

Jumpstart Cloud-connected Computer Vision and Machine Learning Designs



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AWS



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Industrial Marketing Manager
NXP Semiconductors

How ML/Computer Vision Can Drive Better Business Outcomes

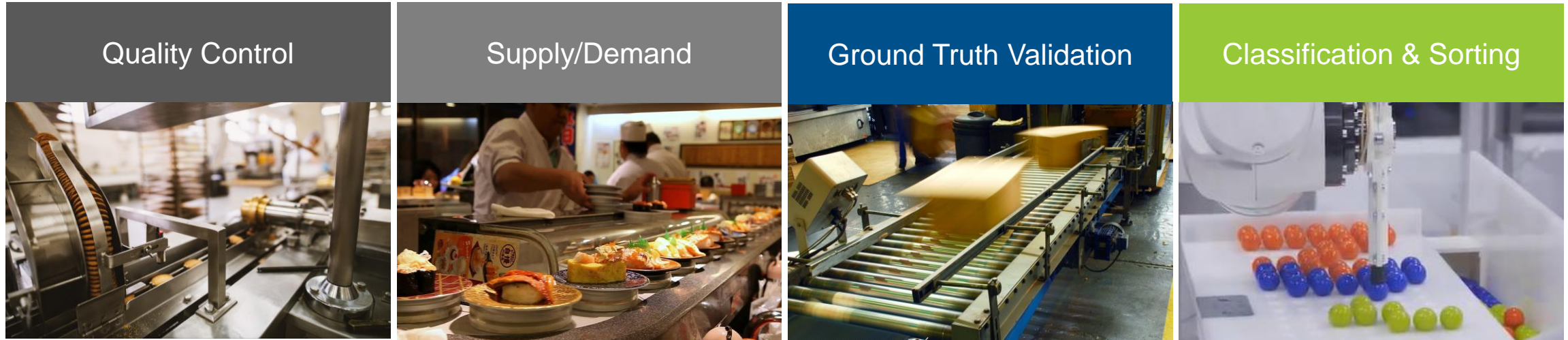


Revenue growth
IoT data drives business growth



Operational efficiency
IoT data decreases OpEx

Machine Learning and Computer Vision Use Cases



Selection of current Toradex customer applications:

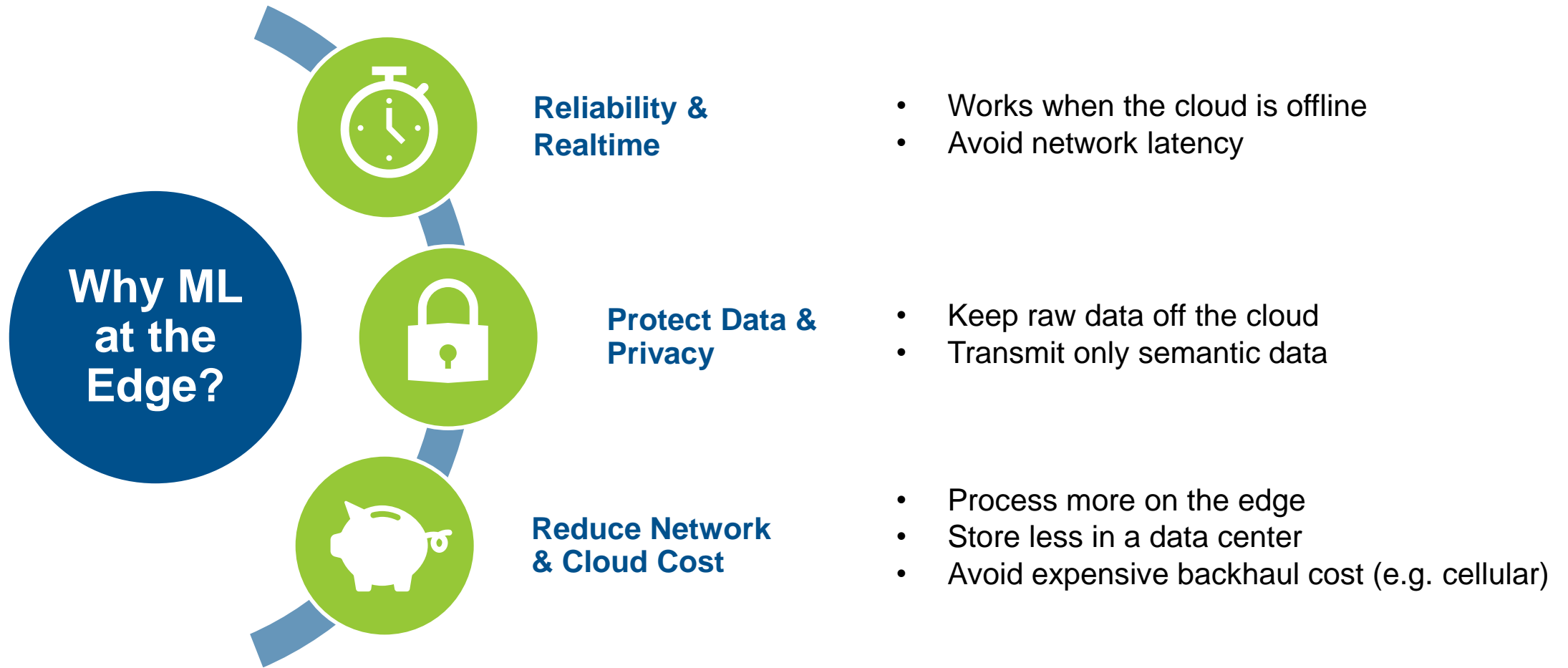
- Violet (flowers) Quality Check - camera and conveyor belt
- Pizza Robot - several conveyor belts and cameras
- Beef Carcass Quality Classification - hanging beef carcass passing in front of a camera
- Production Line Monitoring - 2D/3D cameras for automated visual inspection
- Smart Street Lights - cameras and sensors on streetlights
- Livestock Classification - cattle scale combined with cameras
- Seedling Monitoring - camera mounted on a tractor
- People Counting Retail Analytics - stereo and mono cameras
- Predictive Maintenance Construction Machines - CAN bus messages
- Laboratory Equipment Cell Monitoring
- Smart Water Spray for Pine Tree seedlings
- Retinal Camera - measuring eye at the doctor
- Camera Monitoring Environment - around construction machines, snowplows
-

Poll: What is your experience with Computer Vision?

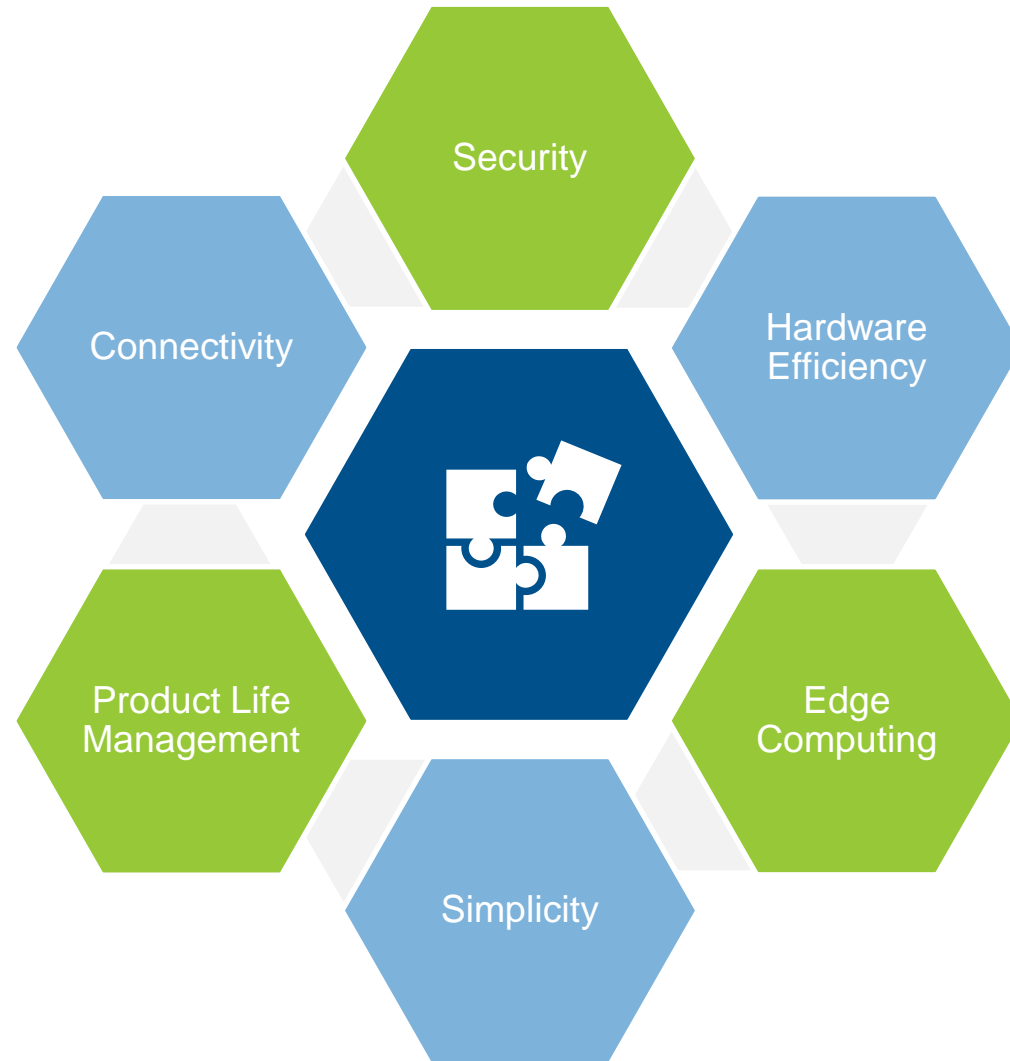
- No experience
- Basic knowledge
- Developed proof of concept
- Computer vision products in production



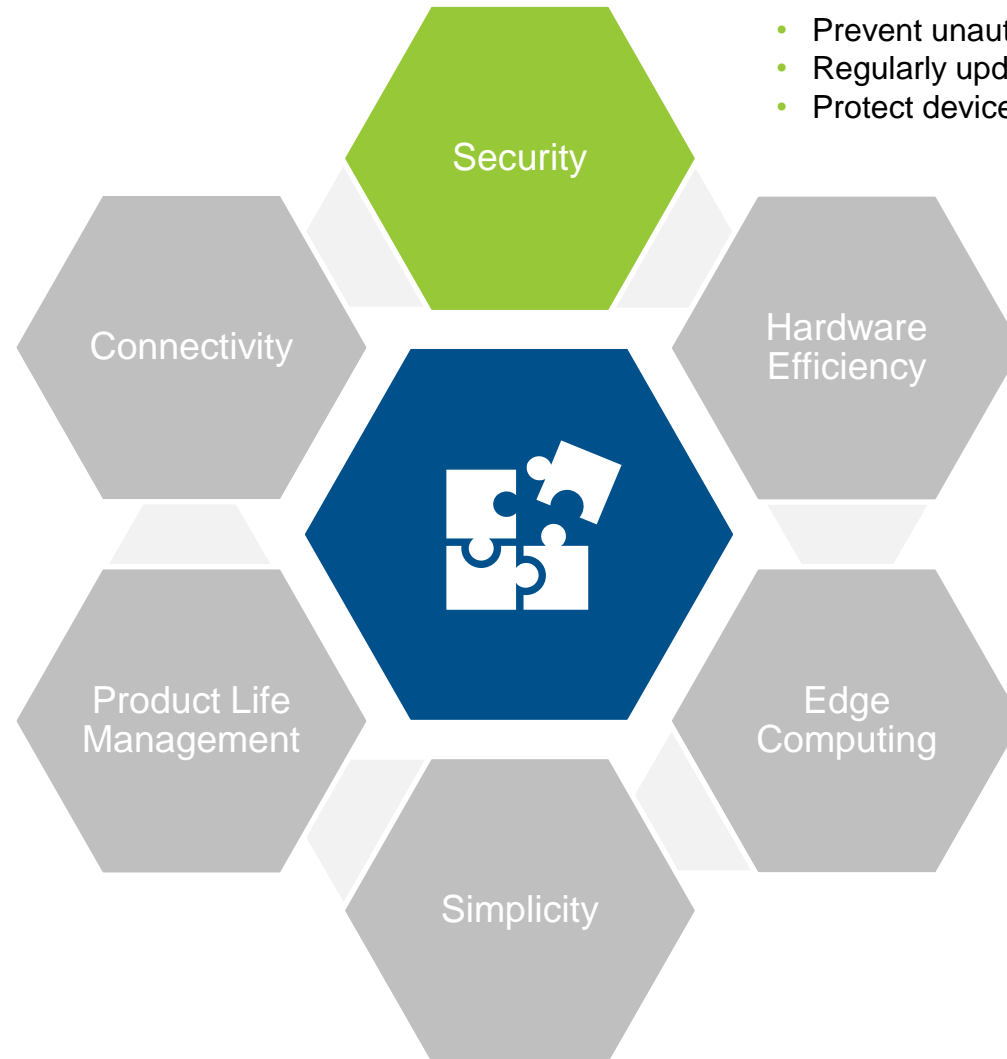
Why Edge Compute?



Typical Requirements for IoT Devices

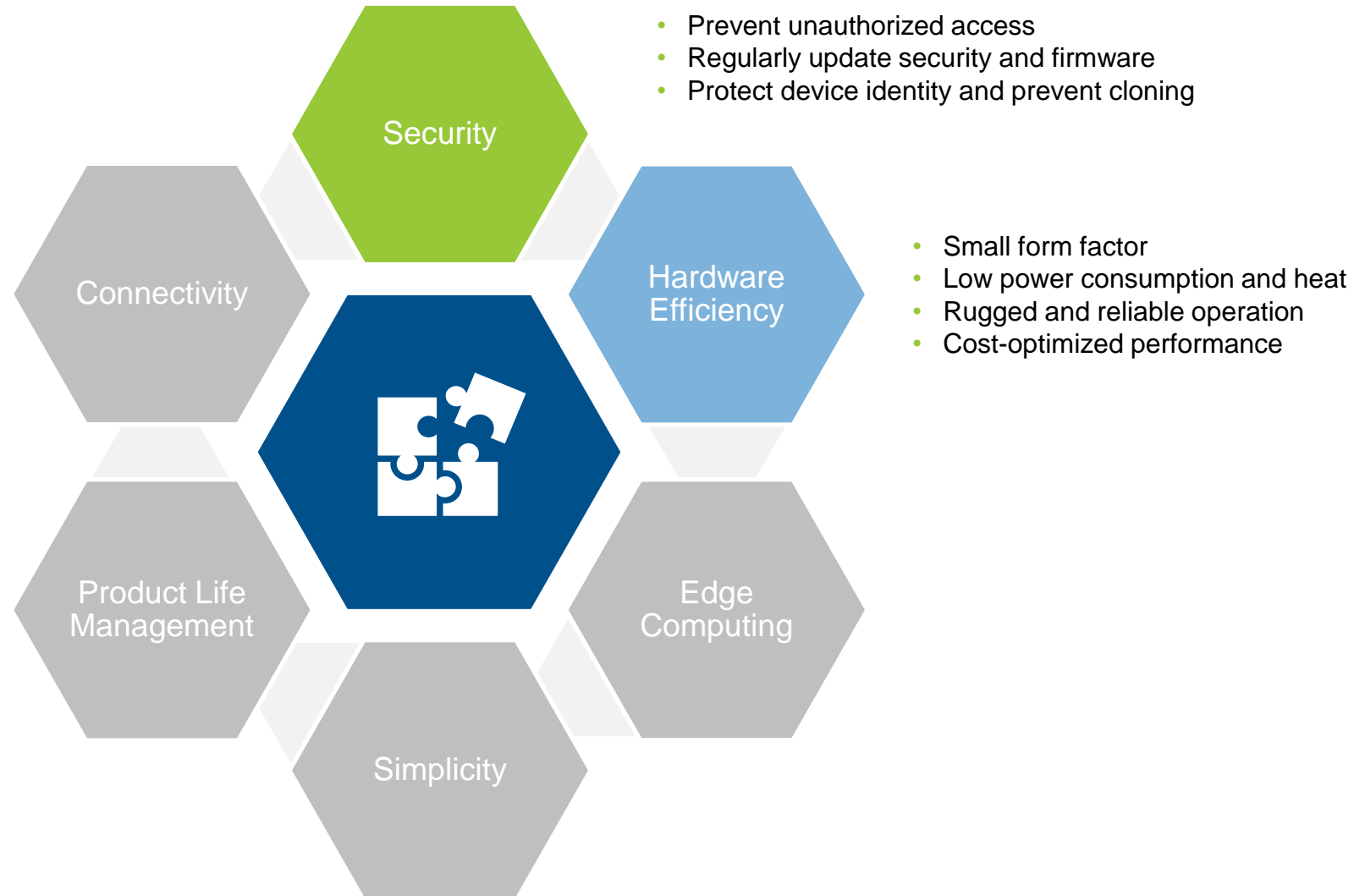


Typical Requirements for IoT Devices

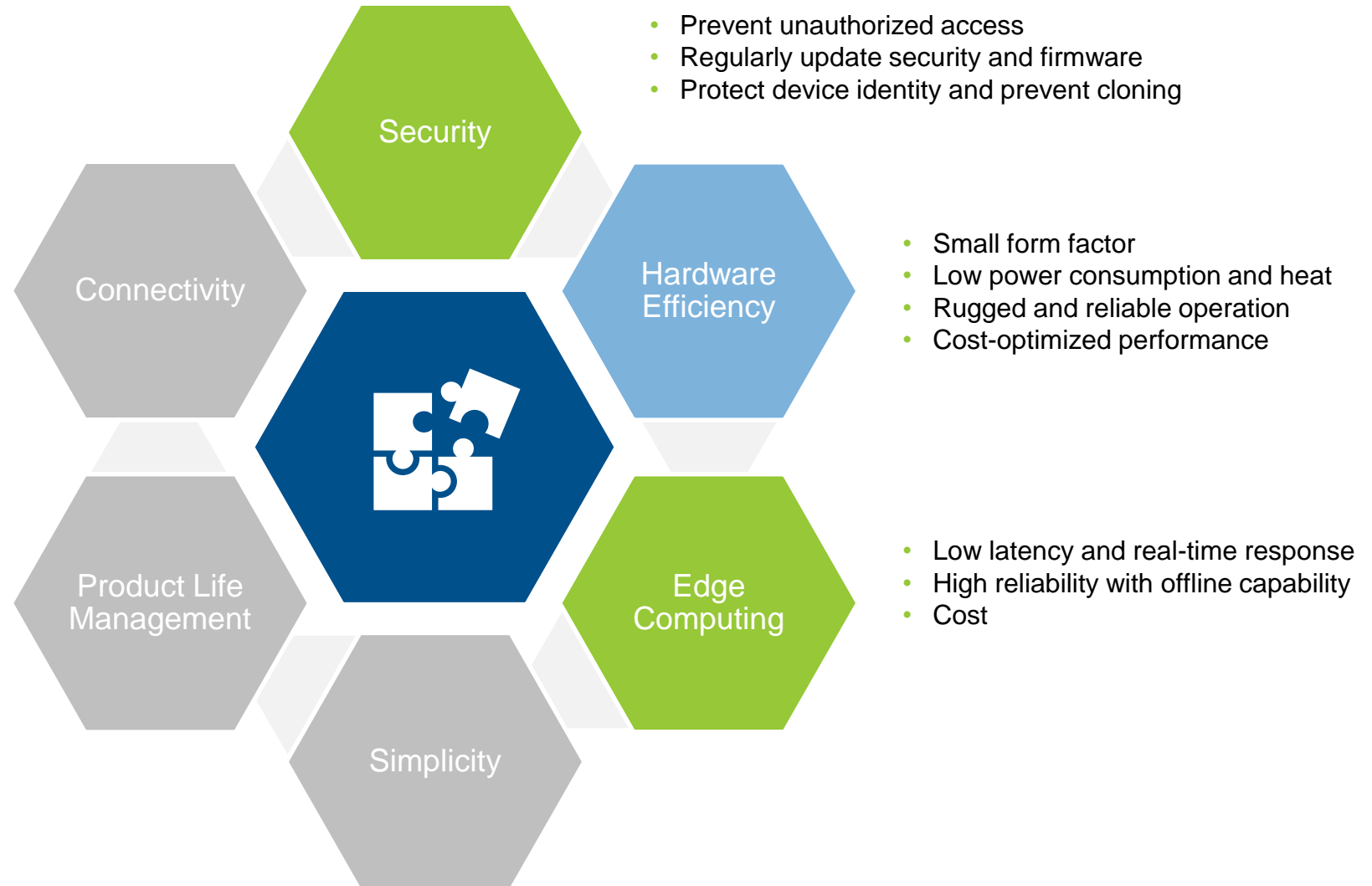


- Prevent unauthorized access
- Regularly update security and firmware
- Protect device identity and prevent cloning

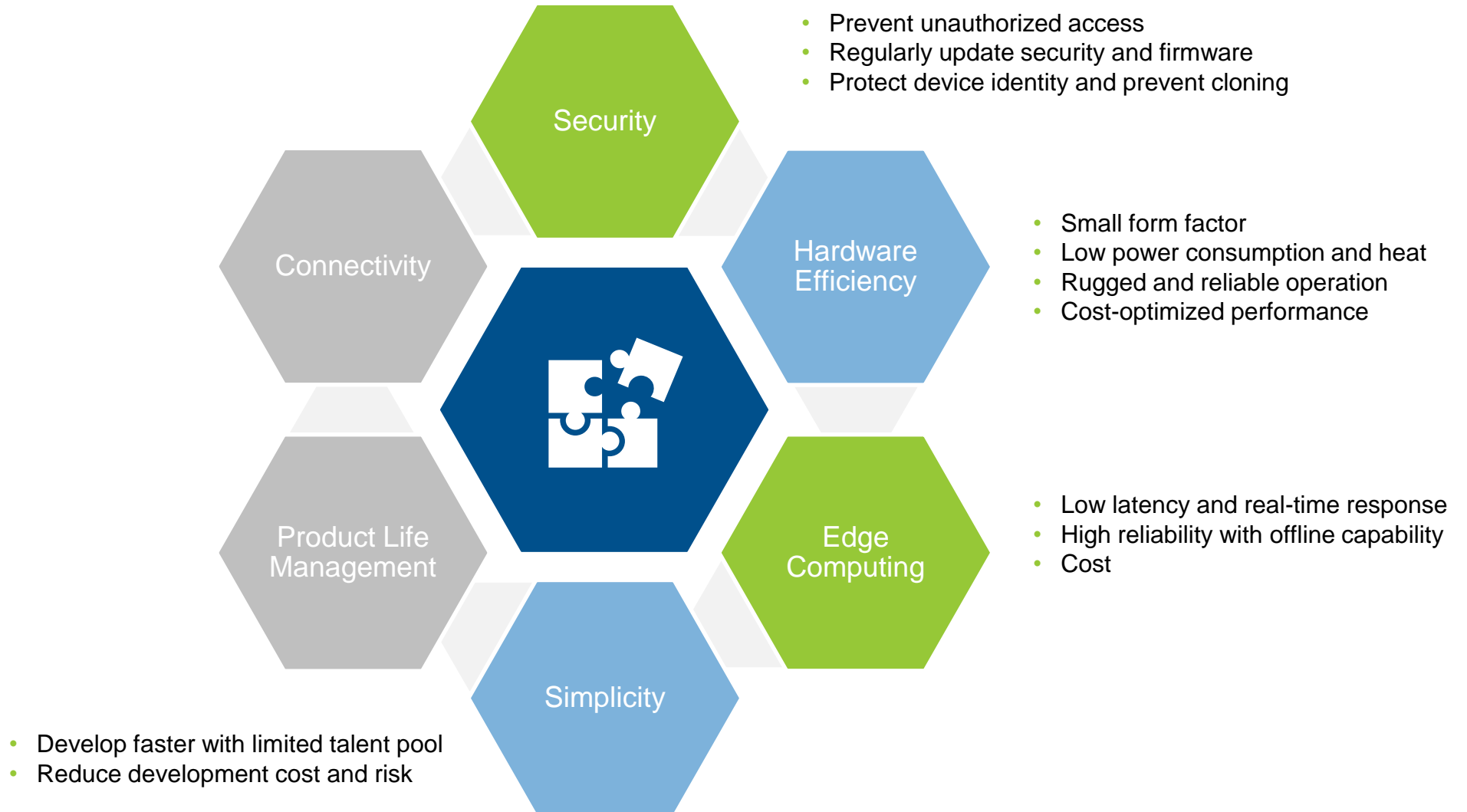
Typical Requirements for IoT Devices



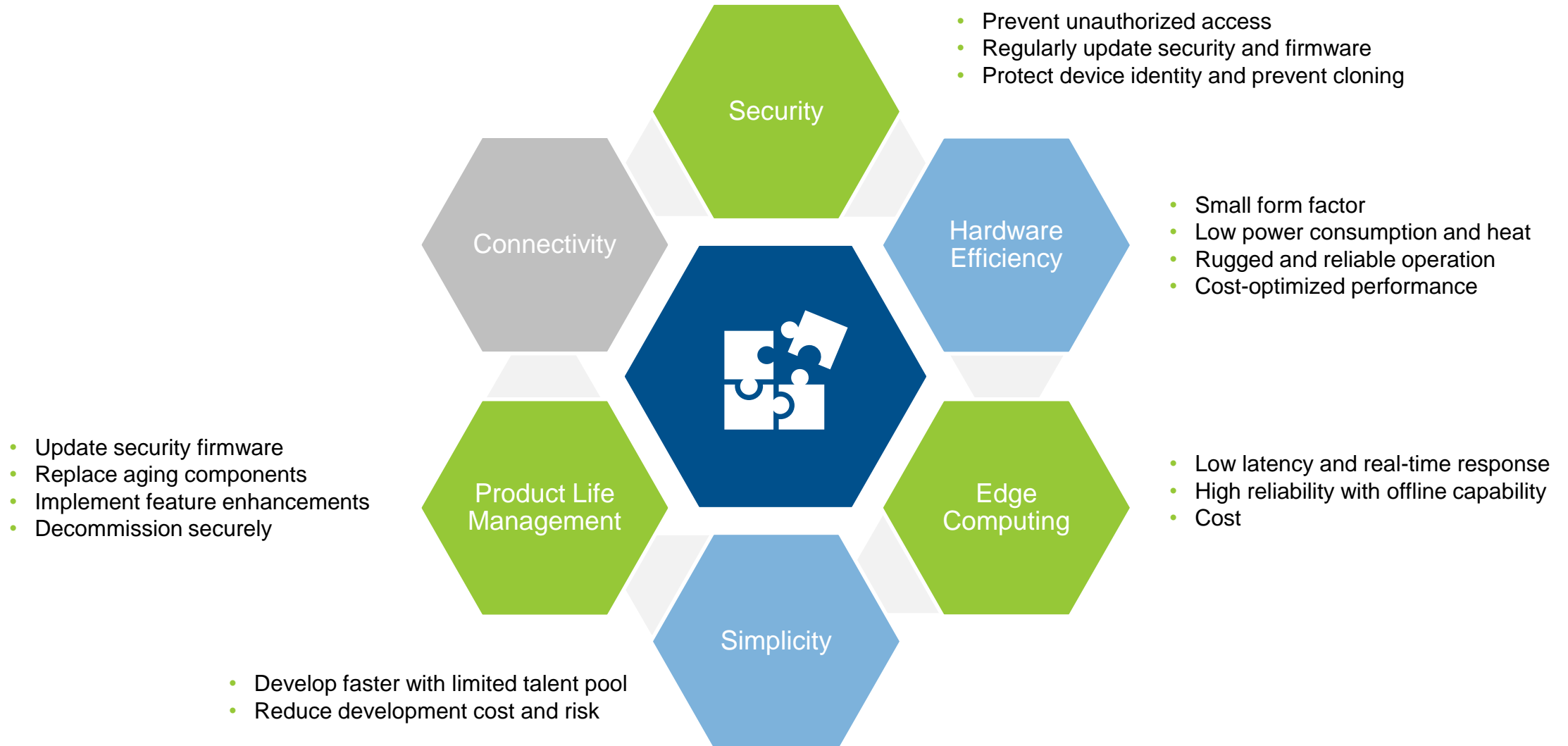
Typical Requirements for IoT Devices



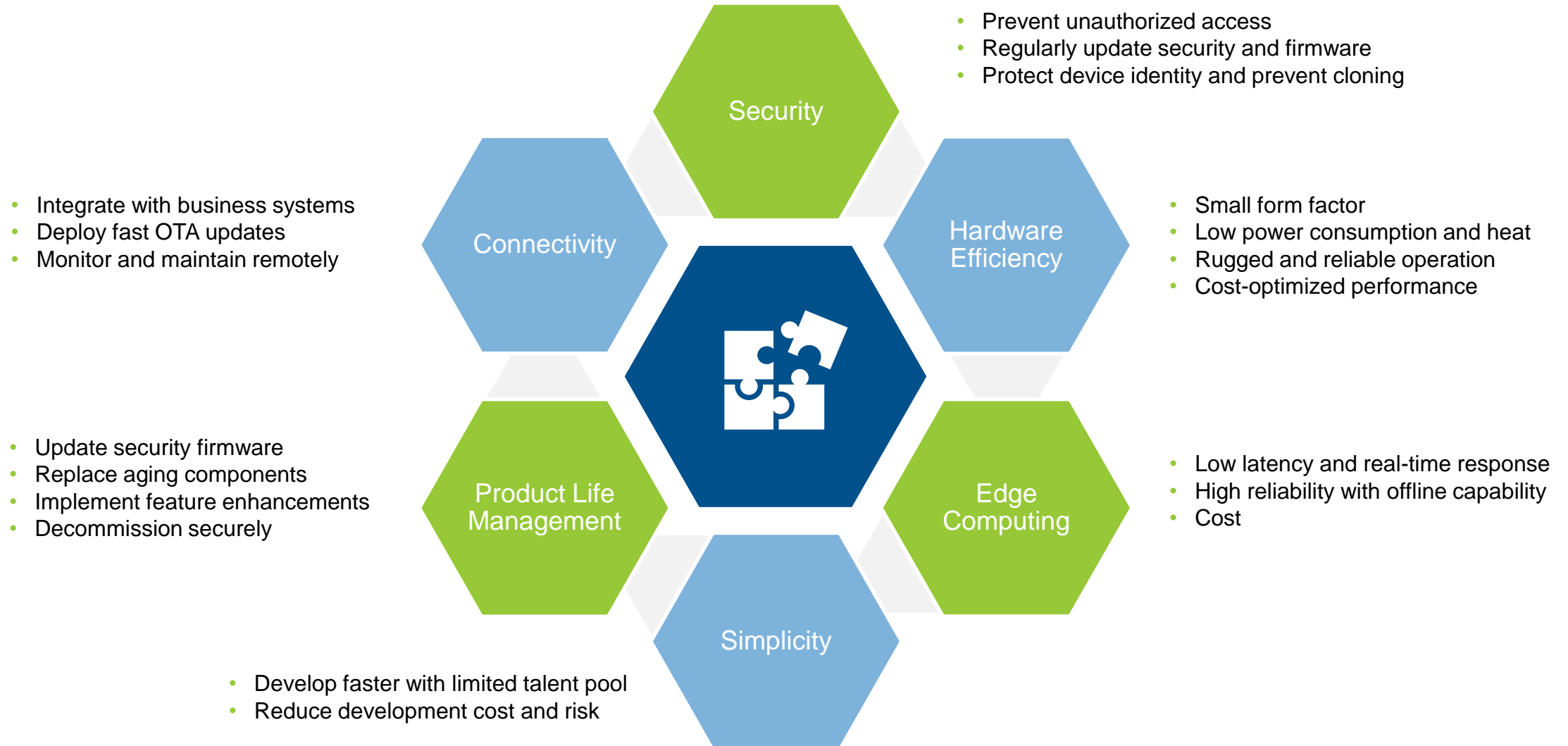
Typical Requirements for IoT Devices



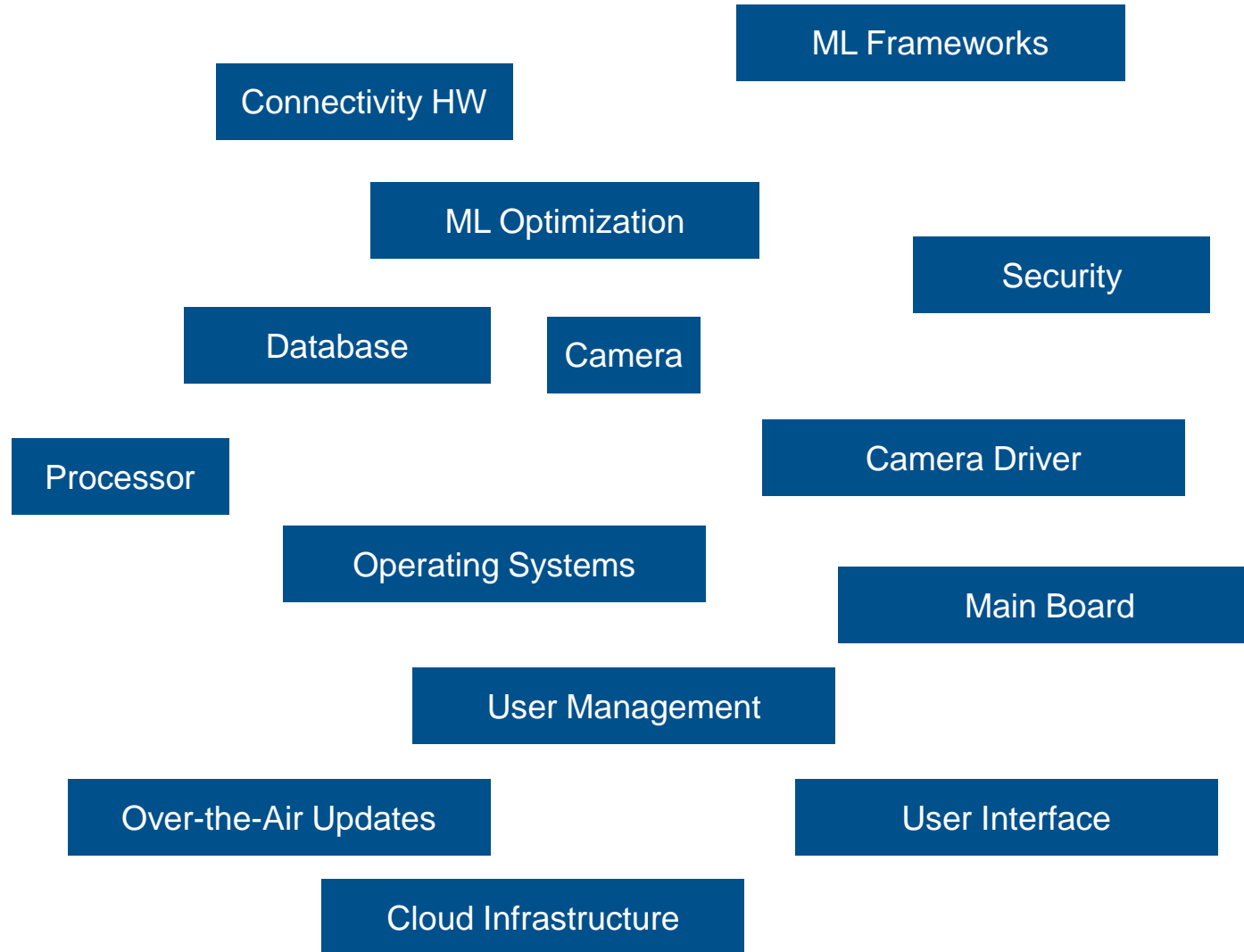
Typical Requirements for IoT Devices



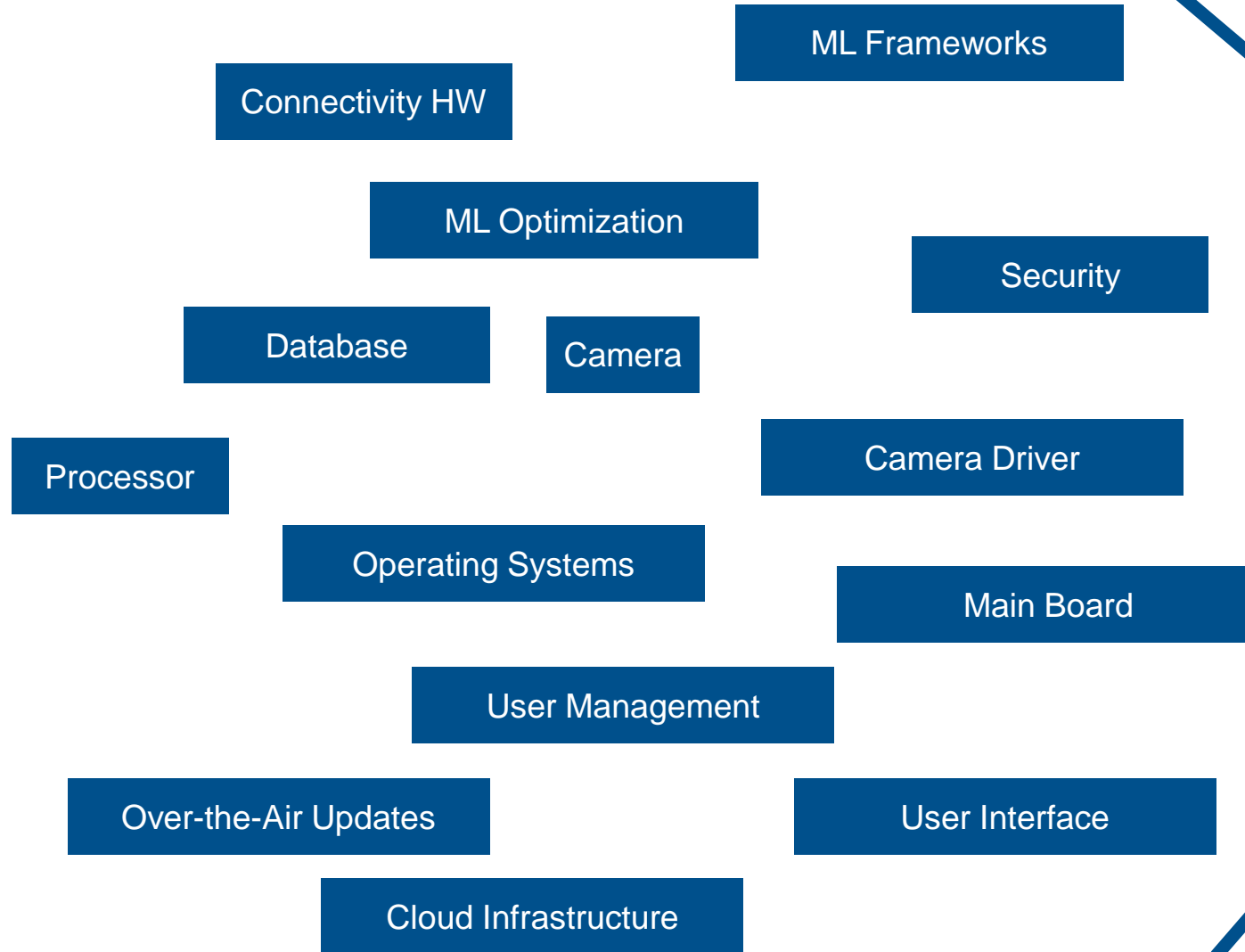
Typical Requirements for IoT Devices



All the Elements Exist



All the Elements Exist



Get Started in a Few Clicks

Apalis iMX8 AI Vision Reference Kit



Please click here to view additional kit contents ▾

✓ Industrial-grade SoM and Camera

✓ Large Software Ecosystem

✓ Long-term Availability



Apalis iMX8 QuadMax



Ixora Carrier Board



Alvium 1500 series camera

\$50
AWS
Credit

Buy Now

Key Technologies



AWS IoT Greengrass



Amazon SageMaker Neo



Torizon



Docker



Amazon Congnito



MQTT



AWS IoT Core

<https://www.toradex.com/imx8-embedded-vision-starter-kit>

Demo



TYPICAL TECHNICAL WORKFLOW

Poll: What is your field of expertise? (Multiple Choice)

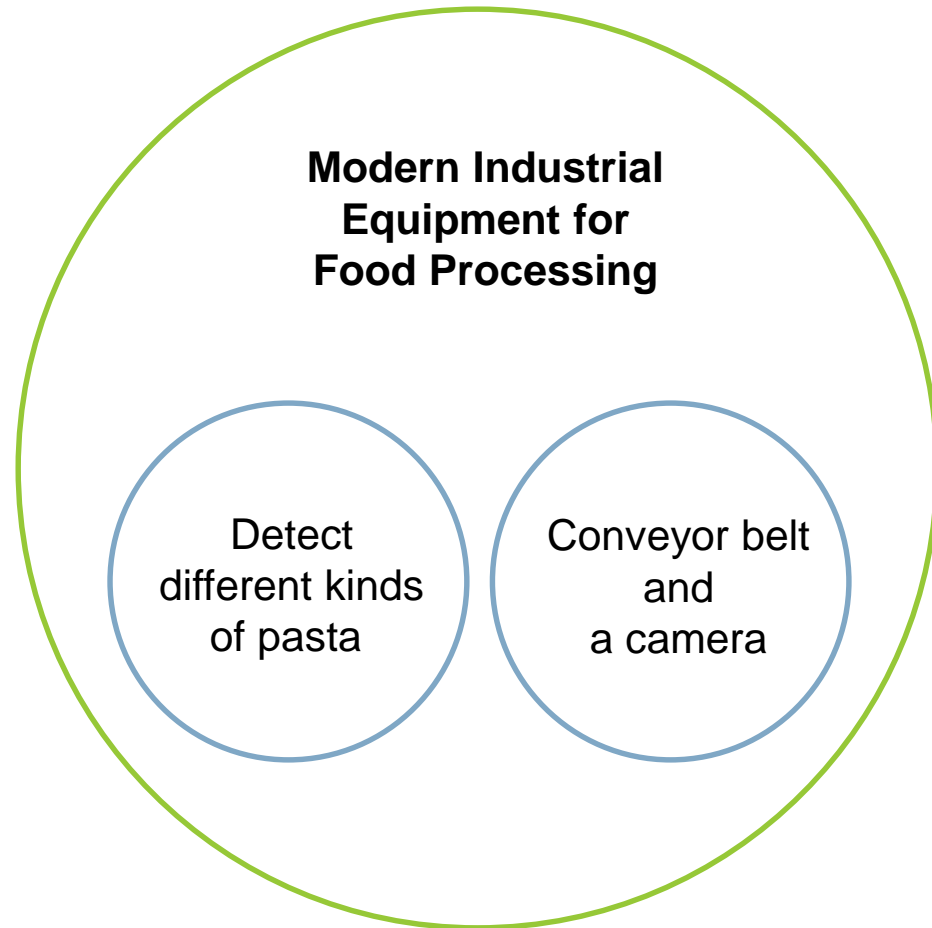
- Hardware Development
- Embedded Software Development
- Cloud Application Development
- Machine Learning



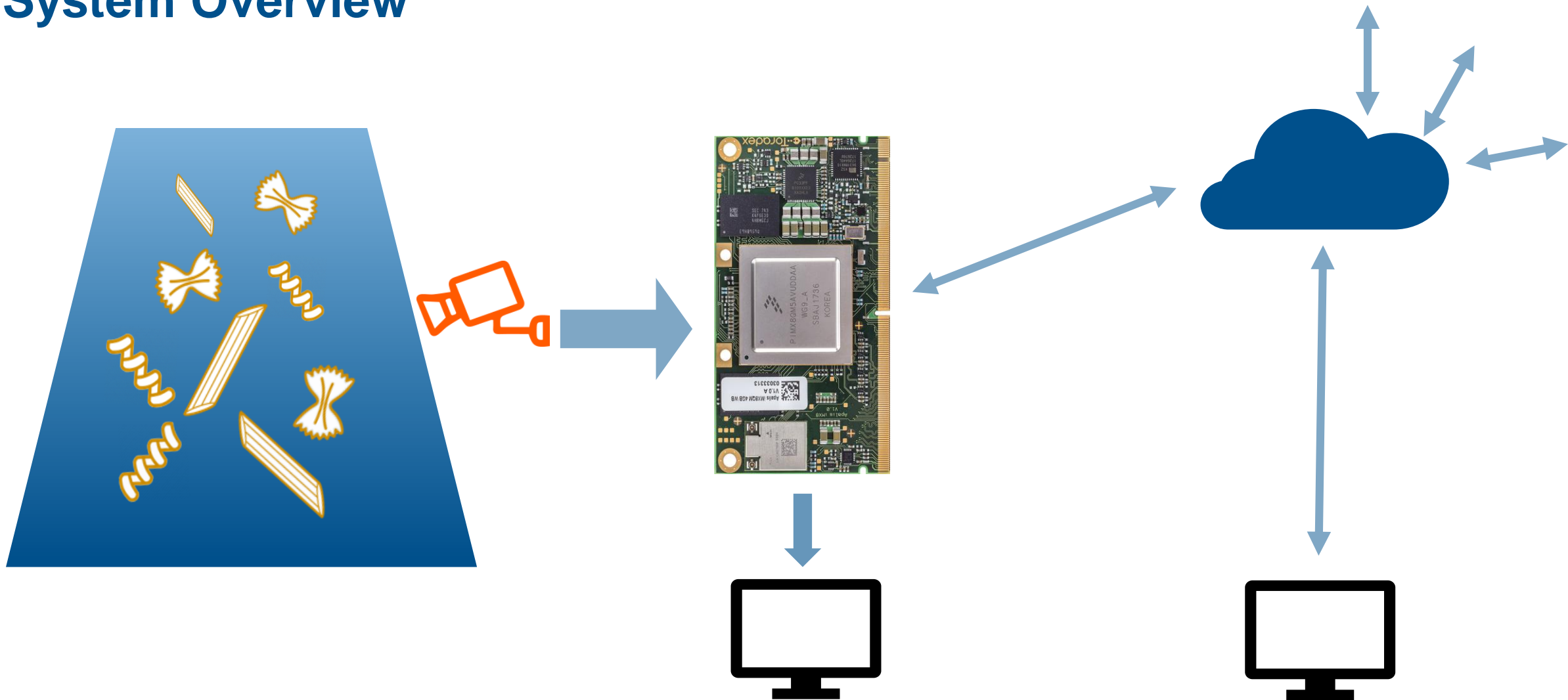
Tasks to create a production-ready connected device with computer vision and machine learning

- Define the problem to solve, e.g. recognize pasta
- Define architecture, build the proof-of-concept
- Collect training data (best to collect via production setup)
- Train the model
- Optimize, deploy and run the model at the edge device
- Build the hardware
- Integrate all peripherals such as cameras, motor controllers,... (HW/SW)
- Develop cloud backend
- Implement secure user management
- Design user interfaces

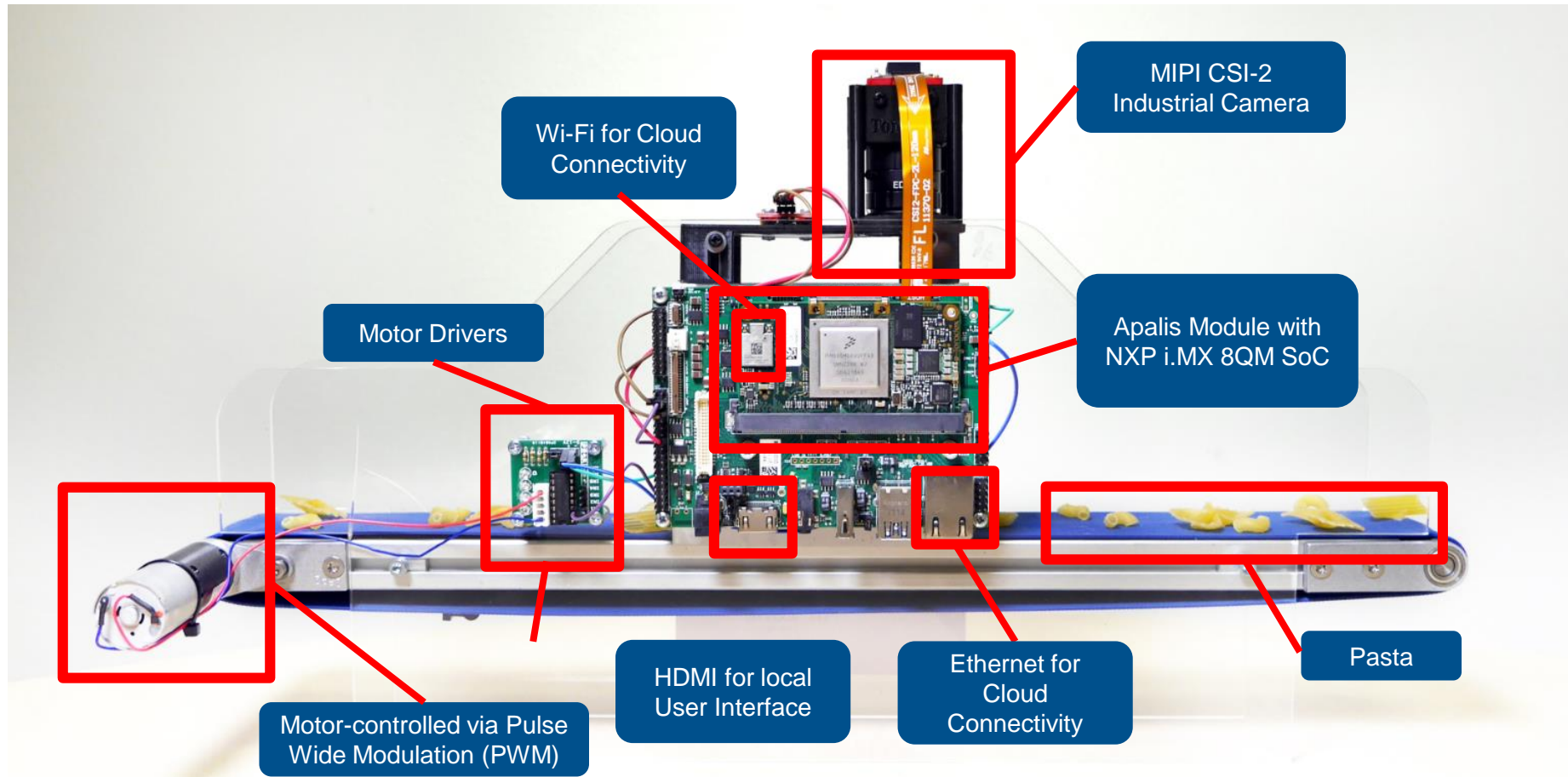
Define the Problem



System Overview



Example Reference Kit Deployment



Allied Vision Alvium MIPI CSI-2 Camera

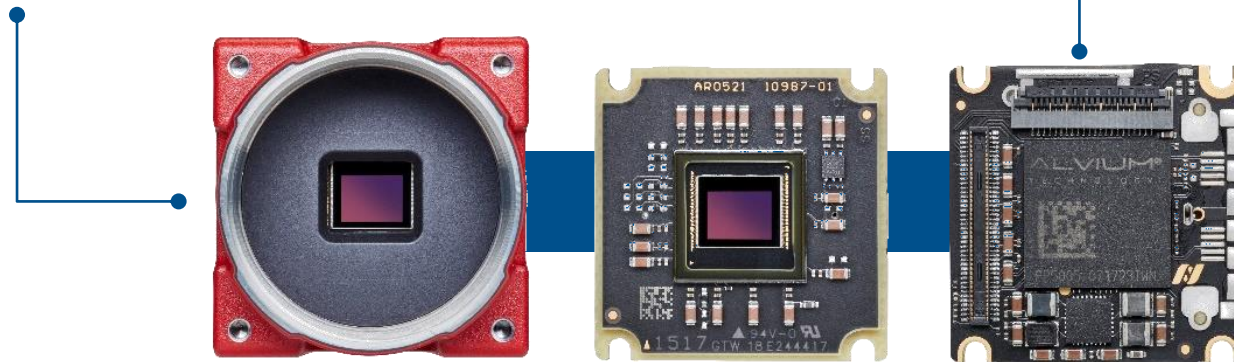


Industrial Grade

- Single Board PCB – high shock and vibration resistance
- High precision lens mount alignment
- Long-term availability

Flexibility

- Large variety of sensors up to 1.1"
- Unified interface – integrate one, integrate all
- Various housing and mounting options



ISP integrated

- Same functionality regardless of sensor
- Powerful features (e.g. 5x5 demosaicing)
- High image quality

Resource friendly

- Low overhead CSI-2 interface
- Integrated ISP – use board performance elsewhere
- Open source driver

Allied Vision Alvium MIPI CSI-2 Camera



Alvium 1500 C-500c camera

Camera Model	1500 C-500c
Sensor	ON Semi AR0521 color
Resolution [MP]	5.0
Pixels	2592x1944
Pixel Size [μm]	2.20
Optical Format	1/2.5"
Shutter Type	Rolling
Max. Frame Rate	67
Interface	MIPI CSI-2 D-PHY with 1,2 or 4 lanes and 1.5GBit/s per lane
Lens Mount	S- / M12-mount
Included Lens	Allied Vision S-mount, 4.1mm, f/3.0, integrated IR cut filter



Alvium Cameras are scalable, several pin compatible cameras are available

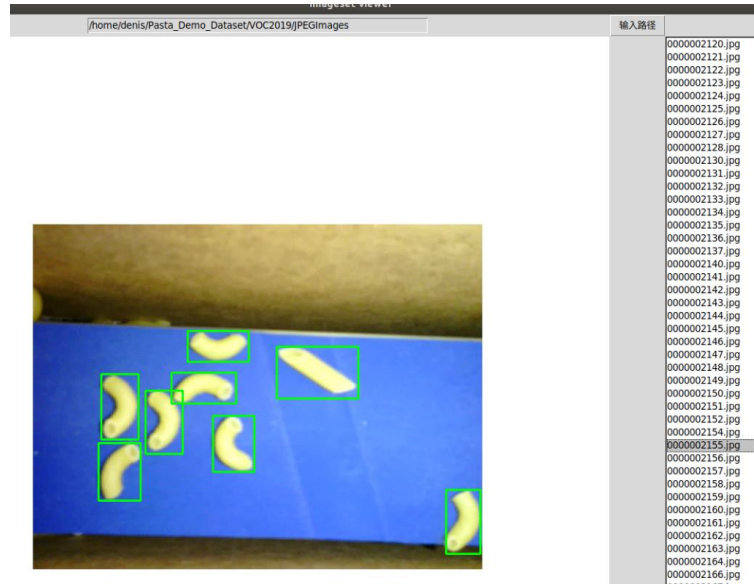
Collect Training Data and Train the Model

Collect Training Data

- 3000 tagged pictures
- 5 classes
- Ideally use final camera setup

Train Model

- MobileNet SSD
- Input Size 224x224
- GluonCV for MXNet (alternative TensorFlow)
- Train in Cloud or on a PC



Documentation

<https://developer.toradex.com/knowledge-base/train-ssd-for-imx8-boards>

Challenges for Machine Learning at the Edge

Development is done on powerful machines
(Cloud or X86 PCs with GPUs)

Focus on simple development not performance

Tooling focusing on Cloud use cases

Developers/Data Scientists not familiar with embedded hardware

Embedded hardware is fragmented and very heterogeneous

Models are optimized for accuracy not performance

Challenges for Machine Learning at the Edge

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(Cloud or X86 PCs with GPUs)

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This leads to sub optimal solutions at the Device Edge

- Edge devices are powerful systems with high cost and thermal footprint
- Maker devices are used due to good documentation, however issues occur with reliability and maintenance

Amazon SageMaker helps you build, train, and deploy models

Prepare

Build

Train & Tune

Deploy & Manage

Web-based IDE for machine learning

Automatically build and train models

Fully managed data processing jobs and data labeling workflows

```
101011010
010101010
000011110
```

Collect and prepare training data

One-click collaborative notebooks and built-in, high performance algorithms and models



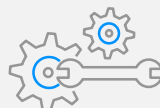
Choose or build an ML algorithm

One-click training



Set up and manage environments for training

Debugging and optimization



Train, debug, and tune models

Visually track and compare experiments



Manage training runs

One-click deployment and autoscaling



Deploy model in production

Automatically spot concept drift



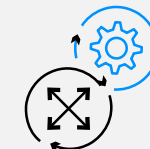
Monitor models

Add human review of predictions



Validate predictions

Fully managed with auto-scaling for 75% less



Scale and manage the production environment

Leverage Amazon SageMaker Neo to Optimize the Inference Model for Target Hardware

Train once deploy anywhere with broad hardware support

Developers can train ML models in the cloud and deploy them in the cloud and at the edge

Optimize the inference to run on the i.MX 8QuadMax Applications Processor

Neo leverages the capabilities of the i.MX 8QuadMax for faster performance and lower power

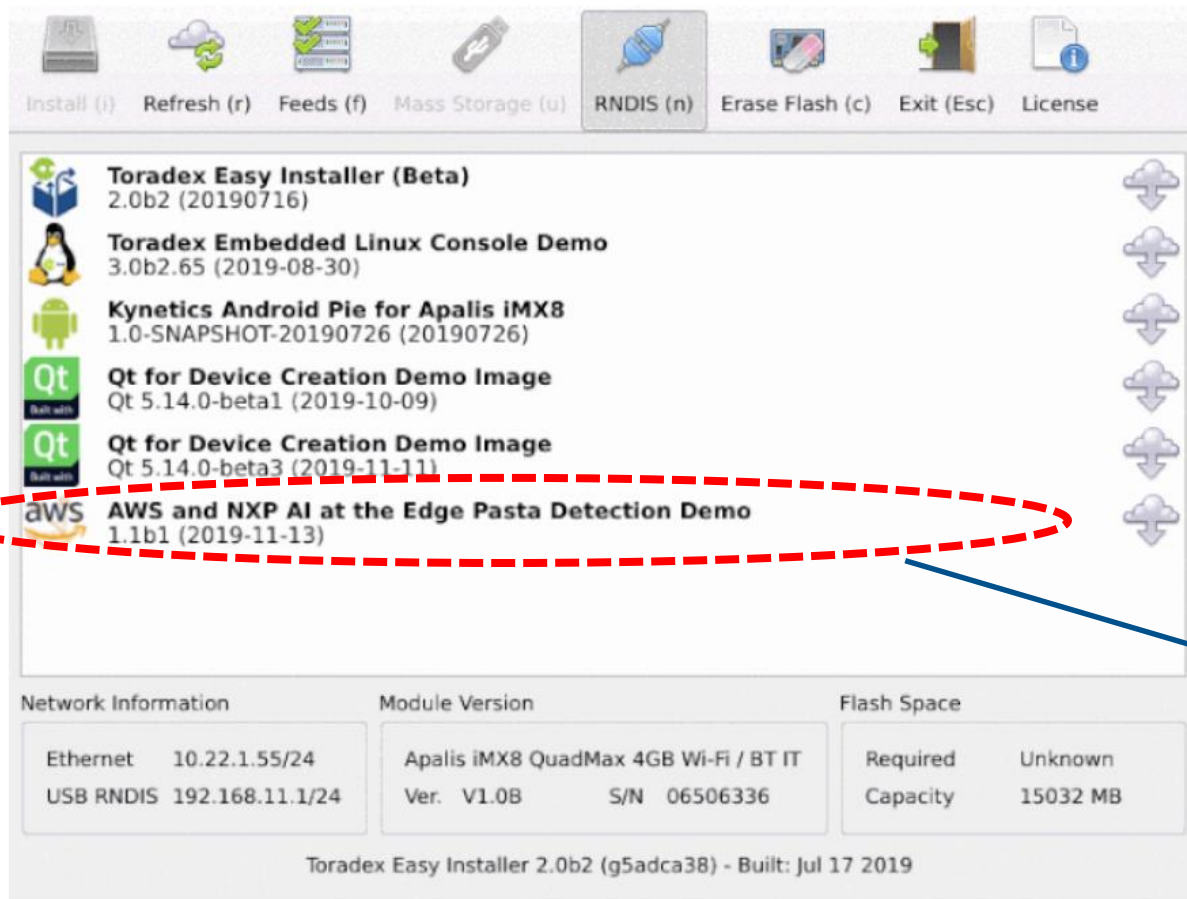
Flexible ML Framework

Start with ML models built using MXNet, TensorFlow, PyTorch or XGBoost



Open-source Neo-AI device runtime and compiler
1/10th the size of original frameworks

One Click Installation of the Image onto Apalis with i.MX 8QuadMax

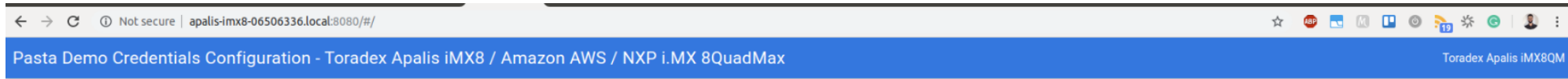


Toradex Easy Installer



Single Click install of OS image

One Click Installation of the Cloud Formation Template From Edge → Cloud



Option A - Enter AWS Credentials

IoT Core Group Name
pasta_demo_cfn

Access key ID

Secret access key

RUN CLOUDFORMATION

0.00%

Option B - Bundle File Upload

Upload <hash>.tar.gz Bundle File
0.0 B / 0.00%

APPLY CREDENTIALS

Option C - Single Files Upload

Upload config.json File
0.0 B / 0.00%

Upload <hash>.cert.pem File
0.0 B / 0.00%

Upload <hash>.private.key File
0.0 B / 0.00%

APPLY CREDENTIALS

Tool Options

DISABLE THIS UI FOREVER

Single Click install of Cloud formation template into customer AWS account

Device Operating System



Easy-to-use Industrial Linux



Fast time-to-market
Ready-to-use
Linux distribution



Simple updates
Built-in, automotive-grade,
over-the-air update capabilities



Secure
Frequent updates, accessible
security features



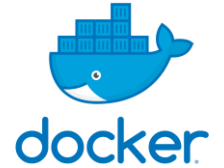
Real-time
Optimized real-time
option



Stable
Modern continuous integration
infrastructure and verification

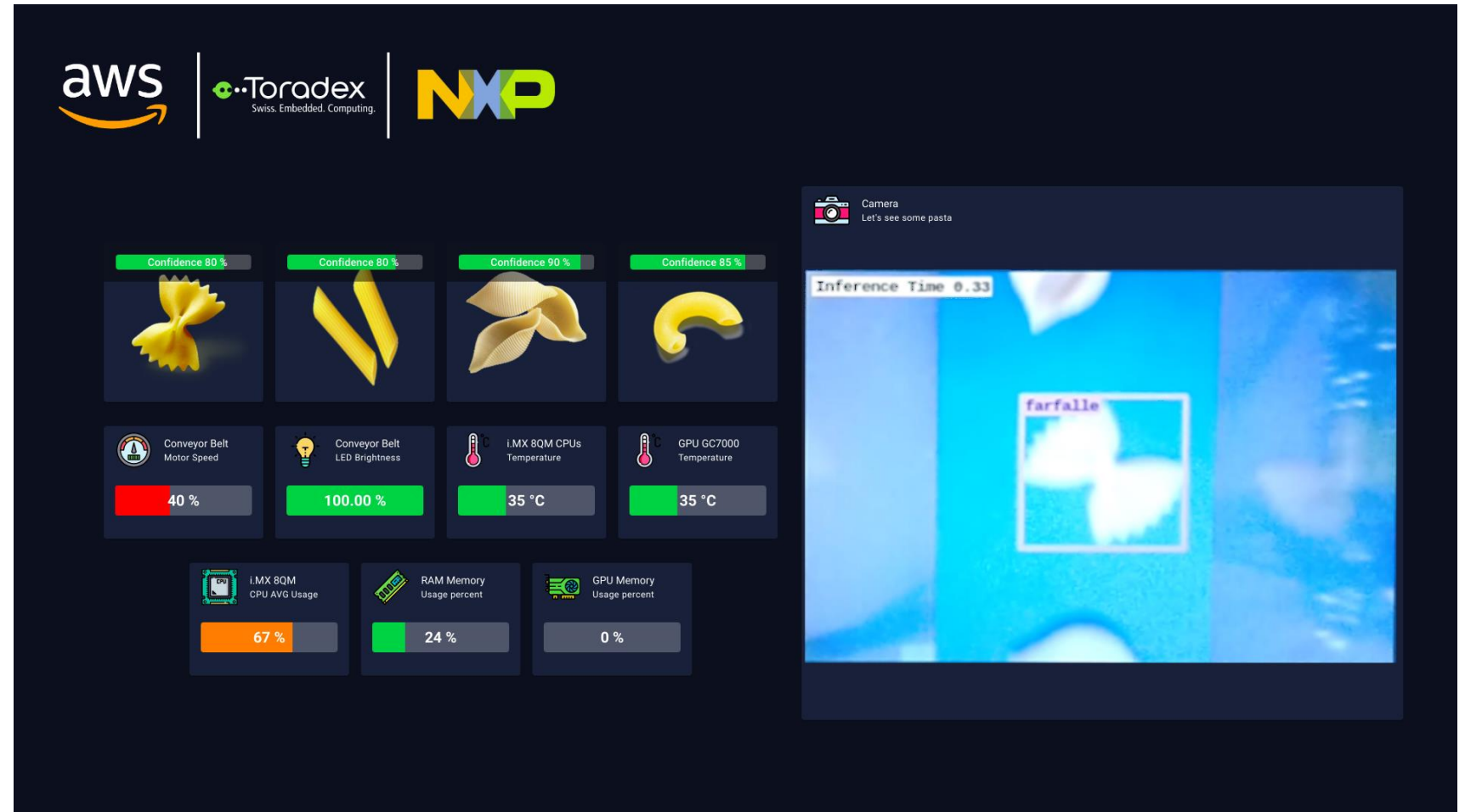


Open Source
Based on open projects
No lock-in



On-Device User Interface

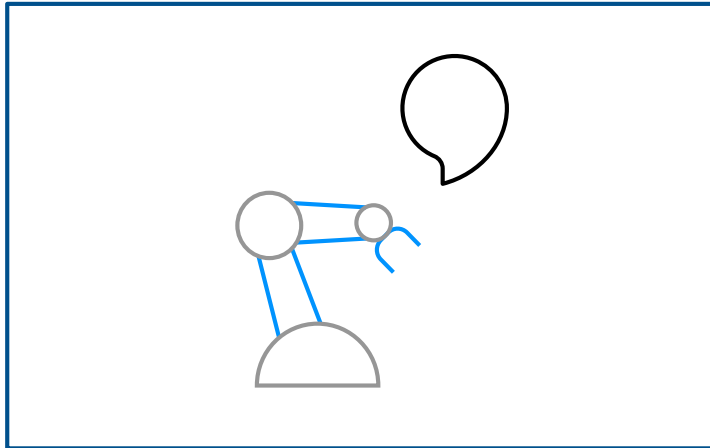
- GStreamer
- JavaScript
- Vue.js
- Electron



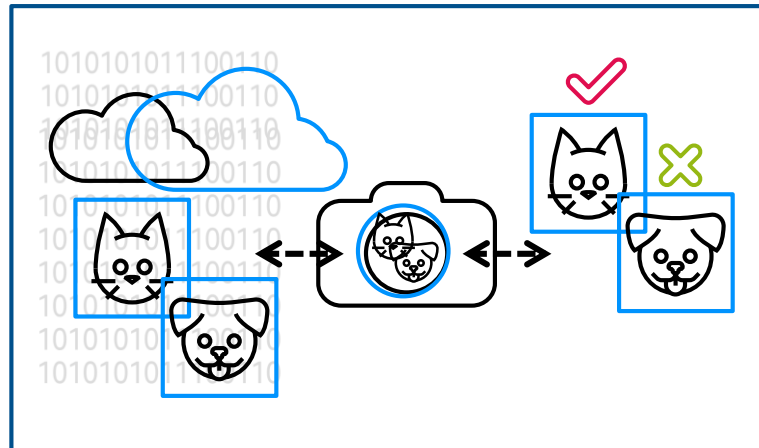


AWS IoT Greengrass

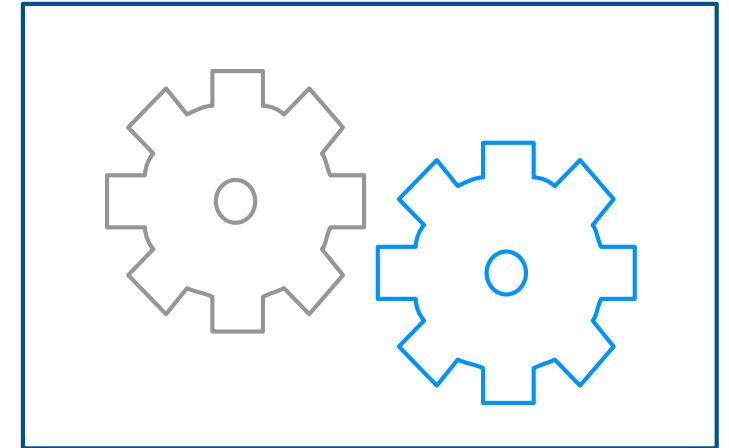
AWS IoT Greengrass extends AWS services onto your devices, so that they can act locally on the data they generate, while still taking advantage of the cloud.



Local Actions & Remote Control



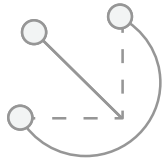
Machine Learning Inference



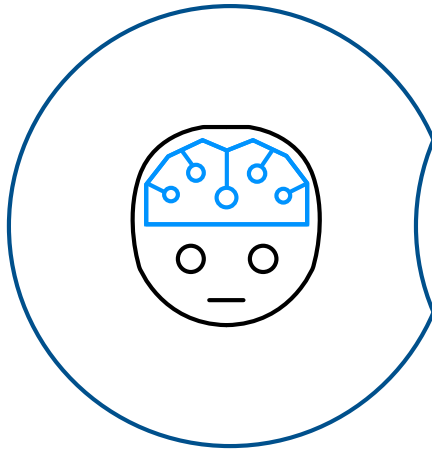
Extract, Aggregate, Load



Device software

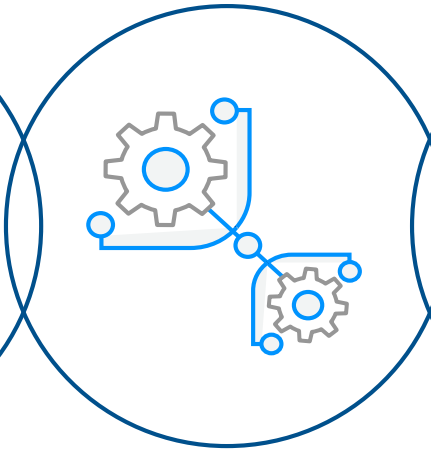


AWS IoT Greengrass Enhanced Capabilities



ML Inference

Perform ML Inference locally



Connectors

Extend edge devices with connections to external services



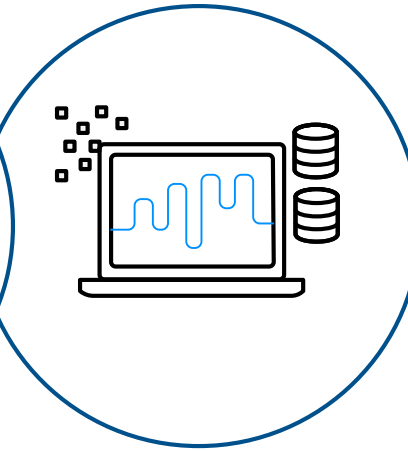
Secrets Manager

Deploy secrets to edge devices



Container Support

Use AWS Lambda, Docker, or a combination of both



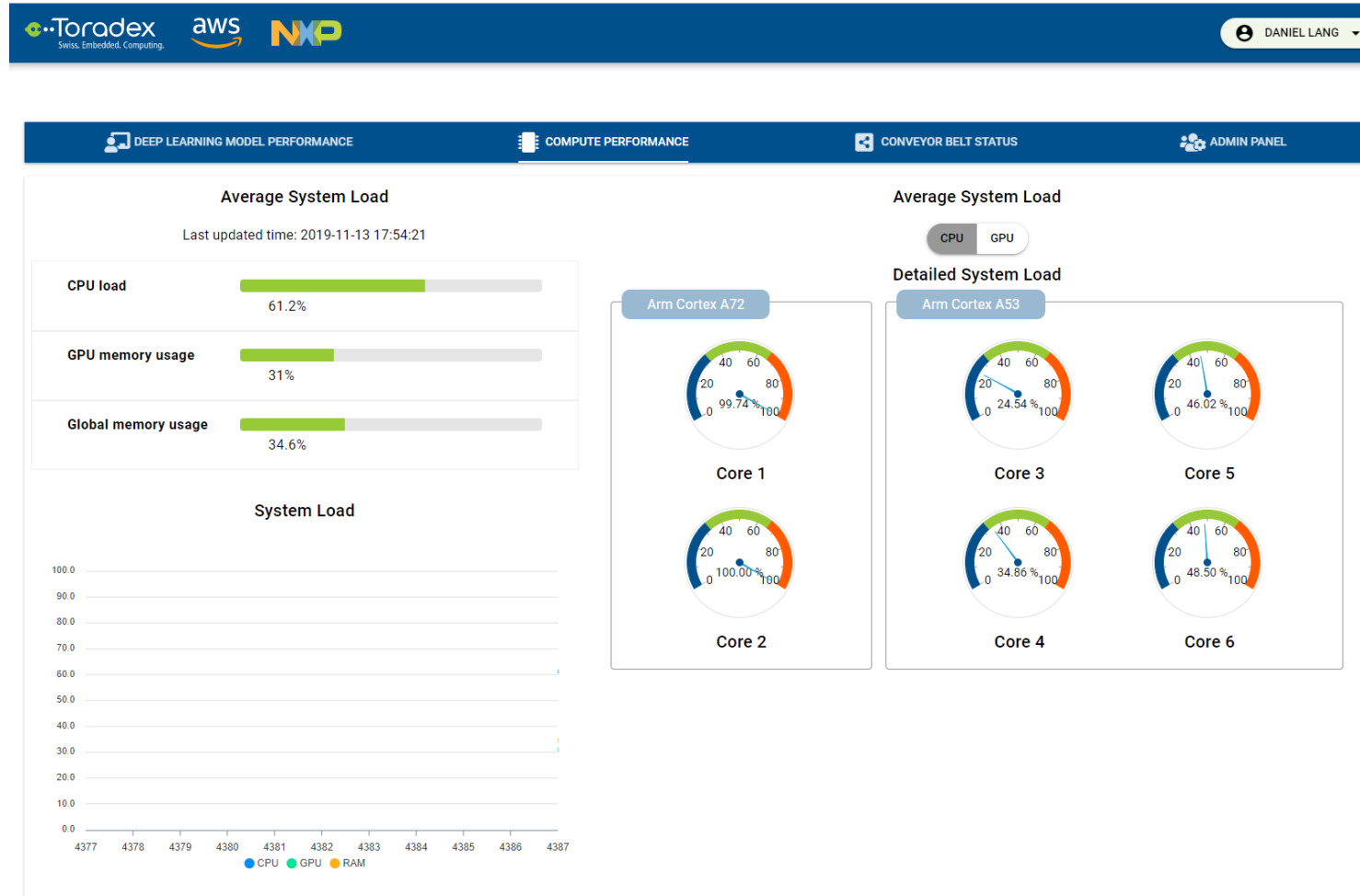
Stream Manager

Collect, process, & export high-volume data streams from edge devices



Device software

Cloud Web UI – Conveyor Belt Dashboard and Live MQTT View



Cloud Web UI – Conveyor Belt Dashboard and Live MQTT View

Select Board
Board-6494595

Conveyor Belt Status

RESET

DEEP LEARNING MODEL PERFORMANCE COMPUTE PERFORMANCE **CONVEYOR BELT STATUS** CONFIGURATIONS

Confidence

Counter pasta/min

Speed r/min

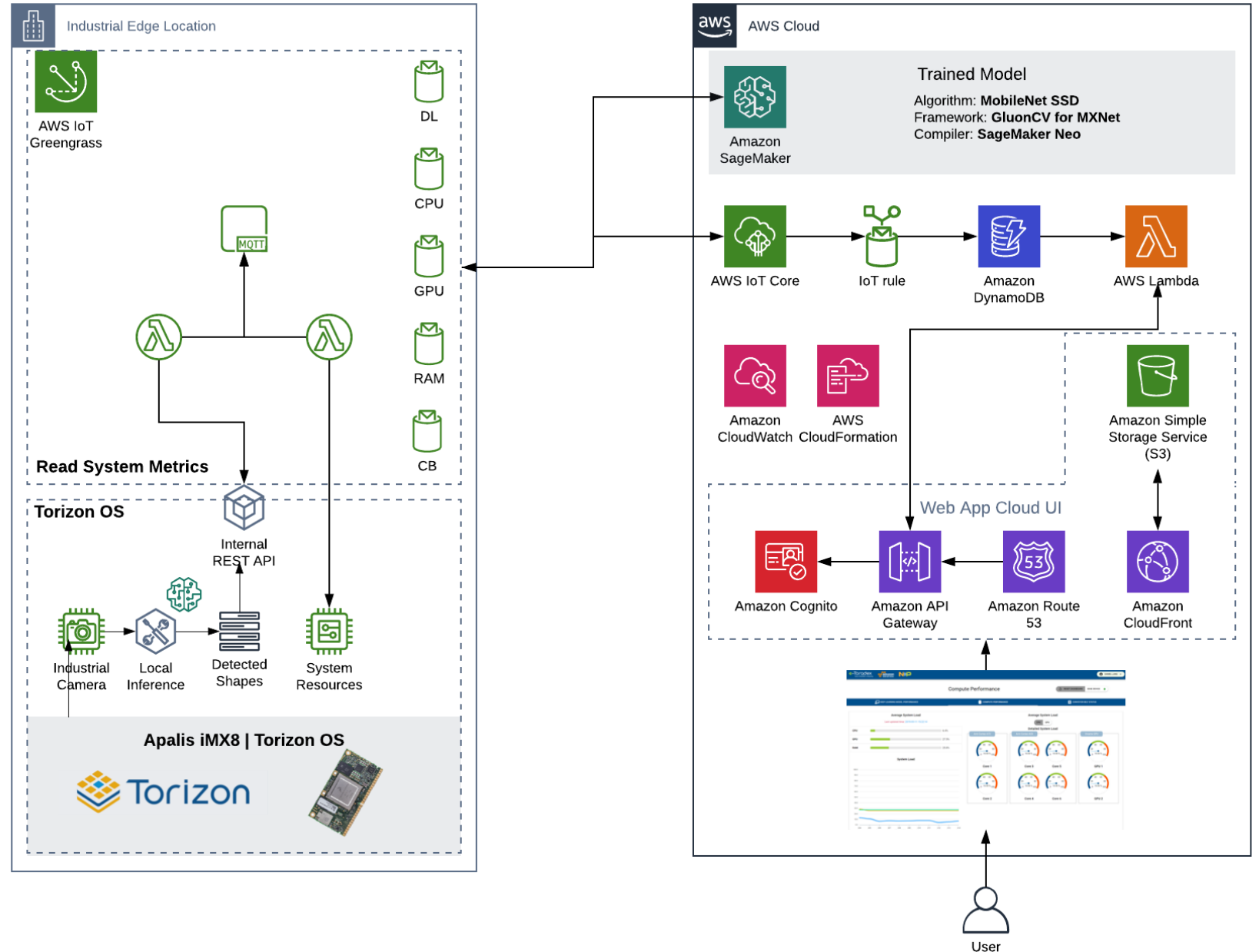
Conveyor Belt Speed Controller

Conveyer Belt Status and Statistics

Data Logger

```
{
  "confidence": 0,
  "sk": "last-6494595",
  "pk": "inference-elbow",
  "last-updated-time": "2020-01-10 23:29:44",
  "pasta-count": 0
}
{
  "confidence": 0,
  "sk": "last-6494595",
  "pk": "inference-farfalle",
  "last-updated-time": "2020-01-10 23:29:44",
  "pasta-count": 0
}
{
  "confidence": 0,
  "sk": "last-6494595",
  "pk": "inference-penne",
  "last-updated-time": "2020-01-10 23:29:44",
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}
{
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}
```

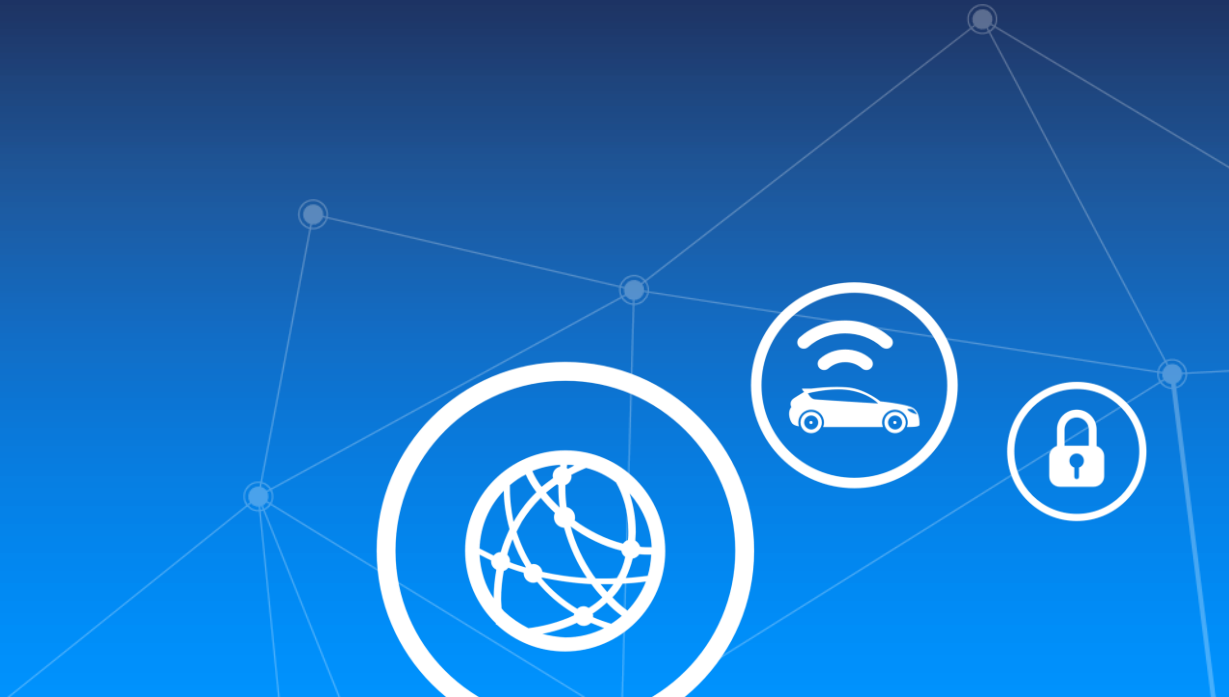
Detailed Architecture



NXP

www.nxp.com

February 2020



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FOR A SMARTER WORLD

PUBLIC



NXP and Our Partners Together Serve 26,000+ Customers

Employees in
30+ Countries

Headquartered in Eindhoven,
Netherlands

~30,000
Employees

9,000
Patent Families

\$8.88B
Annual Revenue¹

60+
Year History

~9,000
R&D Engineers

¹ Posted revenue for 2019 – Please refer to the Financial Information page of the Investor Relations section of our website at www.nxp.com/investor for additional information

Together With Our Valued Customers and Partners, We Are Creating Secure Connections for a Smarter World



Enhanced Security
Mesh Connectivity
Sensors
Smart LED Lighting
Gateway & Cyber Security
Access



Cloud Computing
Gateways
Routers & Switches
Security Appliances
Wireless Base Stations
Smartphones



Manufacturing Automation
Temperature Monitoring
Machine Diagnosis & Control
Remote Asset Control
Fleet Tracking



Distribution
Energy Consumption & Monitoring
Water Pressure Measurement



Car Entertainment
In-vehicle Networking
Car Access
Car2X and Radar



Smart Parking
Smart Roads
Traffic Congestion
Smart Lighting
Waste Management



e-passport
Smart eID
Health Card



Hospital & at-home Patient Monitoring
Fall Detection
Personal Health & Fitness Monitoring



Secure Bank Cards
Mobile Transactions
Loyalty- Reward
RFID Tags/Labels
Supply Chain Monitoring
NFC Readers



Smart Watch
Activity Tracking
Smart Glass



Contactless
Transport Card
Access Solutions
Micro-payments

NXP Supply Longevity

Industrial applications require product longevity

- Long product lifecycles
- Special product certification

NXP Industrial Application Processors

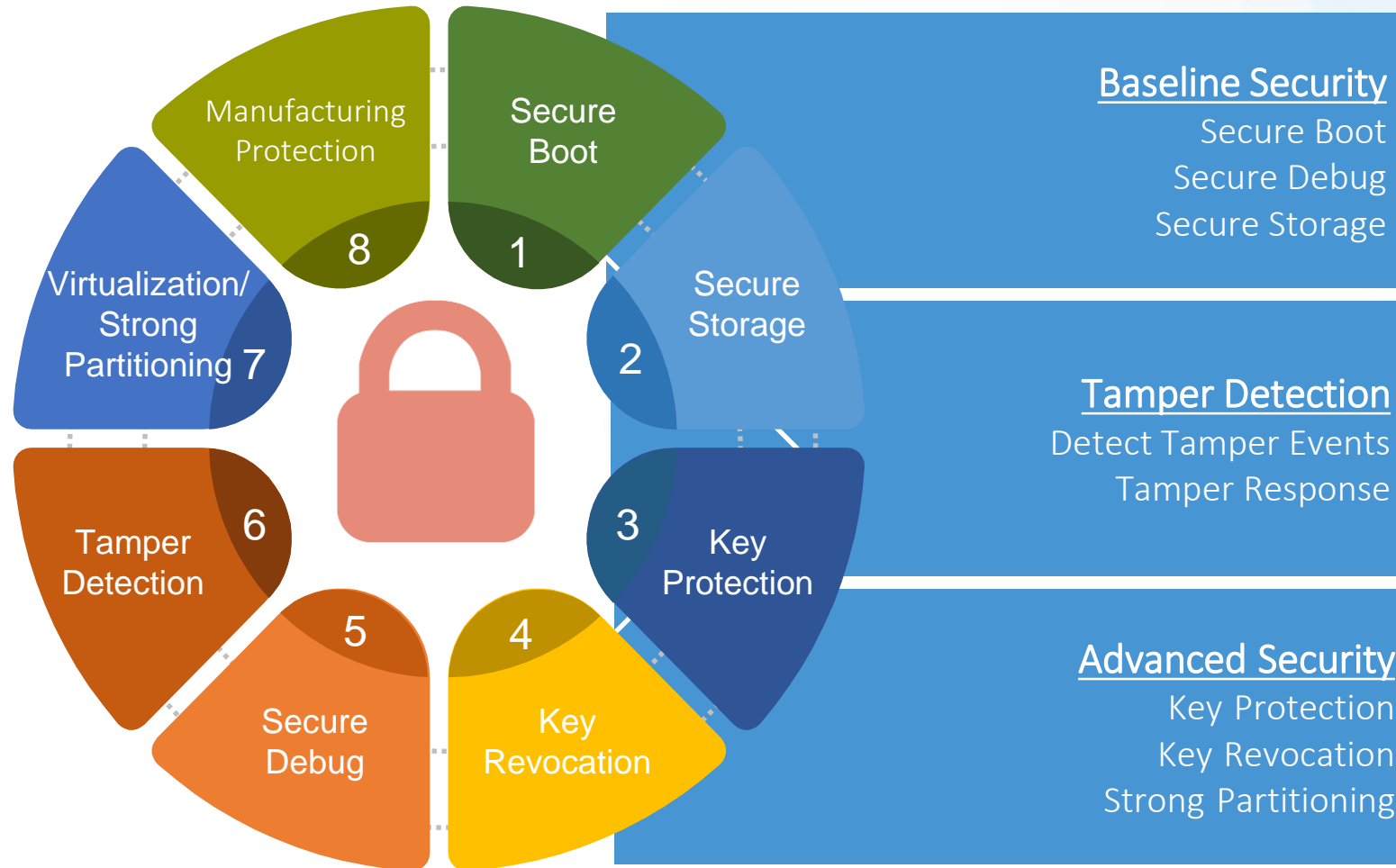
- 10 and 15 year supply longevity options
- Formal program with products listed at www.nxp.com/productlongevity



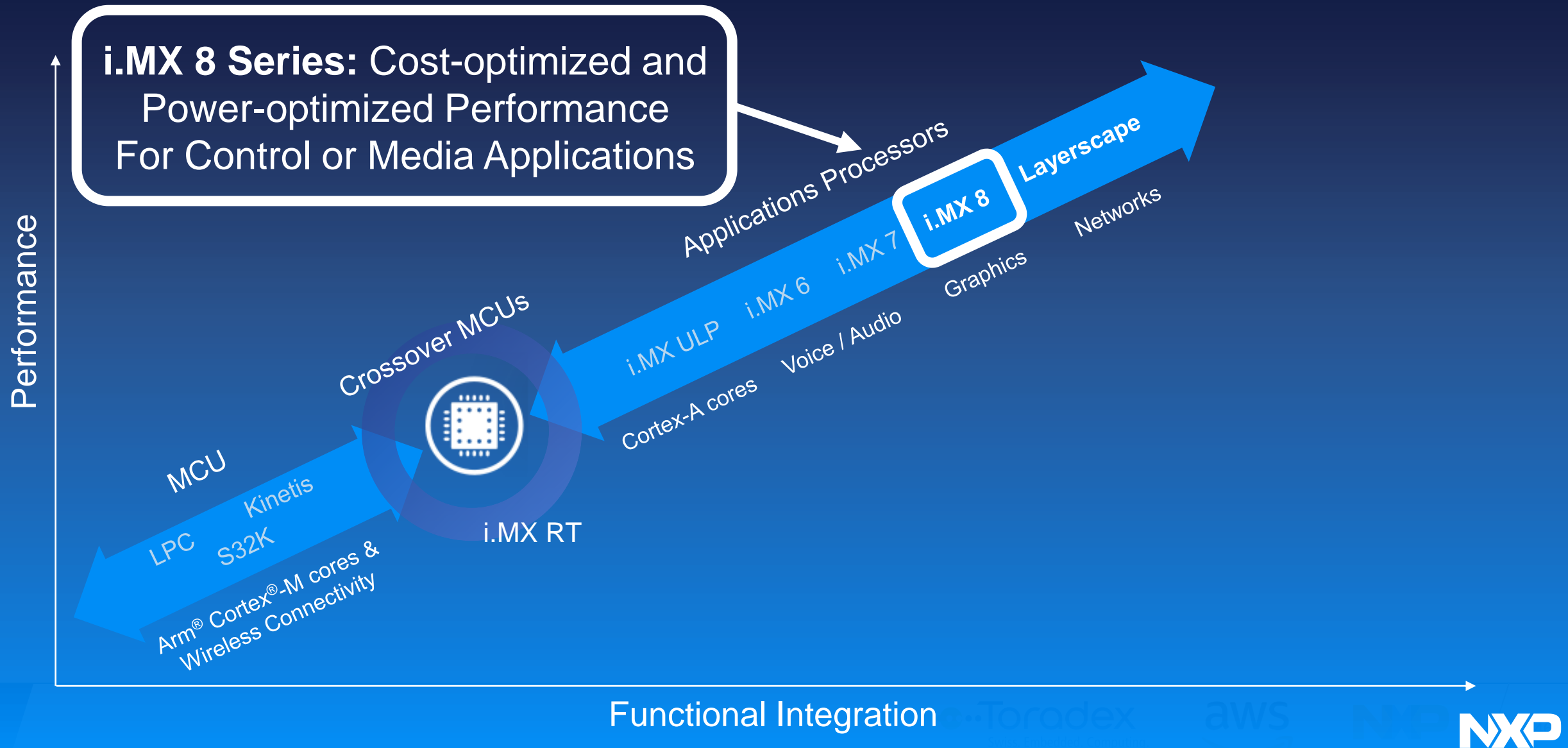
NXP Qualification Specifications

Qualification Level	Characteristics
Commercial or Consumer Highest MHz	5-year life, 50% on Typically: 0C to +85C Tj
Industrial Longest operating life	10-year life, 100% always on Typically: -40C to +105C Tj
Automotive Widest temperature range	15-year life, 10% on Typically: -40C to +125C Tj

NXP Applications Processor Comprehensive Security



NXP Scalable Arm® Processing Continuum

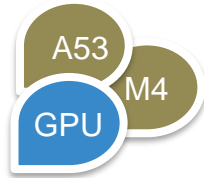


i.MX 8 Series for Consumer, Industrial & Automotive Applications

Advanced graphics, video, image processing, vision, audio and voice

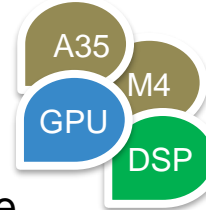
i.MX 8M Family

Advanced Computing,
Audio/Video & Voice



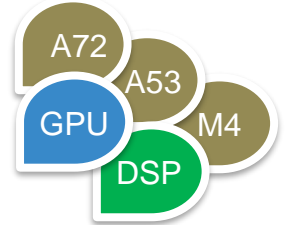
i.MX 8X Family

Safety Certifiable &
Efficient Performance



i.MX 8 Family

Advanced Graphics,
Vision & Performance



i.MX 8 Family (8QuadMax, 8QuadPlus)

In Production: www.nxp.com/imx8

Multiple Systems in One Processor

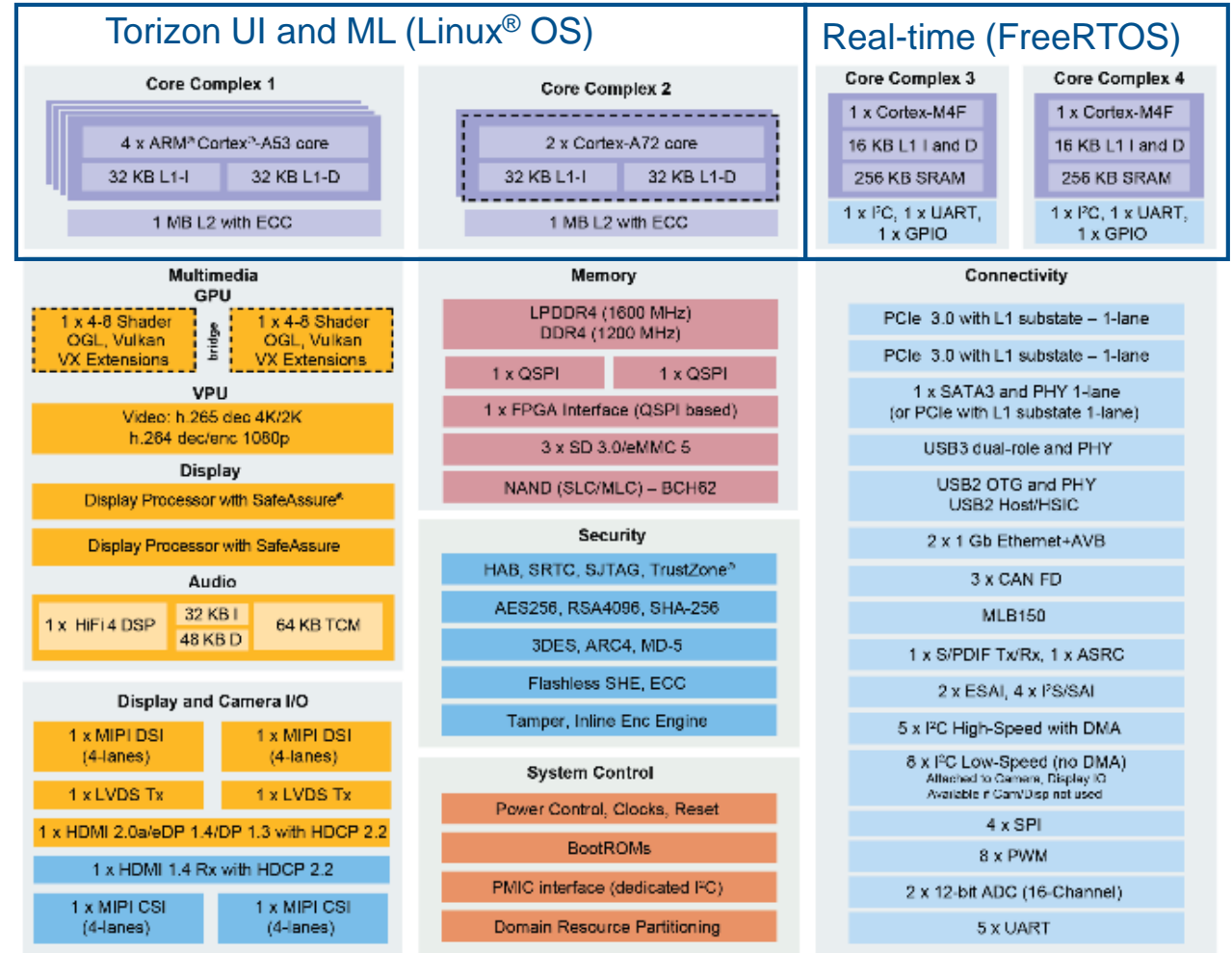
- Combine multiple systems into one
- Run-time system partitioning and isolation
- Advanced, programmable security

Multi-Display and Multi-Domain Functionality

- Up to four screens with independent content
- Split media architecture: Rich Graphics, faster deployment
- SafeAssure ASIL-B ready hardware
- Failover capable display and audio controller: Alive during reset or OTA updates

Enabling the New World of Machine Interfaces

- Advanced vision-based HMI systems (gesture, object): Local and cloud
- Multi-camera support and image stitching
- Multi-domain voice-recognition and audio processing

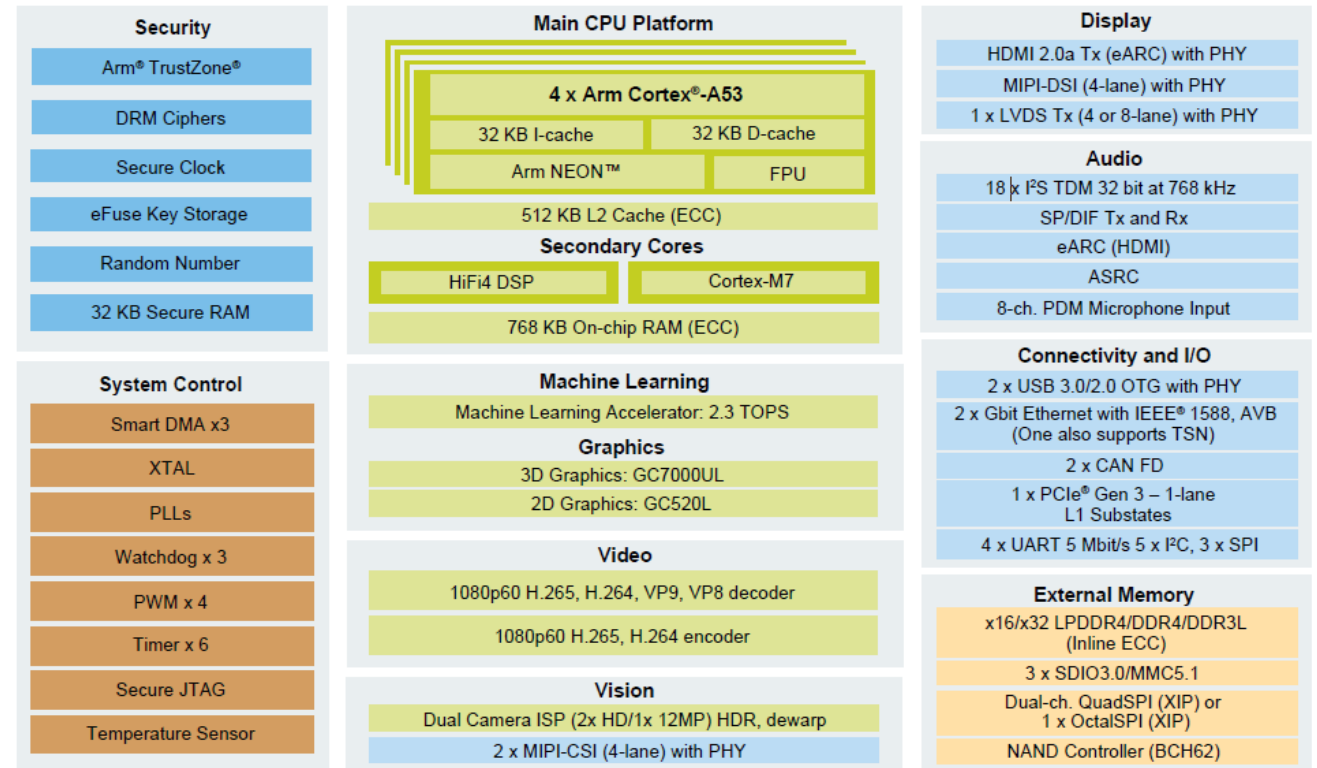


i.MX 8M Plus Family

Sampling: www.nxp.com/imx8MPlus

Highest performing i.MX 8M processor to date

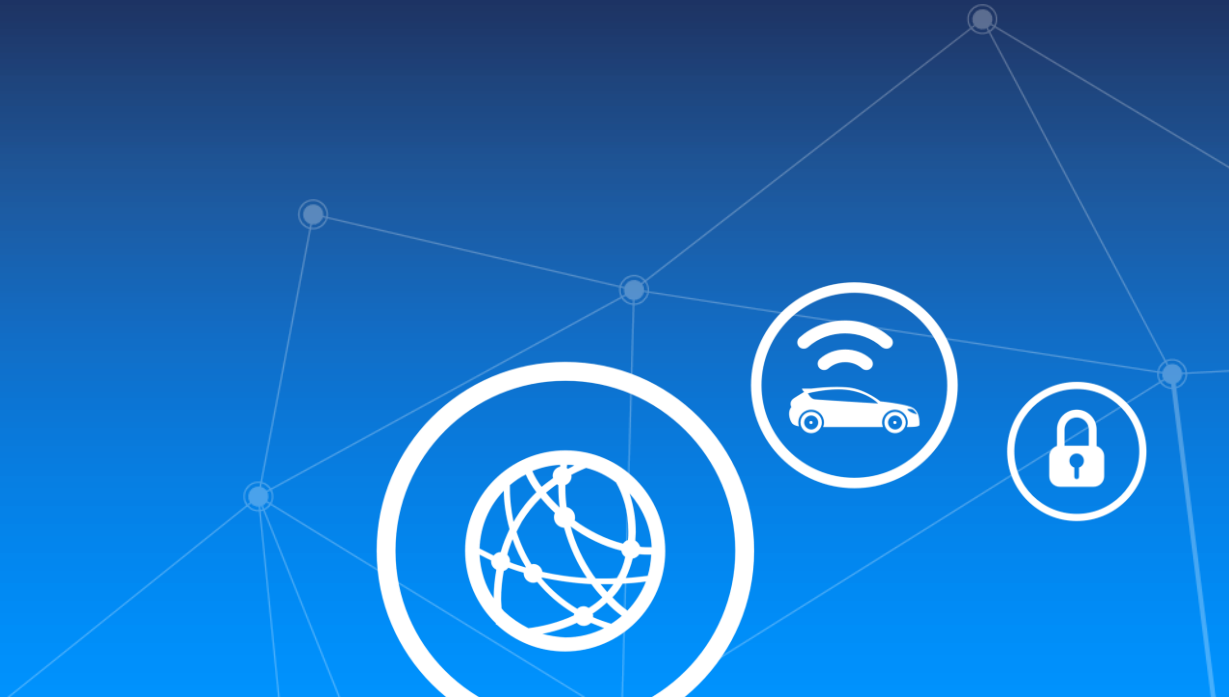
- **First NXP ML accelerator – 2.3 TOPS**
- 4x Arm Cortex-A53 @ 1.8 GHz
- 1x Cortex-M7 @ 800 MHz **for real-time functions**
- LPDDR4/DDR4 with **Inline Error Correcting Code**
- **Attach two cameras**
 - 2x MIPI-CSI (4 lanes) with ISP 12MP (2 streams)
- **Attach three simultaneous displays**
 - 1x HDMI 2.0a Tx (eARC) with PHY
 - 1x LVDS Tx (4 or 8-lane) with PHY
 - 1x MIPI-DSI (4-lane) with PHY
- Video decode **AND encode 1080p60 H.265**
- 2x GbE Controller; 2x CAN-FD Controller
- 15x15mm FCBGA



AWS

<https://www.AWS.com>

January 2020



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AWS IoT architecture fundamentals



Analytics
Services

How can I make sense of my IoT data and take actions to solve business problems?



Connectivity
& Control
Services

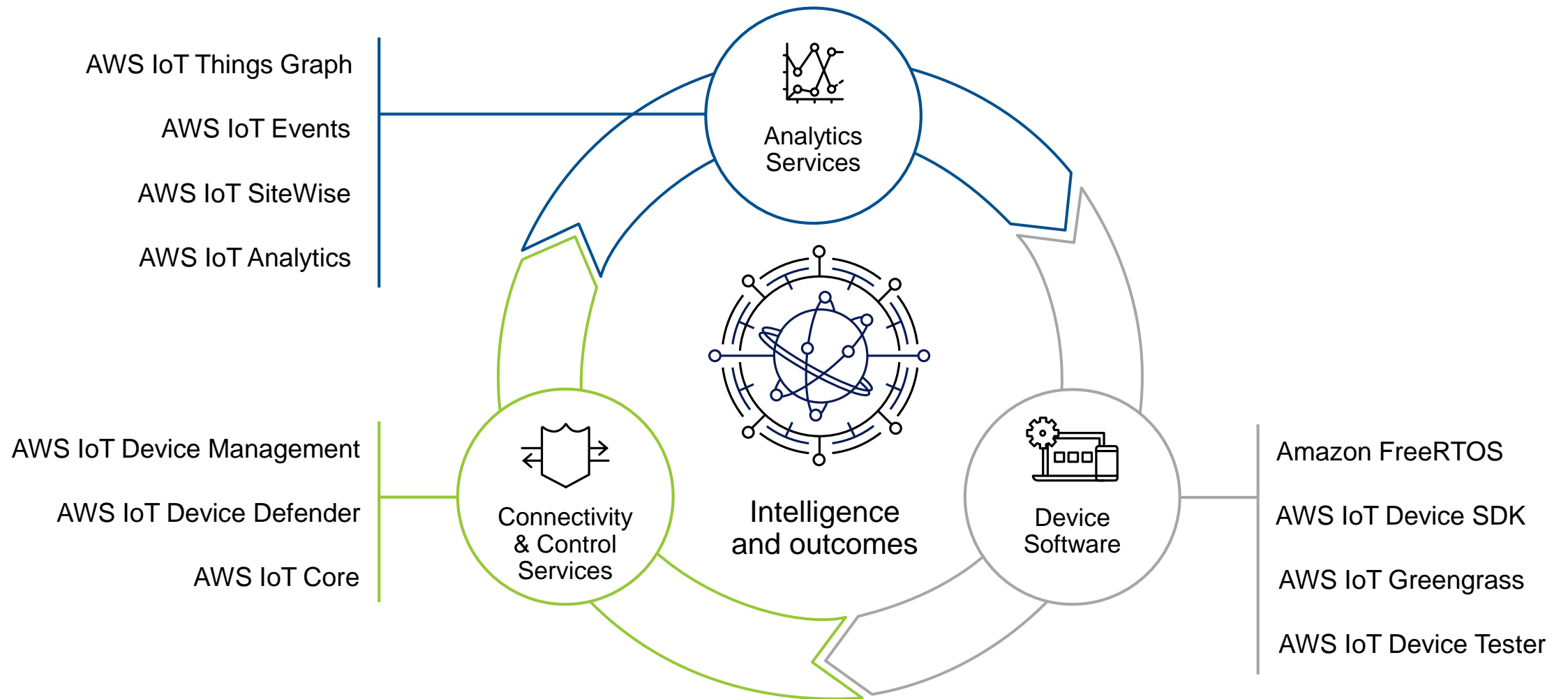
How can I connect, manage, and secure my devices at scale?



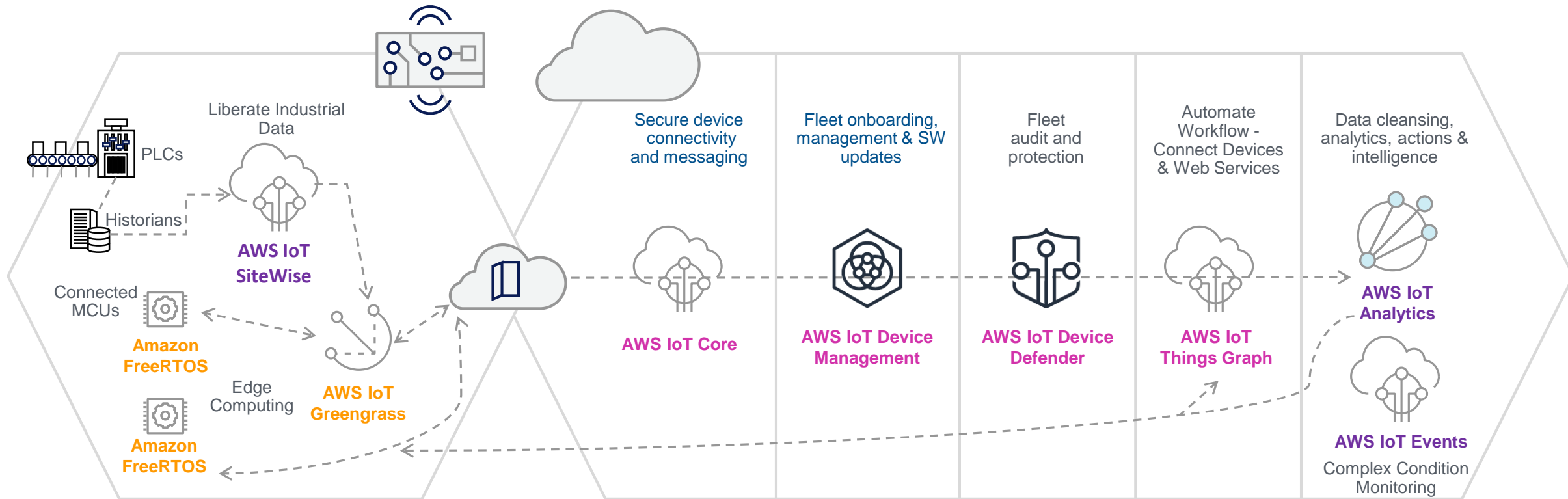
Device
Software

How can I build devices that operate at the edge that work with AWS by default?

AWS IoT services



AWS IoT Architecture: Edge → Cloud Data Flow View



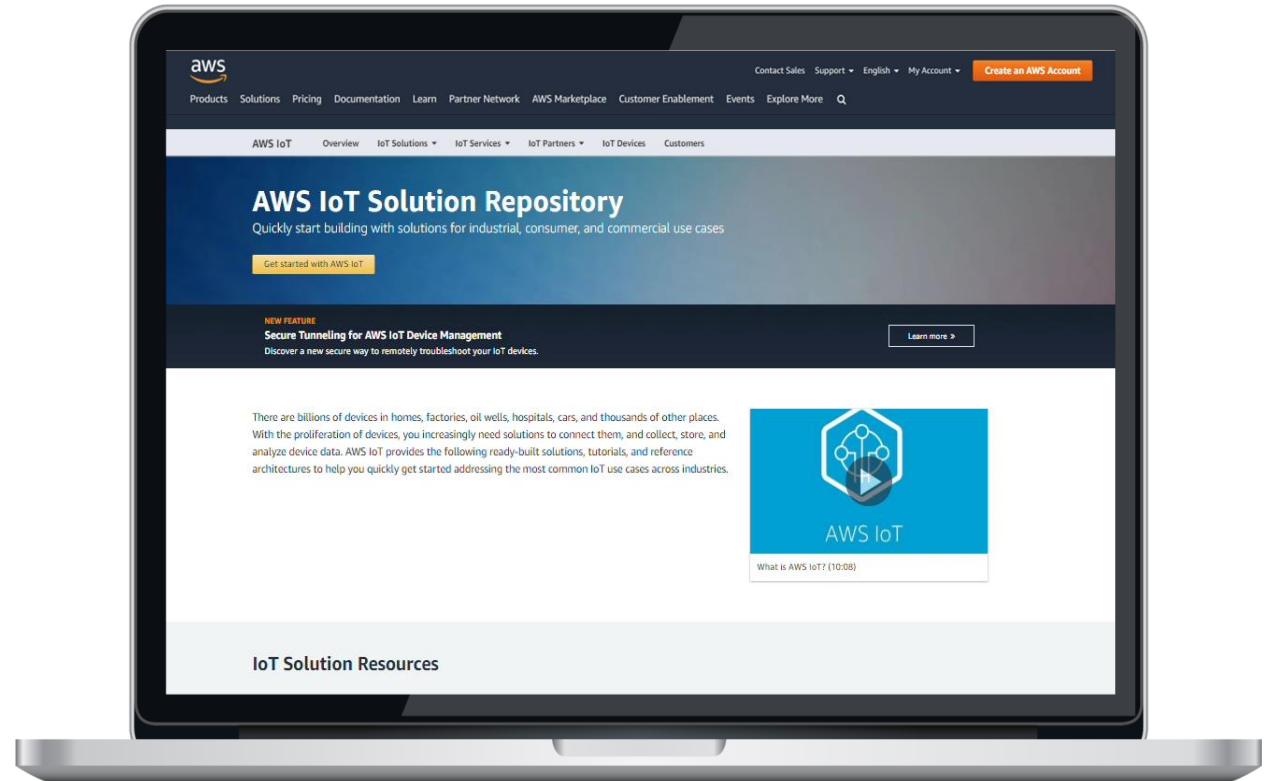
Achieve business outcomes faster using solutions built by AWS and our Partners



Solutions built by AWS that help you quickly solve problems across common industry use cases.

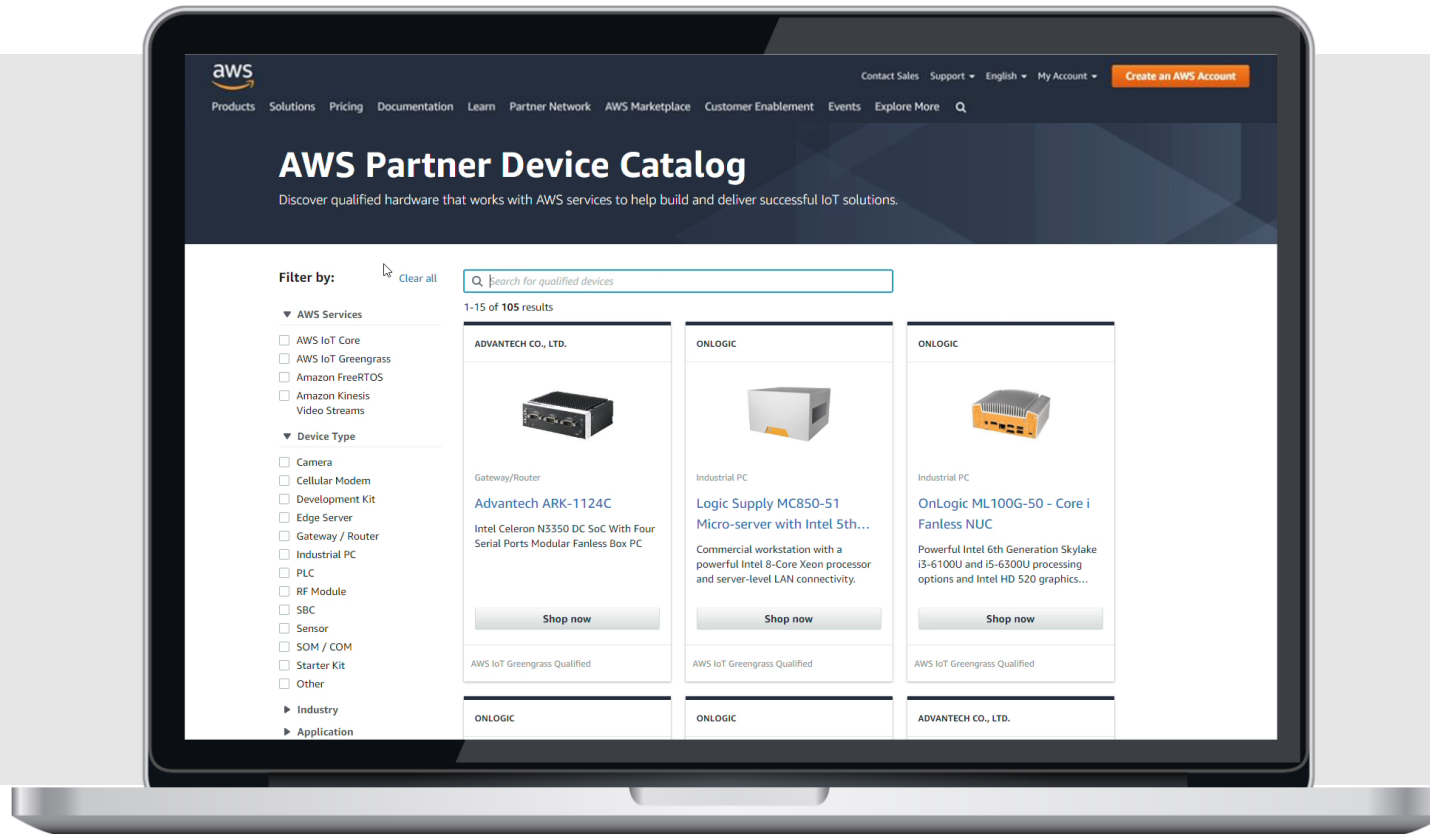


Accelerate your time to value leveraging the expertise of APN Partners and their pre-built solutions.



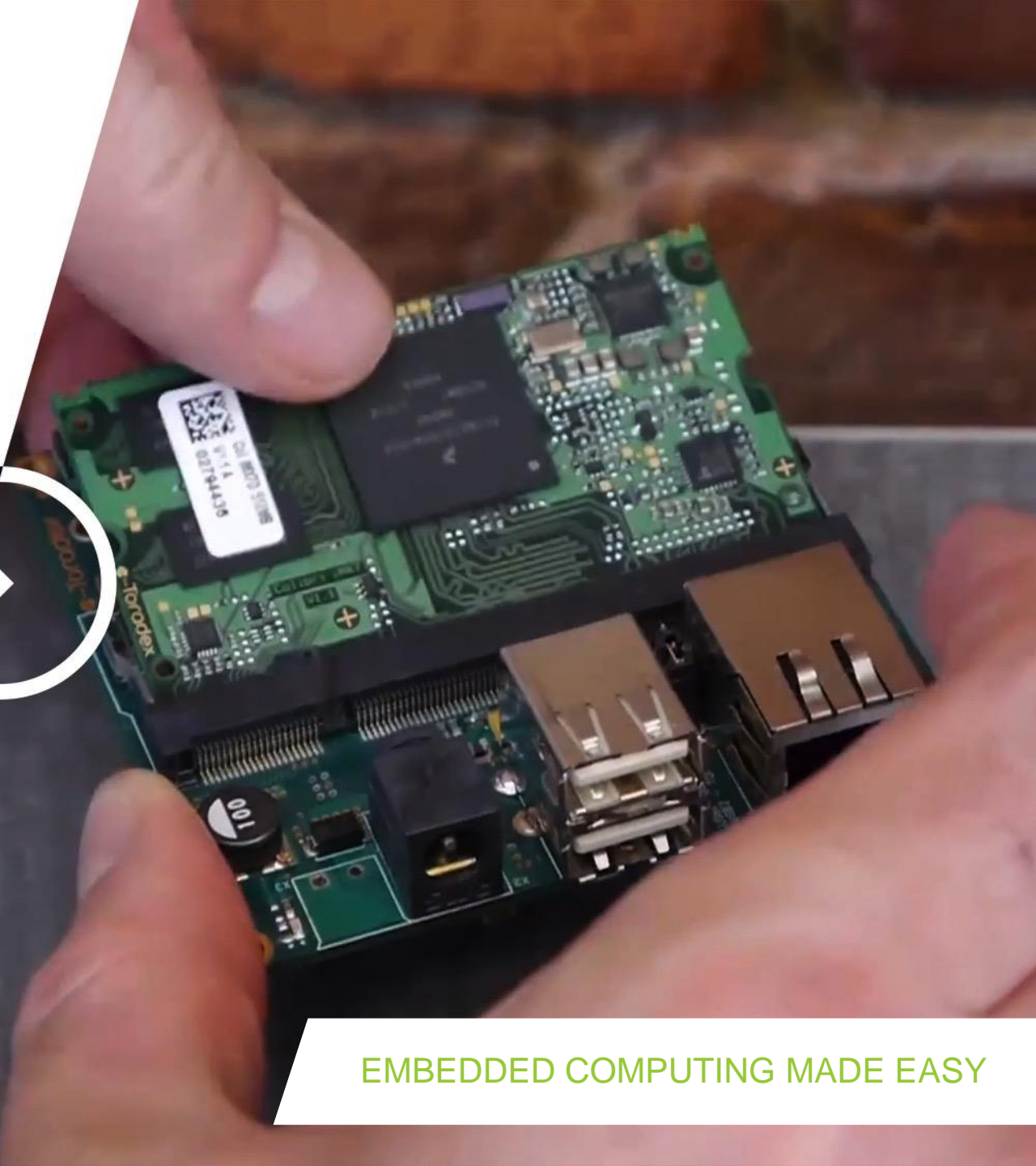
AWS Partner Device Catalog

Discover validated Partner hardware and devices that are qualified to work with AWS by default.



340+

Qualified IoT devices in the Partner Device Catalog.



EMBEDDED COMPUTING MADE EASY

TORADEX OVERVIEW



Embedded Computing Made Easy

Reliable Arm System on Modules

Lowest Cost of Ownership

Industry-leading Support

Global Presence Close to You

Focus customers 100 – 50k pcs a year



WHAT WE DO



Arm System on Modules
Reliable
Long-term Maintenance
Scalable
From Stock

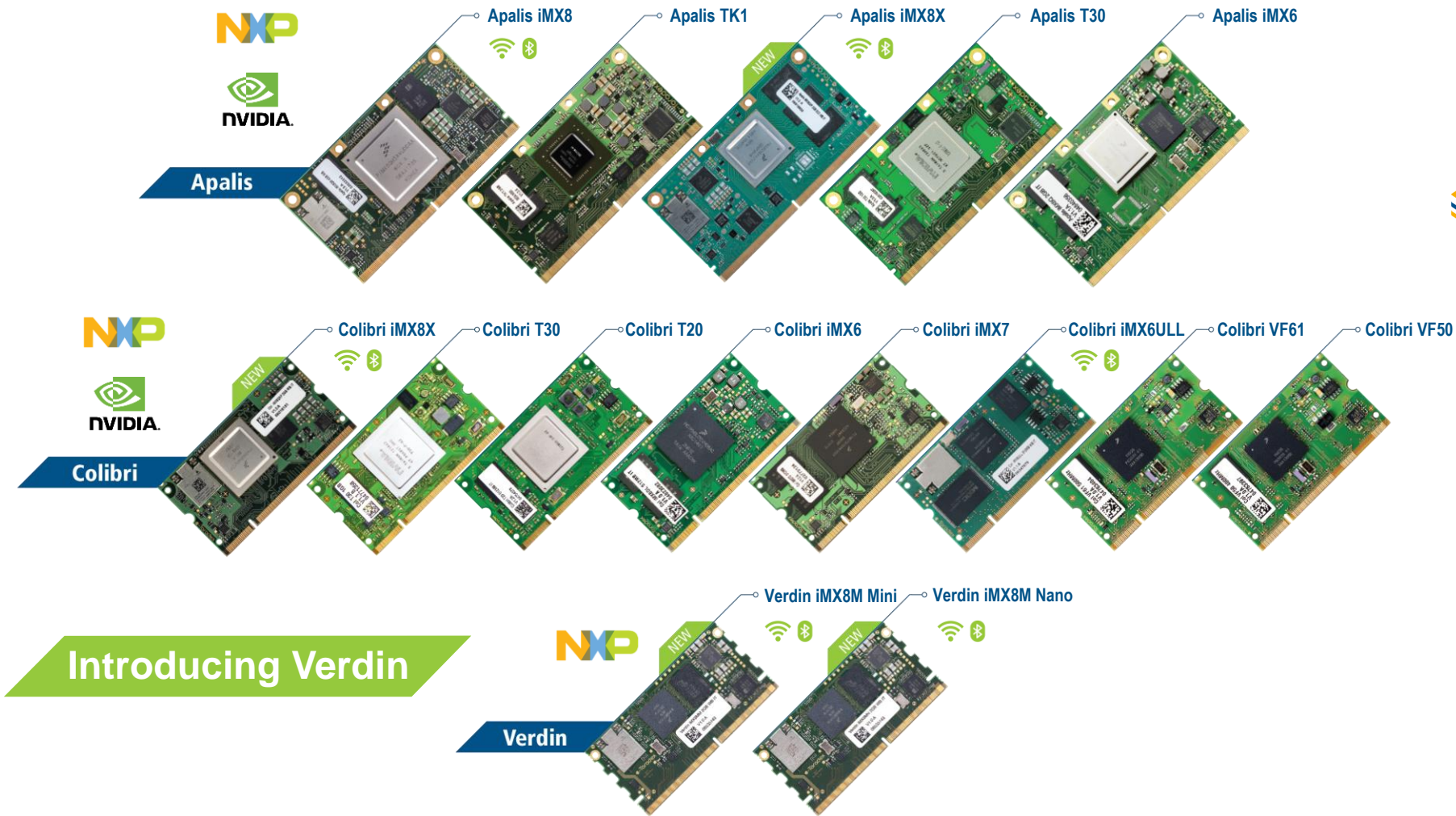


Production-ready Software
Yocto-based Linux
Windows Embedded Compact
Development Tools
Long-term Maintenance



Ease-of-use
Support
Ecosystem

Scalable Product Portfolio



Utilized Products – Toradex



Toradex Apalis iMX8 System on Module

- NXP i.MX 8QuadMax Applications Processor
- 15 years long-term availability
- Ruggedized



Simple Carrier Board Designs

- Reference Designs, Design Guides
- Pinout Designer Tool



Scalable

- Pin-compatible with a wide range of System on Modules



Torizon™

- Easy-to-use industrial Grade Linux
- Focus on your application not the BSP
- Secure, OTA Integrated, Realtime Option



High Quality Partner Ecosystem

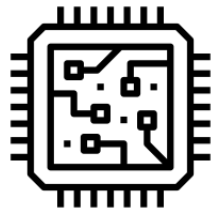
- Get to Market Faster with Proven Partner Software and Hardware
- Get help from Trusted Partners with Hardware and Software Design



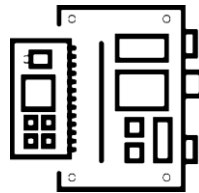
Extensive Support

- Daily Updated Developer Page
- Active Community Moderated by Toradex Developers
- Global Presents with Local Support Engineers

Get to Market Faster – Focus on your Differentiators



**Save Development Time
Reduce Risk**



**Cost and Performance
Optimized Solution**



Get Started Now

✓ AWS Device Catalog

<https://devices.amazonaws.com/detail/a3G0h0000077JScEAM/Toradex-Apalis-AI-Vision-Starter-Kit-for-i.MX8>

✓ Open Source Git Hub

<https://github.com/toradex/aws-nxp-ai-at-the-edge>

✓ One Click Shopping

<https://www.toradex.com/imx8-embedded-vision-starter-kit>

✓ Detailed Step-by-Step Documentation

<https://developer.toradex.com/knowledge-base/object-detection-demo-with-aws-sagemaker-neo-and-torizon#How to Get Started>



Toradex Apalis AI Vision Starter Kit for i.MX8
by Toradex

Get Started with embedded computer vision, on-device AI using Amazon SageMaker Neo & AWS IoT Greengrass the simple way.

This kit comes with industrial-grade hardware and software such as a high-performance Apalis System-on-Module with an NXP i.MX 8QuadMax Application Processor, an Ixora carrier board, and an industrial MIPI CIS-2 Camera by AlliedVision.

You will have a reference implementation running in minutes that is able to demonstrate object detection and classification based on the example of pasta shapes. A local user interface via HDMI screen gives you immediate feedback.

With just a few clicks you can also deploy all cloud services including a web-based user interface for remote monitoring, Amazon DynamoDB for storage of your data, AWS IoT Core to handle the MQTT messages, and user management via Amazon Cognito.

When you are ready to train your own neural network, you will be able to use Amazon SageMaker for training, Amazon SageMaker Neo to compile & optimize your model for the NXP i.MX 8QuadMax, and use AWS IoT Greengrass to deploy it on the edge.

AWS Service	Device Type
AWS IoT Greengrass	Starter Kit
Industry	Application
Agriculture, Energy / Utilities, Healthcare / Life Sciences, Industrial, Retail, Security, Smart City, Transportation	Building Automation, Connected Vehicle, Fleet Management, Food Service, Heavy Equipment, HMI, Industrial Automation, Irrigation, Machine Learning, Machine Vision, Manufacturing, Marine, Medical Devices, Oil / Gas, Pharmaceuticals, Point-of-Sale, Precision Ag, Predictive Maintenance / Quality, Process Control / Automation, Public Transit, Railway, Remote Monitoring, Robotics, Security / Access Control, Tank Monitoring, Traffic Management, UAV, Vending / Kiosks, Video Surveillance, Warehouse

[Shop now](#) [Product page »](#) [Product data sheet »](#) [Getting started »](#)



Visit us at Embedded World 2020



- ✓ 20min 1:1 Developer Session at Toradex Booth 4-410

<https://www.toradex.com/ew-2020-session-booking>

- ✓ Talk at AWS Booth 5-310, February 26th 16:30

- ✓ Demo at NXP Booth 4A-220



Questions?





תודה Спасибо

ਤੁਹਾਡਾ ਧੰਨਵਾਦ

Grazie

ありがとうございました

감사합니다

谢谢 teşekkür ederim

Je vous remercie

Danke

متشکرم Kiitos

Thank you