlib>
#include <cstring>

struct stock {
    char name[80];
    double price;
    long trades;
};

char *Exchange = "BBSE";
char *Company = "Big Bucks Inc.";

int main()
{
    using namespace std;
    stock Opening, Closing;
    strcpy(Opening.name, Company);
    Opening.price = 180.25;
    Opening.trades = 581300;

    // open file for output
    ofstream Market(Exchange,
        ios::out | ios::trunc | ios::binary);

    if(!Market.is_open())
        {cout << "can't open file for output"; exit(1);}

    Market.write((char*) &Opening, sizeof(stock));
    Market.close();

    // open file for input

    ifstream Market2(Exchange, ios::in | ios::binary);

    if(!Market2.is_open())
        {cout << "can't open file for input"; exit(2);}
}
```

```

Market2.read((char*) &Closing, sizeof(stock));
cout << Closing.name << "\n"
    << "The number of trades was: "
    << Closing.trades << '\n';

cout << fixed << setprecision(2)
    << "The closing price is: $"
    << Closing.price << endl;

Market2.close();
return 0;
}

```

**Result:**

```

Big Bucks Inc.

The number of trades was: 581300

The closing price is: $180.25

```

**18.3.4.5 basic\_ostream::flush**

Forces the output buffer to release its contents.

```
basic_ostream<charT, traits>& flush();
```

**Remarks**

The function `flush()` is an output only function in C++. You may use it for an immediate expulsion of the output buffer. This is useful when you have critical data or you need to ensure that a sequence of events occurs in a particular order. If the operation fails, it calls `setstate(badbit)`.

The `this` pointer is returned.

Note that in the [Example of basic\\_ostream::flush\(\) usage](#): if you comment out the flush both lines will display simultaneously at the end of the program.

**Listing: Example of basic\_ostream::flush() usage:**

```

#include <iostream>
#include <iomanip>

#include <ctime>

class stopwatch {
private:
    double begin, set, end;
public:
    stopwatch();

```

## Output streams

```

    ~stopwatch();

    void start();

    void stop();

};

stopwatch::stopwatch()
{
using namespace std;

    begin = (double) clock() / CLOCKS_PER_SEC;
    end    = 0.0;

    start();

    cout << "begin the timer: ";
}

stopwatch::~~stopwatch()
{
using namespace std;

    stop();    // set end

    cout << "\nThe Object lasted: ";
    cout << fixed << setprecision(2)
         << end - begin << " seconds \n";
}

// clock ticks divided by ticks per second
void stopwatch::start()
{
using namespace std;

    set = double(clock()/CLOCKS_PER_SEC);
}

void stopwatch::stop()
{
using namespace std;

    end = double(clock()/CLOCKS_PER_SEC);
}

void time_delay(unsigned short t);

int main()
{

```

```
using namespace std;

    stopwatch watch; // create object and initialize
    cout.flush(); // this flushes the buffer
    time_delay(5);
    return 0; // destructor called at return
}

//time delay function
void time_delay(unsigned short t)
{
using namespace std;
    time_t tStart, tEnd;
    time(&tStart);
    while(tStart + t > time(&tEnd)){};
}
}
```

## Result:

```
begin the timer: < immediate display then pause >
begin the timer:
The Object lasted: 3.83 seconds
```

## 18.3.5 Standard `basic_ostream` manipulators

The `ostream` class provides an inline formatting mechanism.

### 18.3.5.1 `basic_ostream::endl`

To insert a newline and flush the output stream.

```
template < class charT, class traits >
basic_ostream<charT, traits> & endl
(basic_ostream<charT, traits>& os);
```

## Remarks

The manipulator `endl` takes no external arguments, but is placed in the stream. It inserts a newline character into the stream and flushes the output.

A reference to `basic_ostream`. The `this` pointer is returned.

## See Also

[basic\\_ostream::operator](#)

### 18.3.5.2 basic\_ostream::ends

To insert a NULL character.

```
template< class charT, class traits >
basic_ostream<charT, traits> &ends
(basic_ostream<charT,traits>& os);
```

## Remarks

The manipulator `ends`, takes no external arguments, but is placed in the stream. It inserts a NULL character into the stream, usually to terminate a string.

A reference to `ostream`. The `this` pointer is returned.

The `ostringstream` provides in-core character streams but must be null terminated by the user. The manipulator `ends` provides a null terminator.

## Listing: Example of basic\_ostream:: ends usage:

```
#include <iostream>
#include <sstream>

int main()
{
using namespace std;

    ostream out; // see note above
    out << "Ask the teacher anything\n";
    out << "OK, what is 2 + 2?\n";
    out << 2 << " plus " << 2 << " equals "
        << 4 << ends;
    cout << out.str();
    return 0;
}
```

Result:

```
Ask the teacher anything
OK, what is 2 + 2?
2 plus 2 equals 4?
```

### 18.3.5.3 basic\_ostream::flush

To flush the stream for output.

```
template<class charT, class traits>
basic_ostream<charT, traits> &
flush(basic_ostream<charT,traits> (os);
```

#### Remarks

The manipulator `flush`, takes no external arguments, but is placed in the stream. The manipulator `flush` will attempt to release an output buffer for immediate use without waiting for an external input.

A reference to `ostream`. The `this` pointer is returned.

Note in the [Example of basic\\_ostream:: flush usage](#): comment out the `flush` and both lines will display simultaneously at the end of the program.

#### See Also

[basic\\_ostream::flush](#)

#### Listing: Example of basic\_ostream:: flush usage:

```
#include <iostream>
#include <iomanip>
#include <ctime>

class stopwatch {
private:
    double begin, set, end;
public:
    stopwatch();
    ~stopwatch();
    void start();
    void stop();
};

stopwatch::stopwatch()
{
using namespace std;
    begin = (double) clock() / CLOCKS_PER_SEC;
    end    = 0.0;

    start();
    {
        begin = (double) clock() / CLOCKS_PER_SEC;
        end    = 0.0;
        start();
        cout << "begin time the timer: " << flush;
    }
}
```

**Standard manipulators**

```

}

stopwatch::~stopwatch()
{
using namespace std;
    stop(); // set end
    cout << "\nThe Object lasted: ";
    cout << fixed << setprecision(2)
        << end - begin << " seconds \n";
}

// clock ticks divided by ticks per second
void stopwatch::start()
{
    using namespace std;
    set = double(clock()/CLOCKS_PER_SEC);
}

void stopwatch::stop()
{
using namespace std;
    end = double(clock()/CLOCKS_PER_SEC);
}

void time_delay(unsigned short t);

int main()
{
using namespace std;
    stopwatch watch; // create object and initialize
    time_delay(5);
    return 0; // destructor called at return
}

//time delay function
void time_delay(unsigned short t)
{
using namespace std;
    time_t tStart, tEnd;
    time(&tStart);
    while(tStart + t > time(&tEnd)){};
}

```

**Results:**

```

begin time the timer:
< short pause >
The Object lasted: 3.78 seconds

```

## 18.4 Standard manipulators

The include file `iomaniip` defines a template class and related functions for input and output manipulation.

### 18.4.1 Standard Manipulator Instantiations

Creates a specific use instance of a template by replacing the parameterized elements with pre-defined types.



## 18.4.2 resetiosflags

To unset previously set formatting flags.

### Prototypes

```
smanip resetiosflags(ios_base::fmtflags mask)
```

### Remarks

Use the manipulator `resetiosflags` directly in a stream to reset any format flags to a previous condition. You would normally store the return value of `setf()` in order to achieve this task.

A `smanip` type is returned, which is an implementation defined type.

### See Also

```
ios_base::setf(), ios_base::unsetf()
```

### Listing: Example of `resetiosflags()` usage:

```
#include <iostream>
#include <iomanip>

int main()
{
    using namespace std;
    double d = 2933.51;
    long flags;
    flags = ios::scientific | ios::showpos | ios::showpoint;

    cout << "Original: " << d << endl;
    cout << "Flags set: " << setiosflags(flags)
        << d << endl;
    cout << "Flags reset to original: "
        << resetiosflags(flags) << d << endl;
    return 0;
}
```

### Result:

```
Original:    2933.51

Flags set:   +2.933510e+03

Flags reset to original:    2933.51
```

## 18.4.3 setiosflags

To set the stream format flags.

## Prototypes

```
smanip setiosflags(ios_base::fmtflags mask)
```

## Remarks

Use the manipulator `setiosflags()` to set the input and output formatting flags directly in the stream.

A `smanip` type is returned, which is an implementation defined type.

## See Also

`ios_base::setf()`, `ios_base::unsetf()`

For example of `setiosflags()` usage see [resetiosflags](#)

## 18.4.4 setbase

To set the numeric base of an output.

```
smanip setbase(int)
```

## Remarks

The manipulator `setbase()` directly sets the numeric base of integral output to the stream. The arguments are in the form of 8, 10, 16, or 0, and 8 octal, 10 decimal and 16 hexadecimal. Zero represents `ios::basefield`; a combination of all three.

Returns a `smanip` type, which is an implementation defined type.

## See Also

`ios_base::setf()`

### Listing: Example of setbase usage:

```
#include <iostream>
#include <iomanip>

int main()
{
    using namespace std;
    cout << "Hexadecimal "
         << setbase(16) << 196 << '\n';
    cout << "Decimal " << setbase(10) << 196 << '\n';
    cout << "Octal " << setbase(8) << 196 << '\n';
    cout.setf(ios::hex, ios::oct | ios::hex);
}
```

```

cout << "Reset to Hex " << 196 << '\n';
cout << "Reset basefield setting "
    << setbase(0) << 196 << endl;
return 0;
}

```

**Result:**

```

Hexadecimal c4
Decimal 196
Octal 304
Reset to Hex c4
Reset basefield setting 196

```

**18.4.5 setfill**

To specify the characters to insert in unused spaces in the output.

```
smanip setfill(int c)
```

**Remarks**

Use the manipulator `setfill()` directly in the output to fill blank spaces with character `c`.

Returns a `smanip` type, which is an implementation defined type.

**See Also**

```
basic_ios::fill
```

**Listing: Example of `basic_ios::setfill()` usage:**

```

#include <iostream>
#include <iomanip>

int main()
{
using namespace std;
    cout.width(8);
    cout << setfill('*') << "Hi!" << "\n";
    char fill = cout.fill();
    cout << "The filler is a " << fill << endl;
    return 0;
}

```

**Result:**

```

Hi!*****
The filler is a *

```

**18.4.6 setprecision**

Set and return the current format precision.

```
smanip<int> setprecision(int)
```

## Remarks

Use the manipulator `setprecision()` directly in the output stream with floating point numbers to limit the number of digits. You may use `setprecision()` with scientific or non-scientific floating point numbers.

With the flag `ios::floatfield` set, the number in `setprecision` refers to the total number of significant digits generated. If the settings are for either `ios::scientific` or `ios::fixed` then the `setprecision` refers to the number of digits after the decimal place.

This means that `ios::scientific` will have one more significant digit than `ios::floatfield`, and `ios::fixed` will have a varying number of digits.

Returns a `smanip` type, which is an implementation defined type.

## See Also

```
ios_base::setf(), ios_base::precision()
```

## Listing: Example of `setprecision()` usage:

```
#include <iostream>
#include <iomanip>

int main()
{
    using namespace std;
    cout << "Original: " << 321.123456 << endl;
    cout << "Precision set: " << setprecision(8)
        << 321.123456 << endl;
    return 0;
}
```

## Result:

```
Original: 321.123
Precision set: 321.12346
```

## 18.4.7 setw

To set the width of the output field.

```
smanip<int> setw(int)
```

## Remarks

Use the manipulator `setw()` directly in a stream to set the field size for output. A pointer to `ostream` is returned.

## See Also

`ios_base::width()`

### Listing: Example of `setw()` usage:

```
#include <iostream>
#include <iomanip>

int main()
{
using namespace std;
    cout << setw(8)
         << setfill('*')
         << "Hi!" << endl;
    return 0;
}
```

### Result:

```
Hi!*****
```

## 18.4.8 Overloaded Manipulator

To store a function pointer and object type for input.

Overloaded input manipulator for `int` type.

```
istream &manip_name(istream &stream, type param) {
// body of code
return stream;
}
```

Overloaded output manipulator for `int` type.

```
ostream &manip_name(ostream &stream, type param){
// body of code
return stream;
}
```

For other input/output types

```
smanip<type> manip_name(type param) {
return smanip<type> (manip_name, param);
}
```

## Remarks

Use an overloaded manipulator to provide special and unique input handling characteristics for your class.

Returns a pointer to stream object.

### Listing: Example of overloaded manipulator usage:

## Standard manipulators

```

#include <iostream>
#include <cstring>
#include <cstdlib>
#include <cctype>

char buffer[80];
char *Password = "CodeWarrior";

struct verify
{
    explicit verify(char* check) : check_(check) {}
    char* check_;
};

char *StrUpr(char * str);
std::istream& operator >> (std::istream& stream, const verify& v);

int main()
{
    using namespace std;
    cin >> verify(StrUpr(Password));
    cout << "Log in was Completed ! \n";
    return 0;
}

std::istream& operator >> (std::istream& stream, const verify& v)
{
    using namespace std;
    short attempts = 3;
    do {
        cout << "Enter password: ";
        stream >> buffer;
        StrUpr(buffer);

        if (! strcmp(v.check_, buffer)) return stream;
        cout << "\a\a";

        attempts--;
    } while(attempts > 0);
    cout << "All Tries failed \n";
    exit(1);
    return stream;
}

char *StrUpr(char * str)
{
    char *p = str; // dupe string
    while(*p) *p++ = static_cast<char>(std::toupper(*p));
    return str;
}

```

## Result:

```

Enter password: <codewarrior>
Enter password: <mw>
Enter password: <CodeWarrior>
Log in was Completed !

```

## Chapter 19

# String Based Streams

This chapter discusses string-based streams in the standard C++ library.

There are four template classes and 6 various types defined in the header `<sstream>` that are used to associate stream buffers with objects of class `basic_string`.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Header `<sstream>`](#)
- [Template class `basic\_stringbuf`](#)
- [Template class `basic\_istream`](#)
- [Class `basic\_ostringstream`](#)
- [Class `basic\_stringstream`](#)

### 19.1 Header `<sstream>`

The header `<sstream>` includes classes and types that associate stream buffers with string objects for input and output manipulations.

#### NOTE

The class `basic_string` is discussed in previous chapters.

### 19.2 Template class `basic_stringbuf`

The template class `basic_stringbuf` is derived from `basic_streambuf` and used to associate both input and output streams with an object of class `basic_string`.

**template class basic\_stringbuf**

The class `basic_stringbuf` is derived from `basic_streambuf` to associate a stream with a `basic_string` object for in-core memory character manipulations.

## 19.2.1 basic\_stringbuf constructors

The `basic_stringbuf` has two constructors to create a string buffer for characters for input/output.

```
explicit basic_stringbuf(ios_base::openmode which = ios_base::in | ios_base::out);

explicit basic_stringbuf(const basic_string <char_type> &str, ios_base::openmode which =
ios_base::in | ios_base::out);
```

### Remarks

The `basic_stringbuf` constructor is used to create an object usually as an intermediate storage object for input and output. The overloaded constructor is used to determine the input or output attributes of the `basic_string` object when it is created.

No array object is allocated for the first `basic_stringbuf` constructor.

### Listing: Example of `basic_stringbuf::basic_stringbuf()` usage:

```
#include <iostream>
#include <sstream>

const int size = 100;

int main()
{
using namespace std;

    stringbuf strbuf;
    strbuf.pubsetbuf('\0', size);
    strbuf.sputn("ABCDE", 50);

    char ch;

        // look ahead at the next character
    ch =strbuf.snextc();
    cout << ch;

        // get pointer was not returned after peeking
    ch = strbuf.snextc();
    cout << ch;
```



```

return 0;
}

```

Result:

```
BC
```

## 19.2.2 Member functions

The class `basic_stringbuf` has one member function.

### 19.2.2.1 `basic_stringbuf::str`

To return or clear the `basic_string` object stored in the buffer.

```

basic_string<char_type> str() const;
void str(const basic_string<char_type>&s);

```

#### Remarks

The function `str()` freezes the buffer then returns a `basic_string` object.

The function `str(const string s)` assigns the value of the string `s` to the `stringbuf` object.

The no argument version returns a `basic_string` if successful. The function with an argument has no return.

#### Listing: Example of `basic_stringbuf::str()` usage:

```

#include <iostream>
#include <sstream>
#include <cstring>

char CW[] = "CodeWarrior";
char AW[] = " - \"Software at Work\"";

int main()
{
using namespace std;
string buf;
stringbuf strbuf(buf, ios::in | ios::out);
int size;
size = strlen(CW);
strbuf.sputn(CW, size);
size = strlen(AW);
strbuf.sputn(AW, size);

cout << strbuf.str() << endl;

// Clear the buffer then fill it with
// new information and then display it
string clrBuf = "";

```

**template class basic\_stringbuf**

```

string ANewLine = "We Listen we Act";
strbuf.str(clrBuf);
strbuf.sputn( ANewLine.c_str(), ANewLine.size());
cout << strbuf.str() << endl;

return 0;
}

```

**Results**

```
CodeWarrior - "Software at Work"
```

```
We Listen we Act
```

**19.2.3 Overridden virtual functions**

The base class `basic_streambuf` has several virtual functions that are to be overloaded by derived classes. They are:

- `underflow()`
- `pbackfail()`
- `overflow()`
- `seekoff()`
- `seekpos()`

**19.2.3.1 basic\_stringbuf::underflow**

To show an underflow condition and not increment the get pointer.

```
virtual int_type underflow();
```

**Remarks**

The function `underflow` overrides the `basic_streambuf` virtual function.

Returns the first character of the pending sequence and does not increment the get pointer. If the position is `null` returns `traits::eof()` to indicate failure.

**See Also**

```
basic_streambuf::underflow()
```

**19.2.3.2 basic\_stringbuf::pbackfail**

To show a failure in a put back operation.

```
virtual int_type pbackfail
    (int_type c = traits::eof());
```

## Remarks

The function `pbackfail` overrides the `basic_streambuf` virtual function.

The function `pbackfail()` is only called when a put back operation really has failed and returns `traits::eof`. If success occurs the return is undefined.

## See Also

```
basic_streambuf::pbackfail()
```

### 19.2.3.3 `basic_stringbuf::overflow`

Consumes the pending characters of an output sequence.

```
virtual int_type overflow
    (int_type c = traits::eof());
```

## Remarks

The function `overflow` overrides the `basic_streambuf` virtual function.

The function returns `traits::eof()` for failure or some unspecified result to indicate success.

## See Also

```
basic_streambuf::overflow()
```

### 19.2.3.4 `basic_stringbuf::seekoff`

To return an offset of the current pointer in an input or output stream.

```
virtual pos_type seekoff
    (off_type off,
     ios_base::seekdir way,
     ios_base::openmode which =
     ios_base::in | ios_base::out);
```

## Remarks

The function `seekoff` overrides the `basic_streambuf` virtual function.

```
template class basic_istream
```

A `pos_type` value is returned, which is an invalid stream position.

### See Also

```
basic_streambuf::seekoff()
```

### 19.2.3.5 basic\_stringbuf::seekpos

To alter an input or output stream position.

```
virtual pos_type seekpos
    (pos_type sp,
     ios_base::openmode which =
     ios_base::in | ios_base::out);
```

### Remarks

If the open mode is `in` or `out`, the function alters the stream position of both the input and output sequences. If the open mode is `in`, it alters the stream position of the input sequence. If the open mode is `out`, it alters the stream position of the output sequence. If `sp` is an invalid stream position, the operation fails and the return value is `pos_type(off_type(-1))`. Otherwise, the function returns the current new position.

If neither the `in` or `out` sequence is positioned, `pos_type(off_type(-1))` is returned.

### See Also

```
basic_streambuf::seekpos()
```

## 19.3 Template class basic\_istream

The template class `basic_istream` is derived from `basic_istream` and is used to associate input streams with an object of class `basic_string`.

The class `basic_istream` uses an object of type `basic_stringbuf` to control the associated storage.

### 19.3.1 basic\_istream Constructor

The `basic_istringstream` constructors create a `basic_stringstream` object and initializes the `basic_streambuf` object.

```
explicit basic_istringstream (ios_base::openmode which = ios_base::in);

explicit basic_istringstream (const basic_string<charT> &str, ios_base::openmode which =
ios_base::in);
```

## Remarks

The `basic_istringstream` constructor is overloaded to accept an object of class `basic_string` for input.

## See Also

`basic_ostringstream`, `basic_stringstream`

## Listing: Example of `basic_istringstream::basic_istringstream()` usage

```
#include <iostream>
#include <string>
#include <sstream>

int main()
{
using namespace std;
    string sBuffer = "3 12.3 line";
    int num = 0;
    double flt = 0;
    char szArr[20] = "\0";

    istringstream Paragraph(sBuffer, ios::in);
    Paragraph >> num;
    Paragraph >> flt;
    Paragraph >> szArr;

    cout << num << " " << flt << " "
        << szArr << endl;
    return 0;
}
```

## Result

```
3 12.3 line
```

## 19.3.2 Member functions

The class `basic_istringstream` has two member functions.

### 19.3.2.1 `basic_istringstream::rdbuf`

To retrieve a pointer to the stream buffer.

## template class `basic_istream`

```
basic_stringbuf<charT, traits>* rdbuf() const;
```

### Remarks

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer.

A pointer to an object of type `basic_stringbuf sb` is returned by the `rdbuf` function.

### See Also

```
basic_ostringstream::rdbuf()
```

```
basic_ios::rdbuf()
```

```
basic_stringstream::rdbuf()
```

### Listing: Example of `basic_istream::rdbuf()` usage.

```
#include <iostream>
#include <sstream>

std::string buf = "CodeWarrior - \"Software at work\"";
char words[50];

int main()
{
    using namespace std;
    istringstream ist(buf);
    istream in(ist.rdbuf());
    in.seekg(25);
    in.get(words, 50);
    cout << words;
    return 0
}
```

### Result

```
"Software at work"
```

## 19.3.2.2 `basic_istream::str`

To return or assign the `basic_string` object stored in the buffer.

```
basic_string<charT> str() const;
void str(const basic_string<charT> &s);
```

### Remarks

The function `str()` freezes the buffer then returns a `basic_string` object.

The function `str(const string s)` assigns the value of the `string `s'` to the `stringbuf` object.

The no argument version returns a `basic_string` if successful. The function with an argument has no return.

## See Also

```
basic_stringbuf::str()
```

```
basic_ostringstream.str()
```

```
basic_stringstream::str()
```

## Listing: Example of `basic_istringstream::str()` usage.

```
#include <iostream>
#include <sstream>

std::string buf = "CodeWarrior - \"Software at Work\"";

int main()
{
    using namespace std;
    istringstream istr(buf);
    cout << istr.str();
    return 0;
}
```

## Result:

```
CodeWarrior - "Software at Work"
```

## 19.4 Class `basic_ostringstream`

The template class `basic_ostringstream` is derived from `basic_ostream` and used to associate output streams with an object of class `basic_string`.

The class `basic_ostringstream` uses an object of type `basic_stringbuf` to control the associated storage.

### 19.4.1 `basic_ostringstream` Constructor

The `basic_ostringstream` constructors create a `basic_stringstream` object and initialize the `basic_streambuf` object.

```
explicit basic_ostringstream
    (ios_base::openmode which = ios_base::out);

explicit basic_ostringstream
    (const basic_string<charT> &str, ios_base::openmode which = ios_base::out);
```

## Remarks

The `basic_ostringstream` constructor is overloaded to accept an object of class `basic_string` for output.

## See Also

`basic_istringstream`, `basic_stringstream`

## Listing: Example of `basic_ostringstream::basic_ostringstream()` usage

```
// The file ewl-test contains
// CodeWarrior - "Software at Work"
// Registered Trademark

#include <iostream>
#include <fstream>
#include <sstream>
#include <cstdlib>

int main()
{
using namespace std;
    ifstream in("ewl-test");
    if(!in.is_open())
        {cout << "can't open file for input"; exit(1);}

    ostringstream Paragraph;
    char ch = '\0';
    while((ch = in.get()) != EOF)
    {
        Paragraph << ch;
    }
    cout << Paragraph.str();

    in.close();
    return 0;
}
```

## Result:

```
CodeWarrior - "Software at Work"
Registered Trademark
```

## 19.4.2 Member functions

The class `basic_ostringstream` has two member functions.

### 19.4.2.1 `basic_ostringstream::rdbuf`

To retrieve a pointer to the stream buffer.

```
basic_stringbuf<charT, traits>* rdbuf() const;
```



## Remarks

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer.

A pointer to an object of type `basic_stringbuf sb` is returned by the `rdbuf` function.

## See Also

`basic_ostringstream::rdbuf()`

`basic_ios::rdbuf()`

`basic_stringstream::rdbuf()`

## Listing: example of `basic_ostringstream::rdbuf()` usage

```
#include <iostream>
#include <sstream>
#include <string>

std::string motto = "CodeWarrior - \"Software at Work\"";

int main()
{
    using namespace std;
    ostringstream ostr(motto);
    streampos cur_pos(0), start_pos(0);
    cout << "The original array was :\n"
         << motto << "\n\n";
    // associate buffer

    stringbuf *strbuf(ostr.rdbuf());
    streamoff str_off = 10;
    cur_pos = ostr.tellp();
    cout << "The current position is "
         << static_cast<streamoff>(cur_pos);
         << " from the beginning\n";

    ostr.seekp(str_off);
    cur_pos = ostr.tellp();
    cout << "The current position is "
         << static_cast<streamoff>(cur_pos);
         << " from the beginning\n";

    strbuf->sputc('\0');
    cout << "The stringbuf array is\n"
         << strbuf->str() << "\n\n";

    cout << "The ostringstream array is still\n"
         << motto;
    return 0;
}
```

## Results:

```
The original array was :
CodeWarrior - "Software at Work"
The current position is 0 from the beginning
The current position is 10 from the beginning
```

```
The stringbuf array is
CodeWarrior
CodeWarrior - "Software at Work"
```

### 19.4.2.2 basic\_ostringstream::str

To return or assign the `basic_string` object stored in the buffer.

```
basic_string<charT> str() const;
void str(const basic_string<charT> &s);
```

#### Remarks

The function `str()` freezes the buffer then returns a `basic_string` object.

The function `str(const string s)` assigns the value of the string `s` to the `stringstream` object.

The no argument version returns a `basic_string` if successful. The function with an argument has no return.

#### See Also

`basic_stringbuf::str()`, `basic_istringstream.str()`

`basic_stringstream::str()`

#### Listing: Example of `basic_ostringstream::str()` usage.

```
#include <iostream>
#include <sstream>

int main()
{
    using namespace std;
    ostringstream out;

    out << "Ask the teacher anything\n";
    out << "OK, what is 2 + 2?\n";
    out << 2 << " plus " << 2 << " equals "
        << 4 << ends;

    cout << out.str();
    return 0;
}
```

#### Result:

```
Ask the teacher anything
OK, what is 2 + 2?
2 plus 2 equals 4?
```

## 19.5 Class basic\_stringstream

The template class `basic_stringstream` is derived from `basic_ostream` and used to associate input and output streams with an object of class `basic_string`.

The class `basic_stringstream` uses an object of type `basic_stringbuf` to control the associated storage.

### See Also

[Template class `basic\_istringstream`](#)

[Class `basic\_ostringstream`](#)

## 19.5.1 `basic_stringstream` Constructor

The `basic_stringstream` constructors create a `basic_stringstream` object and initialize the `basic_stringbuf` object.

```
explicit basic_stringstream (ios_base::openmode which = ios_base::out | ios_base::out);  
  
explicit basic_stringstream (const basic_string<charT> &str, ios_base::openmode which =  
ios_base::out | ios_base::out);
```

### Remarks

The `basic_stringstream` constructor is overloaded to accept an object of class `basic_string` for input or output.

### See Also

`basic_ostringstream`, `basic_istringstream`

### Listing: Example of `basic_stringstream::basic_stringstream()` usage

```
#include <iostream>  
#include <sstream>  
  
char buf[50] = "ABCD 22 33.33";  
char words[50];  
  
int main()  
{  
    using namespace std;  
    stringstream iost;  
  
    char word[20];  
    long num;  
    double real;  
  
    iost << buf;  
    iost >> word;  
    iost >> num;  
    iost >> real;
```

**Class `basic_stringstream`**

```

    cout << word << " "
         << num << " "
         << real << endl;
    return 0;
}

```

**Result**

```
ABCD 22 33.33
```

## 19.5.2 Member functions

The class `basic_stringstream` has two member functions.

### 19.5.2.1 `basic_stringstream::rdbuf`

To retrieve a pointer to the stream buffer.

```
basic_stringbuf<charT, traits>* rdbuf() const;
```

**Remarks**

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer.

A pointer to an object of type `basic_stringbuf sb` is returned by the `rdbuf` function.

**See Also**

[Template class `basic\_istream`](#)

[Class `basic\_ostringstream`](#)

**Listing: Example of `basic_stringstream::rdbuf()` usage**

```

#include <iostream>
#include <iostream>
#include <sstream>

std::string buf = "CodeWarrior - \"Software at Work\"";
char words[50];

int main()
{
    using namespace std;
    stringstream ist(buf, ios::in);
    istream in(ist.rdbuf());
    in.seekg(25);

    in.get(words, 50);
    cout << words;
}

```

```
    return 0;
}
```

## Result

```
"Software at Work"
```

### 19.5.2.2 basic\_stringstream::str

To return or assign the `basic_string` object stored in the buffer.

```
basic_string<charT> str() const;
void str(const basic_string<charT> &s);
```

#### Remarks

The function `str()` freezes the buffer then returns a `basic_string` object.

The function `str(const string s)` assigns the value of the string `s` to the `stringbuf` object.

The no argument version returns a `basic_string` if successful. The function with an argument has no return.

#### See Also

```
basic_stringbuf::str()
```

```
basic_ostringstream.str()
```

```
basic_istringstream::str()
```

#### Listing: Example of basic\_stringstream::str() usage

```
#include <iostream>
#include <sstream>

std::string buf = "CodeWarrior - \"Software at Work\"";
char words[50];

int main()
{
    using namespace std;
    stringstream iost(buf, ios::in);
    cout << iost.str();
    return 0;
}
```

## Result

```
CodeWarrior - "Software at Work"
```



## Chapter 20

# File Based Streams

Association of stream buffers with files for file reading and writing.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

- [Header `fstream`](#)
- [File Streams Type Defines](#)
- [Template class `basic\_filebuf`](#)
- [Template class `basic\_ifstream`](#)
- [Template class `basic\_ofstream`](#)
- [Template class `basic\_fstream`](#)

### 20.1 Header `fstream`

The header `<fstream>` defines template classes and types to assist in reading and writing of files.

### 20.2 File Streams Type Defines

A `FILE` refers to the type `FILE` as defined in the Standard C Library and provides an external input or output stream with the underlying type `ofchar` or `byte`. A stream is a sequence of `char` or `bytes`.

- `typedef basic_filebuf<char> filebuf;`
- `typedef basic_filebuf<wchar_t> wfilebuf;`
- `typedef basic_ifstream<char> ifstream;`
- `typedef basic_ifstream<wchar_t> wifstream;`

**template class basic\_filebuf**

- typedef basic\_ofstream<char> ofstream;
- typedef basic\_ofstream<wchar\_t> wofstream;

## 20.3 Template class basic\_filebuf

A class to provide for input and output file stream buffering mechanisms.

The `filebuf` class is derived from the `streambuf` class and provides a buffer for file output and or input.

### 20.3.1 basic\_filebuf Constructors

This section describes `basic_filebuf` constructors.

#### 20.3.1.1 Constructor

To construct and initialize a `filebuf` object.

```
basic_filebuf()
```

#### Remarks

The constructor opens a `basic_filebuf` object and initializes it with `basic_streambuf<charT, traits>()` and if successful `is_open()` is `false`.

**Listing: For example of `basic_filebuf::basic_filebuf()` usage:**

```
// The file ewl-test before operation contains.
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdio>
#include <cstring>

char inFile[ ] = "ewl-test";

int main()
{
using namespace std;
FILE *fp = fopen( inFile, "a+");
filebuf in(fp);
```



```
    if( !in.is_open() )
        { cout << "could not open file"; exit(1); }

    char str[] = "\n\ttrademark";
    in.sputn(str, strlen(str));

    in.close();
    return 0;
}
```

### Result:

```
The file ewl-test now contains:
CodeWarrior "Software at Work"
trademark
```

## 20.3.1.2 Destructor

To remove the `basic_filebuf` object from memory.

```
virtual ~basic_filebuf();
```

## 20.3.2 Member functions

The class `basic_filebuf` provides several functions for file buffer manipulations.

### 20.3.2.1 `basic_filebuf::is_open`

Test to ensure `filebuf` stream is open for reading or writing.

```
bool is_open() const
```

#### Remarks

Use the function `is_open()` for a `filebuf` stream to ensure it is open before attempting to do any input or output operation on the stream.

Returns true if stream is available and open.

#### See Also

For example of `basic_filebuf::is_open()` usage see `basic_filebuf::basic_filebuf`

## 20.3.2.2 `basic_filebuf::open`

Open a `basic_filebuf` object and associate it with a file.

```
basic_filebuf<charT, traits>* open
(const char* c, ios_base::openmode mode);
```

### Remarks

You would use the function `open()` to open a `filebuf` object and associate it with a file. You may use `open()` to reopen a buffer and associate it if the object was closed but not destroyed.

If an attempt is made to open a file in an inappropriate file opening mode, the file will not open and a test for the object will not give false, therefore use the function `is_open()` to check for file openings.

If successful the `this` pointer is returned, if `is_open()` equals true then a `null` pointer is returned.

**Table 20-1. Legal `basic_filebuf` file opening modes**

Opening Modes	stdio equivalent
Input Only	
<code>ios::in</code>	"r"
<code>ios::binary   ios::in</code>	"rb"
Output only	
<code>ios::out</code>	"w"
<code>ios::binary   ios::out</code>	"wb"
<code>ios::out   ios::trunc</code>	"w"
<code>ios::binary   ios::out   ios::trunc</code>	"wb"
<code>ios::out   ios::app</code>	"a"
Input and Output	
<code>ios::in   ios::out</code>	"r+"
<code>ios::binary   ios::in   ios::out</code>	"r+b"
<code>ios::in   ios::out   ios::trunc</code>	"w+"
<code>ios::binary   ios::in   ios::out   ios::trunc</code>	"w+b"
<code>ios::binary   ios::out   ios::app</code>	"ab"

### Listing: Example of `filebuf::open()` usage:

```
// The file ewl-test before operation contained:
// CodeWarrior "Software at Work"

#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";
```

```
int main(){
using namespace std;
    filebuf in;
    in.open(inFile, ios::out | ios::app);

    if(!in.is_open())
        {cout << "could not open file"; exit(1);}

    char str[] = "\n\tregistered trademark";
    in.sputn(str, strlen(str));
    in.close();
    return 0;
}
```

### Result:

```
The file ewl-test now contains:
CodeWarrior "Software at Work"
registered trademark
```

### 20.3.2.3 basic\_filebuf::close

To close a `filebuf` stream without destroying it.

```
basic_filebuf<charT, traits>* close();
```

#### Remarks

The function `close()` would remove the stream from memory but will not remove the `filebuf` object. You may re-open a `filebuf` stream that was closed using the `close()` function.

The `this` pointer is returned with success, otherwise a `null` pointer is returned.

#### See Also

For example of `basic_filebuf::close()` usage see `basic_filebuf::open()`.

### 20.3.3 Overridden virtual functions

This section describes overridden virtual functions.

#### 20.3.3.1 basic\_filebuf::showmanyc

Overrides `basic_streambuf::showmanyc()`.

```
template class basic_filebuf
```

```
    virtual int showmanyc();
```

## Remarks

Behaves the same as `basic_sreambuf::showmanyc()`.

### 20.3.3.2 basic\_filebuf::underflow

Overrides `basic_streambuf::underflow()`;

```
    virtual int_type underflow();
```

## Remarks

A sequence of characters is read from the input sequence as though they were read from the associated file into an internal buffer. This must be done so that the class can recover the position corresponding to each character between `intern_buf` and `intern_end`.

### 20.3.3.3 basic\_filebuf::pbackfail

Overrides `basic_streambuf::pbackfail()`.

```
    virtual int_type pbackfail  
        (int_type c = traits::eof());
```

## Remarks

This function puts back the characters designated by `c` to the input sequence if possible.

Returns `traits::eof()` if failure and returns either the character put back or `traits::not_eof(c)` for success.

### 20.3.3.4 basic\_filebuf::overflow

Overrides `basic_streambuf::overflow()`

```
    virtual int_type overflow  
        (int_type c = traits::eof());
```

## Remarks

Behaves the same as `basic_streambuf<charT, traits>::overflow(c)` except the behavior of consuming characters is performed by conversion.

Returns `traits::eof()` with failure.

### 20.3.3.5 `basic_filebuf::seekoff`

Overrides `basic_streambuf::seekoff()`

```
virtual pos_type seekoff
(off_type off,
 ios_base::seekdir way,
 ios_base::openmode which = ios_base::in | ios_base::out);
```

## Remarks

Sets the offset position of the stream as if using the C standard library function `fseek(file, off, whence)`.

Seekoff function returns a newly formed `pos_type` object which contains all information needed to determine the current position if successful. Returns an invalid stream position if it fails.

### 20.3.3.6 `basic_filebuf::seekpos`

Overrides `basic_streambuf::seekpos()`

```
virtual pos_type seekpos
(pos_type sp,
 ios_base::openmode which =
 ios_base::in | ios_base::out);
```

## Remarks

Seekpos function returns a newly formed `pos_type` object which contains all information needed to determine the current position if successful. Returns an invalid stream position if it fails.

### 20.3.3.7 `basic_filebuf::setbuf`

Overrides `basic_streambuf::setbuf()`

```
template class basic_ifstream
```

```
virtual basic_streambuf<charT traits>* setbuf (char_type* s, streamsize n);
```

## Remarks

Setbuf returns zero if the file pointer `fp` is a null pointer. Otherwise, it calls `setvbuf(fp, (char *)buffer, _IOFBF, n * sizeof (E))` to offer the array of `n` elements beginning at `s` as a buffer for the stream. If that function returns a nonzero value, the function returns a null pointer. Otherwise, the `this` pointer is returned to signal success.

### 20.3.3.8 basic\_filebuf::sync

Overrides `basic_streambuf::sync`

```
virtual int sync();
```

## Remarks

This protected member function returns zero if the file pointer `fp` is a null pointer. Otherwise, it returns `fflush(fp)` to flush any pending output to the stream.

### 20.3.3.9 basic\_filebuf::imbue

Overrides `basic_streambuf::imbue`

```
virtual void imbue(const locale& loc);
```

## Remarks

After this function is called, inserted or extracted characters will be converted according to `loc` until another call is made to `imbue`.

## 20.4 Template class basic\_ifstream

A class to provide for input file stream mechanisms.

## 20.4.1 basic\_ifstream Constructor

Creates a file stream for input.

```
basic_ifstream();
explicit basic_ifstream
(const char *s, ios_base::openmode mode = ios_base::in);
```

### Remarks

The constructor creates a stream for file input. It is overloaded to either create and initialize when called or to simply create a class and be opened using the `open()` member function. The default opening mode is `ios::in`. See `basic_filebuf::open()` for valid open mode settings.

See `basic_ifstream::open` for legal opening modes.

### See Also

`basic_ifstream::open()` for overloaded form usage.

### Listing: Example of `basic_ifstream::basic_ifstream()` constructor usage:

```
// The ewl-test file contains:
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";

int main()
{
using namespace std;
    ifstream in(inFile, ios::in);

        if(!in.is_open())
            {cout << "can't open input file"; exit(1);}

    char c = '\0';
    while(in.good())
    {
        if(c) cout << c;
        in.get(c);
    }

    in.close();
    return 0;
}
```

### Result:

```
CodeWarrior "Software at Work"
```

## 20.4.2 Member functions

The `ifstream` class has several public member functions for stream manipulations.

### 20.4.2.1 `basic_ifstream::rdbuf`

The `rdbuf()` function retrieves a pointer to a `filebuf` type buffer.

```
basic_filebuf<charT, traits>* rdbuf() const;
```

#### Remarks

In order to manipulate for random access or use an `ifstream` stream for both input and output you need to manipulate the base buffer. The function `rdbuf()` returns a pointer to this buffer for manipulation.

Returns a pointer to type `basic_filebuf`.

#### Listing: Example of `basic_ifstream::rdbuf()` usage:

```
// The ewl-test file contains originally
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";

int main()
{
    using namespace std;
    ifstream inOut(inFile, ios::in | ios::out);
    if(!inOut.is_open())
        {cout << "Could not open file"; exit(1);}

    ostream Out(inOut.rdbuf());
    char str[] = "\n\tRegistered Trademark";
    inOut.rdbuf()->pubseekoff(0, ios::end);
    Out << str;
    inOut.close();

    return 0;
}
```

#### Result:

```
The File now reads:
CodeWarrior "Software at Work"
Registered Trademark
```

### 20.4.2.2 `basic_ifstream::is_open`



Test for open stream.

```
bool is_open() const
```

### Remarks

Use `is_open()` to test that a stream is indeed open and ready for input from the file.

Returns true if file is open.

### See Also

For example of `basic_ifstream::is_open()` usage see `basic_ifstream::basic_ifstream()`

## 20.4.2.3 basic\_ifstream::open

Open is used to open a file or reopen a file after closing it.

```
void open(const char* s, ios::openmode mode = ios::in);
```

### Remarks

The default open mode is `ios::in`, but can be one of several modes. (see below) A stream is opened and prepared for input or output as selected.

There is no return.

If an attempt is made to open a file in an inappropriate file opening mode, the file will not open and a test for the object will not give false, therefore use the function `is_open()` to check for file openings.

**Table 20-2. Legal basic\_ifstream file opening modes**

Opening Modes	stdio equivalent
Input Only	
<code>ios:: in</code>	"r"
<code>ios:: binary   ios::in</code>	"rb"
Input and Output	
<code>ios::in   ios::out</code>	"r+"
<code>ios::binary   ios::in   ios::out</code>	"r+b"
<code>ios:: in   ios::out   ios::trunc</code>	"w+"
<code>ios::binary   ios::in   ios::out   ios::trunc</code>	"w+b"
<code>ios::binary   ios:: out   ios::app</code>	"ab"

### Listing: Example of basic\_ifstream::open() usage:

**template class basic\_ofstream**

```
// The ewl-test file contains:
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";

int main()
{
using namespace std;
    ifstream in;
    in.open(inFile);

    if(!in.is_open())
        {cout << "can't open input file"; exit(1);}

    char c = NULL;
    while((c = in.get()) != EOF)
    {
        cout << c;
    }
    in.close();
    return 0;
}
```

**Result:**

```
CodeWarrior "Software at Work"
```

**20.4.2.4 basic\_ifstream::close**

Closes the file stream.

```
void close();
```

**Remarks**

The `close()` function closes the stream for operation but does not destroy the `ifstream` object so it may be re-opened at a later time. If the function fails, it calls `setstate(failbit)`, which may throw an exception.

There is no return.

**See Also**

For example of `basic_ifstream::close()` usage see `basic_ifstream::basic_ifstream()`

**20.5 Template class basic\_ofstream**

A class to provide for output file stream mechanisms.

### NOTE

The `basic_ofstream` class supports writing to a file. It uses a `basic_filebuf` object to control the sequence. That object is represented here as `basic_filebuf sb`.

The `basic_ofstream` class provides for mechanisms specific to output file streams.

## 20.5.1 `basic_ofstream` Constructors

To create a file stream object for output.

```
basic_ofstream();
explicit basic_ofstream
(const char *s, ios_base::openmode mode = ios_base::out | ios_base::trunc);
```

### Remarks

The class `basic_ofstream` creates an object for handling file output. It may be opened later using the `ofstream::open()` member function. It may also be associated with a file when the object is declared. The default open mode is `ios::out`.

There are only certain valid file opening modes for an `ofstream` object. See [`basic\_ofstream::open`](#) for a list of valid opening modes.

### Listing: Example of `basic_ofstream::ofstream()` usage:

```
// Before the operation the file ewl-test
// may or may not exist.

#include <iostream>
#include <fstream>
#include <cstdlib>

char outFile[] = "ewl-test";

int main()
{
    using namespace std;
    ofstream out(outFile);

    if(!out.is_open())
        {cout << "file not opened"; exit(1);}

    out << "This is an annotated reference that "
        << "contains a description\n"
        << "of the Working ANSI C++ Standard "
        << "Library and other\nfacilities of "
        << "the Embedded Warrior Library. ";

    out.close();
```

```
template class basic_ofstream
```

```
    return 0;
}
```

Result:

This is an annotated reference that contains a description of the Working ANSI C++ Standard Library and other facilities of the Embedded Warrior Library.

## 20.5.2 Member functions

The ofstream class provides public member functions for output stream manipulation.

### 20.5.2.1 basic\_ofstream::rdbuf

To retrieve a pointer to the stream buffer.

```
basic_filebuf<charT, traits>* rdbuf() const;
```

#### Remarks

In order to manipulate a stream for random access or other operations you must use the streams base buffer. The member function `rdbuf()` is used to return a pointer to this buffer.

A pointer to `basic_filebuf` type is returned.

#### Listing: Example of basic\_ofstream::rdbuf() usage:

```
// The file ewl-test before the operation contains:
// This is an annotated reference that contains a description
// of the Working ANSI C++ Standard Library and other
// facilities of the Embedded Warrior Library

#include <iostream>
#include <fstream>
#include <cstdlib>

char outFile[] = "ewl-test";

int main()
{
    using namespace std;
    ofstream out(outFile, ios::in | ios::out);

    if(!out.is_open())
        {cout << "could not open file for output"; exit(1);}

    istream inOut(out.rdbuf());
    char ch;
    while((ch = inOut.get()) != EOF)
    {
        cout.put(ch);
    }

    out << "\nAnd so it goes...";
}
```

```
    out.close();  
    return 0;  
}
```

### Result:

This is an annotated reference that contains a description of the Working ANSI C++ Standard Library and other facilities of the Embedded Warrior Library.

This is an annotated reference that contains a description of the Working ANSI C++ Standard Library and other facilities of the Embedded Warrior Library.

And so it goes...

### 20.5.2.2 basic\_ofstream::is\_open

To test whether the file was opened.

```
bool is_open();
```

#### Remarks

The `is_open()` function is used to check that a file stream was indeed opened and ready for output. You should always test with this function after using the constructor or the `open()` function to open a stream.

If an attempt is made to open a file in an inappropriate file opening mode, the file will not open and a test for the object will not give false, therefore use the function `is_open()` to check for file openings.

Returns `true` if file stream is open and available for output.

#### See Also

For example of `basic_ofstream::is_open()` usage see `basic_ofstream::ofstream()`

### 20.5.2.3 basic\_ofstream::open

To open or re-open a file stream for output.

```
void open(const char* s, ios_base::openmode mode = ios_base::out);
```

#### Remarks

## template class basic\_ofstream

The function `open()` opens a file stream for output. The default mode is `ios::out`, but may be any valid open mode (see below.) If failure occurs `open()` calls `setstate(failbit)` which may throw an exception.

There is no return.

**Table 20-3. Legal basic\_ofstream file opening modes.**

Opening Modes	stdio equivalent
Output only	
<code>ios::out</code>	"w"
<code>ios::binary   ios::out</code>	"wb"
<code>ios::out   ios::trunc</code>	"w"
<code>ios::binary   ios::out   ios::trunc</code>	"wb"
<code>ios::out   ios::app</code>	"a"
Input and Output	
<code>ios::in   ios::out</code>	"r+"
<code>ios::binary   ios::in   ios::out</code>	"r+b"
<code>ios::in   ios::out   ios::trunc</code>	"w+"
<code>ios::binary   ios::in   ios::out   ios::trunc</code>	"w+b"
<code>ios::binary   ios::out   ios::app</code>	"ab"

### Listing: Example of basic\_ofstream::open() usage:

```
// Before operation, the file ewl-test contained:
// Chapter One

#include <iostream>
#include <fstream>
#include <cstdlib>

char outFile[] = "ewl-test";
int main()
{
using namespace std;
    ofstream out;
    out.open(outFile, ios::out | ios::app);
    if(!out.is_open())
        {cout << "file not opened"; exit(1);}

    out << "\nThis is an annotated reference that "
        << "contains a description\n"
        << "of the Working ANSI C++ Standard "
        << "Library and other\nfacilities of "
        << "the Embedded Warrior Library.";

    out.close();
    return 0;
}
```

### Result:

After the operation ewl-test contained

**Chapter One**

This is an annotated reference that contains a description of the Working ANSI C++ Standard Library and other facilities of the Embedded Warrior Library.

### 20.5.2.4 `basic_ofstream::close`

The member function closes the stream but does not destroy it.

```
void close();
```

#### Remarks

Use the function `close()` to close a stream. It may be re-opened at a later time using the member function `open()`. If failure occurs `open()` calls `setstate(failbit)` which may throw an exception.

There is no return.

#### See Also

For example of `basic_ofstream::close()` usage see `basic_ofstream()`.

## 20.6 Template class `basic_fstream`

template class for the association of a file for input and output.

A

### 20.6.1 `basic_fstream` Constructor

To construct an object of `basic_ifstream` for input and output operations.

```
basic_fstream();
```

```
explicit basic_fstream (const char *s, ios_base::openmode = ios_base::in | ios_base::out);
```

#### Remarks

The `basic_fstream` class is derived from `basic_istream` and a `basic_filebuf` object is initialized at construction.

```
template class basic_fstream
```

## Listing: Example of basic\_fstream:: basic\_fstream() usage

```
// The ewl-test file contains originally
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";

int main()
{
    using namespace std;
    fstream inOut(inFile, ios::in | ios::out);
    if(!inOut.is_open())
        {cout << "Could not open file"; exit(1);}

    char str[] = "\n\tRegistered Trademark";
    char ch;

    while((ch = inOut.get())!= EOF)
    {
        cout << ch;
    }

    inOut.clear();
    inOut << str;
    inOut.close();

    return 0;
}
```

### Result:

CodeWarrior "Software at Work"

The File now reads:

CodeWarrior "Software at Work"

Registered Trademark

## 20.6.2 Member Functions

The `fstream` class provides public member functions for input and output stream manipulations.

### 20.6.2.1 basic\_fstream::rdbuf

The `rdbuf()` function retrieves a pointer to a `filebuf` type buffer.

```
basic_filebuf<charT, traits>* rdbuf() const;
```



## Remarks

In order to manipulate for random access or use an `fstream` stream you may need to manipulate the base buffer. The function `rdbuf()` returns a pointer to this buffer for manipulation.

A pointer to type `basic_filebuf` is returned.

### Listing: Example of `basic_fstream::rdbuf()` usage

```
// The ewl-test file contains originally
// CodeWarrior "Software at Work"

#include <iostream>
#include <fstream>
#include <cstdlib>

char inFile[] = "ewl-test";

int main()
{
using namespace std;
    fstream inOut;
    inOut.open(inFile, ios::in | ios::out);

    if(!inOut.is_open())
        {cout << "Could not open file"; exit(1);}

    char str[] = "\n\tRegistered Trademark";
    inOut.rdbuf()->pubseekoff(0,ios::end);
    inOut << str;
    inOut.close();
    return 0;
}
```

## Result:

The File now reads:

CodeWarrior "Software at Work"

Registered Trademark

### 20.6.2.2 `basic_fstream::is_open`

Test to ensure `basic_fstream` file is open and available for reading or writing.

```
bool is_open() const
```

## Remarks

Use the function `is_open()` for a `basic_fstream` file to ensure it is open before attempting to do any input or output operation on a file.

template class `basic_fstream`

Returns true if a file is available and open.

### See Also

For an example, see [Example of `basic\_fstream::basic\_fstream\(\)` usage](#).

## 20.6.2.3 `basic_fstream::open`

To open or re-open a file stream for input or output.

```
void open (const char* s, ios_base::openmode = ios_base::in | ios_base::out);
```

### Remarks

You would use the function `open()` to open a `basic_fstream` object and associate it with a file. You may use `open()` to reopen a file and associate it if the object was closed but not destroyed.

If an attempt is made to open a file in an inappropriate file opening mode, the file will not open and a test for the object will not give false, therefore use the function `is_open()` to check for file openings.

There is no return value.

**Table 20-4. Legal file opening modes**

Opening Modes	stdio equivalent
Input Only	
<code>ios::in</code>	"r"
<code>ios::binary   ios::in</code>	"rb"
Output only	
<code>ios::out</code>	"w"
<code>ios::binary   ios::out</code>	"wb"
<code>ios::out   ios::trunc</code>	"w"
<code>ios::binary   ios::out   ios::trunc</code>	"wb"
<code>ios::out   ios::app</code>	"a"
Input and Output	
<code>ios::in   ios::out</code>	"r+"
<code>ios::binary   ios::in   ios::out</code>	"r+b"
<code>ios::in   ios::out   ios::trunc</code>	"w+"
<code>ios::binary   ios::in   ios::out   ios::trunc</code>	"w+b"
<code>ios::binary   ios::out   ios::app</code>	"ab"

### See Also

For an example, see [Example of basic\\_fstream::rdbuf\(\) usage](#).

### 20.6.2.4 basic\_fstream::close

The member function closes the stream but does not destroy it.

```
void close();
```

#### Remarks

Use the function `close()` to close a stream. It may be re-opened at a later time using the member function `open()`. If failure occurs `open()` calls `setstate(failbit)` which may throw an exception.

There is no return value.

#### See Also

For an example, see [Example of basic\\_fstream:: basic\\_fstream\(\) usage](#).



# Chapter 21

## C Library Files

The header `<stdio>` contains the C++ implementation of the Standard C Headers.

This chapter is constructed in the following sub sections and uses the ISO (International Organization for Standardization) C++ Standard as a guide:

**Table 21-1. `<stdio>` Macros**

Macros		
BUFSIZ	EOF	FILENAME_MAX
FOPEN_MAX	L_tmpnam	NULL
SEEK_CUR	SEEK_END	SEEK_SET
stderr	stdin	stdout
TMP_MAX	_IOFBF	_IOLBF
_IONBF		

**Table 21-2. `<stdio>` Types**

Types:		
FILE	fpos_t	size_t

**Table 21-3. `<stdio>` Functions**

Functions:		
clearerr	fclose	feof
ferror	fflush	fgetc
fgetpos	fgets	fopen
fprintf	fputc	fputs
fread	freopen	fscanf
fseek	fsetpos	ftell
fwrite	getc	getchar
gets	perror	printf
putc	putchar	puts

*Table continues on the next page...*

**Table 21-3. <stdio> Functions (continued)**

<b>Functions:</b>		
remove	rename	rewind
scanf	setbuf	setvbuf
sprintf	scanf	tmpnam
ungetc	vprintf	vfprintf
vsprintf	tmpfile	

## Chapter 22

# Strstream

The header `<strstream>` defines `streambuf` derived classes that allow for the formatting and storage of character array based buffers, as well as their input and output.

The chapter is constructed in the following sub sections and is guided by annex D of the ISO (International Organization for Standardization) C++ Standard.

- [Strstreambuf Class](#) a base class for `strstream` classes
- [Istrstream Class](#) a `strstream` class for input
- [Ostrstream Class](#) a `strstream` class for output
- [Strstream Class](#) a class for input and output

### 22.1 Header `strstream`

The include file `strstream` includes three classes for in memory character array based stream input and output.

### 22.2 `Strstreambuf` Class

The class `strstreambuf` is derived from `streambuf` to associate a stream with an in memory character array.

The `strstreambuf` class includes virtual protected and public member functions

- [freeze](#) freezes the buffer
- [pcount](#) determines the buffer size
- [str](#) returns a string
- [setbuf](#) a virtual function to set the buffer

**strstreambuf Class**

- [seekoff](#) a virtual function for stream offset
- [seekpos](#) a virtual function for stream position
- [underflow](#) a virtual function for input error
- [pbackfail](#) a virtual function for put back error
- [overflow](#) a virtual function for output error

**NOTE**

The template class `s streambuf` is an abstract class for deriving various stream buffers whose objects control input and output sequences.

**22.2.1 Strstreambuf constructors and Destructors**

Special constructors and destructors are included for the `strstreambuf` class.

**22.2.1.1 Constructors**

Constructs an object of type `streambuf`.

```
explicit strstreambuf(streamsize a_size_arg = 0);
strstreambuf(void* (*palloc_arg)(size_t),
void (*pfree_arg)(void*));
```

**Dynamic constructors**

```
strstreambuf(char* gnext_arg, streamsize n, char* pbeg_arg = 0);
strstreambuf(const char* gnext_arg, streamsize n);
strstreambuf(signed char* gnext_arg,
streamsize n, signed char* pbeg_arg = 0);
strstreambuf(const signed char* gnext_arg, streamsize n);
strstreambuf(unsigned char* gnext_arg, streamsize n, unsigned char* pbeg_arg = 0);
strstreambuf(const unsigned char* gnext_arg, streamsize n);
```

**Remarks**

The constructor sets all pointer member objects to null pointers.



The `strstreambuf` object is used usually for an intermediate storage object for input and output. The overloaded constructor that is used determines the attributes of the array object when it is created. These might be allocated, or dynamic and are stored in a bitmask type. The first two constructors listed allow for dynamic allocation. The constructors with character array arguments will use that character array for a buffer.

### 22.2.1.2 Destructor

To destroy a `strstreambuf` object.

```
virtual ~strstreambuf();
```

#### Remarks

Removes the object from memory.

## 22.2.2 Strstreambuf Public Member Functions

The public member functions allow access to member functions from derived classes.

### 22.2.2.1 freeze

To freeze the allocation of `strstreambuf`.

```
void freeze(bool freezeFl = true);
```

#### Remarks

The function `freeze()` stops allocation if the `strstreambuf` object is using dynamic allocation and prevents the destructor from freeing the allocation.

The function `freeze(false)` releases the freeze to allow for destruction.

There is no return.

#### Listing: Example of `strstreambuf::freeze()` usage:

```
#include <iostream>
#include <strstream>
#include <string.h>

const int size = 100;
```

**strstreambuf Class**

```

int main()
{
    // dynamic allocation minimum allocation 100
    strstreambuf strbuf(size);

    // add a string and get size
    strbuf.sputn( "CodeWarrior", strlen("CodeWarrior"));
    cout << "The size of the stream is: "
         << strbuf.pcount() << endl;

    strbuf.sputc('\0');    // null terminate for output

    // now freeze for no more growth
    strbuf.freeze();

    // try to add more
    strbuf.sputn( " -- Software at Work --",
                 strlen(" -- Software at Work --"));
    cout << "The size of the stream is: "
         << strbuf.pcount() << endl;
    cout << "The buffer contains:\n"
         << strbuf.str() << endl;
    return 0;
}

```

**22.2.2.2 pcount**

To determine the effective length of the buffer.

```
int pcount() const;
```

**Remarks**

The function `pcount()` is used to determine the offset of the next character position from the beginning of the buffer.

For an example of `strstreambuf::pcount()` usage refer to `strstreambuf::freeze`.

**22.2.2.3 str**

To return the character array stored in the buffer.

```
char* str();
```

**Remarks**

The function `str()` freezes the buffer and appends a null character then returns the beginning pointer for the input sequence. The user is responsible for destruction of any dynamically allocated buffer.

## Listing: Example of `strstreambuf::str()` usage

```
#include <iostream>
#include <strstream>

const int size = 100;
char buf[size];
char arr[size] = "CodeWarrior - Software at Work";

int main()
{
    ostrstream ostr(buf, size);
    ostr << arr;

    // associate buffer
    strstreambuf *strbuf(ostr.rdbuf());

    // do some manipulations
    strbuf->pubseekoff(10, ios::beg);
    strbuf->sputc('\0');
    strbuf->pubseekoff(0, ios::beg);

    cout << "The original array was\n" << arr << "\n\n";
    cout << "The strstreambuf array is\n"
         << strbuf->str() << "\n\n";
    cout << "The ostrstream array is now\n" << buf;
    return 0;
}
```

### 22.2.3 Protected Virtual Member Functions

Protected member functions that are overridden for stream buffer manipulations by the `strstream` class and derived classes from it.

#### 22.2.3.1 `setbuf`

To set a buffer for stream input and output sequences.

```
virtual streambuf* setbuf(char* s, streamsize n);
```

#### Remarks

The function `setbuf()` is overridden in `strstream` classes.

The `this` pointer is returned.

#### 22.2.3.2 `seekoff`

Alters the stream position within one of the controlled sequences if possible.

```
virtual pos_type seekoff(
    off_type off,
    ios_base::seekdir way,
    ios_base::openmode which = ios_base::in | ios_base::out);
```

### Remarks

The function `seekoff()` is overridden in `strstream` classes.

Returns new stream position if successful. Otherwise, it returns `pos_type(off_type(-1))`.

### 22.2.3.3 seekpos

To alter an input or output stream position.

```
virtual pos_type seekpos(
    pos_type sp,

    ios_base::openmode
        which = ios_base::in | ios_base::out);
```

### Remarks

The function `seekpos()` is overridden in `strstream` classes.

Returns new stream position if successful. Otherwise, it returns `pos_type(off_type(-1))`.

### 22.2.3.4 underflow

This function attempts to extract the current item from the input buffer and advance the current stream position. The item is returned as `(int)(unsigned char)`.

```
virtual int_type underflow();
```

### Remarks

The virtual function `underflow()` is called when a character is not available for input.

There are many constraints for `underflow()`.

The pending sequence of characters is a concatenation of end pointer minus the get pointer plus some sequence of characters to be read from input.

Returns the result character if the sequence is not empty, which is the first character in the sequence or the next character in the sequence.

Returns the backup sequence if the beginning pointer is null or the sequence is empty. Otherwise the sequence is the `get_pointer` minus the `beginning pointer`.

If the position is null, returns `traits::eof()` to indicate failure. Otherwise, it returns the current element in the input stream.

### 22.2.3.5 pbackfail

To show a failure in a put back operation.

```
virtual int_type pbackfail(int_type c = EOF);
```

#### Remarks

The resulting conditions are the same as the function `underflow()`.

The function `pbackfail()` is only called when a put back operation really has failed and returns `traits::eof`. If successful, returns `traits::not_eof(c)`.

### 22.2.3.6 overflow

Consumes the pending characters of an output sequence.

```
virtual int_type overflow (int_type c = EOF);
```

#### Remarks

The pending sequence is defined as the concatenation of the `put` pointer minus the `beginning pointer` plus either the sequence of characters or an empty sequence, unless the `beginning pointer` is null in which case the pending sequence is an empty sequence.

This function is called by `sputc()` and `sputn()` when the buffer is not large enough to hold the output sequence.

Overriding this function requires that:

- When overridden by a derived class how characters are consumed must be specified.
- After the overflow either the `beginning pointer` must be null or the `beginning` and `put` pointer must both be set to the same `non-null` value.

The function may fail if appending characters to an output stream fails or failure to set the previous requirement occurs.

The function returns `traits::eof()` for failure or `traits::not_eof(c)` to indicate success.

## 22.3 istream Class

The class `istream` is used to create and associate a stream with an array for input.

The `istream` class includes the following facilities

- [Constructors](#) and [Destructor](#) to create and remove an `istream` object
- [rdbuf](#) to access the buffer
- [str](#) returns the buffer

### 22.3.1 Constructors and Destructor

The `istream` class has an overloaded constructor.

#### 22.3.1.1 Constructors

Creates an array based stream for input.

```
explicit istream(const char* s);
explicit istream(char* s);
istream(const char* s, streamsize n);
istream(char* s, streamsize n);
```

#### Remarks

The `istream` constructor is overloaded to accept a dynamic or pre-allocated character based array for input. It is also overloaded to limit the size of the allocation to prevent accidental overflow.

#### Listing: Example of usage.

```
#include <iostream>
#include <sstream>

char buf[100] = "double 3.21 string array int 321";

int main()
{
    char arr[4][20];
    double d;
    long i;
```

```
    istrstream istr(buf);
    istr >> arr[0] >> d >> arr[1] >> arr[2] >> arr[3] >> i;
    cout << arr[0] << " is " << d << "\n"
         << arr[1] << " is " << arr[2] << "\n"
         << arr[3] << " is " << i << endl;
    return 0;
}
```

### Result:

```
double is 3.21
string is array
int is 321
```

## 22.3.1.2 Destructor

To destroy an `istrstream` object.

```
virtual ~istrstream();
```

### Remarks

The `istrstream` destructor removes the `istrstream` object from memory.

## 22.3.2 Public Member Functions

There are two public member functions.

### 22.3.2.1 `rdbuf`

Returns a pointer to `strstreambuf`.

```
strstreambuf* rdbuf() const;
```

### Remarks

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer.

Returns a pointer to `strstreambuf`.

For an example of `istrstream::rdbuf()` usage refer to `strstreambuf::str()`

### 22.3.2.2 str

Returns a pointer to the stored array.

```
char* str();
```

#### Remarks

The function `str()` freezes and terminates the character array stored in the buffer with a null character. It then returns the null terminated character array.

A null terminated char array is returned.

#### Listing: Example of `istream::str()` usage.

```
#include <iostream>
#include <sstream>

const int size = 100;
char buf[size] = "CodeWarrior - Software at Work";

int main()
{
    istringstream istr(buf, size);
    cout << istr.str();
    return 0;
}
```

#### Result:

```
CodeWarrior - Software at Work
```

## 22.4 ostream Class

The class `ostream` is used to create and associate a stream with an array for output.

### 22.4.1 Constructors and Destructor

The `ostream` class has an overloaded constructor.

#### 22.4.1.1 Constructors

Creates a stream and associates it with a `char` array for output.



```
ostrstream();  
ostrstream(char* s, int n,  
ios_base::openmode mode = ios_base::out);
```

## Remarks

The `ostrstream` class is overloaded for association with a pre allocated array or for dynamic allocation.

When using an `ostrstream` object the user must supply a null character for termination. When storing a string which is already null terminated that null terminator is stripped off to allow for appending.

## Listing: Example of `ostrstream` usage.

```
#include <iostream>  
#include <strstream>  
  
int main()  
{  
    ostrstream out;  
    out << "Ask the teacher anything you want to know" << ends;  
    istream inOut(out.rdbuf() );  
    char c;  
    while( inOut.get(c) ) cout.put(c);  
    return 0;  
}
```

## Result:

```
Ask the teacher anything you want to know
```

### 22.4.1.2 Destructor

Destroys an `ostrstream` object.

```
virtual ~ostrstream();
```

## Remarks

An `ostrstream` destructor removes the `ostrstream` object from memory.

### 22.4.2 Public Member Functions

The `ostrstream` class has four public member functions.

### 22.4.2.1 freeze

Freezes the dynamic allocation or destruction of a buffer.

If `N` is nonzero (the default), the string associated with this `ostream` should be declared not to change dynamically. While frozen, the string will not be reallocated if it needs more space, and will not be deallocated when the `ostream` is destroyed.

```
void ostream::freeze ([int N])
```

#### Remarks

This member function calls `rdbuf() -> freeze(freezeit)`.

#### Listing: Example of `ostream freeze()` usage.

```
#include <iostream>
#include <sstream>

int main()
{
    ostream out;
    out << "CodeWarrior " << 1234;
    out << "the size of the array so far is "
        << out.pcount() << " characters \n";
    out << " Software" << '\0';
    out.freeze(); // freezes so no more growth can occur
    out << " at work" << ends;
    out << "the final size of the array is "
        << out.pcount() << " characters \n";

    cout << out.str() << endl;
    return 0;
}
```

### 22.4.2.2 pcount

Determines the number of bytes offset from the current stream position to the beginning of the array.

```
int pcount() const;
```

#### Remarks

The function `pcount()` is used to determine the offset of the array. This may not equal to the number of characters inserted due to possible positioning operations.

Returns an `int_type` that is the length of the array.

#### Listing: Example of `ostream pcount()` usage.

```
#include <iostream>
#include <strstream>

int main()
{
    ostrstream out;

    out << "CodeWarrior " << 1234 << ends;
    out << "the size of the array so far is "
        << out.pcount() << " characters \n";
    out << " Software at work" << ends;
    out << "the final size of the array is "
        << out.pcount() << " characters \n";
    cout << out.str() << endl;

    return 0;
}
```

### 22.4.2.3 rdbuf

To retrieve a pointer to the streams buffer.

```
strstreambuf* rdbuf() const;
```

#### Remarks

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer.

Returns a pointer to `strstreambuf`.

For an example of `ostrstream rdbuf()` usage refer to `streambuf::pubseekoff()`

### 22.4.2.4 str

Returns a pointer to a character array.

```
char* str();
```

#### Remarks

## ostream Class

The function `str()` freezes any dynamic allocation.

Returns a null terminated character array.

For an example of `ostream` `str()` usage refer to `ostream::freeze()`,

## 22.5 Strstream Class

The class `strstream` associates a stream with an array buffer for input and or output.

### 22.5.1 Strstream Types

The `strstream` class type defines a `char_type`, `int_type`, `pos_type` and `off_type`, for stream positioning and storage.

### 22.5.2 Constructors and Destructor

Specialized constructors and destructors are provided.

#### 22.5.2.1 Constructors

Creates a stream and associates it with a character array for input and output.

```
strstream();  
strstream(char* s, int n, ios_base::openmode mode =  
ios_base::in|ios_base::out);
```

#### Remarks

The `strstream` constructor is overloaded for association with a pre allocated array or for dynamic allocation.

#### 22.5.2.2 Destructor

Destroys a `strstream` object.

```
virtual ~strstream();
```

## Remarks

Removes the `strstream` object from memory.

## 22.5.3 Public Member Functions

The class `strstream` has four public member functions.

### 22.5.3.1 freeze

Freezes the dynamic allocation or destruction of a buffer.

```
void freeze(bool freezeFl = true);
```

## Remarks

The function `freeze` stops dynamic allocation of a buffer.

### 22.5.3.2 pcount

Determines the number of bytes offset from the current stream position to the beginning of the array.

```
int pcount() const;
```

## Remarks

The function `pcount()` is used to determine the offset of the array. This may not equal to the number of characters inserted due to possible positioning operations.

Returns an `int_type` that is the length of the array.

### 22.5.3.3 rdbuf

Retrieves a pointer to the streams buffer.

**strstream Class**

```
strstreambuf* rdbuf() const;
```

**Remarks**

To manipulate a stream for random access or synchronization it is necessary to retrieve a pointer to the streams buffer. The function `rdbuf()` allows you to retrieve this pointer.

Returns a pointer to `strstreambuf`.

**22.5.3.4 str**

Returns a pointer to a character array.

```
char* str();
```

**Remarks**

The function `str()` freezes any dynamic allocation.

Returns a null terminated character array.

## Chapter 23

# Bitvector Class Library

The bitvector class template interface is based on the `std::vector<bool>` interface. It is a dynamically sized array of bools packed into 1 bit per bool representation. In the default shipping configuration, `Metrowerks::bitvector<>` and `std::vector<bool>` provide identical functionality and performance. However clients can use the statement `#define _EWL_NO_VECTOR_BOOL` which removes the `std::vector<bool>` specialization, causing `std::vector<bool>` to behave like any other `vector<T>`. In this configuration, `Metrowerks::bitvector<>` remains available and as described herein. This allows clients the opportunity to use both packed and unpacked arrays of `bool` in the same application.

The `bitvector` class consists of:

- [Nested types](#)
- [Constructors](#)
- [Capacity](#)
- [Iteration](#)
- [Access](#)
- [Insertion](#)
- [Erasure](#)
- [Miscellaneous](#)
- [Namespace scope functions](#)

### Listing: Class bitvector synopsis

```
namespace Metrowerks {
template <class Allocator = std::allocator<bool> >

class bitvector
{
public:
    // types:
    typedef Allocator allocator_type;
    typedef typename allocator_type::size_type size_type;
    typedef typename allocator_type::difference_type difference_type;
    typedef bool value_type;

    class reference;
    class const_reference;
    class pointer;
    class const_pointer;
    class iterator; // random access
```

```

class const_iterator; // random access

typedef std::reverse_iterator<iterator> reverse_iterator;
typedef std::reverse_iterator<const_iterator> const_reverse_iterator;
explicit bitvector(const allocator_type& a = Allocator());
explicit bitvector(size_type n, bool x = false, const allocator_type&
    a = Allocator());

template <class InputIterator>
    bitvector(InputIterator first, InputIterator last, const
        allocator_type& a = Allocator());
bitvector(const bitvector& x);
bitvector& operator=(const bitvector& x);
~bitvector();
size_type size() const;
bool empty() const;
size_type capacity() const;
size_type max_size() const;
void reserve(size_type n);
allocator_type get_allocator() const;
iterator begin();
const_iterator begin() const;
iterator end();
const_iterator end() const;
reverse_iterator rbegin();
const_reverse_iterator rbegin() const;
reverse_iterator rend();
const_reverse_iterator rend() const;
reference front();
const_reference front() const;
reference back();
const_reference back() const;
reference operator[] (size_type n);
const_reference operator[] (size_type n) const;
const_reference at(size_type n) const;
reference at(size_type n);
void assign(size_type n, bool x);

template <class InputIterator>
    void assign(InputIterator first, InputIterator last);
void push_back(bool x);
void pop_back();
iterator insert(iterator position, bool x);
void insert(iterator position, size_type n, bool x);

template <class InputIterator>
void insert(iterator position, InputIterator first, InputIterator last);
void clear();
iterator erase(iterator position);
iterator erase(iterator first, iterator last);
void resize(size_type sz, bool c = false);
void swap(bitvector& x);
void flip();
bool invariants() const;
};

template <class Allocator>
bool operator==(const bitvector<Allocator>& x, const bitvector<Allocator>& y);

template <class Allocator>
bool operator!=(const bitvector<Allocator>& x, const bitvector<Allocator>& y);

template <class Allocator>
bool operator< (const bitvector<Allocator>& x, const bitvector<Allocator>& y);

template <class Allocator>
bool operator> (const bitvector<Allocator>& x, const bitvector<Allocator>& y);

template <class Allocator>

```



```
bool operator>=(const bitvector<Allocator>& x, const bitvector<Allocator>& y);

template <class Allocator>
bool operator<=(const bitvector<Allocator>& x, const bitvector<Allocator>& y);

template <class Allocator>
void swap(bitvector<Allocator>& x, bitvector<Allocator>& y);

} // Metrowerks
```

## 23.1 Nested types

This section describes nested types.

### 23.1.1 allocator\_type

```
typedef Allocator allocator_type;
```

The single template parameter of `bitvector` must be an allocator meeting the standard allocator requirements. This parameter defaults to `std::allocator<bool>`. Clients can refer to this type via the nested name: `allocator_type`.

### 23.1.2 size\_type

```
typedef typename allocator_type::size_type size_type;
```

`size_type` is constrained to be an unsigned integral type capable of representing all `bitvector` capacities. It is introduced into `bitvector` as a nested type of the allocator. The default type is `std::size_t`.

### 23.1.3 difference\_type

```
typedef typename allocator_type::difference_type
difference_type;
```

## nested types

`difference_type` is a signed integral type capable of representing the difference between two bitvector iterators. It is introduced into bitvector as a nested type of the allocator. The default type is `std::ptrdiff_t`.

### 23.1.4 value\_type

```
typedef bool value_type;
```

For compatibility with other standard containers, the nested type `value_type` is defined as `bool`.

### 23.1.5 reference

```
class reference;
```

The nested class `reference` is a "smart reference" class which emulates a reference to an internal `bool`. An actual reference (`bool&`) can not be used here since the internal booleans are stored as a single bit. In most cases the behavior will be identical to `bool&`. One exception is that the reference has a member function named `flip()` that will change the value of the underlying bit.

```
#include <bitvector>
#include <algorithm>
#include <cassert>

int main()
{
    Metrowerks::bitvector<> v(3);
    Metrowerks::bitvector<>::reference r = v[0];

    assert(v[0] == false);
    assert(r == false);
    r = true;

    assert(v[0] == true);
    r.flip();

    assert(v[0] == false);
    v[1] = true;
    swap(r, v[1]);

    assert(r == true);
    assert(v[0] == true);
    assert(v[1] == false);

    Metrowerks::bitvector<>::pointer p = &r;

    assert(*p == true);
    *p = false;
```

```

    assert(v[0] == false);
    assert(r == false);
    assert(*p == false);
}

```

## NOTE

`swap` can be called with this reference type, even with an `rvalue` reference. As it applies to `std::vector<bool>::reference`, this is an extension to the standard. Another extension to better emulate a real reference is that you can take the address of a reference that yields the nested type pointer.

### 23.1.6 const\_reference

```
class const_reference;
```

The nested class `const_reference` is a "smart reference" class which emulates a `const` reference to an internal `bool`. An actual reference (`const bool&`) can not be used here since the internal `bools` are stored as a single bit. In most cases the behavior will be identical to `const bool&`. As it applies to `std::vector<bool>::const_reference`, this is an extension to the standard. The standard specifies that `std::vector<bool>::const_reference` is just a `bool`. But the following code demonstrates how this proxy class more closely emulates a `const bool&` than does a `bool`. Another extension to better emulate a real `const` reference is that you can take the address of a `const_reference` which yields the nested type `const_pointer`.

```

#include <bitvector>
#include <cassert>

int main()
{
    Metrowerks::bitvector<> v(3);
    Metrowerks::bitvector<>::const_reference cr = v[0];
    assert(cr == false);
    v[0] = true;
    assert(cr == true);
    Metrowerks::bitvector<>::const_pointer cp = &cr;
    assert(*cp == true);
}

```

### 23.1.7 iterators and pointers

```

class      pointer;
class  const_pointer;
class      iterator;
class  const_iterator;

```

**Constructors**

The nested types `iterator` and `pointer` are the same type, as are `const_iterator` and `const_pointer`. Both are random access iterators, except that they return `reference` and `const_reference` respectively when dereferenced (as opposed to `bool&` and `const bool&`).

The following standard algorithms are specialized for `iterator` and `const_iterator` as appropriate. They will operate on a word at a time instead of a bit at a time for superior performance.

```
Iterator copy(Iterator first, Iterator last, Iterator result);
Iterator copy_backward(Iterator first, Iterator last, Iterator result);
void fill_n(Iterator first, size_type n, const T& value);
void fill(Iterator first, Iterator last, const T& value);
bool equal(Iterator first1, Iterator last1, Iterator first2);
```

## 23.2 Constructors

This section explains Constructors.

```
explicit bitvector(const allocator_type& a = Allocator());
```

Constructs an empty bitvector, with the supplied (or defaulted) allocator. It will not throw an exception unless constructing or copying the allocator throws an exception. The default allocator, `std::allocator<bool>`, will not throw in this context.

Postcondition: `size() == 0` and `capacity() == 0`. If an allocator was supplied then `get_allocator() == a`, else `get_allocator() == Allocator()`.

```
explicit bitvector(size_type n, bool x = false, const
allocator_type& a = Allocator());
```

Constructs a bitvector of length `n` with all values set to `x`.

Postcondition: `size() == n` and `capacity() >= n`. All elements are equal to `x`. If an allocator was supplied then `get_allocator() == a`, else `get_allocator() == Allocator()`.

```
template <class InputIterator>
```

```
bitvector(InputIterator first, InputIterator last, const
allocator_type& a = Allocator());
```

Constructs a bitvector from the range `[first, last)`.

Postcondition: `size() == distance(first, last)` and `capacity() >= size()`. All elements are equal to the corresponding values in the range `[first, last)`. If an allocator was supplied then `get_allocator() == a`, else `get_allocator() == Allocator()`.

```
bitvector(const bitvector& x);
```

Constructs a copy of the bitvector `x`.

Postcondition: `*this == x.get_allocator() == x.get_allocator()`.

### NOTE

The capacity of `x` is not necessarily duplicated in `*this`. In general, the copy will be done with the least amount of capacity sufficient to hold `size()` elements.

## 23.2.1 Destructor

```
~bitvector();
```

Destroys the bitvector and throws nothing.

## 23.2.2 Assignment

```
bitvector& operator=(const bitvector& x);
```

Assigns `x` to `*this`.

Postcondition: `*this == x`.

If `capacity() >= x.size()`, no exception can be thrown.

```
void assign(size_type n, bool x);
```

Assigns to `*this` `n` copies of `x`.

Postcondition: `*this == bitvector(n, x)`.

If `capacity() >= n`, no exception can be thrown.

```
template <class InputIterator>

    void assign(InputIterator first, InputIterator last);
```

Assigns to `*this` the range `[first, last)`.

Precondition: `first` and `last` are not iterators into this bitvector.

Postcondition: `*this == bitvector(first, last)`.

If `capacity() >= distance(first, last)`, and if no operations on the `InputIterator` type can throw, then no exception can be thrown.

## 23.3 Capacity

This section describes capacity functions.

### 23.3.1 size

```
size_type size() const;
```

Returns the current number of elements in the `bitvector`.

Throws nothing.

### 23.3.2 empty

```
bool empty() const;
```

Returns `size() == 0`.

Throws nothing.

### 23.3.3 capacity

```
size_type capacity() const;
```

Returns the maximum `size()` that can be achieved before a memory allocation is required.

Throws nothing.

### 23.3.4 max\_size

```
size_type max_size() const;
```

Returns a maximum size that the bitvector could grow, assuming sufficient memory. This is a design-time limit.

Throws nothing.

### 23.3.5 reserve

```
void reserve(size_type n);
```

If  $n > \text{capacity}()$  will attempt to acquire a `capacity()` greater to or equal to  $n$ , an exception is thrown on failure. The precise type of the exception thrown is dictated by the allocator. The default allocator will throw a `std::bad_alloc` on failure. If an exception is thrown, there are no effects. If  $n \leq \text{capacity}()$  then there are no effects.

Postcondition: `capacity() >= n`.

### 23.3.6 get\_allocator

```
allocator_type get_allocator() const;
```

Returns a copy of the allocator that the `bitvector` was constructed with. If the copy constructor of the `allocator_type` can not throw an exception then `get_allocator()` is also a non-throwing operation.

## 23.4 Iteration

This section describes Iteration functions.

```
iterator      begin();
const_iterator begin() const;
```

Returns an iterator referring to the first element in the `bitvector`. If the `bitvector` is empty, then returns an iterator equal to `end()`.

Throws nothing.

```
iterator      end();
const_iterator end() const;
```

Returns an iterator referring to one past the last element in the `bitvector`. If the `bitvector` is empty, then returns an iterator equal to `begin()`.

Throws nothing.

```
reverse_iterator      rbegin();
const_reverse_iterator rbegin() const;

reverse_iterator      rend();
const_reverse_iterator rend() const;
```

Returns `std::reverse_iterator`'s which operate over the range of the `bitvector` but in reverse order.

Throws nothing.

## 23.5 Access

This section describes access functions.

### 23.5.1 front



```
reference      front();
const_reference front() const;
```

Returns a reference to the first element in the `bitvector`.

Precondition: The `bitvector` is not empty.

Throws nothing.

```
reference      back();
const_reference back() const;
```

Returns a reference to the last element in the `bitvector`.

Precondition: The `bitvector` is not empty.

Throws nothing.

```
reference      operator[] (size_type n);
const_reference operator[] (size_type n) const;
```

Returns a reference to the `n`th element in the `bitvector`.

Precondition: `n < size()`.

Throws nothing.

```
const_reference at(size_type n) const;
reference      at(size_type n);
```

Returns a reference to the `n`th element in the `bitvector`.

Throws nothing if `n < size()`, else throws a `std::out_of_range` object. If an exception is thrown, there are no effects.

## 23.6 Insertion

This section defines insertion functions.

### 23.6.1 `push_back`

```
void push_back(bool x);
```

Appends `x` into the `bitvector`.

Postcondition: If an exception is not thrown, `size()` is increased by one and `back() == x`.

If an exception is thrown, there are no effects.

## 23.6.2 insert

```
iterator insert(iterator position, bool x);
```

Inserts `x` into the `bitvector` at `position`. All elements in the range `[position, end())` are moved down to make room for `x`. The returned iterator refers to the newly inserted element having value `x`.

**Precondition:** `position` is an iterator into this `bitvector`.

**Postcondition:** If an exception is not thrown, `size()` is increased by one and `*returned_iterator == x`.

If an exception is thrown, there are no effects.

```
void insert(iterator position, size_type n, bool x);
```

Inserts `n` copies of `x` into the `bitvector` at `position`. All elements in the range `[position, end())` are moved down to make room for the newly inserted elements.

**Precondition:** `position` is an iterator into this `bitvector`.

**Postcondition:** If an exception is not thrown, `size()` is increased by `n`. The range `[position, position+n)` will all have value `x`.

If an exception is thrown, there are no effects.

```
template <class InputIterator>
void insert(iterator position, InputIterator first,
InputIterator last);
```

Inserts the range `[first, last)` into the `bitvector` at `position`. All elements in the range `[position, end())` are moved down to make room for the newly inserted elements.

**Precondition:** `position` is an iterator into this `bitvector`. `first` and `last` are not iterators into this `bitvector`.

**Postcondition:** If an exception is not thrown, `size()` is increased by `distance(first, last)`.

If an exception is thrown other than by operations on `InputIterator`, there are no effects.

## 23.7 Erasure

This sections defines erasure functions.

### 23.7.1 pop\_back

```
void pop_back();
```

Removes the last element in the `bitvector`.

Precondition: The `bitvector` is not empty.

Postcondition: `size()` is decreased by one.

Throws nothing.

### 23.7.2 clear

```
void clear();
```

Removes all elements in the `bitvector`.

Postcondition: `size() == 0`.

Throws nothing.

### 23.7.3 erase

```
iterator erase(iterator position);
```

## miscellaneous

Removes the element at `position`. Elements in the range `(position, end)` are moved down by one in the `bitvector`. An iterator pointing to the element just after the erased element, in the modified `bitvector`, is returned.

Precondition: `position` is a dereferenceable iterator into this `bitvector`.

Postcondition: `size()` is decreased by one.

Throws nothing.

```
iterator erase(iterator first, iterator last);
```

Removes the range of elements `[first, last)`. Elements in the range `(last, end)` are moved down by `distance(first, last)` in the `bitvector`. An iterator pointing to the element just after the erased range, in the modified `bitvector`, is returned.

Precondition: `first` is a dereferenceable iterator into this `bitvector`. `last` is an iterator into this `bitvector`. `first <= last`.

Postcondition: `size()` is decreased by `last-first`.

Throws nothing.

## 23.8 Miscellaneous

This section defines miscellaneous functions.

### 23.8.1 `resize`

```
void resize(size_type sz, bool c = false);
```

Changes the `size()` of the `bitvector` to `sz`. If `sz` is greater than the current `size()`, extra elements are appended with the value `c`.

Postcondition: `size() == sz`.

Throws nothing if `sz <= capacity()`. If an exception is thrown, there are no effects.

## 23.8.2 swap

```
void swap(bitvector& x);
```

Swaps the contents of `*this` and `x`. If the `allocator_type` contains state, the allocators are also swapped using an unqualified call to `swap`, with `std::swap` in scope.

Postcondition: `*this ==` previous value of `x` and `x ==` previous value of `*this`.

If `swap` on the `allocator_type` can not throw, then this operation will not throw an exception.

## 23.8.3 flip

```
void flip();
```

Changes the value of every element.

Throws nothing.

## 23.8.4 invariants

```
bool invariants() const;
```

This function checks the objects internal invariants and returns `true` if all are satisfied. If it returns `false`, it indicates a bug either in the `bitvector` implementation, or in client code. A common way to use this member is:

```
assert(v.invariants());
```

Throws nothing.

## 23.9 Namespace scope functions

This section explains Namespace scope functions.

**namespace scope functions**

```
template <class Allocator>
bool
operator==(const bitvector<Allocator>& x, const
bitvector<Allocator>& y);
```

Returns `x.size() == y.size() && std::equal(x.begin(), x.end(), y.begin());`

Throws nothing.

```
template <class Allocator>
bool
operator!=(const bitvector<Allocator>& x, const
bitvector<Allocator>& y);
```

Returns `!(x == y);`

Throws nothing.

```
template <class Allocator>
bool
operator< (const bitvector<Allocator>& x, const
bitvector<Allocator>& y);
```

Returns `std::lexicographical_compare(x.begin(), x.end(), y.begin(), y.end());`

Throws nothing.

```
template <class Allocator>
bool
operator> (const bitvector<Allocator>& x, const
bitvector<Allocator>& y);
```

Returns `y < x;`

Throws nothing.

```
template <class Allocator>
bool
operator>=(const bitvector<Allocator>& x, const
bitvector<Allocator>& y);
```

Returns `!(x < y);`

Throws nothing.

```
template <class Allocator>
bool
operator<=(const bitvector<Allocator>& x, const
bitvector<Allocator>& y);
```

Returns `!(y < x);`

Throws nothing.

```
template <class Allocator>
void
swap(bitvector<Allocator>& x, bitvector<Allocator>& y);
```

Calls `x.swap(y);`

## Chapter 24

# EWL\_UTILITY

This chapter is a reference guide to the General utility support in the Embedded Warrior Library.

This chapter consists of utilities for support of non standard headers.

- [Header ewl\\_utility](#)
- [Basic Compile-Time Transformations](#)
- [Type Query](#)
- [CV Query](#)
- [Type Classification](#)
- [POD classification](#)
- [Miscellaneous](#)

### 24.1 Header ewl\_utility

The purpose of this header is to offer a collection of non-standard utilities collected under the namespace Metrowerks.

These utilities are of a fundamental nature, and are typically used in other utilities, rather than top level code. Example usage assumes that a declaration or directive has been previously issued.

#### NOTE

This header is non-standard. The classes herein are offered as extensions to the C++ standard. They are marked as such by the namespace Metrowerks. Concepts and ideas co-developed on Boost.

<http://www.boost.org/>

**NOTE**

Unnamed namespaces are displayed using a compiler generated unique name that has the form: `__unnamed_<filename>` where `<filename>` is the source file name of the main translation unit that contains the unnamed namespace.

**NOTE**

When generating multiple template instantiations, the compiler may choose to optimize functions that have same binary representation regardless of the specialization being compiled. This results in smaller code, but while debugging no breakpoints can be placed inside optimized functions. To alleviate this, use the `"-xcofe -f1=dont_inline"` switch. For more information about `dont_inline` switch, see the *<product> C/C++ Compiler User Guide*.

## 24.2 Basic Compile-Time Transformations

A collection of templated struct types which can be used for simple compile-time transformations of types.

### 24.2.1 `remove_const`

Will remove the top level `const` (if present) from a type.

```
typedef typename  
remove_const<T>::type non_const_type;
```

#### Remarks

The resulting `"non_const_type"` will be the same as the input type `T`, except that if `T` is `const` qualified, that constant qualification will be removed.

#### Listing: Example of `remove_const`

```
typedef typename remove_const <const int>::type Int;  
Int has type int.
```

### 24.2.2 `remove_volatile`



Will remove the top level volatile (if present) from a type.

```
typedef typename  
remove_volatile<T>::type non_volatile_type;
```

### Remarks

The resulting "non\_volatile\_type" will be the same as the input type  $T$ , except that if  $T$  is volatile qualified, that volatile qualification will be removed.

### Listing: Example of remove\_volatile

```
typedef typename remove_volatile <volatile int>::type Int;  
Int has type int.
```

## 24.2.3 remove\_cv

Will remove the top level qualifiers (const and/or volatile, if present) from a type.

```
typedef typename  
remove_cv<T>::type non_qualified_type;
```

### Remarks

The resulting "non\_qualified\_type" will be the same as the input type  $T$ , except that if  $T$  is  $cv$  qualified, the qualifiers will be removed.

### Listing: Example of remove\_cv

```
typedef typename remove_cv <const int>::type Int;  
Int has type int.
```

## 24.2.4 remove\_pointer

If given a pointer, returns the type being pointed to. If given a non-pointer type, simply returns the input.

```
typedef typename  
remove_pointer<T>::type pointed_to_type;
```

### Listing: Example of remove\_pointer

```
typedef typename  
remove_pointer<const int*volatile*const>::type IntPtr;  
  
typedef typename remove_pointer<IntPtr>::type Int;
```

IntPtr will have type `type const int*volatile`. Int will have the type `const int`.

## 24.2.5 remove\_reference

If given a reference, returns the type being referenced. If given a non-reference, simply returns the input.

```
typedef typename  
remove_reference<T>::type referenced_type;
```

### Listing: Example of remove\_reference

```
typedef typename remove_reference<int&>::type Int;  
typedef typename remove_reference<const int&>::type ConstInt;
```

Int has the type `int`, and ConstInt has the type `const int`.

## 24.2.6 remove\_bounds

If given an array type, will return the type of an element in the array. If given a non-array type, simply returns the input.

```
typedef typename remove_bounds<T>::type Element;
```

### Listing: Example of remove\_bounds

```
typedef int IntArray[4];  
typedef typename remove_bounds<IntArray>::type Int;
```

Int has the type `int`.

## 24.2.7 remove\_all

This transformation will recursively remove `cv` qualifiers, pointers, references and array bounds until the type is a fundamental type, enum, union, class or member pointer.

```
typedef typename remove_all<T>::type fundamental_type;
```

### Listing: Example of remove\_all

```
typedef const int** Array[4];
typedef typename remove_all<Array*&>::type Int;

Int has the type int.
```

## 24.3 Type Query

The following structs perform basic queries on one or more types and return a `bool` value.

### 24.3.1 `is_same`

This struct can be used to tell if two types are the same type or not.

```
bool b = is_same<T, U>::value;
```

#### Listing: Example of `is_same`

```
bool b = is_same<const int, int>::value;
The resulting value is false. int and const int are two distinct types.
```

## 24.4 CV Query

This section defines CV Query functions.

### 24.4.1 `is_const`

Returns true if type has a top level `const` qualifier, else false.

```
bool b = is_const<T>::value;
```

#### Listing: Example of `is_const`

```
bool b = is_const<const int>::value;
The resulting value is true.
```

## 24.4.2 is\_volatile

Returns true if type has a top level volatile qualifier, else false.

```
bool b = is_volatile<T>::value;
```

### Listing: Example of is\_volatile

```
bool b = is_volatile<const int>::value;  
The resulting value is false.
```

## 24.5 Type Classification

The following structs implement classification as defined by section 3.9 in the C++ standard.

All types can be classified into one of ten basic categories:

- integral
- floating
- void
- pointer
- member pointer
- reference
- array
- enum
- union
- class

Top level cv qualifications do not affect type classification. For example, both `const int` and `int` are considered to be of integral type.

```
bool b = is_XXX<T>::value;
```

where `is_XXX` is one of the ten basic categories.

- `is_integral`
- `is_floating`
- `is_void`
- `is_pointer`
- `is_member_pointer`
- `is_reference`

- `is_array`
- `is_enum`
- `is_union`
- `is_class`

There are also five categories that are made up of combinations of the ten basic categories:

- `is_arithmetic` - `is_integral` or `is_floating`
- `is_fundamental` - `is_arithmetic` or `is_void`
- `is_scalar` - `is_arithmetic` or `is_pointer` or `is_member_pointer` or `is_enum`
- `is_compound` - not `is_fundamental`
- `is_object` - anything but a void or reference type

The classifications: `is_enum` and `is_union` do not currently work automatically. Enumerations and unions will be mistakenly classified as class type. This can be corrected on a case by case basis by specializing `is_enum_imp` or `is_union_imp`. These specializations are in the `Metrowerks::details` namespace.

`is_extension` is also provided for those types that we provide as an extension to the C++ standard. `is_extension<T>::value` will be false for all types except for long long and unsigned long long.

`has_extension` is a modified form of `is_extension` that answers to `true` if a type is either an extension or contains an extension.

### Listing: Example of `is_integral`

```
bool b = is_integral<volatile int>::value;
The value of b is true.
```

### Listing: Example of `Metrowerks::details` namespace

```
enum MyEnum {zero, one, two};

template <>

struct Metrowerks::details::is_enum_imp<MyEnum>
    {static const bool value = true;};
```

### Listing: Example of `is_extension` and `has_extension`

```
is_extension<long long*&>::value;    // false
has_extension<long long*&>::value;  // true
```

## 24.5.1 `is_signed` / `is_unsigned`

These structs only work on arithmetic types. The type must be constructable by an int and be less-than comparable.

## Remarks

In the [Example of is\\_signed and is\\_unsigned](#) the signedness of char is tested. Since it is implementation-defined whether or not char is signed, this is a way to find out how it is defined. Either b1 will be true and b2 false, or vice-versa.

### Listing: Example of is\_signed and is\_unsigned

```
bool b1 = is_signed<char>::value;
bool b2 = is_unsigned<char>::value;
```

## 24.6 POD classification

Four structs classify types as to whether or not they have trivial special members as defined in section 12 of the C++ standard.

- has\_trivial\_default\_ctor
- has\_trivial\_copy\_ctor
- has\_trivial\_assignment
- has\_trivial\_dtor

This library will answer correctly for non-class types. But user defined class types will always answer false to any of these queries. If you create a class with trivial special members, and you want that class to be able to take advantage of any optimizations that might arise from the assumption of trivial special members, you can specialize these structs:

Note that in the [Example of specialized structs](#) these specializations need not worry about cv qualifications. The higher level has\_trivial\_XXX structs do that for you.

Finally there is an is\_POD struct that will answer true if a type answers true on all four of the above queries.

### Listing: Example of specialized structs

```
template <>
struct Metrowerks::details::class_has_trivial_default_ctor<MyClass>
{
    static const bool value = true;
};

template <>
struct Metrowerks::details::class_has_trivial_copy_ctor<MyClass>
{
    static const bool value = true;
};
```

```

template <>
struct Metrowerks::details::class_has_trivial_assignment<MyClass>
    {static const bool value = true;};

template <>
struct Metrowerks::details::class_has_trivial_dtor<MyClass>
    {static const bool value = true;};

```

## 24.7 Miscellaneous

Miscellaneous utility functions are included in the EWL Utilities library.

### 24.7.1 compile\_assert

This is a compile time assert. This is a very basic version of this idea. Can be used to test assertions at compile time.

#### Listing: Example of compile\_assert use

```

#include <ewl_utility>

template <class T>
T
foo(const T& t)
{
    Metrowerks::compile_assert<sizeof(T) >= sizeof(int)>
T_Must_Be_At_Least_As_Big_As_int;
    //...
    return t;
}

int main()
{
    int i;
    foo(i); // ok
    char c;
    foo(c); // Error      : illegal use of incomplete struct/union/class
                //          'Metrowerks::compile_assert<0>'
}

```

### 24.7.2 array\_size

Given an array type, you can get the size of the array with `array_size`.

The code fragment `array_size<type>::value` will only compile if `type` is an array. It won't compile if `type` is a union, struct or class.

### Listing: Example usage of `array_size`

```
typedef int Array[10];
size_t n = array_size<Array>::value;
```

`n` has the value of 10.

## 24.7.3 `can_derive_from`

The code fragment `can_derive_from<T>::value` will be true if `T` is a class (but not a union), otherwise it will be false. Only classes which are not unions can be derived from.

```
bool b = can_derive_from<T>::value;
```

## 24.7.4 `call_traits`

This struct is a collection of type definitions that ease coding of template classes when the template parameter may be a non-array object, an array, or a reference. The type definitions specify how to pass a type into a function, and how to pass it back out either by value, reference or const reference. The interface is:

```
call_traits<T>::value_type
call_traits<T>::reference
call_traits<T>::const_reference
call_traits<T>::param_type
```

### Remarks

The first three types are suggestions on how to return a type from a function by value, reference or const reference. The fourth type is a suggestion on how to pass a type into a method.

The `call_traits` struct is most useful in avoiding references to a reference which are currently illegal in C++. Another use is in helping to decay array-type parameters into pointers. In general, use of `call_traits` is limited to advanced techniques, and will not require specializations of `call_traits` to be made. For example uses of `call_traits` see `compressed_pair`. For an example specialization see `alloc_ptr`.



## 24.7.5 is\_empty

Answers true if the type is a class or union that has no data members, otherwise answers false. This is a key struct for determining if the space for an "empty" object can be optimized away or not.

```
bool b = is_empty<T>::value;
```

## 24.7.6 compressed\_pair

Like `std::pair`, but attempts to optimize away the space for either the first or second template parameter if the type is "empty". And instead of the members being accessible via the public data members `first` and `second`, they are accessible via member methods `first()` and `second()`. The `compressed_pair` handles reference types as well as other types thanks to the `call_traits` template. This is a good example to study if you're wanting to see how to take advantage of either `call_traits` or `is_empty`. To see an example of how `compressed_pair` is used see `alloc_ptr`.

### Remarks

Use of the single argument constructors will fail at compile time (ambiguous call) if `first_type` and `second_type` are the same type.

The swap specialization will call `swap` on each member if and only if its size has not been optimized away. The call to `swap` on each member will look both in `std`, and in the member's namespace for the appropriate swap specialization. Thus clients of `compressed_pair` need not put swap specializations into namespace `std`.

A good use of `compressed_pair` is in the implementation of a container that must store a function object. Function objects are typically zero-sized classes, but are also allowed to be ordinary function pointers. If the function object is a zero-sized class, then the container can optimize its space away by using it as a base class. But if the function object instantiates to a function pointer, it can not be used as a base class. By putting the function object into a `compressed_pair`, the container implementor need not worry whether it will instantiate to a class or function pointer.

MyContainer1 uses a zero-sized Compare object. On a 32 bit machine, the sizeof MyContainer1 will be 4 bytes as the space for Compare is optimized away by compressed\_pair. But MyContainer2 instantiates Compare with an ordinary function pointer which can't be optimized away. Thus the sizeof MyContainer2 is 8 bytes.

### Listing: Example of compressed\_pair

```
#include <iostream>
#include <functional>
#include <ewl_utility>

template <class T, class Compare>
class MyContainer
{
public:
    explicit MyContainer(const Compare& c = Compare()) : data_(0, c) {}
    T* pointer() {return data_.first();}
    const T* pointer() const {return data_.first();}
    Compare& compare() {return data_.second();}
    const Compare& compare() const {return data_.second();}
    void swap(MyContainer& y) {data_.swap(y.data_);}

private:
    Metrowerks::compressed_pair<T*, Compare> data_;
};

int main()
{
    typedef MyContainer<int, std::less<int>> MyContainer1;
    typedef MyContainer<int, bool (*)(int, int)> MyContainer2;
    std::cout << sizeof(MyContainer1) << '\n';
    std::cout << sizeof(MyContainer2) << '\n';
}
```

## 24.7.7 alloc\_ptr

An extension of std::auto\_ptr. alloc\_ptr will do everything that auto\_ptr will do with the same syntax. Additionally alloc\_ptr will deal with array new/delete:

```
alloc_ptr<int, array_deleter<int>> a(new int[4]);
// Ok, destructor will use delete[]
```

### Remarks

By adding the array\_deleter<T> template parameter you can enable alloc\_ptr to correctly handle pointers to arrays of elements.

alloc\_ptr will also work with allocators which adhere to the standard interface. This comes in very handy if you are writing a container that is templated on an allocator type. You can instantiate an alloc\_ptr to work with an allocator with:

```
alloc_ptr<T, Allocator<T>, typename Allocator<T>::size_type> a;
```

The third parameter can be omitted if the allocator is always going to allocate and deallocate items one at a time (e.g. node based containers).

`alloc_ptr` takes full advantage of `compressed_pair` so that it is as efficient as `std::auto_ptr`. The `sizeof(alloc_ptr<int>)` is only one word. Additionally `alloc_ptr` will work with a reference to an allocator instead of an allocator (thanks to `call_traits`). This is extremely useful in the implementation of node based containers.

This is essentially the `std::auto_ptr` interface with a few twists to accommodate allocators and size parameters.



## Chapter 25

# EWL C++ Debug Mode

This chapter describes the EWL Debug Mode for code diagnostics.

### 25.1 Overview of EWL C++ Debug Mode

The STL portion of EWL C++ has a debug mode that can be used to diagnose common mistakes in code that uses the EWL C++ containers and their iterators.

When an error is detected, a `std::logic_error` is thrown with an appropriate error message.

#### 25.1.1 Types of Errors Detected

Given a container (such as vector), the following errors are detected in EWL Debug mode:

- Incrementing an iterator beyond `end()`.
- Decrementing an iterator before `begin()`.
- Dereferencing an iterator that it not dereferenceable.
- Any use of an invalid iterator besides assigning a valid value to it.
- Passing an iterator to a container method when that iterator does not point into that container.
- Comparison of two iterators that don't point into the same container.

#### 25.1.2 How to Enable Debug Mode

To enable EWL C++ Debug mode simply uncomment this line in the EWL Configuration header `<ewlconfig>` See [C++ Switches, Flags and Defines](#) for more information.

```
#define _EWL_DEBUG
```

Alternatively you can `#define _EWL_DEBUG` in a prefix file. Either way, you must rebuild your C++ library after flipping this switch. Convenience makefiles are provided under `ewl/EWL_C++/` to make this task easier. After rebuilding the C++ library, rebuild your application and run it. If there are any errors, a `std::logic_error` will be thrown. If exceptions are disabled, then instead the error function `__ewl_error(const char*)` is called. This function can be defined by client code. There are some sample implementations in `<ewlconfig>`. The default simply calls `fprintf` and `abort`.

## 25.2 Debug Mode Implementations

The debug facilities are available for the standard containers as well as the EWL extension containers.

Each container has methods that will invalidate some or all outstanding iterators. If those iterators are invalidated, then their use (except for assigning a new valid iterator) will generate an error. An iterator is considered invalidated if it no longer points into the container, or if the container's method silently causes the iterator to point to a new element within the container. Some methods (such as `swap`, or `list::splice`) will transfer ownership of outstanding iterators from one container to another, but otherwise leave them valid.

In this [Example of dereference at end](#): the iterator `i` is incremented to the end of the vector and then dereferenced and assigned through. In release mode this is undefined behavior and may overwrite other important information in your application. However in debug mode this example prints out:

```
EWL DEBUG: dereferenced invalid iterator
```

### Listing: Example of dereference at end:

```
#include <iostream>
#include <vector>
#include <stdexcept>

int main()
{
    try
    {
        std::vector<int> v(10);
        std::vector<int>::iterator i = v.begin() + 9;

        *i = 9; // ok
        ++i;   // ok
        *i = 10; // error
    } catch (std::exception& e)
```

```

    {
        std::cerr << e.what() << '\n';
    }

    catch (...)
    {
        std::cerr << "Unknown exception caught\n";
    }
}

```

In the [Example of iterator/list mismatch](#): an iterator is initialized to point into the first list. But then this iterator is mistakenly used to erase an element from a second list. This is normally undefined behavior. In debug mode this example prints out:

```
EWL DEBUG: invalid iterator given to list
```

### Listing: Example of iterator/list mismatch:

```

#include <iostream>
#include <list>
#include <stdexcept>

int main()
{
    try
    {
        std::list<int> l1(10), l2(10);
        std::list<int>::iterator i = l1.begin();
        l2.erase(i); // error
    }

    catch (std::exception& e)
    {
        std::cerr << e.what() << '\n';
    }

    catch (...)
    {
        std::cerr << "Unknown exception caught\n";
    }
}

```

In the [Example of use of invalidated iterator](#): the `push_back` method on deque invalidates all iterators. When the loop goes to increment `i`, it is operating on an invalidated iterator. This is normally undefined behavior. In debug mode this example prints out:

```
EWL DEBUG: increment end or invalid iterator
```

### Listing: Example of use of invalidated iterator:

```

#include <iostream>
#include <deque>
#include <stdexcept>

int main()
{
    try
    {
        std::deque<int> d(10);
        std::deque<int>::iterator i = d.begin(), e = d.end();
        for (; i != e; ++i)
            d.push_back(0);
    }
}

```

```
    catch (std::exception& e)
    {
        std::cerr << e.what() << '\n';
    }

    catch (...)
    {
        std::cerr << "Unknown exception caught\n";
    }
}
```

## 25.2.1 Debug Mode Containers

The list below documents when iterators are invalidated for each container, and for each method in that container:

### 25.2.1.1 deque

Various functions are included for debugging the `deque` class.

#### **assign**

All assign methods (including operator=) invalidate all iterators.

#### **push\_front/back**

Invalidates all iterators.

#### **pop\_front/back**

Only the iterators to the erased elements are invalidated.

#### **insert**

All iterators are invalidated.

#### **erase**

If erasing at either end, only iterators to elements erased are invalidated, else all iterators are invalidated.

#### **resize**

If the size increases, all iterators are invalidated. Else only iterators to the erased elements are invalidated.

#### **clear**

Invalidates all iterators.



**swap**

Iterators remain valid, but they now point into the swapped container.

**Remarks**

The index operator is range checked just like the `at()` method.

**25.2.1.2 list**

Various functions are included for debugging the `list` class.

**assign**

All assign methods (including `operator=`) invalidate all iterators.

**push\_front/back**

No iterators are invalidated.

**pop\_front/back**

Only the iterators to the erased elements are invalidated.

**insert**

No iterators are invalidated.

**erase**

Only the iterators to the erased elements are invalidated.

**resize**

Only the iterators to the erased elements are invalidated.

**clear**

Invalidates all iterators.

**swap**

Iterators remain valid, but they now point into the swapped container.

**splice, merge**

Iterators remain valid, but iterators into the argument list now point into this.

### 25.2.1.3 string

Various functions are included for debugging the `string` class.

#### **assign**

All assign methods (including `operator=`) invalidate all iterators.

#### **push\_back**

If capacity is not exceeded no iterators are invalidated, else all iterators are invalidated.

#### **pop\_back**

Only the iterators to the erased element is invalidated.

#### **insert**

If capacity is not exceeded iterators to elements beyond the insertion point are invalidated, else all iterators are invalidated.

#### **erase**

Iterators to elements at and beyond the erased elements are invalidated.

#### **resize**

If capacity is exceeded all iterators are invalidated, else iterators to any erased elements are invalidated.

#### **clear**

Invalidates all iterators.

#### **swap**

Iterators remain valid, but they now point into the swapped container.

#### **Remarks**

The index operator is range checked just like the `at()` method.

### 25.2.1.4 vector

Various functions are included for debugging the `vector` class.

#### **assign**

All assign methods (including operator=) invalidate all iterators.

### **push\_back**

If capacity is not exceeded no iterators are invalidated, else all iterators are invalidated.

### **pop\_back**

Only the iterators to the erased element is invalidated.

### **insert**

If capacity is not exceeded iterators to elements beyond the insertion point are invalidated, else all iterators are invalidated.

### **erase**

Iterators to elements at and beyond the erased elements are invalidated.

### **resize**

If capacity is exceeded all iterators are invalidated, else iterators to any erased elements are invalidated.

### **clear**

Invalidates all iterators.

### **swap**

Iterators remain valid, but they now point into the swapped container.

### **Remarks**

The index operator is range checked just like the at() method.

## **25.2.1.5 tree-based containers - map, multimap, set, multiset**

Various functions are included for debugging the `tree-based container classes map, multimap, set and multiset` classes.

### **assign**

Invalidates all iterators.

### **insert**

No iterators are invalidated.

**erase**

Only the iterators to the erased elements are invalidated.

**clear**

Invalidates all iterators.

**swap**

Iterators remain valid, but they now point into the swapped container.

### 25.2.1.6 `cdeque`

Various functions are included for debugging the `cdeque` class.

**assign**

All assign methods (including operator=) invalidate all iterators.

**push\_front/back**

If capacity exceeded invalidates all iterators, else no iterators are invalidated.

**pop\_front/back**

Only the iterators to the erased elements are invalidated.

**insert**

If capacity exceeded or if insert position is not at the front or back, invalidates all iterators, else no iterators are invalidated.

**erase**

If erasing at either end, only iterators to elements erased are invalidated, else all iterators are invalidated.

**resize**

If capacity exceeded invalidates all iterators, else iterators to any erased elements are invalidated.

**clear**

Invalidates all iterators.

**swap**

Iterators remain valid, but they now point into the swapped container.

### Remarks

The index operator is range checked just like the `at()` method.

## 25.2.1.7 `slist`

Various functions are included for debugging the `slist` class.

### **assign**

All assign methods (including `operator=`) invalidate all iterators.

### **push\_front/back**

No iterators are invalidated.

### **pop\_front/back**

Only the iterators to the erased elements are invalidated.

### **insert**

No iterators are invalidated.

### **erase**

Only the iterators to the erased elements are invalidated.

### **resize**

Only the iterators to the erased elements are invalidated.

### **clear**

Invalidates all iterators.

### **swap**

Iterators remain valid, but they now point into the swapped container.

### **splice,splice\_after,merge**

Iterators remain valid, but iterators into the argument list now point into this.

### Remarks

Incrementing `end()` is not an error, it gives you `begin()`.

### 25.2.1.8 hash-based containers - map, multimap, set, multiset

Various functions are included for debugging the `hash` based `map`, `multimap`, `set` and `multiset` classes.

#### **assign**

Invalidates all iterators.

#### **insert**

If `load_factor()` attempts to grow larger than `load_factor_limit()`, then the table is rehashed which invalidates all iterators, else no iterators are invalidated.

#### **erase**

Only the iterators to the erased elements are invalidated.

#### **clear**

Invalidates all iterators.

#### **swap**

Iterators remain valid, but they now point into the swapped container.

## 25.2.2 Invariants

In addition to the iterator checking described above, each container (except `string`) has a new member method:

```
bool invariants() const;
```

This method can be called at any time to assess the container's class invariants. If the method returns `false`, then the container has somehow become corrupted and there is a bug (most likely in client code, but anything is possible). If the method returns `true`, then no errors have been detected. This can easily be used in debug code like:

#### **Listing: Example of invariant debugging**

```
#include <vector>
#include <cassert>

int main()
{
    int iarray[4];
    std::vector<int> v(10);
    assert(v.invariants());
}
```

```
for (int i = 0; i <= 4; ++i)
    iarray[i] = 0;

assert(v.invariants());
```

The for loop indexing over `iarray` goes one element too far and steps on the vector. The assert after the loop detects that the vector has been compromised and fires.

Be warned that the `invariants` method for some containers can have a significant computational expense, so this method is not advised for release code (nor are any of the debug facilities).





## Chapter 26

# Hash Libraries

This chapter is a reference guide to the hash support in the Embedded Warrior Libraries.

This chapter on EWL implementation of hashes is made up of the following topics. A separate chapter [EWL\\_UTILITY](#) is also useful when understanding the methodology.

- [General Hash Issues](#)
- [Hash\\_set](#)
- [Hash\\_map](#)
- [Hash\\_fun](#)

### 26.1 General Hash Issues

This document reflects issues that are common to `hash_set`, `hash_multiset`, `hash_map` and `hash_multimap`.

Rather than repeat each of these issues for each of the four hash containers, they are discussed here.

#### 26.1.1 Introduction

These classes are analogous to `std::set`, `std::multiset`, `std::map` and `std::multimap`, but are based on a hash table. The design and implementation of these classes has the following goals:

- High CPU performance
- Minimum memory usage
- Ease of use
- Control over hashing details

- Backward compatibility with previous EWL hash containers
- Compatibility with hash containers supplied by SGI and Microsoft

Not all of these goals can be simultaneously met. For example, optimizations often require a trade-off between size and speed. "Ease of use" can pull the design in opposite directions from "control over details". And it is not possible to be 100% compatible with two or more other implementations, when they are not compatible among themselves. Nevertheless, thought and concessions have been made toward all of these goals.

## 26.1.2 Namespace Issues

These classes are a EWL extension to the standard C++ library, so they have been implemented within the namespace `Metrowerks`. There are several techniques available for accessing these classes:

### 26.1.2.1 Fully Qualified Reference

One technique is to fully qualify each use of an EWL extension with the full namespace. For example:

#### Listing: Qualified Reference

```
#include <hash_set>

int main()
{
    Metrowerks::hash_set<int> a;
}
```

### 26.1.2.2 Namespace Alias

"Metrowerks" is a long name but it is not likely to conflict with other library's namespaces. You can easily shorten the Metrowerks namespace while still retaining the protection of namespaces through the use of an alias. For example, here is how to refer to the Metrowerks namespace as "ewl":

#### Listing: Namespace Alias

```
#include <hash_map>

namespace ewl = Metrowerks;

int main()
{
```

```
    ewl::hash_map<int, int> a;  
}
```

The short name " `ewl` " is much more likely to conflict with other's libraries, but as the implementor of your code you can choose your aliases such that there is no conflict.

### 26.1.2.3 Using Declaration

Using declarations can bring individual names into the current namespace. They can be used either at namespace scope (outside of functions) or at function scope (inside of functions). Here is an example use of using a declaration at namespace scope:

#### Listing: Namespace Scope

```
#include <hash_set>  
  
using Metrowerks::hash_multiset;  
  
int main()  
{  
    hash_multiset<int> a;  
}
```

#### Remarks

Anywhere below the declaration, `hash_set` can be referred to without the use of the Metrowerks qualifier.

### 26.1.2.4 Using Directive

Using directives will import every name in one namespace into another. These can be used to essentially "turn off" namespaces so that you don't have to deal with them. They can be used at namespace scope, or to limit their effect, can also be used at function scope. For example:

#### Listing: Function Scope

```
#include <hash_map>  
  
int main()  
{  
    using namespace Metrowerks;  
    hash_multimap<int, int> a;  
}
```

#### Remarks

In the above example, any name in the Metrowerks namespace can be used in main without qualification.

### 26.1.2.5 Compatibility Headers

Most headers with the name `<name>` have an associated compatibility header `<name.h>`. These compatibility headers simply issue using declarations for all of the names they contain. Here is an example use:

#### Listing: Using Declarations for Names

```
#include <hash_set.h>
#include <hash_map.h>

int main()
{
    hash_set<int> a;
    hash_map<int, int> b;
}
```

### 26.1.2.6 Constructors

Each hash container has a constructor which takes the following arguments, with the following defaults:

```
size_type num_buckets = 0
const key_hasher& hash = key_hasher()
const key_compare& comp = key_compare()
float load_factor_limit = 2
float growth_factor = 4
const allocator_type& a = allocator_type()
```

#### Remarks

Since all arguments have defaults, the constructor serves as a default constructor. It is also declared explicit to inhibit implicit conversions from the first argument: `size_type`. The first argument is a way to specify the initial number of buckets. This was chosen as the first parameter in order to remain compatible both with previous versions of EWL hash containers, as well as the SGI hash containers.

The second and third parameters allow client code to initialize the hash and compare function objects if necessary. This will typically only be necessary if ordinary function pointers are being used. When function objects are used, the default constructed function object is often sufficient.

The fourth and fifth parameters allow you to set the initial values of `load_factor_limit` and `growth_factor`. Details on how these parameters interact with the `size()` and `bucket_count()` of the container can be found in the capacity section.

A second constructor also exists that accepts templated input iterators for constructing a hash container from a range. After the pair of iterators, the six parameters from the first constructor follow in the same order, and with the same defaults.

### 26.1.2.7 Iterator Issues

The hash iterators are of the forward type. You can increment them via prefix or postfix `++`, but you can not decrement them. This is compatible with our previous implementation of the hash containers, and with the hash containers provided by SGI. But the hash iterators provided by Microsoft are bidirectional. Code that takes advantage of the decrement operators offered by Microsoft will fail at compile time in the EWL implementation.

#### Remarks

Forward iterators were chosen over bidirectional iterators to save on memory consumption. Bidirectional iterators would add an additional word of memory to each entry in the hash container. Furthermore a hash container is an unordered collection of elements. This "unordered" can even change as elements are added to the hash container. The ability to iterate an unordered collection in reverse order has a diminished value.

Iterators are invalidated when the number of buckets in the hash container change. This means that iteration over a container while adding elements must be done with extra care (see Capacity for more details). Despite that iterators are invalidated in this fashion, pointers and references into the hash container are never invalidated except when the referenced element is removed from the container.

### 26.1.2.8 Capacity

`empty`, `size` and `max_size` have semantics identical with that described for standard containers.

#### Remarks

The load factor of a hash container is the number of elements divided by the number of buckets:

```
size()
```

```
load_factor = -----
```

```
bucket_count()
```

During the life time of a container, the load factor is at all times less than or equal to the load factor limit:

```
size()
----- <= load_factor_limit()
bucket_count()
```

This is a class invariant. When both `size()` and `bucket_count()` are zero, the `load_factor` is interpreted to be zero. `size()` can not be greater than zero if `bucket_count()` is zero. Client code can directly or indirectly alter `size()`, `bucket_count()` and `load_factor_limit()`. But at all times, `bucket_count()` may be adjusted so that the class invariant is not compromised.

- If client code increases `size()` via methods such as `insert` such that the invariant is about to be violated, `bucket_count()` will be increased by `growth_factor()`.
- If client code decreases `size()` via methods such as `erase`, the invariant can not be violated.
- If client code increases `load_factor_limit()`, the invariant can not be violated.
- If client code decreases `load_factor_limit()` to the point that the invariant would be violated, then `bucket_count()` will be increased just enough to satisfy the invariant.
- If client code increases `bucket_count()`, the invariant can not be violated.
- If client code decreases `bucket_count()` to the point that the invariant would be violated, then `bucket_count()` will be decreased only to the minimum amount such that the invariant will not be violated.

The final item in the bulleted list results to a "shrink to fit" statement.

```
myhash.bucket_count(0); // shrink to fit
```

The above statement will reduce the bucket count to the point that the `load_factor()` is just at or below the `load_factor_limit()`.

```
bucket_count()
```

`Bucket_count` returns the current number of buckets in the container.

The `bucket_count(size_type num_buckets)` sets the number of buckets to the first prime number that is equal to or greater than `num_buckets`, subject to the class invariant described above. It returns the actual number of buckets that were set. This is a relatively expensive operation as all items in the container must be rehashed into the new container. This routine is analogous to `vector`'s `reserve`. But it does not reserve space for a number of elements. Instead it sets the number of buckets which in turn reserves space for elements, subject to the setting of `load_factor_limit()`.

```
load_factor()
```

returns `size()/bucket_count()` as a float.

```
load_factor_limit()
```

returns the current `load_factor_limit`.

The `load_factor_limit(float lf)` sets the load factor limit. If the new load factor limit is less than the current load factor limit, the number of buckets may be increased.

You can completely block the automatic change of `bucket_count` with:

```
myhash.load_factor_limit(INFINITY);
```

This may be important if you are wanting outstanding iterators to not be invalidated while inserting items into the container. The argument to `load_factor_limit` must be positive, else an exception of type `std::out_of_range` is thrown.

The `growth_factor` functions will read and set the `growth_factor`. When setting, the new growth factor must be greater than 1 else an exception of type `std::out_of_range` is thrown.

The `collision(const_iterator)` method will count the number of items in the same bucket with the referred to item. This may be helpful in diagnosing a poor hash distribution.

### 26.1.2.9 insert

#### Insert For Unique Hashed Containers

`hash_set` and `hash_map`

have the following insert method:

```
std::pair<iterator, bool>  
insert(const value_type& x);
```

#### Remarks

If `x` does not already exist in the container, it will be inserted. The returned iterator will point to the newly inserted `x`, and the `bool` will be `true`. If `x` already exists in the container, the container is unchanged. The returned iterator will point to the element that is equal to `x`, and the `bool` will be `false`.

```
iterator insert(iterator, const value_type& x);
```

Operates just like the version taking only a `value_type`. The iterator argument is ignored. It is only present for compatibility with standard containers.

```
template <class InputIterator> void insert
(InputIterator first, InputIterator last);
```

Inserts those elements in (first, last) that don't already exist in the container.

### 26.1.2.10 insert

The `insert` for multi-hashed containers functions `hash_multiset` and `hash_multimap` have the following `insert` methods.

```
iterator insert(const value_type& x);
iterator insert(iterator p, const value_type& x);
template <class InputIterator> void insert
(InputIterator first, InputIterator last);
```

#### Remarks

In the first `insert` prototype `x` is inserted into the container and an iterator pointing to the newly inserted value is returned. If values equal to `x` already exist in the container, then the new element is inserted after all other equal elements. This ordering is stable throughout the lifetime of the container.

In the second prototype `insert` first checks to see if `*p` is equivalent to `x` according to the compare function. If it is, then `x` is inserted before `p`. If not then `x` is inserted as if the `insert` without an iterator was used. An iterator is returned which points to the newly inserted element.

The final `insert` prototype inserts (first, last) into the container. Equal elements will be ordered according to which was inserted first.

### 26.1.2.11 erase

Erases items at the position or selected items.

```
void erase(iterator position);
size_type erase(const key_type& x);
void erase(iterator first, iterator last);
```

#### Remarks



The first `erase` function erases the item pointed to by position from the container. The second erases all items in the container that compare equal to `x` and returns the number of elements erased. The third `erase` erases the range (`first`, `last`) from the container.

```
swap(hash_set& y);
```

Swaps the contents of `*this` with `y` in constant time.

```
clear();
```

Erases all elements from the container.

### 26.1.2.12 Observers

Miscellaneous functions used in the hash implementation.

```
get_allocator() const;
```

Returns the allocator the hash container was constructed with.

```
key_comp() const
```

Returns the comparison function the hash container was constructed with.

```
value_comp() const
```

Returns the comparison function used in the underlying hash table. For `hash_set` and `hash_multiset`, this is the same as `key_comp()`.

```
key_hash()
```

Returns the hash function the hash container was constructed with.

```
value_hash()
```

Returns the hash function used in the underlying hash table. For `hash_set` and `hash_multiset`, this is the same as `key_hash()`.

### 26.1.2.13 Set Operations

Miscellaneous hash set utility functions.

## find

```
iterator find(const key_type& x) const;
```

Returns an iterator to the first element in the container that is equal to *x*, or if *x* is not in the container, returns `end()`.

## count

```
count(const key_type& x) const
```

Returns the number of elements in the container equal to *x*.

## equal\_range

```
std::pair<iterator, iterator> equal_range(const key_type& x);
```

Returns a pair of iterators indicating a range in the container such that all elements in the range are equal to *x*. If no elements equal to *x* are in the container, an empty range is returned.

### 26.1.2.14 Global Methods

Global has functions.

## swap

```
swap(x, y)
```

Same semantics as `x.swap(y)`.

## operator==

```
operator == (x, y)
```

Returns true if *x* and *y* contain the same elements in the same order. To accomplish this they most likely must have the same number of buckets as well.

## operator!=

```
operator != (x, y)
```

Returns `!(x == y)`

### 26.1.3 Incompatibility with Previous versions of Hash Containers

The current hash containers are very compatible with previous versions except for a few methods:

You can no longer compare two hash containers with the ordering operators: `<`, `<=`, `>`, `>=`. Since hash containers are unordered sets of items, such comparisons have little meaning.

`lower_bound` is no longer supported. Use `find` instead if you expect the item to be in the container. If not in the container, `find` will return `end()`. As there is no ordering, finding the position which an item could be inserted before has no meaning in a hash container.

`upper_bound` is no longer supported. Again because of the fact that hash containers are unordered, `upper_bound` has questionable semantics.

Despite the lack of `lower_bound` and `upper_bound`, `equal_range` is supported. Note that `equal_range().first` suffices for `lower_bound`, and `equal_range().second` suffices for `upper_bound`.

## 26.2 Hash\_set

This header contains two classes: `hash_set` and `hash_multiset`.

`hash_set` is a container that holds an unordered set of items, and no two items in the container can compare equal. `hash_multiset` permits duplicate entries. Also see the General Hash Issues Introduction.

### NOTE

This header is non-standard. The classes herein are offered as extensions to the C++ standard. They are marked as such by the namespace `Metrowerks`.

### 26.2.1 Introduction

These containers are in the namespace `Metrowerks`. See `Namespace Issues` for details and hints about how to best take advantage of this fact.

hash\_set and hash\_multiset are largely compatible with previous versions of these classes which appeared in namespace std. But see Incompatibility for a short list of incompatibilities.

## 26.2.2 Old Hashset Headers

Previous versions of CodeWarrior placed hash\_set and hash\_multiset in the headers <hashset.h> and <hashmset.h> respectively. These headers are still available, but should be used only for transition purposes. They will disappear in a future release. These headers import the contents of <hash\_set> into the std namespace (as previous versions of hash\_(multi)set were implemented in std.

### Listing: Old Hashset Headers

```
#include <hashset.h>

int main()
{
    std::hash_set<int> a;
}
```

## 26.2.3 Template Parameters

Both hash\_set and hash\_multiset have the following template parameters and defaults:

```
template <class T, class Hash = hash<T>, class Compare =
    std::equal_to<T>, class Allocator = std::allocator<T> >
class hash_(multi)set;
```

The first parameter is the type of element the set is to contain. It can be almost any type, but must be copyable.

The second parameter is the hash function used to look up elements. It defaults to the hash function in <hash\_fun>. Client code can use hash<T> as is, specialize it, or supply completely different hash function objects or hash function pointers. The hash function must accept a T, and return a size\_t.

The third parameter is the comparison function which defaults to std::equal\_to<T>. This function should have equality semantics. A specific requirement is that if two keys compare equal according to Compare, then they must also produce the same result when processed by Hash.

The fourth and final parameter is the allocator, which defaults to std::allocator<T>. The same comments and requirements that appear in the standard for allocators apply here as well.

## 26.2.4 Nested Types

`hash_set` and `hash_multiset` define a host of nested types similar to standard containers. Several noteworthy points:

- `key_type` and `value_type` are the same type and represent the type of element stored.
- `key_hasher` and `value_hasher` are the same type and represent the hash function.
- `key_compare` and `value_compare` are the same type and represent the comparison function.
- `iterator` and `const_iterator` are the same type and have semantics common to a forward `const_iterator`.

## 26.2.5 Iterator Issues

See Iterator Issues that are common to all hash containers.

Iterators of `hash_set` and `hash_multiset` are not mutable. They act as `const_iterator`s. One can cast away the `const` qualification of references returned by iterators, but if the element is modified such that the hash function now has a different value, the behavior is undefined.

See Capacity for details on how to control the number of buckets.

## 26.2.6 `hash_set`

`hash_set` is a container based on a hash table that supports fast find, insert and erase. The elements in a `hash_set` are unordered. A `hash_set` does not allow multiple entries of equivalent elements.

## 26.3 `Hash_map`

The `hash_map` is a container that holds an unordered set of key-value pairs, and no two keys in the container can compare equal.

`hash_multimap` permits duplicate entries. Also see the General Hash Issues Introduction.

This header contains two classes:

- hash\_map
- hash\_multimap

### NOTE

This header is non-standard. The classes herein are offered as extensions to the C++ standard. They are marked as such by the namespace Metrowerks.

## 26.3.1 Introduction

These containers are in the namespace Metrowerks. See Namespace Issues for details and hints about how to best take advantage of this fact.

hash\_map and hash\_multimap are largely compatible with previous versions of these classes which appeared in namespace std. But see Incompatibility for a short list of incompatibilities.

## 26.3.2 Old Hashmap Headers

Previous versions of CodeWarrior placed hash\_map and hash\_multimap in the headers <hashmap.h> and <hashmmmap.h> respectively. These headers are still available, but should be used only for transition purposes. They will disappear in a future release. These headers import the contents of <hash\_map> into the std namespace (as previous versions of hash\_(multi)map were implemented in std.

### Listing: Old Hashmap Headers

```
#include <hashmap.h>

int main()
{
    std::hash_map<int, int> a;
}
```

## 26.3.3 Template Parameters

Both hash\_map and hash\_multimap have the following template parameters and defaults:

### Listing: Hashmap Template Parameters

```
template <class Key, class T, class Hash = hash<Key>,
class Compare = std::equal_to<Key>,
class Allocator = std::allocator<std::pair<const Key, T> > >
```

```
class hash_(multi)map;
```

The first parameter is the type of key the map is to contain. It can be almost any type, but must be copyable.

The second parameter is the type of value that will be associated with each key. It can be almost any type, but must be copyable.

The third parameter is the hash function used to look up elements. It defaults to the hash function in `<hash_fun>`. Client code can use `hash<Key>` as is, specialize it, or supply completely different hash function objects or hash function pointers. The hash function must accept a `Key`, and return a `size_t`.

The fourth parameter is the comparison function which defaults to `std::equal_to<Key>`. This function should have equality semantics. A specific requirement is that if two keys compare equal according to `Compare`, then they must also produce the same result when processed by `Hash`.

The fifth and final parameter is the allocator, which defaults to `std::allocator<std::pair<const Key, T>>`. The same comments and requirements that appear in the standard for allocators apply here as well.

### 26.3.4 Nested Types

`hash_map` and `hash_multimap` define a host of nested types similar to standard containers. Several noteworthy points:

- `key_type` and `value_type` are not the same type. `value_type` is a `pair<const Key, T>`.
- `key_hasher` and `value_hasher` are not the same type. `key_hasher` is the template parameter `Hash`. `value_hasher` is a nested type which converts `key_hasher` into a function which accepts a `value_type`.
  - `Value_hasher` has the public typedef's

```
typedef value_type argument_type;
typedef size_type  result_type;
```

This qualifies it as a `std::unary_function` (as defined in `<functional>`) and so could be used where other functionals are used.

- `value_hasher` has these public member functions:

```
size_type operator()(const value_type& x) const;
size_type operator()(const key_type& x) const;
```

These simply return the result of `key_hasher`, but with the first operator extracting the `key_type` from the `value_type` before passing the `key_type` on to `key_hasher`.

- `Key_compare` and `value_compare` are not the same type. `key_compare` is the template parameter `Compare`. `value_compare` is a nested type which converts `key_compare` into a function which accepts a `value_type`.
- `value_compare` has the public typedef's

```
typedef value_type first_argument_type;
typedef value_type second_argument_type;
typedef bool result_type;
```

This qualifies it as a `std::binary_function` (as defined in `<functional>`) and so could be used where other functionals are used.

- `value_compare` has these public member functions:

```
bool operator()(const value_type& x,
               const value_type& y) const;
bool operator()(const key_type& x,
               const value_type& y) const;
bool operator()(const value_type& x,
               const key_type& y) const;
```

These pass their arguments on to `key_compare`, extracting the `key_type` from `value_type` when necessary.

## 26.3.5 Iterator Issues

See [Iterator Issues](#) that are common to all hash containers.

See [Capacity](#) for details on how to control the number of buckets.

## 26.3.6 Element Access

```
mapped_type& operator[](const key_type& x);
```

If the key `x` already exists in the container, returns a reference to the `mapped_type` associated with that key. If the key `x` does not already exist in the container, inserts a new entry: `(x, mapped_type())`, and returns a reference to the newly created, default constructed `mapped_type`.



## 26.4 Hash\_fun

`<hash_fun>` declares a templated struct which serves as a function object named `hash`.

This is the default hash function for all hash containers. As supplied, `hash` works for integral types, `basic_string` types, and `char*` types (c-strings).

### NOTE

This header is non-standard. The classes herein are offered as extensions to the C++ standard. They are marked as such by the namespace `Metrowerks`.

Client code can specialize `hash` to work for other types.

Alternatively, client code can simply supply customized hash functions to the hash containers via the template parameters.

The returned `size_t` should be as evenly distributed as possible in the range `[0, numeric_limits<size_t>::max()]`. Logic in the hash containers will take care of folding this output into the range of the current number of buckets.



## Chapter 27

# Metrowerks::threads

This chapter is a reference guide to the threads support in the Embedded Warrior Library for C++.

### 27.1 Overview of EWL Threads

If you're already familiar with `boost::threads`, then you'll be very comfortable with `Metrowerks::threads`. The interface closely follows the boost library. There are some minor differences.

The biggest difference is that the library is part of EWL C++, and lives in namespace `Metrowerks`. The entire package can be accessed via `<ewl_thread>`. It is essentially a fairly thin C++ wrapper over a sub-set of Posix-threads. And there is also a "single thread" version where most of the code just does nothing. It is there to ease porting multithreaded code to a single threaded environment. But be aware that your multithreaded logic may or may not translate into a working single threaded application (especially if you deal with condition variables).

The threads library currently has these configuration flags:

**Table 27-1. Threads Configuration Flags**

Flag	Effects
<code>_EWL_SINGLE_THREAD</code>	A do-nothing stand-in
<code>_EWL_USE_PTHREADS</code>	Posix-Threads
<code>_EWL_USE_WINTHREADS</code>	Windows threads

EWL C++ will automatically configure itself based on how `_EWL_THREADSAFE` is set. However you can override the automatic configuration simply by setting it yourself in your prefix file or preprocessor preference panel. You must recompile the C++ library to have the same setting.

You can now create a runtime check to make sure your EWL C++ is compiled with consistent settings:

```
#include <ewl_utility>
int main()
{
    check(Metrowerks::ewl_settings());
}
```

This program will assert if it finds anything inconsistent between itself and the way EWL C++ was compiled.

## 27.2 Mutex and Locks

`Metrowerks::threads` has 6 types of mutexes.

- `mutex`
- `try_mutex`
- `timed_mutex`
- `recursive_mutex`
- `recursive_try_mutex`
- `recursive_timed_mutex`

### Listing: Mutex synopsis

```
class mutex
{
public:
    typedef /* details */ scoped_lock;
    mutex();
    ~mutex();
};

class try_mutex
{
public:
    typedef /* details */ scoped_lock;
    typedef /* details */ scoped_try_lock;
    try_mutex();
    ~try_mutex();
};

class timed_mutex
{
public:
    typedef /* details */ scoped_lock;
    typedef /* details */ scoped_try_lock;
    typedef /* details */ scoped_timed_lock;
    timed_mutex();
    ~timed_mutex();
};

class recursive_mutex
{
public:
```

```

        typedef /* details */ scoped_lock;
        recursive_mutex();
        ~recursive_mutex();
    };

    class recursive_try_mutex
    {
    public:
        typedef /* details */ scoped_lock;
        typedef /* details */ scoped_try_lock;
        recursive_try_mutex();
        ~recursive_try_mutex();
    };

    class recursive_timed_mutex
    {
    public:
        typedef /* details */ scoped_lock;
        typedef /* details */ scoped_try_lock;
        typedef /* details */ scoped_timed_lock;
        recursive_timed_mutex();
        ~recursive_timed_mutex();
    };

```

Note that each mutex type has only a default constructor and destructor. It is not copyable, and it does not have lock and unlock functions. You access this functionality via one of the nested types:

- `scoped_lock`
- `scoped_try_lock`
- `scoped_timed_lock`

### Listing: A `scoped_lock`

```

template <typename Mutex>
class scoped_lock
{
public:
    typedef Mutex mutex_type;
    explicit scoped_lock(mutex_type& m);
    scoped_lock(mutex_type& m, bool lock_it);
    ~scoped_lock();
    void lock();
    void unlock();
    bool locked() const;
    operator int bool_type::* () const;
};

```

You can use the `scoped_lock` to `lock` and `unlock` the associated `mutex`, and test whether it is locked or not (the operator `bool_type` is just a safe way to test the `lock` in an if statement like you might a pointer), for example:

```
if (my_lock) ...
```

Normally you won't use any of the `scoped_lock`'s members except it's constructor and destructor. These `lock` and `unlock` the `mutex` respectively.

### Listing: Example of lock and unlock usage

```

#include <ewl_thread>
Metrowerks::mutex foo_mut;

```

```
void foo()
{
    Metrowerks::mutex::scoped_lock lock(foo_mut);
    // only one thread can enter here at a time
} // foo_mut is implicitly unlocked here, no matter how foo returns
```

In single thread mode, the above example compiles, and the lock simply doesn't do anything. If you expect `foo()` to call itself, or to call another function which will lock the same `mutex` (before `foo` releases `foo_mut`), then you should use a recursive `mutex`.

A `mutex` can conveniently be a class member, which can then be used to lock various member functions on entry. But recall that your class copy constructor will need to create a fresh `mutex` when copying, as the `mutex` itself can not be copied (or assigned to).

In some cases you want to lock the `mutex` only if you don't have to wait for it. If it is unlocked, you lock it, else your thread can do something else. Use `scoped_try_lock` for this application. Note that not all `mutex` types support `scoped_try_lock` (have it as a nested type). The `scoped_try_lock` looks just like `scoped_lock` but adds this member function `bool try_lock()`,

### Listing: Example of `try_lock()` usage

```
#include <ewl_thread>
Metrowerks::try_mutex foo_mut;

void foo()
{
    Metrowerks::try_mutex::scoped_try_lock lock(foo_mut, false);
    if (lock.try_lock())
    {
        // got the lock
    }
    else
    {
        // do something else
    }
}
```

In the above example, the second parameter in the constructor tells the lock to not lock the `mutex` upon construction (else you might have to wait).

Sometimes you are willing to wait for a `mutex` lock, but only for so long, and then you want to give up. `scoped_timed_lock` is the proper lock for this situation. It looks just like a `scoped_lock` but adds two members:

```
bool timed_lock(const universal_time& unv_time);
bool timed_lock(const elapsed_time& elps_time);
```

These let you specify the amount of time you're willing to wait, either in terms of an absolute time (`universal_time`), or in terms of an interval from the current time (`elapsed_time`).

### Listing: Example of `timed_lock()`

```

Metrowerks::timed_mutex foo_mut;
void foo()
{
    Metrowerks::timed_mutex::scoped_timed_lock lock(foo_mut, false);
    Metrowerks::elapsed_time time_out(1, 500000000);
    if (lock.timed_lock(time_out))
    {
        // got the lock
    }
    else
    {
        // do something else
    }
}

```

This specifies that the thread should quit trying for the lock after 1.5 seconds. Both `elapsed_time` and `universal_time` are simple structs with `sec_` and `nsec_` exposed data members representing seconds and nanoseconds. In the case of `universal_time`, this is the number of seconds and nanoseconds since midnight Jan. 1, 1970. The `universal_time` default constructor returns the current time. So the above example could have also been written as in [Alternate example of timed\\_lock\(\) usage](#) .

### Listing: Alternate example of timed\_lock() usage

```

void foo()
{
    Metrowerks::timed_mutex::scoped_timed_lock lock(foo_mut, false);
    Metrowerks::elapsed_time time_out(1, 500000000);
    Metrowerks::universal_time now;

    if (lock.timed_lock(now + time_out))
    {
        // got the lock
    }
    else
    {
        // do something else
    }
}

```

In general you can add and subtract and compare `universal_time` and `elapsed_time` as makes sense.

In single thread mode, all locks will lock their mutexes and return immediately (times are ignored). However, if you try to lock a `lockedmutex`, or unlock an `unlockedmutex`, then an exception of type `Metrowerks::lock_error` (derived from `std::exception`) will be thrown (even in single thread mode).

## 27.3 Threads

The class `Metrowerks::thread` represents a thread of execution.

### Listing: Class thread synopsis

## threads

```
class thread
{
public:
    thread();
    explicit thread(const std::tr1::function<void ()>& f);
    explicit thread(void (*f)());
    ~thread();

    bool operator==(const thread& rhs) const;
    bool operator!=(const thread& rhs) const;

    void join();

    static void sleep(const universal_time& unv_time);
    static void sleep(const elapsed_time& elps_time);
    static void yield();
};
```

A default constructed thread object represents the current thread. You can create a new thread of execution by passing a general function object, or a simple function pointer. In either case, the function must take no parameters and return void. When a thread destructs, it "detaches" the thread of execution (to use Posix-threads terminology). Once this happens, the thread is independent. You will no longer be able to refer to it, and it will clean up after itself when it terminates. But should main terminate before the thread does, the program ends anyway. You can have one thread wait on another with the `join()` member function.

### Listing: Example of join() function

```
#include <ewl_thread>
#include <iostream>

void do_something()
{
    std::cout << "Thread 1!"
}

int main()
{
    Metrowerks::thread t1(do_something);
    t1.join();
}
```

In the above example, `main` will wait for (join with) `t1`. Note that global objects like `std::cout` must be protected if more than one thread is going to access it. You must do this work yourself.

### Listing: Example of protecting threads

```
#include <ewl_thread>
#include <iostream>

Metrowerks::mutex cout_mutex;

void do_something()
{
    Metrowerks::mutex::scoped_lock lock(cout_mutex);
    std::cout << "Thread 1!"
}

void do_something_else()
```



```

{
    Metrowerks::mutex::scoped_lock lock(cout_mutex);
    std::cout << "Thread 2!
}

int main()
{
    std::cout << "Main
    Metrowerks::thread t1(do_something);
    Metrowerks::thread t2(do_something_else);
    t1.join();
    t2.join();
}

```

In this example, each thread locks `cout_mutex` before using `cout`. `main()` didn't have to lock `cout` because no other threads started until after `main()` was done with `cout`.

You can also have threads sleep, but using a `mutex` and/or a condition variable (described in [Condition Variables](#)) is almost always a better solution. Similarly for `thread::yield` which is really just a convenience function for calling `sleep` with `elapsed_time(0)`.

In single thread mode, creating a thread is equivalent to a synchronous function call (though not nearly as efficient).

If you have multiple threads to create, you can create a `Metrowerks::thread_group`.

### Listing: Example of `thread_group`

```

class thread_group
{
public:
    thread_group();
    ~thread_group();
    const thread* create_thread(const thread::func_type& f);
    void join_all();
};

```

The main feature of `thread_group` is that it makes it very easy to join with all of the threads.

### Listing: Example of joining threads

```

int main()
{
    std::cout << "Main
    Metrowerks::thread_group g;
    g.create_thread(do_something);
    g.create_thread(do_something_else);
    g.join_all();
}

```

## 27.4 Condition Variables

A condition variable is a way for two threads to signal each other based on some predicate, such as a `queue` being empty or full. This is represented by `Metrowerks::condition`.

**Listing: Metrowerks::condition class synopsis**

```

class condition
{
public:
condition();
~condition();

void notify_one();
void notify_all();
template <typename ScopedLock> void wait(ScopedLock& lock);

template <typename ScopedLock, typename Predicate>
    void wait(ScopedLock& lock, Predicate pred);

template <typename ScopedLock>
    bool timed_wait(ScopedLock& lock,
        const universal_time& unv_time);

template <typename ScopedLock, typename Predicate>
    bool timed_wait(ScopedLock& lock,
        const universal_time& unv_time, Predicate pred);

template <typename ScopedLock, typename Predicate>
    bool timed_wait(ScopedLock& lock,
        const elapsed_time& elps_time, Predicate pred);

};

```

Note that `condition` is not copyable nor assignable.

A `condition` allows one thread to pass a `locked` lock to the condition's wait function. The current thread then atomically unlocks the locks and goes to sleep. It will stay asleep until another thread calls this condition's `notify_one()` or `notify_all()` member function. The original thread will then atomically awake and lock the lock.

The difference between `notify_one` and `notify_all` is that the former notifies only one thread waiting on the condition, whereas the latter notifies all threads waiting on the condition.

When using the variation of the wait function without the predicate, it is important that you recheck the predicate (data) you were waiting for when the wait returns. You can not assume that whatever it is that you were wanting to be true is now true. This is most easily done by calling the wait within a while loop:

```

Metrowerks::condition cond;
...
Metrowerks::mutex::scoped_lock lock(some_mutex);
while (I_need_more_data)
    cond.wait(lock);

```

It is up to some other thread to make `I_need_more_data` false, and it will likely need to lock `some_mutex` in order to do it. When it does, it should execute one of:

```
cond.notify_one();
```

or

```
cond.notify_all();
```

It must also unlock `some_mutex` to allow the other thread's wait to return. But it does not matter whether `some_mutex` gets unlocked before or after the notification call. Once the original wakes from the wait, then the signal is satisfied. Should it wait again, then another thread will have to renotify it.

If it is more convenient, you can pass a predicate to the wait function, which will then do the while loop for you. Note that there are also several timed waits if you want to limit the sleep time (which can be thought of as an additional "condition" on the system clock).

[Example of condition usage](#) is a full example of condition usage. One thread puts stuff into a queue while another thread reads stuff back out of the other end.

### Listing: Example of condition usage

```
#include <iostream>
#include <queue>
#include <ewl_thread>

class unbounded_queue
{
public:
    typedef Metrowerks::mutex Mutex;
    typedef Mutex::scoped_lock Lock;
    void send (int m);
    int receive();

private:
    std::queue<int> the_queue_;
    Metrowerks::condition queue_is_empty_so_;
    Mutex mut_;
};

void unbounded_queue::send (int m)
{
    Lock lock(mut_);
    the_queue_.push(m);
    std::cout << "sent: " << m << '

    if (the_queue_.size() == 1)
        queue_is_empty_so_.notify_one();
}

int unbounded_queue::receive()
{
    Lock lock(mut_);
    while (the_queue_.empty())
        queue_is_empty_so_.wait(lock);

    int i = the_queue_.front();
    std::cout << "received: " << i << '
    the_queue_.pop();
    return i;
}

unbounded_queue buf;

void sender()
{
    int n = 0;
    while (n < 1000)
    {
```

## Condition Variables

```

        buf.send(n);
        ++n;
    }
    buf.send(-1);
}

void receiver()
{
    int n;
    do
    {
        n = buf.receive();
    } while (n >= 0);
}

int main()
{
    Metrowerks::thread send(sender);
    Metrowerks::thread receive(receiver);
    send.join();
    receive.join();
}

```

In the above example one thread continually sends data to a `std::queue`, while another thread reads data out of the queue. The reader thread must wait if the queue is empty, and the sender thread must notify the reader thread (to wake up) if the queue changes from empty to non-empty.

An interesting exercise is to transform the above example into a "bounded queue". That is, there is nothing from stopping the above example's queue from sending all of the data before the receiver thread wakes up and starts consuming it.

[Example of queue limitation](#) is an example if you wanted to limit the above queue to a certain number of elements (like 20).

### Listing: Example of queue limitation

```

#include <iostream>
#include <cdeque>
#include <ewl_thread>

class bounded_queue
{
public:

    typedef Metrowerks::mutex Mutex;
    typedef Mutex::scoped_lock Lock;
    typedef Metrowerks::cdeque<int> Queue;
    bounded_queue(int max) {the_queue_.reserve((unsigned)max);}
    void send (int m);
    int receive();

private:
    Queue the_queue_;
    Metrowerks::condition queue_is_empty_so_;
    Metrowerks::condition queue_is_full_so_;
    Mutex mut_;
};

template <class C>
struct container_not_full
{
    container_not_full(const C& c) : c_(c) {}
}

```

```

    bool operator()() const {return c_.size() != c_.capacity();}

private:
    const C& c_;
};

template <class C>
struct container_not_empty
{
    container_not_empty(const C& c) : c_(c) {}
    bool operator()() const {return !c_.empty();}
};

private:
const C& c_;
};

void bounded_queue::send (int m)
{
    Lock lock(mut_);
    queue_is_full_so_.wait(lock,
        container_not_full<Queue>(the_queue_));
    the_queue_.push_back(m);
    std::cout << "sent: " << m << '
    if (the_queue_.size() == 1)
    queue_is_empty_so_.notify_one();
}

int bounded_queue::receive()
{
    Lock lock(mut_);
    queue_is_empty_so_.wait(lock,
        container_not_empty<Queue>(the_queue_));

    int i = the_queue_.front();
    std::cout << "received: " << i << '

    if (the_queue_.size() == the_queue_.capacity())
        queue_is_full_so_.notify_one();

    the_queue_.pop_front();
    return i;
}

bounded_queue buf(20);
void sender()
{
    int n = 0;
    while (n < 1000)
    {
        buf.send(n);
        ++n;
    }
    buf.send(-1);
}

void receiver()
{
    int n;
    do
    {
        n = buf.receive();
    } while (n >= 0);
}

int main()
{
    Metrowerks::thread send(sender);
    Metrowerks::thread receive(receiver);
    send.join();
}

```

**call\_once**

```

    receive.join();
}

```

The above example actually demonstrates more than was advertised. Not only does it limit the queue length to 20, it also introduces a non-std container (`Metrowerks::cdeque`) which easily enables the monitoring of maximum queue length. It also demonstrates how more than one condition can be associated with a mutex. And furthermore, it uses the predicate versions of the wait statements so that explicit while loops are not necessary for the waits. Note that the predicates are negated: the wait will loop until the predicate is true.

Condition variables are fairly dangerous in single threaded code. They will compile and do nothing. But note that you may loop forever waiting for a predicate that won't change:

```

while (the_queue.empty())
    queue_not_empty.wait(1k);

```

If `the_queue.empty()` is true then this is just an infinite loop in single thread mode. There is no other thread that is going to make the predicate false.

## 27.5 call\_once

Every once in a while, you need to make sure a function is called exactly once. This is useful for initialization code for example.

The concept is similar to a local static, but local statics are not thread safe. It is possible two threads might try to construct a local static at once, before the initialization flag gets set.

### Listing: Example two threads constructing a static

```

Metrowerks::mutex&
get_mutex()
{
    static Metrowerks::mutex mut; // ?!?!?!
    return mut;
}

```

If more than one thread can call `get_mutex()` for the first time, at the same time, then it is possible that two threads may try to construct `mut` (and this would be bad). There are a couple of ways to deal with this problem.

You could make `mut` a global. But that may give you an undefined order of construction among global objects that is unacceptable for your application's start up code.

You could call `get_mutex()` once before you create any threads:

```
int main()
{
    get_mutex(); // just initialize the local static
}
```

Now it is safe to call `get_mutex()` from multiple threads as the construction step is already done.

Simple, but a little ugly. And you may not have control over `main` (what if you're writing a library?).

Enter `Metrowerks::call_once`. You can use `call_once` to ensure that only one thread calls `get_mutex` for the first time. The prototype for `call_once` looks like:

```
void call_once(void (*func)(), once_flag& flag);
```

`Metrowerks::once_flag` is the type of flag that you must initialize (at link time) to the macro: `_EWL_THREAD_ONCE_INIT`.

If `call_once` is called with such a flag, it will atomically execute the function, and set the flag to some other value. All other threads attempting to call `call_once` will block until the first call returns. Later threads calling into `call_once` with the same flag will return without doing anything. Here is how you could use it to "initialize" `get_mutex()`.

### Listing: Example of initializing using `get_mutex()`

```
Metrowerks::mutex&
get_mutex_impl()
{
    static Metrowerks::mutex mut;
    return mut;
}

void init_get_mutex()
{
    get_mutex_impl();
}

Metrowerks::once_flag init_get_mutex_flag = _EWL_THREAD_ONCE_INIT;

Metrowerks::mutex&
get_mutex()
{
    Metrowerks::call_once(init_get_mutex, init_get_mutex_flag);
    return get_mutex_impl();
}
```

The first thread into `get_mutex` will also go into `call_once` while blocking other threads from getting past that point. It then constructs the static `mutex` at its leisure. Once it returns, then threads can have unfettered access to the fully constructed static `mutex`.

`call_once` works identically in single thread mode.

## 27.6 thread\_specific\_ptr

This is a way to create "thread specific data".

For example, you could create a "global" variable that is global to all functions, but local to each thread that accesses it. For example, `errno` is often implemented this way.

`Metrowerks::thread_specific_ptr` is a templated smart pointer that you can pass a new pointer to. It will associate that pointer with whatever thread passed it in (via its `reset` function). Other threads won't see that pointer. They will see `NULL` until they pass in their own heap-based data. The smart pointer will take care of releasing the heap data when the thread exits.

### Listing: Class `thread_specific_ptr` synopsis

```
template <typename T>
class thread_specific_ptr
{
public:
    thread_specific_ptr();
    ~thread_specific_ptr();
    T* get() const;
    T* operator->() const {return get();}
    T& operator*() const {return *get();}
    T* release();
    void reset(T* p = 0);
};
```

You can have as many `thread_specific_ptr`'s as you want, and pointing to whatever type you desire. The `thread_specific_ptr` is not copyable or assignable, but you can assign a pointer to it.

### Listing: Example of assigning a pointer

```
thread_specific_ptr<int> my_data;
...
my_data.reset(new int(3));
From then on, the thread that called reset can access that data like:
std::cout << *my_data;
*my_data = 4;
// etc.
```

You can release the memory with `my_data.release()`. This transfers pointer ownership back to you, so you must then delete the pointer. But you need not call `release` just to prevent memory leaks. `thread_specific_ptr` will automatically delete its data. And you can put in a new pointer by calling `reset` again. `thread_specific_ptr` will make sure the original pointer gets properly deleted. Do not use the array form of `new` with `thread_specific_ptr`. It will be using `delete` to free your pointer.

### Listing: Example of freeing a pointer



```
#include <iostream>
#include <ewl_thread>

Metrowerks::thread_specific_ptr<int> value;
void increment()
{
    ++*value;
}

Metrowerks::mutex cout_mutex;
void thread_proc()
{
    value.reset(new int(0));
    for (int i = 0; i < 1000; ++i)
        increment();

    Metrowerks::mutex::scoped_lock lock(cout_mutex);
    std::cout << *value << ' '
}

int main()
{
    Metrowerks::thread_group threads;
    for (int i = 0; i < 5; ++i)
        threads.create_thread(&thread_proc);

    thread_proc();
    threads.join_all();
}
```

### Should print out

```
1000
 1000
 1000
 1000
 1000
 1000
 1000
```

Once for main, and once for the five threads. Note how no locking is necessary in accessing the "global" `thread_specific_ptr`. It is as if each thread has its own local copy of this global.



## Chapter 28

### EWL `std::tr1`

The C++ standards committee is currently considering what will go into the next C++ standard. Several proposals have been voted into a Technical Report for consideration and the Embedded Warrior Library for C++ has some of these items in namespace `std::tr1`.

#### 28.1 Overview of EWL Implementation of Technical Report 1

The C++ Standards Committee's report is a statement by the committee that these proposals are "interesting", but nothing more. They are not standard. They may change in the future, or even completely disappear. The EWL implementation of some of the technical report exists in namespace `std::tr1`.

You can force them to be in namespace `std` instead with:

```
#define _EWL_TR1_NAMESPACE 0
```

EWL support consists of:

- [Template class Sig class result\\_of](#)
- [Template class T class reference\\_wrapper](#)
- [Template class Sig class function](#)
- [Template class T class shared\\_ptr](#)
- [Template class T class enable\\_shared\\_from\\_this](#)
- [Template class T0, class T1, ... class T9 class tuple](#)
- [Template bind](#)

#### 28.2 Template class Sig class result\_of

```
template class Sig class result_of
```

The template class `result_of` is included in the header `<functional>`.

## 28.2.1 result\_of

The template class `result_of` defines a nested typedef named type, that is the return type of the function type in `result_of`'s template parameter.

### Listing: Class `result_of` synopsis

```
Namespace std::tr1{
template <class Sig>

class result_of
{
public:
typedef /* implementation details */ type;
};
}
```

## 28.2.2 Public Members

The template class `result_of` provides one type defined for implementation.

### 28.2.2.1 get\_result\_type

A nested typedef named type, that is the return type of the function type in `result_of`'s template parameter.

```
typedef /* implementation details */ type; ();
```

### Remarks

This can be used to specify the operator within function objects that have multiple signatures. `result_of` is typically used in template programming (as opposed to just determining the return type).

### Listing: Example usage of template class `result_of`

```
namespace std::tr1{
#include <functional>
#include <iostream>
#include <typeinfo>

typedef double (*FP)(int, short);
int main()
```

```
{
    std::cout << typeid(std::tr1::result_of<FP>::type).name() << '\n';
    std::cout << typeid(result_of<less<int>(int, int)>::type).name()
    << '\n'
};
```

result

```
double
bool
```

**See Also**

[Class type\\_info](#)

## 28.3 Template class T class reference\_wrapper

The template class `reference_wrapper` is included in the header `<functional>` and is used as a wrapper around or wrapper into a container.

### Listing: Class Synopsis

```
Namespace std::tr1 {
template <class T> class reference_wrapper

template <class T> reference_wrapper<T> ref(T& t)

template <class T> reference_wrapper<const T> cref(const T& t)
}
```

### 28.3.1 reference\_wrapper

The `reference_wrapper` is a templated wrapper class that behaves as an assignable reference.

```
template <class T> class reference_wrapper
```

#### Remarks

You can pass `reference_wrapper`'s around, and even put them into containers.

The `reference_wrapper` also serves as a marker for some packages that explicitly look for it, and behave differently when they find it. For example if you send a `reference_wrapper` to the function `make_tuple`, a `T&` will be put in the tuple instead of a `T` or a `reference_wrapper<T>`. See the description of `tuple` for more details.

```
template class Sig class function
```

The template class `reference_wrapper` can also be used as a function object. It is instantiated with a function pointer or function object.

### See Also

`tuple`, `cref`, `ref`

## 28.3.2 Public Member Functions

Public member functions that return an instance of `reference_wrapper`.

### 28.3.2.1 `ref`

Returns an instance of `reference_wrapper` when passed a normal reference argument.

```
template <class T> reference_wrapper<T> ref(T& t)
```

### See Also

`Reference_wrapper`, `cref()`

### 28.3.2.2 `cref`

Returns an instance of `reference_wrapper` when passed a const reference argument.

```
template<class T> reference_wrapper<const T> cref(const T& t)
```

### Listing: Example of class usage

```
namespace std::tr1 {  
No example  
}
```

### See Also

`Reference_wrapper`, `ref()`

## 28.4 Template class Sig class function

The template class function is included in the header <functional>.

### Remarks

This is a highly generic and powerful "call back" mechanism that includes function pointers, member function pointers, and arbitrary function objects while maintaining similar syntax and semantics to function pointers.

### Listing: Class Synopsis

```
Namespace std::tr1 {  
  Stuff  
}
```

### 28.4.1 Constructors Destructors and Assignment Operator

The class provides overloaded constructors for creating and copying the class object.

#### 28.4.1.1 Constructor

Initializes the `mutex` object.

```
mutex ();  
mutex(const mutex&);
```

A default and a copy constructor are defined.

The copy constructor is declared private and not defined to prevent the `mutex` object from being copied.

```
mutex& operator=(const mutex&);
```

The assignment operator is declared private and not defined to prevent the `mutex` object from being copied.

#### 28.4.1.2 Destructor

Used for implicit mutex destruction.

```
~mutex ();
```

## Remarks

Destroys the `mutex` object.

## Listing: Example of class usage

```

#include <vector>
#include <utility>

#include <functional>

#include <iostream>

#include <cassert>

int add(int x, int y) { return x+y; }

bool adjacent(int x, int y) { return x == y-1 || x == y+1; }

struct compare_and_record
{
    std::vector<std::pair<int, int> > values;

    bool operator()(int x, int y)
    {
        values.push_back(std::make_pair(x, y));

        return x == y;
    }
};

int main()
{
    std::tr1::function <int (int, int)> f;

    f = &add;

    std::cout << f(2, 3) << '\n'; // 5

    f = std::minus<int>();

    std::cout << f(2, 3) << '\n'; // -1

    assert(f); // okay, f refers to a minus<int> object

    std::tr1::function <bool (int, int)> g;

    assert(!g); // okay, g doesn't refer to any object

    g = &adjacent;

    assert(g(2, 3)); // okay, adjacent(2, 3) returns true

    g = std::equal_to<long>(); // argument conversions ok

    assert(g(3, 3)); //okay, equal_to<long>()(3,3) returns true

    compare_and_record car;

    g = std::tr1::ref(car);

```



```
assert(g(3, 3)); // okay, and adds (3, 3) to car.values
g = f; // okay, int return value of f is convertible to bool
}
```

## 28.4.2 Public Member Functions

Public members that provide for mutual exclusion.

### 28.4.2.1 Member\_function

Description.

```
void prototype();
```

#### Listing: Example of class usage

```
Namespace std::tr1 {
#include <iostream>

    // do some stuff

int main()
{
}

result
double
bool
```

## 28.5 Template class T class shared\_ptr

These template shared pointer classes are included in the header <memory>.

## 28.6 Template class T class enable\_shared\_from\_this

The shared\_ptr is the army tank of reference counted pointers.

```
template class T class enable_shared_from_this
```

Its overhead is a little higher than you might be used to, but there are so many handy features (a lot of them safety features) that this pointer is hard to resist. See the proposal for a list of features (which include safety across DLL boundaries).

The `shared_ptr` works closely with `weak_ptr`, where `weak_ptr` takes the place of a raw pointer to break cyclic references. Again see the proposal for many more details and motivation.

This package follows closely from `boost::shared_ptr`, and has all of the latest improvements from that implementation.

### Listing: Class Synopsis

```
Namespace std::tr1 {
  Stuff
}
```

## 28.6.1 Constructors Destructors and Assignment Operator

The class provides overloaded constructors for creating and copying the class object.

### 28.6.1.1 Constructor

Initializes the `mutex` object.

```
mutex ();
mutex(const mutex&);
```

A default and a copy constructor are defined.

The copy constructor is declared private and not defined to prevent the `mutex` object from being copied.

```
mutex& operator=(const mutex&);
```

The assignment operator is declared private and not defined to prevent the `mutex` object from being copied.

### 28.6.1.2 Destructor

Used for implicit `mutex` destruction.

```
~mutex ();
```

## Remarks

Destroys the `mutex` object.

### Listing: Example of class usage

```
Namespace std::tr1 {  
#include <iostream>  
  
    // do some stuff
```

```
int main()  
{  
}
```

### result

```
double  
bool
```

## 28.6.2 Public Member Functions

Public members that provide for mutual exclusion.

### 28.6.2.1 Member\_function

Description.

```
void prototype();
```

### Listing: Example of class usage

```
Namespace std::tr1 {  
#include <iostream>    // do some stuff
```

```
int main()  
{  
  
}
```

### result

```
double  
bool
```

## 28.7 Template class T0, class T1, ... class T9 class tuple

The header `<tuple>` exposes a `std::pair`-like class which generalizes the pair concept up to 10 members.

This proposal lives in two headers: `<tuple>` and `<tupleio>`. It closely follows these two proposals:

### Remarks

#### Listing: Example of tuple

```
#include <tuple>
#include <string>

int main()
{
    int i = 0;
    std::tr1::tuple<int, int&, std::string> t(1, i, "hi");
    // t holds (1, 0, "hi")
    i = 2;
    // t holds (1, 2, "hi")
}
```

#### Listing: Class Synopsis

```
Namespace std::tr1 {
    Stuff
}
```

### 28.7.1 Constructors Destructors and Assignment Operator

The class provides overloaded constructors for creating and copying the class object.

#### 28.7.1.1 Constructor

Initializes the `mutex` object.

```
mutex ();
mutex(const mutex&);
```

A default and a copy constructor are defined.

The copy constructor is declared private and not defined to prevent the `mutex` object from being copied.

```
mutex& operator=(const mutex&);
```

The assignment operator is declared private and not defined to prevent the `mutex` object from being copied.

### 28.7.1.2 Destructor

Used for implicit `mutex` destruction.

```
~mutex ();
```

#### Remarks

Destroys the `mutex` object.

#### NOTE

`<tupleio>` has been preserved. You must include this header to get the I/O abilities. This allows `<tuple>` to remain much smaller. tuples of different sizes can be compared (`==`, `<`, etc.) with the obvious semantics. `tuple_like` types can be compared with each other.

#### Listing: Example of `<codeph> tuple </codeph>` class usage

```
#include <tuple>
#include <string>
#include <utility>

int main()
{
    std::pair<int, double> p(1, 2.0);
    std::tr1::tuple<long, short, std::string> t(1, 2, "hi");
    bool b = p < t;
}
```

`b` gets the value `true`.

*/\** The tuples implemented here are interoperable with your own `tuple_like` types (should you create any).

The tuple I/O manipulators:

```
tuple_open
tuple_close
tuple_delimiter
```

take both `charT` arguments and `const charT*` arguments. Thus you can specify multi-character braces or delimiters. This can come in handy when dealing with tuples of `std::string`:

```
*/
```

## template class T0, class T1, ... class T9 class tuple

```
#include <tupleio>
#include <string>
#include <iostream>
#include <sstream>
int main()
{
    std::tr1::tuple<std::string, std::string> t("Hi", "5");
    std::stringstream s;
        << std::tr1::tuple_delimiter(" , ")
        << std::tr1::tuple_close(" )");
    s << t << '\n';
    s >> t;
    std::cout << std::tr1::tuple_open("( ")
        << std::tr1::tuple_delimiter(" , ")
        << std::tr1::tuple_close(" )");

    if (!s.fail())
        std::cout << t << '\n';
    else
        std::cout << "failed\n";
}
```

**( Hi , 5 )**

/\*And finally, if the TR is put into namespace std (instead of `std::tr1`)

`<tupleio>` extends I/O ability to other tuple\_like types such as `std::pair`.

\*/

```
#define _EWL_TR1_NAMESPACE 0

#include <tupleio>
#include <string>
#include <iostream>
#include <map>

int main()
{
    typedef std::map<std::string, int> Map;
    Map m;
    m["one"] = 1;
    m["two"] = 2;
    m["three"] = 3;

    std::ostream_iterator<Map::value_type> out(std::cout, "\n");
    std::copy(m.begin(), m.end(), out);
}

(one 1)

(three 3)

(two 2)
```

## 28.7.2 Public Member Functions

Public members that provide for mutual exclusion.

### 28.7.2.1 Member\_function

Description.

```
void prototype();
```

#### Remarks

If

#### Listing: Example of class usage

```
Namespace std::tr1 {
#include <iostream>
    // do some stuff
    int main()
{
}
}
```

#### result

```
double
bool
```

## 28.8 Template bind

The bind library is a new library voted into the first Library Technical Report.

As such, it is placed in namespace std::tr1. It is not standard, but is considered "interesting" by the C++ committee. It may become standardized in the future. This is a generalization of the existing std::bind1st and std::bind2nd functions.

The bind library consists of a series of overloaded template functions which when called will return an implementation defined function object that can then be evaluated. The purpose of bind is to adapt one function to another expected signature, or to combine simpler functions into a more complex functor. It is found in the new header <bind>. This implementation supports functions with up to 10 arguments.

#### Listing: Synopsis of the bind library

```
namespace std { namespace tr1 {
// 0 argument functors

template <class F>

// details

bind(F f);

template <class R, class F>

// details
```

## template bind

```

bind(F f);

template <class R>
// details
bind(R (*f)());

// 1 argument functors
template <class F, class A1>
// details
bind(F f, A1 a1);

template <class R, class F, class A1>
// details
bind(F f, A1 a1)

template <class R, class B1, class A1>
// details
bind(R (*f)(B1), A1 a1);

template <class R, class T, class A1>
// details
bind(R (T::*f)(), A1 a1);

template <class R, class T, class A1>
// details
bind(R (T::*f)() const, A1 a1);

template <class R, class T, class A1>
// details
bind(R T::*f, A1 a1);

// 2 argument functors
template <class F, class A1, class A2>
// details
bind(F f, A1 a1, A2 a2);

template <class R, class F, class A1, class A2>
// details
bind(F f, A1 a1, A2 a2);

template <class R, class B1, class B2, class A1, class A2>
// details
bind(R (*f)(B1, B2), A1 a1, A2 a2);

template <class R, class T, class B1, class A1, class A2>
// details

```



```

bind(R (T::*f)(B1), A1 a1, A2 a2);

template <class R, class T, class B1, class A1, class A2>
// details
bind(R (T::*f)(B1) const, A1 a1, A2 a2);
...
// 9 argument functors
template <class F, class A1, class A2, class A3, class A4, class A5,
         class A6, class A7, class A8, class A9>
// details
bind(F f, A1 a1, A2 a2, A3 a3, A4 a4, A5 a5, A6 a6, A7 a7, A8 a8, A9
a9);
template <class R, class F, class A1, class A2, class A3, class A4,
         class A5, class A6, class A7, class A8, class A9>
// details
bind(F f, A1 a1, A2 a2, A3 a3, A4 a4, A5 a5,
         A6 a6, A7 a7, A8 a8, A9 a9);
template <class R, class B1, class B2, class B3, class B4, class B5,
         class B6, class B7, class B8, class B9,
         class A1, class A2, class A3, class A4, class A5,
         class A6, class A7, class A8, class A9>
// details
bind(R (*f)(B1, B2, B3, B4, B5, B6, B7, B8, B9),
         A1 a1, A2 a2, A3 a3, A4 a4, A5 a5,
         A6 a6, A7 a7, A8 a8, A9 a9);

template <class R, class T, class B1, class B2, class B3, class B4,
         class B5, class B6, class B7, class B8,
         class A1, class A2, class A3, class A4, class A5,
         class A6, class A7, class A8, class A9>
// details
bind(R (T::*f)(B1, B2, B3, B4, B5, B6, B7, B8), A1 a1, A2 a2, A3 a3,
         A4 a4, A5 a5, A6 a6, A7 a7, A8 a8, A9 a9);

template <class R, class T, class B1, class B2, class B3, class B4,
         class B5, class B6, class B7, class B8,

```

**template bind**

```

        class A1, class A2, class A3, class A4, class A5,
        class A6, class A7, class A8, class A9>

// details
bind(R (T::*f) (B1, B2, B3, B4, B5, B6, B7, B8)
    const, A1 a1, A2 a2, A3 a3, A4 a4, A5 a5,
    A6 a6, A7 a7, A8 a8, A9 a9);
} } // std::tr1

```

There are `bind` functions that accept a function-like object as the first argument, and then from 0 to 9 arguments. The return type of the functor can be explicitly supplied as the first template argument, or not. When not supplied, it is deduced. If the functor is a function pointer or member pointer, the return type is deduced from that signature. If the functor is a class with a nested type called `result_type`, the return type is deduced as `F::result_type`.

If the functor is a member pointer, then the first argument to the resulting functor must be a reference, pointer or smart pointer to an object containing the pointed to member. That first argument must be supplied to `bind` either explicitly, or implicitly as another `bind` expression, or a placeholder (examples will follow).

The `bind` overloads taking a functor with no arguments and do not accept member pointers, as member pointer functors must have at least one argument for the reference or pointer to the object.

The `bind` overloads taking from 1 thru 9 arguments include overloads for a function-like class, function pointers, and member function pointers.

The `bind` overloads taking a single argument (in addition to the functor) include an overload for taking a pointer to member data. Thus you can create a functor out of a pointer to `pair<T1, T2>::first` (for example).

**Listing: Simple use of `std::bind2nd` example**

```

#include <vector>
#include <functional>

#include <algorithm>

#include <numeric>
#include <iterator>
#include <iostream>

int main()
{
    using namespace std;
    vector<int> v(10, 1);

```

```

partial_sum(v.begin(), v.end(), v.begin());
random_shuffle(v.begin(), v.end());
ostream_iterator<int> out(cout, " ");
copy(v.begin(), v.end(), out);

cout << "\n";

vector<int>::iterator i = partition(v.begin(), v.end(),
    bind2nd(less<int>(), 5));

copy(v.begin(), i, out);

cout << "\n";
}

```

This should print out something similar to:

```
6 3 5 7 10 1 9 8 4 2
```

```
2 3 4 1
```

As stated in the introduction, `bind` is a generalization of `bind1st` and `bind2nd`. To transform the above example to use `bind`:

- **Add** `#include <bind>`;
- **Add** `using namespace std::tr1;`
- **Add** `using namespace std::tr1::placeholders;`
- **And finally, replace:**

```

vector<int>::iterator i = partition(v.begin(), v.end(),
    bind2nd(less<int>(), 5));

```

with:

```

vector<int>::iterator i = partition(v.begin(), v.end(),
    bind(less<int>(), _1, 5));

```

Obviously `bind` is not a big win over `bind2nd` in this example. This example is meant to introduce `bind` by comparing it with the presumably well known `std::bind2nd`. Further examples will show how `bind` goes beyond the limitations of `bind1st` and `bind2nd`.

The `#include <bind>` is needed to bring `std::tr1::bind` into scope. As `bind` is a library technical report item, it lives in namespace `std::tr1` instead of in namespace `std`.

## template bind

The "\_1" notation is new. The \_1 is called a placeholder, it's full name is `std::tr1::placeholders::_1`. You can just say `using namespace std::tr1::placeholders;` to bring just the placeholders into scope without bringing everything else into scope. The \_1 is a signal to the functor returned from `bind` to substitute the first argument used when calling the functor object into the place indicated by the position of the \_1. That is:

```
bind1st(f, x);
```

is equivalent to:

```
bind(f, x, _1);
```

Both functions return a unary functor `F` such that `F(y)` calls `f(x, y)`. In the `bind` example, \_1 is the placeholder for `y` that the client will supply to `F`.

You can also turn `f(x, y)` into a function that takes no arguments by simply not using any placeholders:

```
bind(f, x, y); // -> F() calls f(x, y)
```

You can also use \_1 more than once:

```
bind(f, _1, _1); // -> F(y) calls f(y, y)
```

Additionally there are more placeholders: \_1, \_2, \_3, ... \_9. You can use these placeholders to simply reorder the arguments to a function:

```
bind(f, _2, _1); // -> F(x, y) calls f(y, x)
```

And you can instruct `bind` to ignore parameters:

```
bind(f, _2, x); // -> F(y, z) calls f(z, x), y is ignored
```

And of course `bind` can handle functions (`f`) with a number of arguments ranging from 0 to 9. You must ensure that for every parameter of `f` there is a matching argument in the `bind` expression. Except that when `f` is a member function pointer, then there must be an additional argument in the `bind` expression, as the first argument represents the object (or a pointer to the object).

## 28.8.1 sort predicate

Imagine a class type `Employee` and the desire to sort by the member function `number()` which returns the `Employee` ID:

```
class Employee
{
public:
    int number() const;
};
...

std::sort(v.begin(), v.end(),
    bind(std::less<int>(),
        bind(&Employee::number, _1),
        bind(&Employee::number, _2)
    )
);
```

The member function `number` is converted into a functor: once for the first argument, and once for the second argument to `sort`'s compare predicate. Then those two `bind` expressions are composed as arguments to `std::less<int>`. Without `bind` you would have to write a custom binary compare predicate for this situation (or `operator<` for `Employee`).

Note that if you change `Employee` to:

```
class Employee
{
public:
    int number;
};
```

then the predicate developed above for sorting does not change.

## 28.8.2 remove\_if predicate

Consider a cookie factory with a quality control problem:

```
class Cookie
{
public:
    Cookie(int n_chips, float diameter)
        : n_chips_(n_chips), diameter_(diameter) {}
    int number_of_chips() const {return n_chips_;}
    float diameter() const {return diameter_;}

private:
    int n_chips_;
    float diameter_;
};
```

We've got a container of cookies and we need to erase all those cookies that either have too few chips, or are too small in diameter:

## template bind

```
v.erase(
    remove_if(v.begin(), v.end(),
        bind(logical_or<bool>(),
            bind(less<int>(), bind(&Cookie::number_of_chips, _1), 50),
            bind(less<float>(), bind(&Cookie::diameter, _1), 5.5F)
        )
    ),
    v.end()
);
```

Note that the above continues to work whether our container holds `Cookie`, `Cookie*`, or some `smart_ptr<Cookie>`.

### 28.8.3 function

When used in conjunction with `std::tr1::function`, you can store the bind expression indefinitely, and then execute it at the proper time. For example, here is a crude runtime-configurable menu example:

```
#include <vector>
#include <functional>
#include <bind>

struct Document
{
    Document() {}
    Document* close() {delete this; return 0;}
    Document* save() {return this;}
    Document* print() {return this;}

private:
    Document(const Document&);
    Document& operator=(const Document&);
};

Document* new_doc() {return new Document;}
Document* open() {return new Document;}

int main()
{
    // declare menu structure
    std::vector<std::tr1::function<Document* ()> > menu(5);
    Document* current_doc = 0;

    using std::tr1::bind;
    using std::tr1::ref;

    // load menu call backs
    menu[0] = new_doc;
    menu[1] = open;
    menu[2] = bind(&Document::close, ref(current_doc));
    menu[3] = bind(&Document::save, ref(current_doc));
    menu[4] = bind(&Document::print, ref(current_doc));

    // exercise menu call backs
    current_doc = menu[0](); // new
    current_doc = menu[2](); // close
    current_doc = menu[1](); // open
    current_doc = menu[3](); // save
    current_doc = menu[4](); // print
    current_doc = menu[2](); // close
}
```

In this example a menu is represented by a vector of functions that take no parameters and return a `Document*`. Installed into this menu are both namespace scope functions, and member functions bound to the current document. `std::tr1::function` is smart enough to handle both function pointers and functors (and member functions too for that matter). In this case, we bind a pointer to the object we want with the member function we want to be executed before installing it into the menu. This results in a function object that takes no parameters and returns a `Document*`, just like the ordinary function pointers that are also installed into the menu.

The `ref` in the `bind` call stands for *reference*. This says that instead of `bind` storing a copy of the pointer `current_doc` in the `bind` expression, store a reference to the pointer. This is done so that as the value of `current_doc` changes throughout the demo, the document upon which the menu item acts is automatically updated. In general you can wrap any argument to `bind` in `ref` or `cref` (`cref` is for a `const` reference) when you would like to have `bind` operate on the actual argument instead of a copy of it.

Alternatively `new_doc()` and `open()` could have been static functions of `Document`. Then their installation into the menu would have looked like:

```
menu[0] = &Document::new_doc;
menu[1] = &Document::open;
```

If in the above example, an argument needed to be sent to all of the callbacks (or 2 or 3 arguments), that could easily be handled with placeholders:

```
Document* print(const std::string& printer_name)
{... return this;} ...
menu[4] = bind(&Document::print, ref(current_doc), _1);...
current_doc = menu[4]("color printer");
```

So `bind` is really handy. And when combined with the existing algorithms in `<algorithm>` and `<numeric>`, or when combined with the new `std::tr1::function`, `bind` becomes ultimately flexible, and absolutely indispensable.





## Chapter 29

# Ewlconfig

The EWL header `<ewlconfig>` contains a description of the macros and defines that are used as switches or flags in the EWL C++ library.

### 29.1 C++ Switches, Flags and Defines

The EWL C++ library has various flags that may be set to customize the library to users specifications.

- `_CSTD`
- `_Inhibit_Container_Optimization`
- `_Inhibit_Optimize_RB_bit`
- `_EWL_DEBUG`
- `__ewl_error`
- `_EWL_ARRAY_AUTO_PTR`
- `_EWL_CFILE_STREAM`
- `__EWL_CPP__`
- `_EWL_EXTENDED_BINDERS`
- `_EWL_EXTENDED_PRECISION_OUTP`
- `_EWL_FORCE_ENABLE_BOOL_SUPPORT`
- `_EWL_FORCE_ENUMS_ALWAYS_INT`
- `_EWL_IMP_EXP`
- `__EWL_LONGLONG_SUPPORT__`
- `_EWL_MINIMUM_NAMED_LOCALE`
- `_EWL_NO_BOOL`
- `_EWL_NO_CONSOLE_IO`
- `_EWL_NO_CPP_NAMESPACE`
- `_EWL_NO_EXCEPTIONS`
- `_EWL_NO_EXPLICIT_FUNC_TEMPLATE_ARG`

- `_EWL_NO_FILE_IO`
- `_EWL_NO_IO`
- `_EWL_NO_LOCALE`
- `_EWL_NO_REFCOUNT_STRING`
- `_EWL_NO_VECTOR_BOOL`
- `_EWL_NO_WCHART`
- `_EWL_NO_WCHART_LANG_SUPPORT`
- `_EWL_NO_WCHART_C_SUPPORT`
- `_EWL_NO_WCHART_CPP_SUPPORT`
- `_EWL_POSIX_STREAM`
- `_EWL_WIDE_FILENAME`
- `_EWL_WFILEIO_AVAILABLE`
- `_STD`

### 29.1.1 `_CSTD`

The `_CSTD` macro evaluates to `::std` if the EWL C library is compiled in the `std` namespace, and to nothing if the EWL C library is compiled in the global namespace.

`_STD` and `_CSTD` are meant to prefix C++ and C objects in such a way that you don't have to care whether or not the object is in `std` or not. For example:

```
_STD::cout, or _CSTD::size_t.
```

### 29.1.2 `_Inhibit_Container_Optimization`

If this flag is defined it will disable pointer specializations in the containers. This may make debugging easier.

You must recompile the C++ lib when flipping this switch.

### 29.1.3 `_Inhibit_Optimize_RB_bit`

Normally the red/black tree used to implement the associative containers has a space optimization that compacts the red/black flag with the parent pointer in each node (saving one word per entry). By defining this flag, the optimization is turned off, and the red/black flag will be stored as an enum in each node of the tree.

### 29.1.4 `_EWL_DEBUG`

This switch when enabled and the library is rebuilt will put EWL Standard C++ library into debug mode. For full information see [Overview of EWL C++ Debug Mode](#).

You must recompile the C++ lib when flipping this switch.

### 29.1.5 `__ewl_error`

This feature is included for those wishing to use the C++ lib with exceptions turned off. In the past, with exceptions turned off, the lib would call `fprintf` and `abort` upon an exceptional condition. Now you can configure what will happen in such a case by filling out the definition of `__ewl_error()`.

### 29.1.6 `_EWL_ARRAY_AUTO_PTR`

When defined `auto_ptr` can be used to hold pointers to memory obtained with the array form of `new`. The syntax looks like:

```
auto_ptr<string, _Array<string> >
pString(new string[3]);
pString.get()[0] = "pear";
pString.get()[1] = "peach";
pString.get()[2] = "apple";
```

Without the `_Array` tag, `auto_ptr` behaves in a standard fashion. This extension to the standard is not quite conforming, as it can be detected through the use of template arguments.

This extension can be disabled by not defining `_EWL_ARRAY_AUTO_PTR`.

## 29.1.7 `__EWL_CFILE_STREAM`

Set when the file system does not support wide character streams.

## 29.1.8 `__EWL_CPP__`

Evaluates to an integer value which represents the C++ lib's current version number. This value is best when read in hexadecimal format.

## 29.1.9 `__EWL_EXTENDED_BINDERS`

Defining this flag adds defaulted template parameters to `binder1st` and `binder2nd`. This allows client code to alter the type of the value that is stored. This is especially useful when you want the binder to store the value by const reference instead of by value to save on an expensive copy construction.

### Listing: Example:

```
#include <string>
#include <functional>
#include <algorithm>

struct A
{
public:
    A(int data = 0) : data_(data) {}
    friend bool operator < (const A& x, const A& y) {return x < y;}

private:
    int data_;
    A(const A&);
};

int main()
{
using namespace std;
    A a[5];
    A* i = find_if(a, a+5, binder2nd<less<A> >(less<A>(), A(5)));
}
```

This causes the compile-time error, because `binder2nd` is attempting to store a copy of `A(5)`. But with `__EWL_EXTENDED_BINDERS` you can request that `binder2nd` store a `const A&` to `A(5)`.

```
A* i = find_if(a, a+5,
    binder2nd<less<A>, const A&>(less<A>(), A(5)));
```

This may be valuable when `A` is expensive to copy.

This also allows for the use of polymorphic operators by specifying reference types for the operator.

This extension to the standard is detectable with template parameters so it can be disabled by not defining `_EWL_EXTENDED_BINDERS`.

### 29.1.10 `_EWL_EXTENDED_PRECISION_OUTP`

When defined this allows the output of floating point output to be printed with precision greater than `DECIMAL_DIG`. With this option, an exact binary to decimal conversion can be performed (by bumping precision high enough).

The cost is about 5-6Kb in code size.

You must recompile the C++ lib when flipping this switch.

### 29.1.11 `_EWL_FORCE_ENABLE_BOOL_SUPPORT`

This tri-state flag has the following properties:

- If not defined, then the C++ library and headers will react to the settings in the language preferences panel (as in the past).
- If the flag is set to zero, then the C++ lib/header will force " `Enable bool support` " to be off while processing the header (and then reset at the end of the header).
- If the flag is set to one, then the C++ library and header will force " `Enable bool support` " to be on while processing the header (and then reset at the end of the header).

If `_EWL_FORCE_ENABLE_BOOL_SUPPORT` is defined, the C++ library will internally ignore the " `Enable bool support` " setting in the application's language preference panel, despite the fact that most of the C++ library is compiled into the application (since it is in headers) instead of into the binary C++ library.

The purpose of this flag is (when defined) to avoid having to recompile the C++ library when " `Enable bool` " support is changed in the language preferences panel.

With `_EWL_FORCE_ENABLE_BOOL_SUPPORT` defined to one, `std::methods` will continue to have a real `bool` in their signature, even when `bool` support is turned off in the application. But the user won't be able to form a `bool` (or a `true/false`). The user won't be able to:

```
bool b = std::ios_base::sync_with_stdio(false);
```

```
// error: undefined bool and false
```

but this will work:

```
unsigned char b = std::ios_base::sync_with_stdio(0);
```

And the C++ lib will link instead of getting the ctype link error.

Changing this flag will require a recompile of the C++ library.

### 29.1.12 `_EWL_FORCE_ENUMS_ALWAYS_INT`

This tri-state flag has the following properties

- If not defined, then the C++ library and headers will react to the settings in the language preference panel (as in the past).
- If the flag is set to 0, then the C++ lib/header will force " `Enums always int`" to be off while processing the header (and then reset at the end of the header).
- If the flag is set to 1, then the C++ library and header will force " `Enums always int`" to be on while processing the header (and then reset at the end of the header).

If `_EWL_FORCE_ENUMS_ALWAYS_INT` is defined, the C++ library will internally ignore the " `Enums always int`" setting in the application's language preferences, despite the fact that most of the C++ library is compiled into the application (since it is in headers) instead of into the binary C++ library.

The purpose of this flag is (when defined) to avoid having to recompile the C++ lib when " `Enums always int`" is changed in the language preferences panel.

For example, with `_EWL_FORCE_ENUMS_ALWAYS_INT` defined to zero, and if the user turns " `enums always int`" on in the language preference panel, then any enums the user creates himself will have an underlying `int` type.

This can be exposed by printing out the `sizeof(the enum)` which will be four. However, if the user prints out the `sizeof(a std::enum)`, then the size will be one (because all `std::enums` fit into 8 bits) despite the `enums_always_int` setting in the language preference panel.

Changing this flag will require a recompile of the C++ library.

### 29.1.13 `_EWL_IMP_EXP`

The C, C++, SIOUX and runtime shared libraries have all been combined into one shared library located under the appropriate OS support folder in your CodeWarrior installation path.

The exports files ( `.exp`) have been removed. The prototypes of objects exported by the shared lib are decorated with a macro:

```
_EWL_IMP_EXP_xxx
```

where `xxx` is the library designation and can be defined to `__declspec(dllimport)`.

This replaces the functionality of the `.exp/.def` files. Additionally, the C, C++, SIOUX and runtimes can be imported separately by defining the following 4 macros differently:

```
_EWL_IMP_EXP_C
```

```
_EWL_IMP_EXP_CPP
```

```
_EWL_IMP_EXP_SIOUX
```

```
_EWL_IMP_EXP_RUNTIME
```

Define these macros to nothing if you don't want to import from the associated lib, otherwise they will pick up the definition of `_EWL_IMP_EXP`.

There is a header `<UseDLLPrefix.h>` that can be used as a prefix file to ease the use of the shared lib. It is set up to import all 4 sections.

There is a problem with non-const static data members of templated classes when used in a shared lib. Unfortunately `<locale>` is full of such objects. Therefore you should also define `_EWL_NO_LOCALE` which turns off locale support when using the C++ lib as a shared lib. This is done for you in `<UseDLLPrefix.h>`. See [\\_EWL\\_NO\\_LOCALE](#) for more details.

### 29.1.14 `__EWL_LONGLONG_SUPPORT__`

When defined, C++ supports long long and unsigned long long integral types. Recompile the C++ lib when flipping this switch.

### 29.1.15 `_EWL_MINIMUM_NAMED_LOCALE`

When defined, turns off all of the named locale stuff except for "C" and "" (which will be the same as "C"). This reduces both lib size and functionality, but only if you are already using named locales. If your code does not explicitly use named locales, this flag has no effect.

### 29.1.16 `_EWL_NO_BOOL`

If defined then `bool` will not be treated as a built-in type by the library. Instead it will be a typedef to `unsigned char` (with suitable values for `true` and `false` as well). If `_EWL_FORCE_ENABLE_BOOL_SUPPORT` is not defined then this flag will set itself according to the "Enable `bool` support" switch in the language preference panel.

The C++ lib must be recompiled when flipping this switch.

When `_EWL_NO_BOOL` is defined, `vector<bool>` will really be a `vector<unsigned char>`, thus it will take up more space and not have flip methods. Also there will not be any traits specializations for `bool` (i.e. `numeric_limits`).

### 29.1.17 `_EWL_NO_CONSOLE_IO`

This flag allows you to turn off console support while keeping memory mapped streams (`stringstream`) functional.

#### See Also

[\\_EWL\\_NO\\_FILE\\_IO](#)

### 29.1.18 `_EWL_NO_CPP_NAMESPACE`

If defined then the C++ lib will be defined in the global namespace.

You must recompile the C++ lib when flipping this switch.

### 29.1.19 `_EWL_NO_EXCEPTIONS`



If defined then the C++ lib will not throw an exception in an exceptional condition. Instead `void __ewl_error(const char*);` will be called. You may edit this inline in `<ewlconfig>` to do whatever is desired. Sample implementations of `__ewl_error` are provided in `<ewlconfig>`.

## Remarks

The operator `new` (which is in the runtime libraries) is not affected by this flag.

This flag detects the language preference panel "Enable C++ exceptions" and defines itself if this option is not on.

The C++ lib must be recompiled when changing this flag (also, if the language preference panel is changed).

### 29.1.20 `_EWL_NO_EXPLICIT_FUNC_TEMPLATE_ARG`

When defined, assumes that the compiler does not support calling function templates with explicit template arguments.

On Windows, when "Legacy for-scoping" is selected in the language preference panel, then this switch is automatically turned on. The Windows compiler goes into a MS compatible mode with ARM on.

This mode does not support explicit function template arguments. In this mode, the signatures of `has_facet` and `use_facet` change.

You must recompile the C++ lib when flipping this switch.

#### **Listing: Example of `_EWL_NO_EXPLICIT_FUNC_TEMPLATE_ARG` usage:**

```
Standard setting:
template <class Facet>
    const Facet& use_facet(const locale& loc);

template <class Facet>
    bool has_facet(const locale& loc) throw();
_EWL_NO_EXPLICIT_FUNC_TEMPLATE_ARG setting.
template <class Facet>
    const Facet& use_facet(const locale& loc, Facet*);

template <class Facet>
    bool has_facet(const locale& loc, Facet*) throw();
```

### 29.1.21 `_EWL_NO_FILE_IO`

This flag allows you to turn off file support while keeping memory mapped streams (stringstream) functional.

#### See Also

[\\_EWL\\_NO\\_CONSOLE\\_IO](#)

### 29.1.22 `_EWL_NO_IO`

If this flag is defined, C++ will not support any I/O (not even stringstreams).

### 29.1.23 `_EWL_NO_LOCALE`

When this flag is defined, locale support is stripped from the library. This has tremendous code size benefits.

All C++ I/O will implicitly use the "C" locale. You may not create locales or facets, and you may not call the imbue method on a stream. Otherwise, all streams are completely functional.

The C++ lib must be recompiled when flipping this switch.

### 29.1.24 `_EWL_NO_REFCOUNT_STRING`

The flag `_EWL_NO_REFCOUNT_STRING` is deprecated and will have no effect (it is harmless). This rewrite has higher performance and lower code size compared to previous releases.

### 29.1.25 `_EWL_NO_VECTOR_BOOL`

If this flag is defined it will disable the standard `vector<bool>` partial specialization. You can still instantiate `vector<bool>`, but it will not have the space optimization of one `bool` per bit.

There is no need to recompile the C++ lib when flipping this switch, but you should remake any precompiled headers you might be using.

### 29.1.26 `_EWL_NO_WCHART`

This flag has been replaced by three new flags:

[\\_EWL\\_NO\\_WCHART\\_LANG\\_SUPPORT](#)

[\\_EWL\\_NO\\_WCHART\\_C\\_SUPPORT](#)

[\\_EWL\\_NO\\_WCHART\\_CPP\\_SUPPORT](#)

### 29.1.27 `_EWL_NO_WCHART_LANG_SUPPORT`

This flag is set if the compiler does not recognize `wchar_t` as a separate data type (no `wchar_t` support in the language preference panel). The C++ lib will still continue to support wide character functions. `wchar_t` will be typedef'd to another built-in type.

The C++ library must be recompiled when turning this switch on (but not when turning it off).

### 29.1.28 `_EWL_NO_WCHART_C_SUPPORT`

This flag is set if the underlying C lib does not support wide character functions. This should not be set when using EWL C.

The C++ library must be recompiled when turning this switch on (but not when turning it off).

### 29.1.29 `_EWL_NO_WCHART_CPP_SUPPORT`

This flag can be set if wide character support is not desired in the C++ lib. Setting this flag can cut the size of the I/O part of the C++ lib in half.

The C++ library must be recompiled when turning this switch on (but not when turning it off).

### 29.1.30 `_EWL_POSIX_STREAM`

Set when a POSIX based library is being used as the underlying C runtime library.

### 29.1.31 `_EWL_WIDE_FILENAME`

If the flag `_EWL_WIDE_FILENAME` is defined, then the file stream classes support wide character filenames (null terminated arrays of `const wchar_t*`). Each stream class has an overloaded constructor, and an overloaded open member taking the `const wchar_t`. If the underlying system supports wide filenames, EWL C++ will pass the `wchar_t` straight through without any locale encoding.

Thus the interpretation of the wide filename is done by the OS, not by the C++ library. If the underlying system does not support wide filenames, the open will fail at runtime.

By default `_EWL_WIDE_FILENAME` is not defined as these signatures are not standard.

Turning on this flag does not require a recompile of EWL C++.

When EWL C is not being used as the underlying C library, and when the file stream is implemented in terms of `FILE*` (see [\\_EWL\\_CFILE\\_STREAM](#)), the system is said to not support wide filenames and the open will fail at runtime.

When using Posix as the underlying implementation (see [\\_EWL\\_POSIX\\_STREAM](#)), wide filenames are supported if the Posix library comes from the EWL Extras Library (in which case the [\\_EWL\\_WFILEIO\\_AVAILABLE](#) flag must be on).

### 29.1.32 `_EWL_WFILEIO_AVAILABLE`

Set when a wide character file name is available for a file name.

### 29.1.33 `_STD`

This macro evaluates to `::std` if the C++ lib is compiled in the std namespace, and to nothing if the C++ lib is compiled in the global namespace.

#### SeeAlso

[\\_CSTD](#)



# Index

[\\_\\_EWL\\_CPP\\_\\_](#) 668  
[\\_\\_ewl\\_error](#) 667  
[\\_\\_EWL\\_LONGLONG\\_SUPPORT\\_\\_](#) 671  
[\\_CSTD](#) 666  
[\\_EWL\\_ARRAY\\_AUTO\\_PTR](#) 667  
[\\_EWL\\_CFILE\\_STREAM](#) 668  
[\\_EWL\\_CX\\_LIMITED\\_RANGE](#) 375  
[\\_EWL\\_DEBUG](#) 667  
[\\_EWL\\_EXTENDED\\_BINDERS](#) 668  
[\\_EWL\\_EXTENDED\\_PRECISION\\_OUTP](#) 669  
[\\_EWL\\_FORCE\\_ENABLE\\_BOOL\\_SUPPORT](#) 669  
[\\_EWL\\_FORCE\\_ENUMS\\_ALWAYS\\_INT](#) 670  
[\\_EWL\\_IMP\\_EXP](#) 670  
[\\_EWL\\_MINIMUM\\_NAMED\\_LOCALE](#) 671  
[\\_EWL\\_NO\\_BOOL](#) 672  
[\\_EWL\\_NO\\_CONSOLE\\_IO](#) 672  
[\\_EWL\\_NO\\_CPP\\_NAMESPACE](#) 672  
[\\_EWL\\_NO\\_EXCEPTIONS](#) 672  
[\\_EWL\\_NO\\_EXPLICIT\\_FUNC\\_TEMPLATE\\_ARG](#) 673  
[\\_EWL\\_NO\\_FILE\\_IO](#) 674  
[\\_EWL\\_NO\\_IO](#) 674  
[\\_EWL\\_NO\\_LOCALE](#) 674  
[\\_EWL\\_NO\\_REFCOUNT\\_STRING](#) 674  
[\\_EWL\\_NO\\_VECTOR\\_BOOL](#) 674  
[\\_EWL\\_NO\\_WCHART](#) 675  
[\\_EWL\\_NO\\_WCHART\\_C\\_SUPPORT](#) 675  
[\\_EWL\\_NO\\_WCHART\\_CPP\\_SUPPORT](#) 675  
[\\_EWL\\_NO\\_WCHART\\_LANG\\_SUPPORT](#) 675  
[\\_EWL\\_POSIX\\_STREAM](#) 676  
[\\_EWL\\_RAW\\_ITERATORS](#) 321  
[\\_EWL\\_WFILEIO\\_AVAILABLE](#) 676  
[\\_EWL\\_WIDE\\_FILENAME](#) 676  
[\\_Inhibit\\_Container\\_Optimization](#) 666  
[\\_Inhibit\\_Optimize\\_RB\\_bit](#) 666  
[\\_STD](#) 677  
[<cmath>](#) 373  
[<cstdlib>](#) 373  
[<sstream>](#) 511

## A

Abnormal Termination 93  
[abort](#) 82  
[abrev\\_monthname](#) 229  
[abrev\\_weekday](#) 229  
[abs](#) 383  
[Access](#) 576  
[accumulate](#) 370  
[Adaptors](#) 116, 117  
[Addition Operator](#) 143  
[address](#) 121  
[adjacent\\_difference](#) 372

[adjacent\\_find](#) 325  
[advance](#) 306  
[Algorithms](#) 125  
[alloc\\_ptr](#) 594  
[allocate](#) 121  
[allocator\\_type](#) 569  
[allocator members](#) 121  
[Allocator Requirements](#) 104  
[always\\_noconv](#) 192  
[am\\_pm](#) 230  
[any](#) 299  
[append](#) 148  
[apply](#) 358  
[Arbitrary-Positional Stream](#) 58  
[arg](#) 384  
[Arithmetic operations](#) 109  
[array\\_size](#) 591  
[Array Forms](#) 84  
[Assertions](#) 100  
[assign](#) 136, 148, 275, 277, 285  
[Assignment](#) 573  
[Assignment Operator](#) 143, 353  
[Assignments](#) 141  
[Associative Containers](#) 287  
[at](#) 147  
[atexit](#) 82  
[auto\\_ptr](#) 126, 129–132  
[auto\\_ptr\\_ref](#) 132

## B

[back\\_insert\\_iterator](#) 311  
[Back\\_insert\\_iterator Operators](#) 311  
[back\\_inserter](#) 312  
[bad](#) 429  
[bad\\_alloc](#) 86  
[Bad\\_alloc](#) 86  
[bad\\_cast](#) 89  
[bad\\_exception](#) 92  
[bad\\_typeid](#) 90  
[base](#) 307  
[basic\\_filebuf::close](#) 531  
[basic\\_filebuf::imbue](#) 534  
[basic\\_filebuf::is\\_open](#) 529  
[basic\\_filebuf::open](#) 530  
[basic\\_filebuf::overflow](#) 532  
[basic\\_filebuf::pbackfail](#) 532  
[basic\\_filebuf::seekoff](#) 533  
[basic\\_filebuf::seekpos](#) 533  
[basic\\_filebuf::setbuf](#) 533  
[basic\\_filebuf::showmanyc](#) 531  
[basic\\_filebuf::sync](#) 534  
[basic\\_filebuf::underflow](#) 532

[basic\\_filebuf Constructors 528](#)  
[basic\\_filebuf Template Class 528](#)  
[basic\\_fstream::close 547](#)  
[basic\\_fstream::is\\_open 545](#)  
[basic\\_fstream::open 546](#)  
[basic\\_fstream::rdbuf 544](#)  
[basic\\_fstream Constructor 543](#)  
[basic\\_fstream Template Class 543](#)  
[basic\\_ifstream::close 538](#)  
[basic\\_ifstream::is\\_open 536](#)  
[basic\\_ifstream::open 537](#)  
[basic\\_ifstream::rdbuf 536](#)  
[basic\\_ifstream::ws 485](#)  
[basic\\_ifstream Constructor 535](#)  
[basic\\_ifstream Template Class 534](#)  
[basic\\_ios Constructor 417](#)  
[basic\\_ios Member Functions 418](#)  
[basic\\_ios Template Class 416](#)  
[basic\\_iostream Constructor 487](#)  
[basic\\_istream::gcount 470](#)  
[basic\\_istream::get 471](#)  
[basic\\_istream::getline 473](#)  
[basic\\_istream::ignore 475](#)  
[basic\\_istream::peek 476](#)  
[basic\\_istream::putback 480](#)  
[basic\\_istream::read 477](#)  
[basic\\_istream::readsome 478](#)  
[basic\\_istream::seekg 483](#)  
[basic\\_istream::sentry 463](#)  
[basic\\_istream::sync 482](#)  
[basic\\_istream::tellig 483](#)  
[basic\\_istream::unget 481](#)  
[basic\\_istream Constructors 462](#)  
[basic\\_istream Destructor 462](#)  
[basic\\_istream Template Class 462](#)  
[basic\\_istreambuf::rdbuf 517](#)  
[basic\\_istreambuf::str 518](#)  
[basic\\_istreambuf Constructor 516](#)  
[basic\\_istreambuf Template Class 516](#)  
[basic\\_ofstream::close 543](#)  
[basic\\_ofstream::is\\_open 541](#)  
[basic\\_ofstream::open 541](#)  
[basic\\_ofstream::rdbuf 540](#)  
[basic\\_ofstream Constructors 539](#)  
[basic\\_ofstream Template Class 538](#)  
[basic\\_ostream::endl 501](#)  
[basic\\_ostream::ends 502](#)  
[basic\\_ostream::flush 499, 503](#)  
[basic\\_ostream::operator<< 492](#)  
[basic\\_ostream::put 497](#)  
[basic\\_ostream::seekp 495](#)  
[basic\\_ostream::sentry 489](#)  
[basic\\_ostream::tellig 495](#)  
[basic\\_ostream::write 498](#)  
[basic\\_ostream Constructor 488](#)  
[basic\\_ostream Destructor 488](#)  
[basic\\_ostream Template Class 487](#)  
[basic\\_ostreambuf::rdbuf 520](#)  
[basic\\_ostreambuf::str 522](#)  
[basic\\_ostreambuf Class 519](#)  
[basic\\_ostreambuf Constructor 519](#)  
[basic\\_streambuf 450](#)  
[basic\\_streambuf::eback 451](#)  
[basic\\_streambuf::egptr 451](#)  
[basic\\_streambuf::epptr 453](#)  
[basic\\_streambuf::gbump 452](#)  
[basic\\_streambuf::getloc 440](#)  
[basic\\_streambuf::gptr 451](#)  
[basic\\_streambuf::imbue 454](#)  
[basic\\_streambuf::in\\_avail 444](#)  
[basic\\_streambuf::overflow 459](#)  
[basic\\_streambuf::pbackfail 458](#)  
[basic\\_streambuf::pbase 452](#)  
[basic\\_streambuf::pbump 453](#)  
[basic\\_streambuf::pptr 453](#)  
[basic\\_streambuf::pubimbue 439](#)  
[basic\\_streambuf::pubseekoff 441](#)  
[basic\\_streambuf::pubseekpos 442](#)  
[basic\\_streambuf::pubsetbuf 440](#)  
[basic\\_streambuf::pubsync 443](#)  
[basic\\_streambuf::sbumpc 445](#)  
[basic\\_streambuf::seekoff 455](#)  
[basic\\_streambuf::seekpos 455](#)  
[basic\\_streambuf::setbuf 455](#)  
[basic\\_streambuf::setg 452](#)  
[basic\\_streambuf::setp 453](#)  
[basic\\_streambuf::sgetc 446](#)  
[basic\\_streambuf::sgetn 447](#)  
[basic\\_streambuf::showmanyc 456](#)  
[basic\\_streambuf::snxetc 444](#)  
[basic\\_streambuf::sputbackc 447](#)  
[basic\\_streambuf::sputc 449](#)  
[basic\\_streambuf::sputn 450](#)  
[basic\\_streambuf::sungetc 449](#)  
[basic\\_streambuf::sync 456](#)  
[basic\\_streambuf::uflow 457](#)  
[basic\\_streambuf::underflow 457](#)  
[basic\\_streambuf::xsgetn 457](#)  
[basic\\_streambuf::xsputn 459](#)  
[basic\\_streambuf Class 438](#)  
[basic\\_streambuf Constructor 438](#)  
[basic\\_streambuf Public Functions 439](#)  
[basic\\_streambuf Virtual Functions 454](#)  
[basic\\_string 140](#)  
[basic\\_stringbuf::overflow 515](#)  
[basic\\_stringbuf::pbackfail 514](#)  
[basic\\_stringbuf::seekoff 515](#)  
[basic\\_stringbuf::seekpos 516](#)  
[basic\\_stringbuf::str 513](#)  
[basic\\_stringbuf::underflow 514](#)  
[basic\\_stringbuf Constructors 512](#)  
[basic\\_stringbuf Template Class 511](#)  
[basic\\_stringstream::rdbuf 524](#)  
[basic\\_stringstream::str 525](#)  
[basic\\_stringstream Class 522](#)  
[basic\\_stringstream Constructor 523](#)



Basic Iterator [305](#)  
 before [89](#)  
 begin [144](#)  
 Bidirectional Iterators [304](#)  
 binary\_negate [114](#)  
 binary\_search [340](#)  
 bind1st [115](#)  
 bind2nd [116](#)  
 binder1st [115](#)  
 binder2nd [115](#)  
 Binders [115](#)  
 bind Library [655](#)  
 bitset Constructor [294](#)  
 Bitset Members [294](#)  
 Bitset Operators [300](#)  
 bitvector Destructor [573](#)  
 bool Operator [422](#)  
 bsearch [348](#)  
 Buffer Management Positioning [454](#)  
 Byte strings [63](#)

## C

c\_str [151](#)  
 C++ [665](#)  
 C++ Library [57](#)  
 call\_once [638](#)  
 call\_traits [592](#)  
 can\_derive\_from [592](#)  
 capacity [146](#), [285](#), [575](#)  
 Capacity [145](#), [574](#)  
 Case Transformation [185](#)  
 cdeque [604](#)  
 char\_traits [139](#)  
 character [136](#)  
 Character [58](#)  
 Character Classification [177](#)  
 Character Conversions [178](#)  
 Character sequences [63](#)  
 Character Sequences [58](#)  
 Character Support [161](#)  
 Character Trait Definitions [136](#)  
 Character traits [135](#)  
 Class [463](#), [489](#)  
 classic [176](#)  
 classic\_table [190](#)  
 Classification [184](#)  
 clear [146](#), [279](#), [425](#), [579](#)  
 C Library Locales [270](#)  
 close [263](#)  
 CodecvT [191](#)  
 codecvT\_byname [194](#)  
 CodecvT\_byname [195](#)  
 codecvT Members [191](#)  
 codecvT Virtual Functions [193](#)  
 collate\_byname [208](#)  
 collate Data Section [208](#)

collate Virtual Functions [207](#)  
 combine [174](#)  
 compare [137](#), [155](#), [206](#)  
 Comparison Function [58](#)  
 Comparisons [110](#)  
 compile\_assert [591](#)  
 complex Class [375](#)  
 complex Class Operators [378](#)  
 complex Member Functions [377](#)  
 complex Template Class [376](#)  
 Component [59](#)  
 compressed\_pair [593](#)  
 Condition Variables [633](#)  
 conj [384](#)  
 const\_mem\_fun\_ref\_t [120](#)  
 const\_mem\_fun\_t [119](#)  
 const\_mem\_fun1\_ref\_t [120](#)  
 const\_mem\_fun1\_t [119](#)  
 const\_reference [311](#), [571](#)  
 Constraints [67](#)  
 construct [122](#)  
 Constructor [86](#), [189](#)  
 Constructors [88–92](#), [107](#), [141](#), [173](#)  
 Container Adaptors [281](#)  
 containers [603](#)  
 Containers [271](#)  
 Contraction [211](#)  
 Conversion Constructor [131](#)  
 copy [138](#), [150](#), [328](#)  
 copy\_backward [328](#)  
 Copy Construction [104](#)  
 copyfmt [422](#)  
 cos [385](#)  
 cosh [385](#)  
 count [297](#), [326](#)  
 count\_if [326](#)  
 cref [646](#)  
 cshift [358](#)  
 ctype [179](#)  
 ctype\_base [179](#)  
 ctype\_byname [183](#)  
 ctype\_byname<char> [191](#)  
 ctype<Char> Static Members [190](#)  
 ctype Members [189](#)  
 ctype Specializations [188](#)  
 ctype Virtual Functions [182](#)  
 curr\_symbol [252](#), [259](#)

## D

data [151](#)  
 Data file syntax [258](#)  
 date [230](#)  
 Date [132](#)  
 date\_time [230](#)  
 deallocate [121](#)  
 decimal\_point [201](#), [204](#), [251](#), [258](#)

default\_century [231](#)  
 Default Construction [104](#)  
 Defines [665](#)  
 Definitions [57](#)  
 delete [84](#)  
 delete[] [85](#)  
 denorm\_min [78](#)  
 deque [600](#)  
 deque Constructor [274](#)  
 deque Template Class [274](#)  
 Derived classes [68](#)  
 destroy [122](#)  
 destructor [86, 91, 130, 173, 189, 316](#)  
 Destructor [143](#)  
 Diagnostics Library [97](#)  
 digits [73](#)  
 Directive [611](#)  
 distance [306](#)  
 divides [110](#)  
 do\_is [182](#)  
 do\_narrow [183](#)  
 do\_scan\_is [182](#)  
 do\_scan\_not [182](#)  
 do\_tolower [183](#)  
 do\_toupper [182](#)  
 do\_widen [183](#)  
 domain\_error [98](#)  
 Dynamic Memory Management [83](#)

## E

Element Access [147](#)  
 empty [146, 283, 574](#)  
 Enable Debug Mode [597](#)  
 end [144](#)  
 eof [139, 427](#)  
 epsilon [74](#)  
 eq [137](#)  
 eq\_int\_type [139](#)  
 equal [319, 327](#)  
 equal\_range [289, 291, 340](#)  
 equal\_to [111](#)  
 Equality Comparisons [103](#)  
 erase [149, 276, 278, 286, 579, 616](#)  
 Erasure [579](#)  
 Error Numbers [101](#)  
 Escape sequences [167](#)  
 EUC [196](#)  
 EWL [643](#)  
 EWL\_Utility [583](#)  
 EWL C++ Library [57](#)  
 Ewlconfig [665](#)  
 EWL Threads [627](#)  
 exception [91](#)  
 Exception Classes [97](#)  
 Exception Handling [91](#)  
 exceptions [431](#)

exit [82](#)  
 exp [386](#)  
 Expansion [211](#)  
 Extending derivation [235](#)  
 External Linkage [68](#)  
 extractors [160](#)

## F

fail [428](#)  
 failed [320](#)  
 failure [403](#)  
 failure::what [403](#)  
 false\_name [205](#)  
 falsename [202](#)  
 fill [331, 421](#)  
 fill\_n [332](#)  
 find [137, 152, 288, 290, 324](#)  
 find\_end [324](#)  
 find\_first\_not\_of [153](#)  
 find\_first\_of [152, 325](#)  
 find\_if [324](#)  
 find\_last\_not\_of [154](#)  
 find\_last\_of [153](#)  
 flags [407](#)  
 Flags [665](#)  
 flip [297, 581](#)  
 float\_denorm\_style [80](#)  
 float\_round\_style [80](#)  
 fmtflags [403](#)  
 for\_each [323](#)  
 Format Parsing [220](#)  
 Forward Iterators [304](#)  
 fpos Template Class [401](#)  
 frac\_digits [253, 260](#)  
 Freestanding Implementations [66](#)  
 freeze [553, 562, 565](#)  
 French collation [211](#)  
 front [576](#)  
 front\_insert\_iterator [312](#)  
 Front\_insert\_iterator operators [313](#)  
 front\_insert\_iterator Template Class [312](#)  
 front\_inserter [313](#)  
 ostream Header [527](#)  
 Function objects [108](#)

## G

General Utilities Libraries [103](#)  
 generate [332](#)  
 generate\_n [332](#)  
 get [131, 198, 247, 263](#)  
 get\_allocator [151, 575](#)  
 get\_result\_type [644](#)  
 get\_state [139](#)  
 get\_temporary\_buffer [125](#)  
 getline [161](#)

[getloc](#) [413](#)  
[global](#) [176](#)  
[good](#) [427](#)  
[greater](#) [111](#)  
[greater\\_equal](#) [112](#)  
[grouping](#) [201](#), [204](#), [252](#), [259](#)  
[gslice](#) [365](#)  
[gslice\\_array](#) [366](#)  
[gslice\\_array](#) Template Class [366](#)  
[gslice](#) Access Functions [365](#)

## H

[Handler function](#) [69](#)  
[Handler Function](#) [59](#)  
[has\\_denorm](#) [76](#)  
[has\\_denorm\\_loss](#) [77](#)  
[has\\_facet](#) [177](#)  
[has\\_infinity](#) [76](#)  
[has\\_quiet\\_NaN](#) [76](#)  
[has\\_signaling\\_NaN](#) [76](#)  
[hash](#) [207](#)  
[hash\\_fun](#) [625](#)  
[hash\\_map](#) [621](#)  
[hash\\_set](#) [619](#), [621](#)  
[Hash Libraries](#) [609](#)  
[Header](#) [401](#)  
[Header Algorithm](#) [323](#)  
[Header iterator](#) [305](#)  
[Headers](#) [65](#), [67](#), [68](#)

## I

[Ignorable Characters](#) [212](#)  
[imag](#) [378](#), [383](#)  
[imbue](#) [413](#), [420](#)  
[Implementation messages](#) [264](#)  
[in](#) [180](#), [192](#)  
[includes](#) [341](#)  
[indirect\\_array](#) [369](#)  
[indirect\\_array](#) Template Class [369](#)  
[infinity](#) [77](#)  
[Init Class Constructor](#) [406](#)  
[inner\\_product](#) [371](#)  
[inplace\\_merge](#) [341](#)  
[Input/Output Manipulations](#) [162](#)  
[Input Iterators](#) [303](#)  
[insert](#) [149](#), [275](#), [277](#), [286](#), [578](#), [615](#), [616](#)  
[insert\\_iterator](#) [314](#)  
[insert\\_iterator](#) Operators [314](#)  
[inserter](#) [315](#)  
[Inserters](#) [160](#)  
[Insertion](#) [577](#)  
[Insert Iterators](#) [311](#)  
[invalid\\_argument](#) [98](#)  
[invariants](#) [581](#)  
[Invariants](#) [606](#)

[ios](#) [401](#)  
[ios\\_base](#) [416](#)  
[ios\\_base](#) Class [402](#)  
[ios\\_base](#) Constructor [416](#)  
[ios\\_base](#) Destructor [416](#)  
[ios\\_base](#) Format Flags [407](#)  
[ios\\_base](#) Locale Functions  
[ios\\_base](#) Storage Function [414](#)  
[iosfwd](#) [391](#)  
[iostate](#) [404](#)  
[iostream](#) [395](#)  
[Iostream Class Templates](#) [59](#)  
[Iostream Objects](#) [395](#)  
[Iostreams Base Classes](#) [401](#)  
[is\\_bounded](#) [78](#)  
[is\\_const](#) [587](#)  
[is\\_empty](#) [593](#)  
[is\\_exact](#) [74](#)  
[is\\_iec559](#) [78](#)  
[is\\_integer](#) [73](#)  
[is\\_modulo](#) [78](#)  
[is\\_same](#) [587](#)  
[is\\_signed](#) [73](#), [589](#)  
[is\\_specialized](#) [72](#)  
[is\\_unsigned](#) [589](#)  
[is\\_volatile](#) [588](#)  
[istream\\_iterator](#) [316](#)  
[istream\\_iterator](#) Operations [316](#)  
[istream\\_iterator](#) Template Class [315](#)  
[istreambuf\\_iterator](#) [318](#)  
[istreambuf\\_iterator](#) Operators [318](#)  
[istreambuf\\_iterator](#) Template Class [318](#)  
[istream cin](#) [396](#)  
[istrstream](#) Class [558](#)  
[istrstream](#) Destructor [559](#)  
[iter\\_swap](#) [329](#)  
[Iteration](#) [576](#)  
[Iterators Library](#) [303](#)  
[Iterator Support](#) [144](#)  
[Iterator Traits](#) [305](#)  
[iword](#) [414](#)

## J

[JIS](#) [196](#)

## L

[Language Support Library](#) [71](#)  
[length](#) [137](#), [145](#), [192](#)  
[length\\_error](#) [99](#)  
[less](#) [112](#)  
[less\\_equal](#) [112](#)  
[lexicographical\\_compare](#) [347](#)  
[library](#) [67](#)  
[Library-wide Requirements](#) [65](#)  
[Linkage](#) [67](#)

- list [601](#)
- list Template Class [276](#)
- locale [169](#)
- locale::Category [171](#)
- locale::facet [172](#)
- locale::id [172](#)
- Locale Globals [176](#)
- Locale Members [174](#)
- Locale Names [170](#)
- Locale Operators [174](#)
- Locales [169](#), [439](#), [454](#)
- Locale Static Members [175](#)
- Locale Types [171](#)
- Localization Library [165](#)
- Locks [628](#)
- log [386](#)
- log10 [386](#)
- logic\_error [98](#)
- logical\_and [113](#)
- logical\_not [113](#)
- logical\_or [113](#)
- Logical operations [113](#)
- lower\_bound [288](#), [291](#), [339](#)
- lt [137](#)

## M

- make\_heap [344](#)
- make\_pair [108](#)
- map, [603](#)
- Map Operations [288](#)
- map Template Class [287](#)
- mask\_array [367](#), [368](#)
- mask\_array Template Class [367](#)
- max [73](#), [345](#), [357](#)
- max\_element [346](#)
- max\_exponent [75](#)
- max\_exponent10 [75](#)
- max\_length [192](#)
- max\_size [122](#), [145](#), [575](#)
- mem\_fun [118](#)
- mem\_fun\_ref [119](#)
- mem\_fun\_ref\_t [118](#)
- mem\_fun\_t [117](#)
- mem\_fun1\_ref\_t [118](#)
- mem\_fun1\_t [117](#)
- Memory [120](#)
- merge [280](#), [341](#)
- messages\_byname [266](#)
- Messages Virtual Functions [263](#)
- min [72](#), [345](#), [357](#)
- min\_element [346](#)
- min\_exponent [75](#)
- min\_exponent10 [75](#)
- minus [109](#)
- mismatch [326](#)
- Modifier [59](#), [209](#)

- Modifiers [147](#)
- modulus [110](#)
- money\_get [246](#)
- Money\_get Members [247](#)
- Money\_get Virtual Functions [248](#)
- money\_put [248](#)
- Money\_put Members [249](#)
- Money\_put Virtual Functions [249](#)
- Money class [241](#)
- Money\_punct [250](#)
- money\_punct\_byname [256](#)
- money\_punct Derivation [255](#)
- Money\_punct Members [251](#)
- Money\_punct Virtual Functions [254](#)
- monthname [229](#)
- move [138](#)
- Multibyte strings [64](#)
- multimap, [603](#)
- multimap Constructor [290](#)
- multimap Template Class [290](#)
- multiplies [109](#)
- multiset [603](#)
- multiset Constructor [293](#)
- multiset Template Class [293](#)
- Multi-Thread Safety [61](#)
- Mutex [628](#)

## N

- name [89](#), [174](#)
- narrow [181](#)
- Narrow-oriented Iostream Classes [60](#)
- Narrow stream objects [396](#)
- neg\_format [254](#), [260](#)
- negate [110](#)
- negative\_sign [252](#), [259](#)
- Negators [114](#)
- new [84](#)
- new\_handler [87](#)
- new[] [84](#)
- next\_permutation [347](#)
- noconv [195](#)
- none [299](#)
- Non-Member Functions [155](#)
- Non-member Logical Operations [361](#)
- norm [384](#)
- not\_eof [138](#)
- not\_equal\_to [111](#)
- NTCTS [60](#), [136](#)
- nth\_element [339](#)
- Null Terminated Sequence Utilities [161](#)
- Num\_get Members [198](#)
- Num\_get Virtual Functions [199](#)
- Num\_put Members [200](#)
- Num\_put Virtual Functions [200](#)
- Numeric\_wide [205](#)
- Numeric arrays [352](#)

Numeric limits [72](#)  
 Numerics Library [351](#)  
 numpunct\_byname [203](#)  
 numpunct Derivation [205](#)  
 Numpunct Members [201](#)  
 Numpunct virtual functions [202](#)

## O

open [263](#)  
 openmode [405](#)  
 operator [107, 124, 129, 174, 175, 281](#)  
 operator!= [88, 106, 123, 157, 298](#)  
 operator^ [300](#)  
 operator^= [295](#)  
 operator~ [296](#)  
 operator[] [147, 288, 354](#)  
 operator\* [130](#)  
 Operator\* [312](#)  
 operator& [300](#)  
 operator&= [294](#)  
 operator+ [155](#)  
 operator++ [124](#)  
 Operator++ [312](#)  
 operator+= [147](#)  
 operator< [157, 282](#)  
 operator<< [160, 299, 301](#)  
 Operator<< [490](#)  
 operator<<= [295](#)  
 operator<= [106, 158](#)  
 operator= [124](#)  
 operator== [88, 122, 156, 298](#)  
 operator> [106, 158](#)  
 operator->([130](#)  
 operator>= [107, 159](#)  
 operator>> [160, 299, 301](#)  
 Operator>> [464](#)  
 operator>>= [295](#)  
 operator! [300](#)  
 operator|= [295](#)  
 Operators [106](#)  
 ostream\_iterator [317](#)  
 ostream\_iterator Operators [317](#)  
 ostream\_iterator Template Class [317](#)  
 ostreambuf\_iterator [320](#)  
 ostreambuf\_iterator Operators [320](#)  
 ostreambuf\_iterator Template Class [319](#)  
 ostream cerr [397](#)  
 ostream clog [397](#)  
 ostream cout [397](#)  
 ostrstream Class [560](#)  
 ostrstream Destructor [561](#)  
 out [191](#)  
 out\_of\_range [99](#)  
 Output Iterators [304](#)  
 overflow [557](#)  
 overflow\_error [100](#)

Overloaded complex Operators [380](#)

## P

Pairs [107](#)  
 partial\_sort [338](#)  
 partial\_sort\_copy [338](#)  
 partial\_sum [371](#)  
 partition [336](#)  
 pbackfail [557](#)  
 pcount [554, 562, 565](#)  
 Placement Forms [85](#)  
 Placement operator delete [85](#)  
 Placement operator new [85](#)  
 plus [109](#)  
 pointer\_to\_binary\_function [116](#)  
 pointer\_to\_unary\_function [116](#)  
 Pointers [116, 117](#)  
 polar [384](#)  
 pop [283, 284](#)  
 pop\_back [279, 579](#)  
 pop\_front [278](#)  
 pop\_heap [344](#)  
 pos\_format [253, 260](#)  
 positive\_sign [252, 259](#)  
 pow [387](#)  
 precision [411](#)  
 Predefined Iterators [307](#)  
 prev\_permutation [347](#)  
 priority\_queue [282](#)  
 Private members [64](#)  
 Protected Member Functions [450](#)  
 push [282, 284](#)  
 push\_back [278, 577](#)  
 push\_front [278](#)  
 push\_heap [344](#)  
 put [200, 249](#)  
 Putback [447](#)  
 pword [415](#)

## Q

qsort [348](#)  
 Query [587](#)  
 quiet\_NaN [77](#)

## R

radix [74](#)  
 random\_shuffle [336](#)  
 Random Access Iterators [304](#)  
 range\_error [99](#)  
 raw\_storage\_iterator [123](#)  
 Raw storage iterator [123](#)  
 rbegin [144](#)  
 rdbuf [419, 559, 563, 565](#)  
 rdstate [423](#)

- real [378](#), [383](#)
- ref [646](#)
- reference [570](#)
- reference\_wrapper [645](#)
- register\_callback [415](#)
- Relation [209](#)
- Relationals [210](#)
- release [131](#)
- remove [279](#), [332](#)
- remove\_all [586](#)
- remove\_bounds [586](#)
- remove\_const [584](#)
- remove\_copy [333](#)
- remove\_copy\_if [333](#)
- remove\_cv [585](#)
- remove\_if [280](#), [333](#)
- remove\_pointer [585](#)
- remove\_reference [586](#)
- remove\_volatile [584](#)
- rend [145](#)
- replace [150](#), [330](#)
- replace\_copy [330](#)
- replace\_copy\_if [331](#)
- Replacement Function [60](#), [68](#)
- Repositional Stream [60](#)
- reserve [146](#), [575](#)
- Reserved Function [61](#)
- Reserved Names [67](#)
- reset [131](#), [296](#)
- Reset [209](#)
- resetiosflags [505](#)
- resize [146](#), [275](#), [277](#), [286](#), [358](#), [580](#)
- result\_of [643](#), [644](#)
- return\_temporary\_buffer [125](#)
- reverse [280](#), [335](#)
- reverse\_copy [335](#)
- reverse\_iterator [307](#)
- reverse\_iterator Operators [308](#)
- Reverse Iterators [307](#)
- rfind [152](#)
- rotate [335](#)
- rotate\_copy [335](#)
- round\_error [74](#)
- round\_style [79](#)
- rriority\_queue Template Class [282](#)
- Rule Format [209](#)
- runtime\_error [99](#)
  
- S**
  
- scan\_is [180](#)
- scan\_not [180](#)
- search [327](#)
- search\_n [328](#)
- seekdir [405](#)
- seekoff [555](#)
- seekpos [556](#)
  
- sentry::Operator bool [464](#), [490](#)
- Sequences [272](#), [274](#)
- Set [296](#)
- set\_difference [343](#)
- set\_intersection [342](#)
- set\_new\_handler [87](#)
- set\_symetric\_difference [343](#)
- set\_terminate [94](#)
- set\_unexpected [93](#)
- set\_union [342](#)
- set, [603](#)
- setbase [506](#)
- setbuf [555](#)
- setf [409](#)
- setfill [507](#)
- setiosflags [505](#)
- setprecision [507](#)
- setstate [426](#)
- set Template Class [292](#)
- setw [508](#)
- shared\_ptr [649](#)
- shift [358](#)
- Shift-JIS [196](#)
- signaling\_NaN [77](#)
- sin [387](#)
- Single Object Forms [83](#)
- sinh [387](#)
- size [145](#), [284](#), [298](#), [356](#), [363](#), [365](#), [574](#)
- size\_type [569](#)
- slice [363](#)
- slice\_array [364](#)
- slice\_array Template Class [363](#)
- slice Class [362](#)
- slist [605](#)
- sort [280](#), [337](#)
- sort\_heap [345](#)
- Sorting Operations [337](#)
- sort predicate [661](#)
- splice [279](#)
- sqrt [388](#)
- stable\_partition [337](#)
- stable\_sort [337](#)
- stack Template Class [283](#)
- Standard Locale Categories [178](#)
- start [363](#), [365](#)
- Start [81](#)
- std::tr1 [643](#)
- Storage Allocation [83](#)
- Storage Allocation Errors [86](#)
- Storage Deallocation [83](#)
- str [554](#), [560](#), [563](#), [566](#)
- Stream Buffering [395](#)
- Stream Buffers [437](#)
- Stream Iterators [315](#)
- stride [363](#), [366](#)
- string [602](#)
- String-based Streams [511](#)
- String Classes [140](#)

[stringfwd](#) [391](#)  
[String Operations](#) [151](#)  
[Strings Library](#) [135](#)  
[String Support](#) [162](#)  
[String Syntax](#) [169](#)  
[Strstream](#) [551](#)  
[strstreambuf Class](#) [551](#)  
[strstreambuf Destructor](#) [553](#)  
[strstream Class](#) [564](#)  
[strstream Destructor](#) [564](#)  
[struct char\\_traits<T>](#) [140](#)  
[substr](#) [154](#)  
[sum](#) [357](#)  
[Supported Locale Names](#) [165](#)  
[swap](#) [151](#), [160](#), [276](#), [281](#), [291–293](#), [329](#), [581](#)  
[swap\\_ranges](#) [329](#)  
[Switches](#), [665](#)  
[sync\\_with\\_stdio](#) [415](#)  
[SZ\\_T](#) [390](#)

## T

[tan](#) [388](#)  
[tanh](#) [388](#)  
[Template Class](#) [126](#)  
[Temporary buffers](#) [125](#)  
[terminate](#) [94](#)  
[terminate\\_handler](#) [93](#)  
[termination](#) [81](#)  
[test](#) [298](#)  
[Text-Argument:](#) [209](#)  
[thousands\\_sep](#) [201](#), [204](#), [251](#), [258](#)  
[thread\\_specific\\_ptr](#) [640](#)  
[Threads](#) [631](#)  
[Thread Safety Policy](#) [62](#)  
[tie](#) [418](#)  
[time](#) [230](#)  
[Time](#) [132](#)  
[time\\_12hour](#) [230](#)  
[time\\_get](#) [217](#), [218](#)  
[time\\_get\\_byname](#) [225](#)  
[time\\_put](#) [226](#)  
[time\\_put\\_byname](#) [227](#)  
[time\\_put Virtual Functions](#) [226](#)  
[time\\_zone](#) [231](#)  
[timepunct\\_byname](#) [237](#)  
[tinyness\\_before](#) [79](#)  
[to\\_char\\_type](#) [138](#)  
[to\\_int\\_type](#) [139](#)  
[to\\_string](#) [297](#)  
[to\\_ulong](#) [297](#)  
[tolower](#) [178](#), [181](#)  
[top](#) [284](#)  
[toupper](#) [178](#), [181](#)  
[traits](#) [136](#)  
[Traits](#) [61](#)  
[transform](#) [207](#), [330](#)

[traps](#) [79](#)  
[tree-based](#) [603](#)  
[true\\_name](#) [205](#)  
[truenamename](#) [201](#)  
[type\\_info](#) [88](#)  
[typedef Declarations](#) [402](#)  
[Type identification](#) [87](#)  
[Types](#) [71](#)

## U

[UCS-2](#) [195](#)  
[Unary\\_negate](#) [114](#)  
[uncaught\\_exception](#) [94](#)  
[underflow](#) [556](#)  
[underflow\\_error](#) [100](#)  
[unexpected](#) [93](#)  
[unexpected\\_handler](#) [93](#)  
[uninitialized\\_copy](#) [125](#)  
[uninitialized\\_fill](#) [126](#)  
[uninitialized\\_fill\\_n](#) [126](#)  
[unique](#) [280](#), [334](#)  
[unique\\_copy](#) [334](#)  
[unsetf](#) [410](#)  
[unshift](#) [192](#)  
[upper\\_bound](#) [289](#), [339](#)  
[use\\_facet](#) [176](#)  
[utc\\_offset](#) [231](#)  
[UTF-8](#) [196](#)  
[Utility Components](#) [106](#)

## V

[valarray](#) [353](#)  
[valarray Binary Operators](#) [359](#)  
[valarray Destructor](#) [353](#)  
[valarray Logical Operators](#) [360](#)  
[valarray Member Functions](#) [356](#)  
[valarray Template Class](#) [352](#)  
[valarray Unary Operators](#) [354](#)  
[value\\_type](#) [570](#)  
[vector](#) [602](#)  
[Vector<bool>](#) [287](#)  
[vector Template Class](#) [284](#)

## W

[weekday](#) [229](#)  
[what](#) [86](#), [90](#), [92](#)  
[Wide-character sequences](#) [64](#)  
[widen](#) [181](#)  
[Wide-oriented IOSTREAM Classes](#) [61](#)  
[Wide stream objects](#) [398](#)  
[width](#) [412](#)  
[wistream wcin](#) [398](#)  
[wostream wcerr](#) [398](#)  
[wostream wcout](#) [398](#)

wostream wlog [399](#)

## **X**

xalloc [414](#)





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