AN14212

802.11kvr Roaming

Rev. 2.0 — 13 January 2025 Application note

Document information

Information	Content
Keywords	802.11kvr, roaming, bgscan, wpa_supplicant, fast transition, resource management, basic service set transition management, neighbor report, beacon report, wireless network management
Abstract	Explains how to enable fast transition, configure wpa_supplicant, load the driver parameters. And describes different types of fast transition.

1 Introduction

NXP Wi-Fi radios support 802.11kvr roaming standards:

- **802.11k (Radio Resource Measurement):** provides information about the available APs and respective RSSI to help the client choose the best AP.
- **802.11v (Wireless Network Management):** provides information to the client about available APs for roaming, without a full scan.
- **802.11r (Fast Basic Service Set Transition):** eliminates the need for fresh authentication when a client roams to another network.

This document explains how to use 802.11kvr for roaming.

Note: *802.11kvr is supported only in STA mode. Mobile AP mode does not support 802.11k, 802.11v, and 802.11r standards.*

1.1 Supported devices

Refer to the feature list in the release note to check if 802.11kvr is supported in the software release package. The wireless SoCs that support 802.11kvr are:

- 88W8987 [5]
- 88W8997 [6]
- 88Q9098 [7]
- 88W9098 [8]
- IW416 [13]
- IW611 [14]
- IW612 [15]
- IW620 [16]
- AW611 [9]
- AW690 [10]
- AW692 [11]
- AW693 [12]

1.2 Prerequisites

- Open source wpa_supplicant v2.10 or higher [17]
- Open source kernel v4.6 or higher

2 802.11kvr

Figure 1 shows the interaction between 802.11k, 802.11v, and 802.11r for roaming.

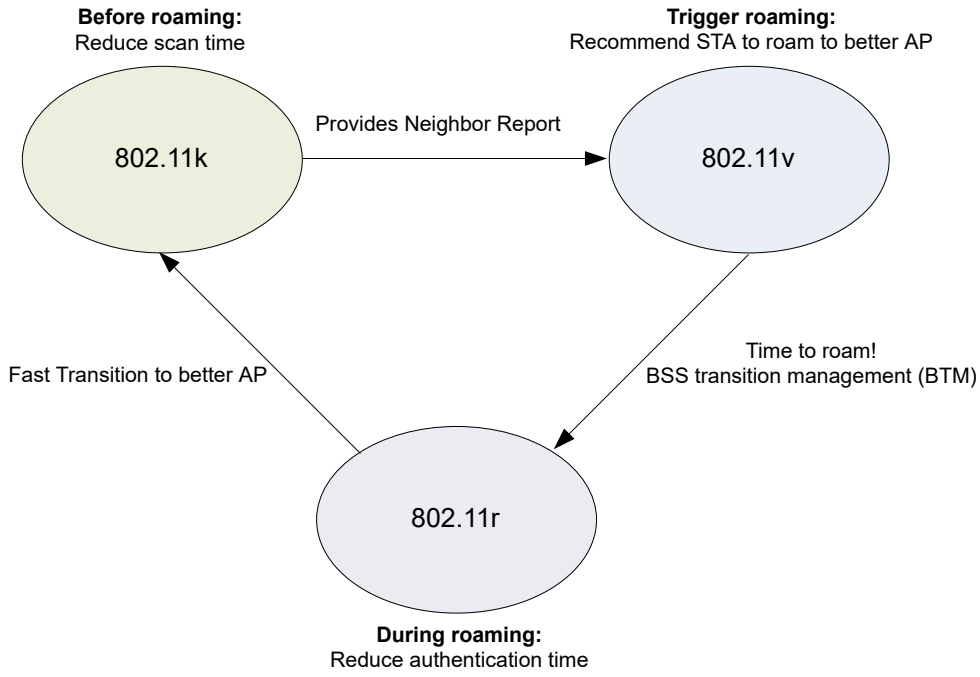

Figure 1. Overview of 802.11kvr

802.11k is a Radio Resource Management (RRM) that provides mechanisms for APs and clients to dynamically measure the available radio resources. APs and clients can send neighbor reports, beacon reports, and link measurement reports to each other.

- Neighbor reports: information about known neighbor APs to help STA better understand its surroundings
- Beacon reports: information about channel configuration, location, coverage/frequency planning, and AP detection
- Link measurement reports: information about a requested link

802.11v is BSS transition management (BTM) with Wireless Network Management (WNM) that allows client devices to exchange information about the network topology. The information includes RF environment, making each client network aware of its surroundings. STA can send a BTM query to the AP and get a list of preferred candidates.

- BTM query: A connected AP suggests the STA to roam to another APs with a better connection with a preferred candidate list.

802.11r is Fast Basic Service Set Transition (FT), which is faster than normal roaming because it avoids a 4-way handshake when transitioning from one AP to another. The two types of FT are over-the-air and over-the-distribution-system (over-the-DS).

3 Configuration

This section explains how to configure 802.11kvr.

3.1 Driver load parameters

To enable 802.11kvr, load the driver with the parameters:

```
host_mlme=1
cfg80211_wext = 0xf (STA mask of CFG80211 and WEXT control)
```

Note: *For more details about the driver load parameters, refer to README in the SW release package.*

Example of driver loading:

```
insmod mlan.ko
insmod moal.ko fw_name=nxp/<fw_name>.bin cfg80211_wext=0xf auto_ds=2 ps_mode=2
 txpwrlimit_cfg=nxp/<power_table>.bin cal_data_cfg=nxp/WlanCalData.conf host_mlme=1
 drvdbg=0x20037
```

Note: *Setting `drvrdbg = 0x20037` is optional and used to log roaming messages on dmesg.*

3.2 wpa_supplicant

wpa_supplicant is the MAC Sublayer Management Entity (MLME) to send/receive RRM action frames, FT action frames, and BTM frames. Refer to */wpa_supplicant/README* for more information.

Note: *Open source wpa_supplicant version v.2.10 or above must be used. wpa_supplicant must be built with the flag, CONFIG_80211R enabled.*

Step 1 – Download wpa_supplicant open source code (*wpa_supplicant-2.10.tar.gz*) (see [17]).

Step 2 – Decompress the file.

```
tar -xvf wpa_supplicant-2.10.tar.gz
```

Step 3 – Move to the *wpa_supplicant* directory. See Figure 2.

```
cd wpa_supplicant
```

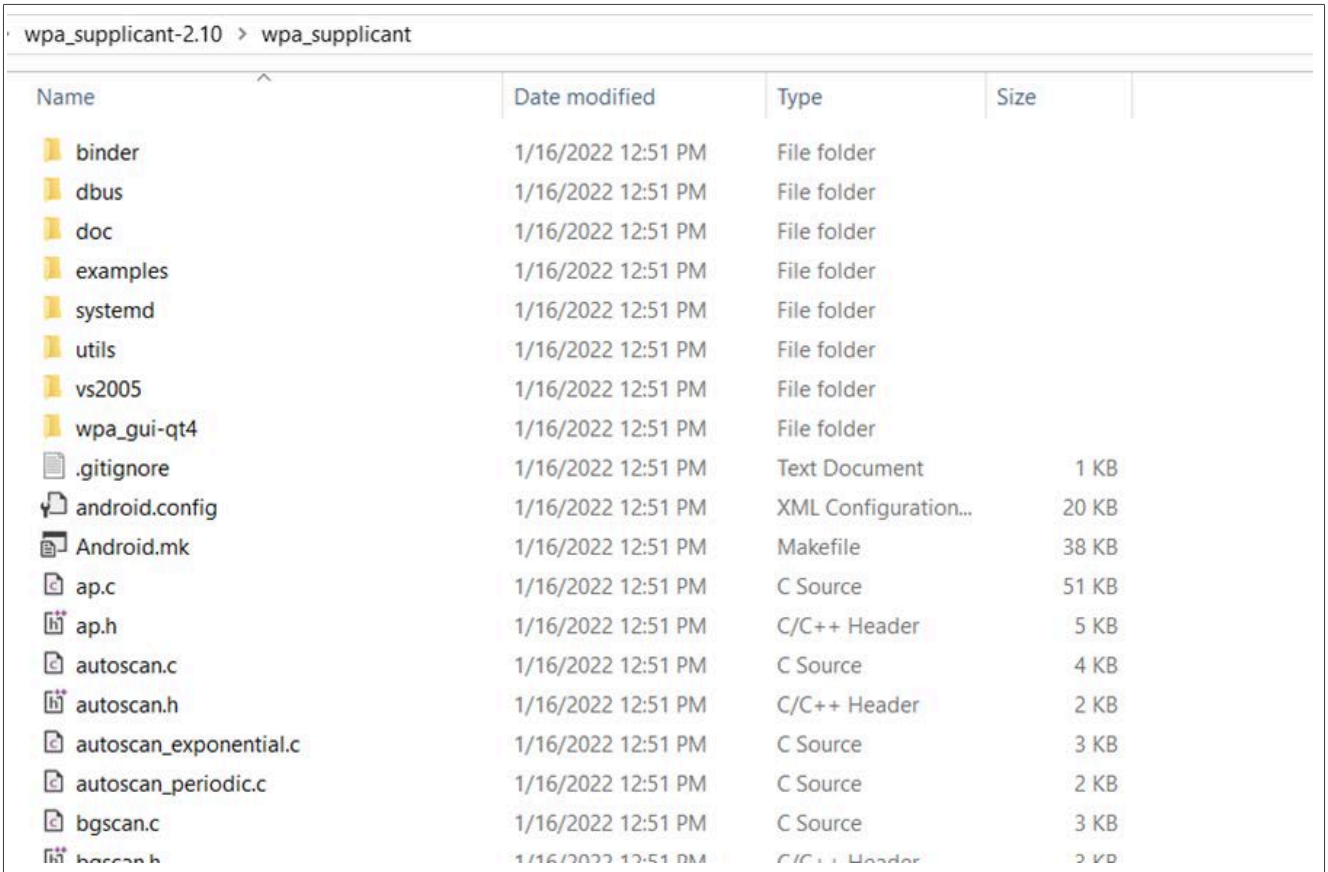

Figure 2. wpa_supplicant directory content

Step 4 – Enable the IEE80211R flag in the *.config* file.

```
CONFIG_IEEE80211R=y
```

Step 5 – Build wpa_supplicant.

```
make
```

Example of output:

```
CC ../src/drivers/driver_nl80211.c
CC ../src/drivers/driver_nl80211_capa.c
CC ../src/drivers/driver_nl80211_event.c
CC ../src/drivers/driver_nl80211_monitor.c
…
```

Step 6 – Create the configuration file *wpa_supplicant.conf*.

Example of *wpa_supplicant.conf* content:

```
ctrl_interface=/var/run/wpa_supplicant
ctrl_interface_group=0
update_config=1
ap_scan=1
network={
 ssid="TEST_NETWORK"
 key_mgmt=FT-PSK                    # Fast Transition Key Management
 proto=RSN
 pairwise=CCMP
 group=CCMP
 psk="1234567890"
 bgscan="simple:30:-75:120"        # Background scan settings
}
```

- Set the key management to FT-PSK or FT-EAP.

```
key_mgmt=FT-PSK
key_mgmt=FT-EAP
```

- Set the background scanning parameters.

```
bgscan=”simple :<short scan interval> : <signal strength threshold> : <long scan
 interval>”
```

Where:

Table 1. Command parameters

Parameter	Description
short scan interval	Perform a scan every X seconds when the signal strength is weaker than the threshold
signal strength threshold	Signal strength from AP (dBm)
long scan interval	Perform a scan every X seconds when the signal strength is higher than the threshold

Example of command:

```
bgscan="simple:30:-75:120"
```

In the example, a scan is performed every 30 seconds when the signal strength from the current AP is below -75dBm. If the signal strength is above -75dBm, the interval is every 120 seconds.

Step 7 – Run `wpa_supplicant`.

```
wpa_supplicant -B  -Dnl80211 -<interface> -c/etc/wpa_supplicant.conf
```

4 wpa_cli

Once 802.11kvr is enabled, wpa_supplicant automatically handles roaming. The command line interface wpa_cli is used to interact with wpa_supplicant and trigger the following actions:

- Neighbor report
- BTM query
- Over-the-Air Fast Transition
- Over-the-DS Fast Transition

5 Setup

The setup to demonstrate 802.11kvr consists of:

- Enterprise Wireless LAN controller
- at least two APs
- at least one STA

Note: *Refer to the user manual of your Enterprise controller and APs to enable 802.11kvr.*

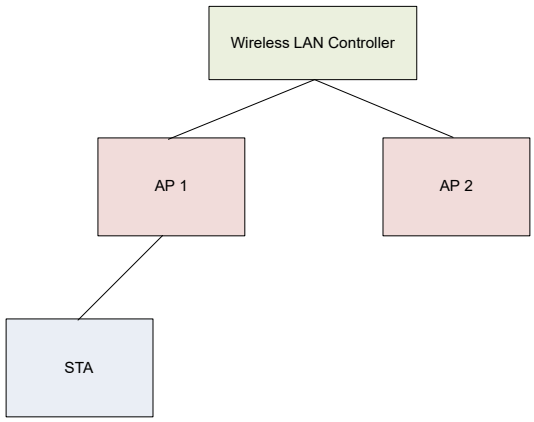

Figure 3. 802.11kvr set up example

Step 1 – Connect the APs to the Wireless LAN controller.

Figure 4 shows the AP enabled with 802.11kvr.

- AP MAC= d0:4d:c6:b2:07:32
- 802.11kvr (Link measurement and Neighbor report) is enabled in the AP.

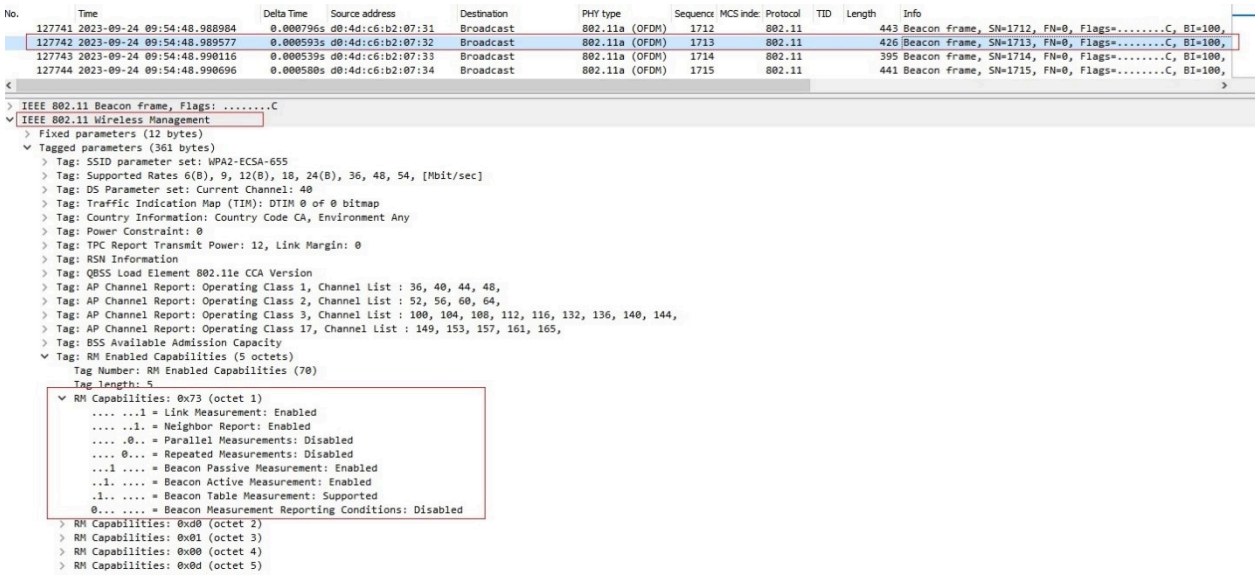

Figure 4. Example of AP enabled with 802.11kvr

Step 2 – Bring up the DUT in STA mode and define the configuration (Section 3).

Step 3 – Connect the STA to the AP.

Figure 5 shows the STA enabled with 802.11kvr.

- AP MAC= d0:4d:c6:b2:07:32
- STA MAC= 00:04:9f:06:7a:f6
- STA and AP exchange association request and responses.
- 802.11kvr (Link measurement and Neighbor report) is enabled in the Wi-Fi environment.

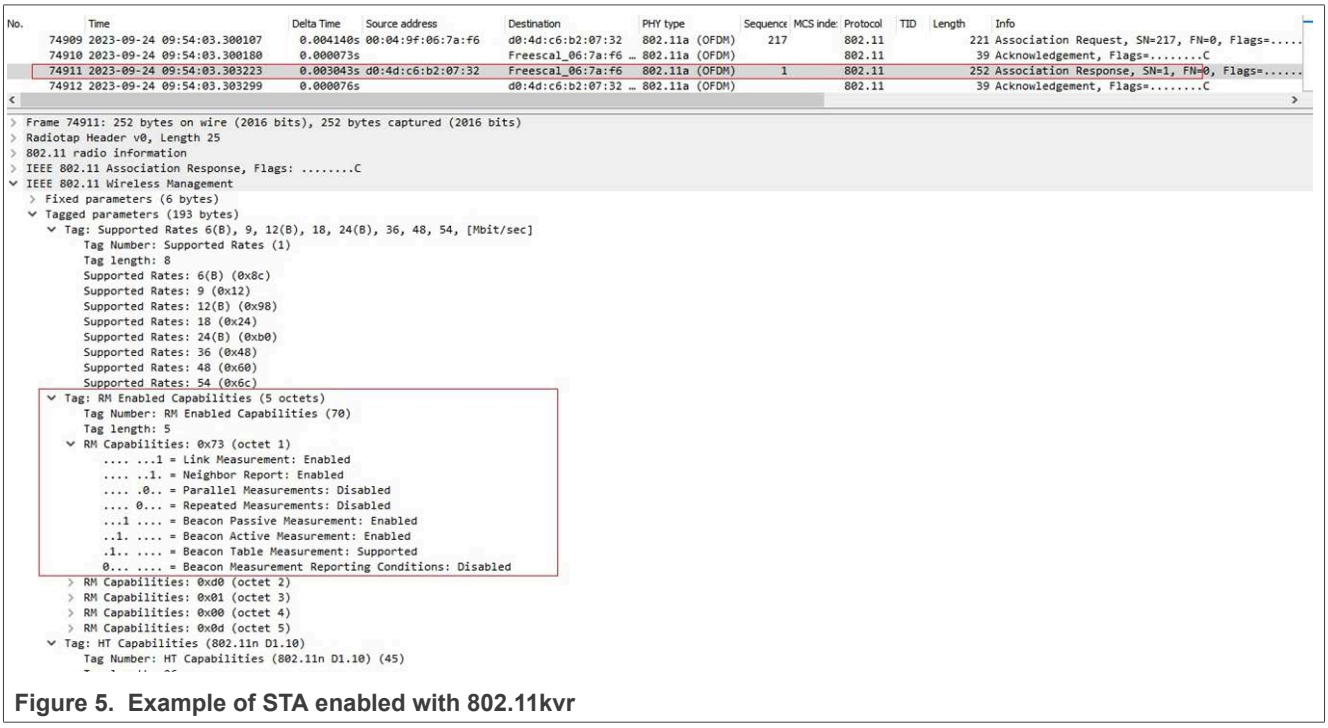

Figure 5. Example of STA enabled with 802.11kvr

6 802.11k examples

This section provides examples for Neighbor Report, Link measurement, and Beacon report.

6.1 Neighbor report

The example demonstrates a Neighbor report request from the STA. AP 1 responds with a list of neighboring APs on the same Wi-Fi network, including AP 2. If there are no other APs in the environment, the neighbor report is empty.

wpa_supplicant handles the Neighbor reports. A `wpa_cli` command (in step 2) can be used to manually request a neighbor report.

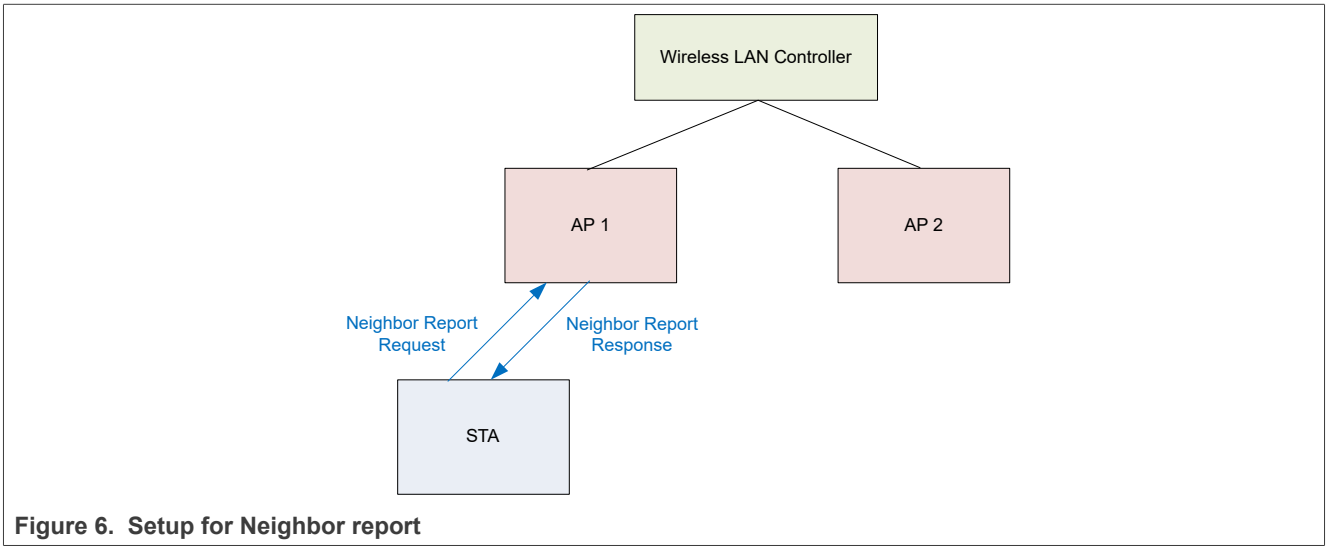

Figure 6. Setup for Neighbor report

Step 1 – Set up the environment (Section 5).

Step 2 – Run the `wpa_cli` command to trigger a Neighbor report request.

```
./wpa_cli neighbor_rep_request
```

Command output example:

The log shows STA sending “RRM: Neighbor report request” to the AP.

```
RRM: Neighbor report request (for ), token=4
nl80211: Send Action frame (ifindex=3, freq=2422 MHz wait=0 ms no_cck=0 offchanok=1)
nl80211: Drv Event 60 (NL80211_CMD_FRAME_TX_STATUS) received for mlan0
nl80211: Frame TX status event A1=00:11:32:ed:9e:b0 stype=13 cookie=0xf6573dff ack=1
nl80211: Frame TX status: cookie=0xf6573dff (match) (ack=1)
mlan0: Event TX_STATUS (16) received
mlan0: EVENT_TX_STATUS dst=00:11:32:ed:9e:b0 type=0 stype=13
Off-channel: Ignore Action TX status - no pending operation
nl80211: BSS Event 59 (NL80211_CMD_FRAME) received for mlan0
nl80211: RX frame da=c0:95:da:00:e5:38 sa=00:11:32:ed:9e:b0 bssid=00:11:32:ed:9e:b0
 freq=2422 ssi_signal=0 fc=0xd0 seq_ctrl=0x60 stype=13 (WLAN_FC_STYPE_ACTION) len=27
mlan0: Event RX_MGMT (18) received
mlan0: Received Action frame: SA=00:11:32:ed:9e:b0 Category=5 DataLen=2 freq=2422 MHz
```

Figure 7 shows a sniffer capture example of the Neighbor Report Request from the STA to the AP.

- STA MAC= 00:04:9f:06:7a:f6
- AP MAC= d0:4d:c6:b2:07:32

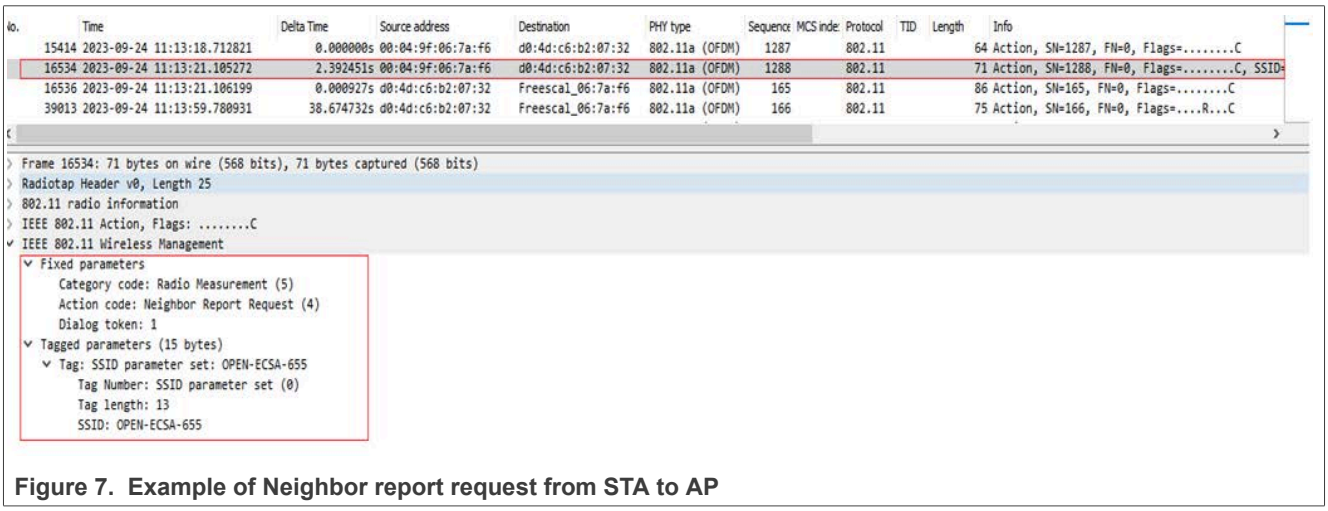

Figure 7. Example of Neighbor report request from STA to AP

Step 3 – Look for AP response (Neighbor report displayed on the console of the STA).

Command output example:

The log shows “RRM: New Neighbor Report”.

```
<3>CTRL-EVENT-SCAN-RESULTS
<3>RRM-NEIGHBOR-REP-RECEIVED bssid=dc:ce:c1:23:9a:4b info=0x2f7 op_class=115 chan=40
 phy_type=7
<3>RRM-NEIGHBOR-REP-RECEIVED bssid=dc:ce:c1:23:9a:44 info=0x2e7 op_class=81 chan=1
 phy_type=7
<3>CTRL-EVENT-SCAN-STARTED
<3>CTRL-EVENT-SCAN-RESULTS
...
RRM: New Neighbor Report - hexdump(len=31): 02 34 0d d0 4d c6 b2 07 32 f7 02 00 00 7d a1
 07 34 d0 4d c6 b2 07 12 e7 02 00 00 51 0b 07
mlan0: RRM: Notifying neighbor report (token = 2)
mlan0: RRM-NEIGHBOR-REP-RECEIVED bssid= d0:4d:c6:b2:07:32 info=0x2f7 op_class=125
 chan=161 phy_type=7
mlan0: RRM-NEIGHBOR-REP-RECEIVED bssid= d0:4d:c6:b2:07:12 info=0x2e7 op_class=81 chan=11
 phy_type=7
```

Figure 8 shows a sniffer capture example of Neighbor report response from the AP.

- AP MAC= d0:4d:c6:b2:07:32
- STA MAC= 00:04:9f:06:7a:f6

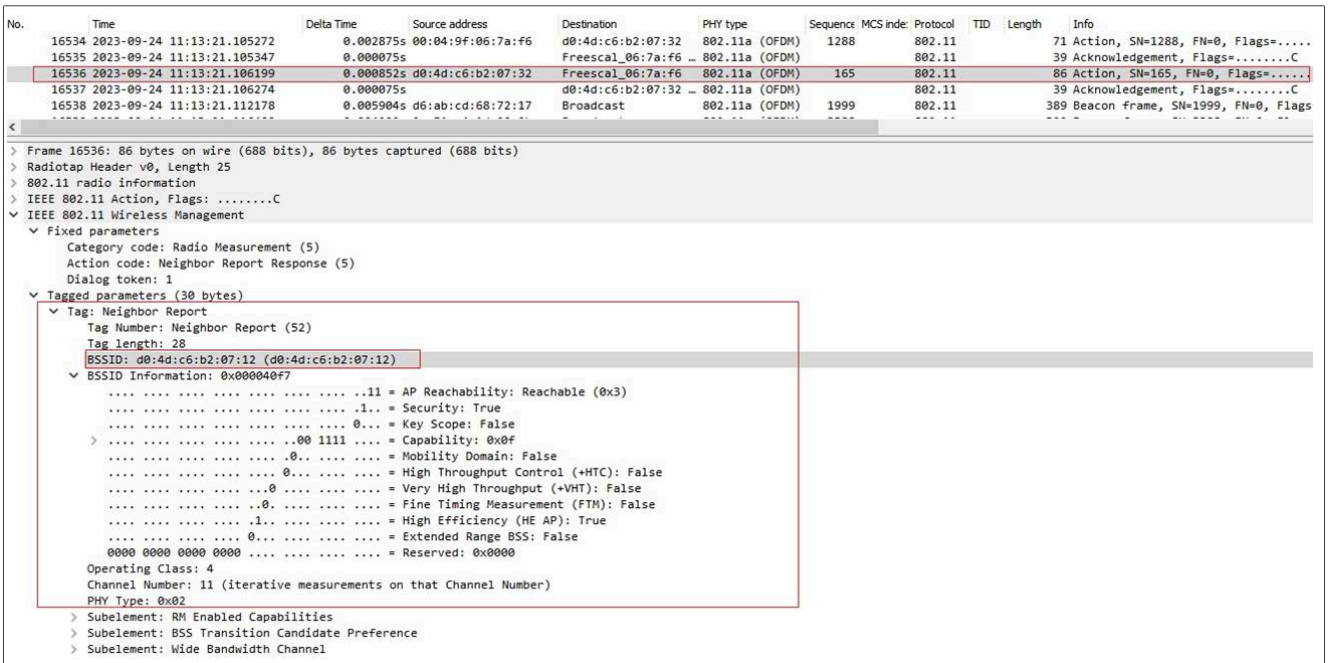

Figure 8. Neighbor report response from the AP

6.2 Link measurement

wpa_supplicant initiates link measurement requests and responses to and from the AP and STA. In this example, the STA sends a link measurement report to the AP.

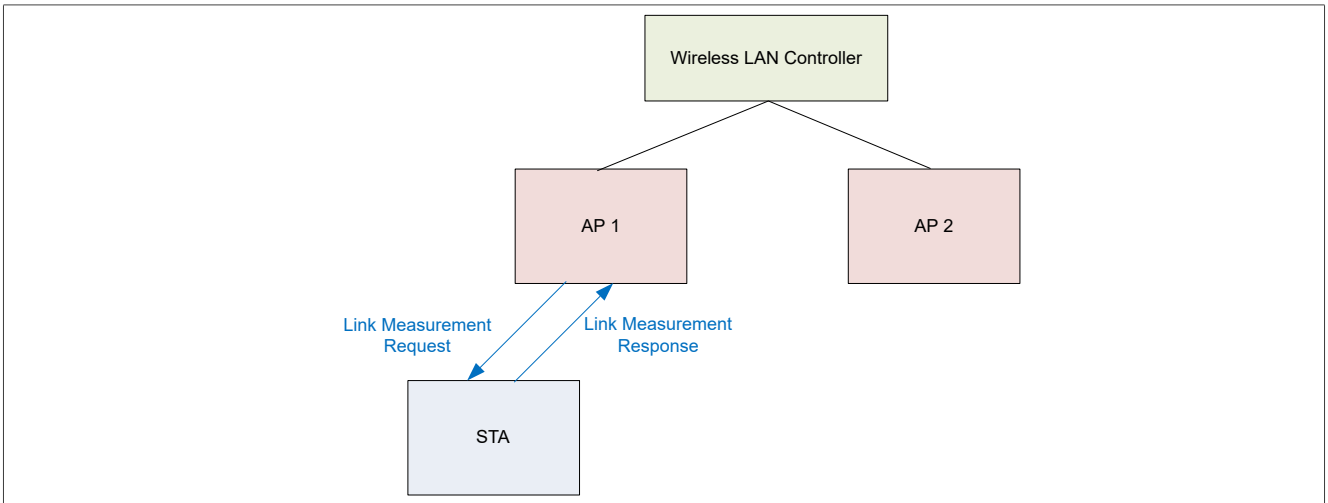

Figure 9. Link measurement setup

Step 1 – Set up the environment (Section 5).

Step 2 – The AP sends a link measurement request to the STA. The request shows on the console of the STA.

Example of output:

```
mlan0: Received Action frame: SA=cc:88:c7:10:d7:11 Category=5 DataLen=31 freq=5805 MHz
Measurement request type 5 token 151
SSID subelement with zero length - wildcard SSID
```

Figure 10 shows an example of the STA receiving a link measurement request from the AP.

- AP MAC= d0:4d:c6:b2:07:32
- STA MAC= 00:04:9f:06:7a:f6

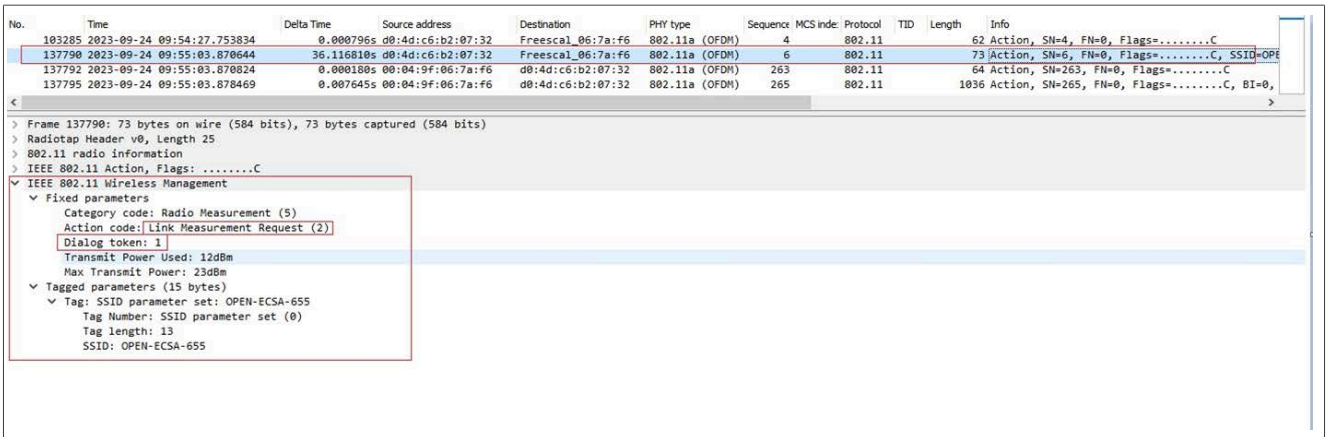

Figure 10. Example of STA receiving link measurement request from the AP

Step 3 – STA responds with a link measurement response on the console.

Command output example:

```
RRM: Radio Measurement report - hexdump(len=35): 27 21 97 00 05 80 a1 00 00 00 00 00 00
 00 00 00 00 09 3e ff cc 88 c7 10 d7 11 00 00 00 00 00 02 02 01 00
nl80211: Send Action frame (ifindex=3, freq=5805 MHz wait=0 ms no_cck=0 offchanok=1)
```

Figure 11 shows an example of link measurement response from STA to AP.

- AP MAC= d0:4d:c6:b2:07:32
- STA MAC= 00:04:9f:06:7a:f6

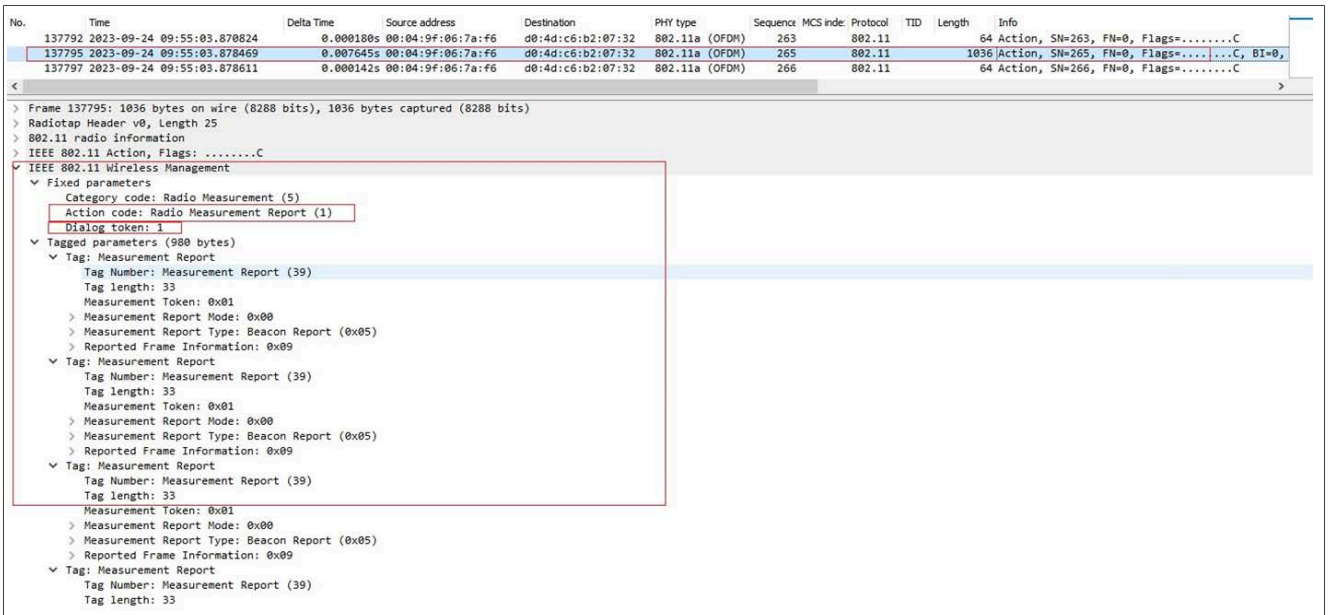

Figure 11. Example of link measurement response from the STA to the AP

6.3 Beacon report

wpa_supplicant initiates the STA and AP to send beacon reports to each other. In this example, the STA sends a beacon report to the AP.

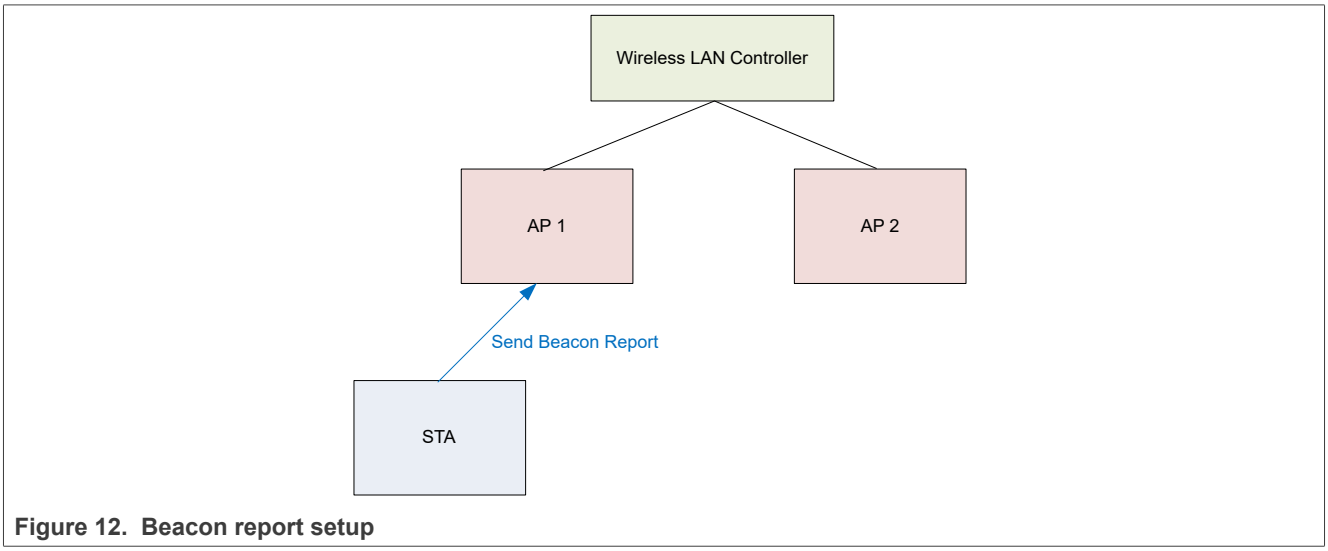

Figure 12. Beacon report setup

Step 1 – Set up the environment (Section 5).

Step 2 – STA sends a beacon report to the AP.

Figure 13 shows a sniffer capture example of the STA sending a Beacon Report to the AP.

- AP MAC= d0:4d:c6:b2:07:32
- STA MAC= 00:04:9f:06:7a:f6

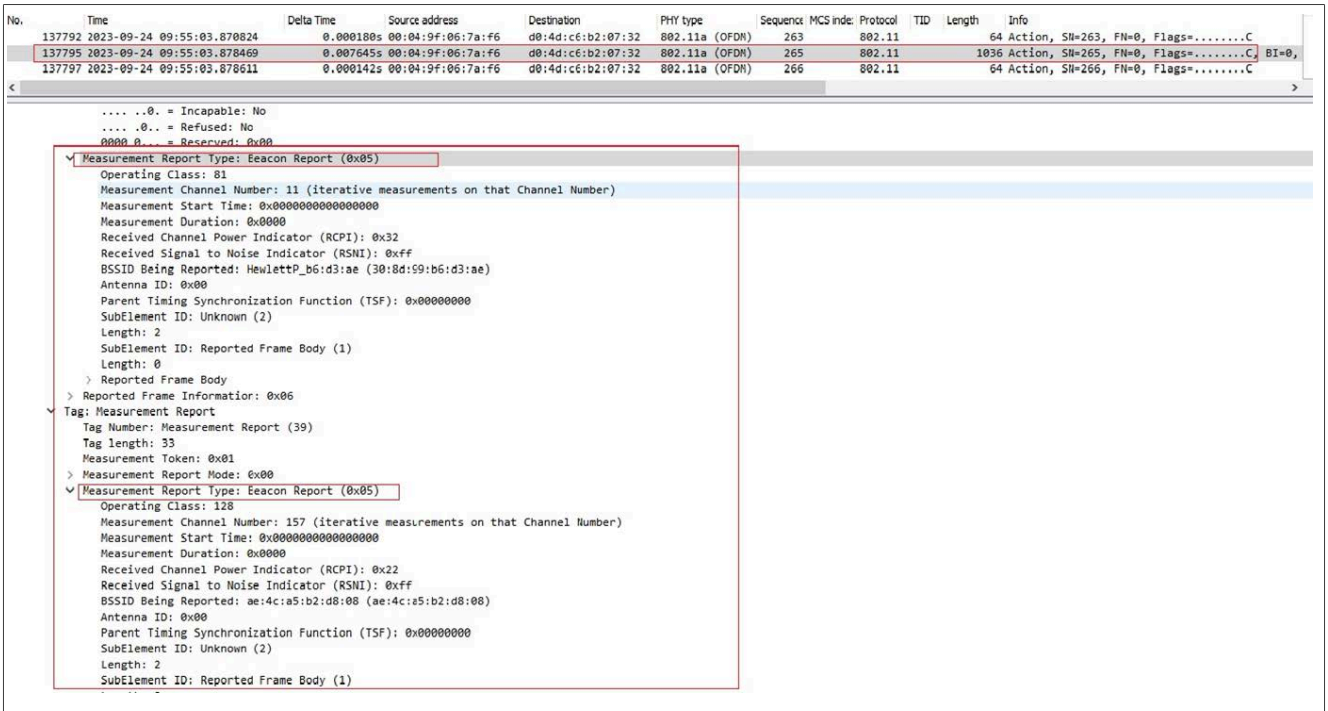

Figure 13. Example of the STA sending a beacon report to the AP

7 802.11v example

The example shows a BSS transition management query (BTM) from the STA. The AP responds with a request for the STA to roam based on a preferred candidate list. The request is in a BSS management frame.

If the AP is configured with disassociation imminent function enabled, the STA is forced to roam to a better AP. If disassociation imminent function is disabled, the STA can reject or accept the request. Refer to the user manual of the AP manual for this configuration.

wpa_supplicant handles BTM queries. Issue a wpa_cli command (in step 2) to manually send a BTM query.

Figure 14 shows the BTM query sequence, where:

1. BTM query
2. BTM request
3. BTM response

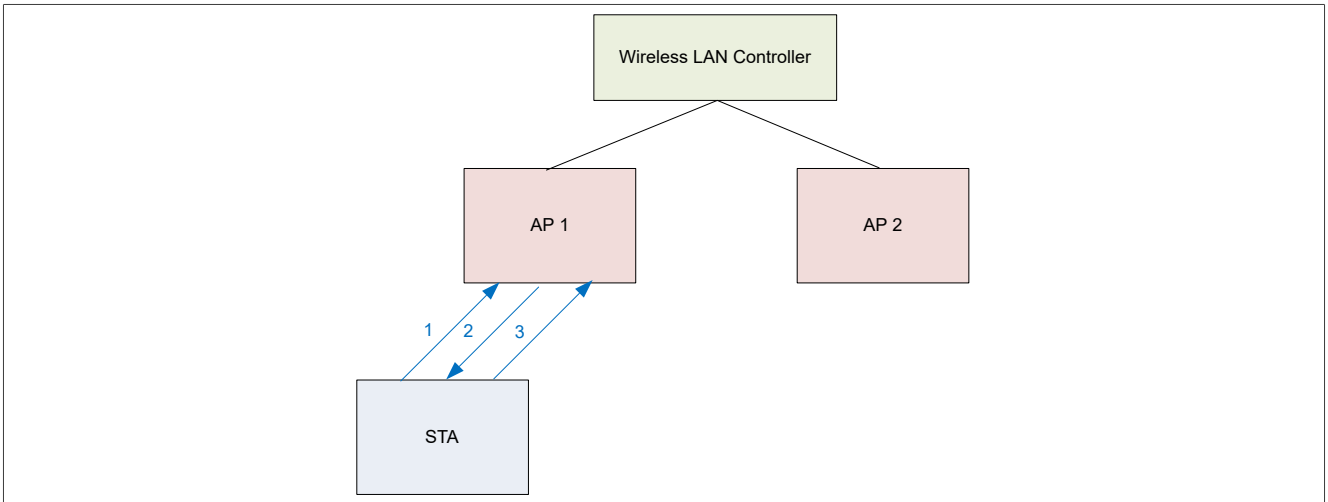

Figure 14. BTM query communication

Step 1 – Set up the environment (Section 5).

Step 2 – Issue a wpa_cli command to trigger a BTM query.

```
./wpa_cli wnm_bss_query 1
```

Command output example:

```
WNM: Send BSS Transition Management Query to 00:11:32:ed:9e:b0 query_reason=1
nl80211: Send[ 3172.437052] wlan: mlan0 START SCAN
Action frame (ifindex=3, freq=2422 MHz wait=0 ms no_cck=0 offchanok=1)
OK
nl80211: Drv Event 60 (NL80211_CMD_FRAME_TX_STATUS) received for mlan0
nl80211: Frame TX status event A1=00:11:32:ed:9e:b0 stype=13 cookie=0x75319743 ack=1
nl80211: Frame TX status: cookie=0x75319743 (match) (ack=1)
mlan0: Event TX_STATUS (16) received
mlan0: EVENT_TX_STATUS dst=00:11:32:ed:9e:b0 type=0 stype=13
Off-channel: Ignore Action TX status - no pending operation
nl80211: BSS Event 59 (NL80211_CMD_FRAME) received for mlan0
nl80211: RX frame da=c0:95:da:00:e5:38 sa=00:11:32:ed:9e:b0 bssid=00:11:32:ed:9e:b0
 freq=2422 ssi_signal=0 fc=0xd0 seq_ctrl=0x90 stype=13 (WLAN_FC_STYPE_ACTION) len=54
mlan0: Event RX_MGMT (18) received
mlan0: Received Action frame: SA=00:11:32:ed:9e:b0 Category=10 DataLen=29 freq=2422 MHz
WNM: RX action 7 from 00:11:32:ed:9e:b0
```

Figure 15 shows the example where the STA sends a BTM query to the AP 1.

- STA MAC= c0:95:da:00:e5:38
- AP MAC= dc:ce:c1:23:9a:4b

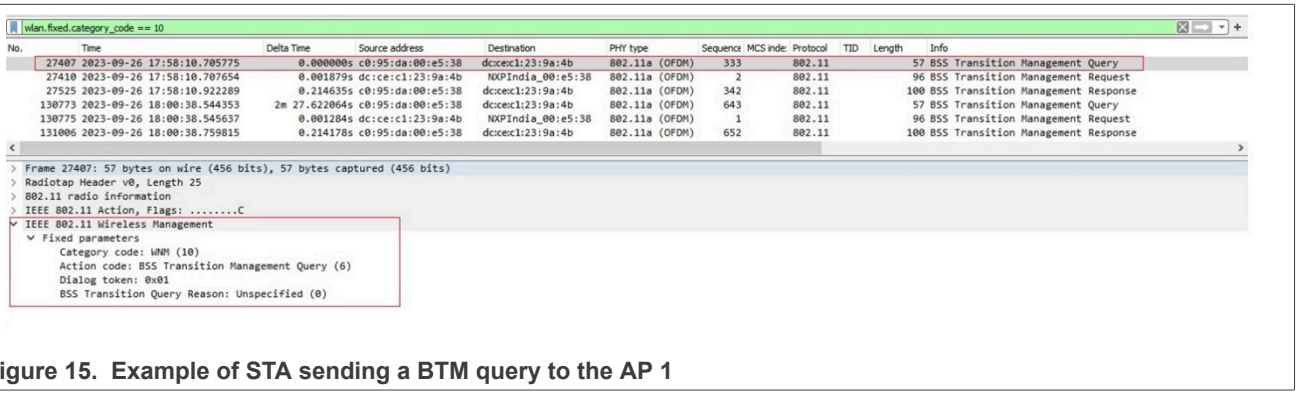

Figure 15. Example of STA sending a BTM query to the AP 1

Step 3 – AP 1 sends STA a BTM request with a preferred candidate list. The request is displayed on the console of the STA. The STA decides whether to roam or not based on this information.

dmesg output example:

```
WNM: BSS Transition Management Request: dialog_token=1 request_mode=0x1 disassoc_timer=0
 validity_interval=100
mlan0: WNM: Preferred List Available
WNM: Neighbor report tag 52
WNM: Subelement id=6 le[ 3172.532203] wlan: SCAN COMPLETED: scanned AP count=1
n=3
WNM: Subelement id=3 len=1
…
WNM: BSS Transition Candidate List
0: 00:11:32:ed:9e:b0 info=0x17 op_class=12 chan=3 phy=0 pref=1 freq=2422
WNM: Candidate list valid for 10240 ms
mlan0: WNM: Fetch current scan results from the driver for checking transition candidates
nl80211: Received scan results (1 BSSes)
nl80211: Scan results indicate BSS status with 00:11:32:ed:9e:b0 as associated
mlan0: WNM: No transition candidate matches existing scan results
WNM: Scan 1 frequencies based on transition candidate list
WNM: Scan only for a specific BSSID since there is only a single candidate
 00:11:32:ed:9e:b0
mlan0: Setting scan request: 0.000000 sec
mlan0: Starting AP scan for wildcard SSID
WPS: Building WPS IE for Probe Request
WPS:  * Version (hardcoded 0x10)
WPS:  * Request Type
WPS:  * Config Methods (3108)
WPS:  * UUID-E
WPS:  * Primary Device Type
WPS:  * RF Bands (3)
WPS:  * Association State
WPS:  * Configuration Error (0)
WPS:  * Device Password ID (0)
WPS:  * Manufacturer
WPS:  * Model Name
WPS:  * Model Number
WPS:  * Device Name
WPS:  * Version2 (0x20)
P2P: * P2P IE header
P2P: * Capability dev=25 group=00
P2P: * Listen Channel: Regulatory Class 81 Channel 6
mlan0: Optimize scan based on previously generated frequency list
mlan0: Scan a previously specified BSSID 00:11:32:ed:9e:b0 and SSID synology_wifi_2.4G
mlan0: Add radio work 'scan'@0xaaab1e40e190
mlan0: First radio work item in the queue - schedule start immediately
mlan0: Starting radio work 'scan'@0xaaab1e40e190 after 0.000030 second wait
mlan0: nl80211: scan request
nl80211: Scan for a specific BSSID: 00:11:32:ed:9e:b0
Scan requested (ret=0) - scan timeout 30 seconds
nl80211: Drv Event 33 (NL80211_CMD_TRIGGER_SCAN) received for mlan0
mlan0: nl80211: Scan trigger
```

Figure 16 shows an example of BTM query request from the AP to the STA.

- STA MAC= c0:95:da:00:e5:38
- AP MAC= dc:ce:c1:23:9a:4b
- Preferred candidate list with the AP BSSID = 00:a6:ca:42:8b (AP 2).
- Dissociation Imminent enabled. STA is forced to roam.

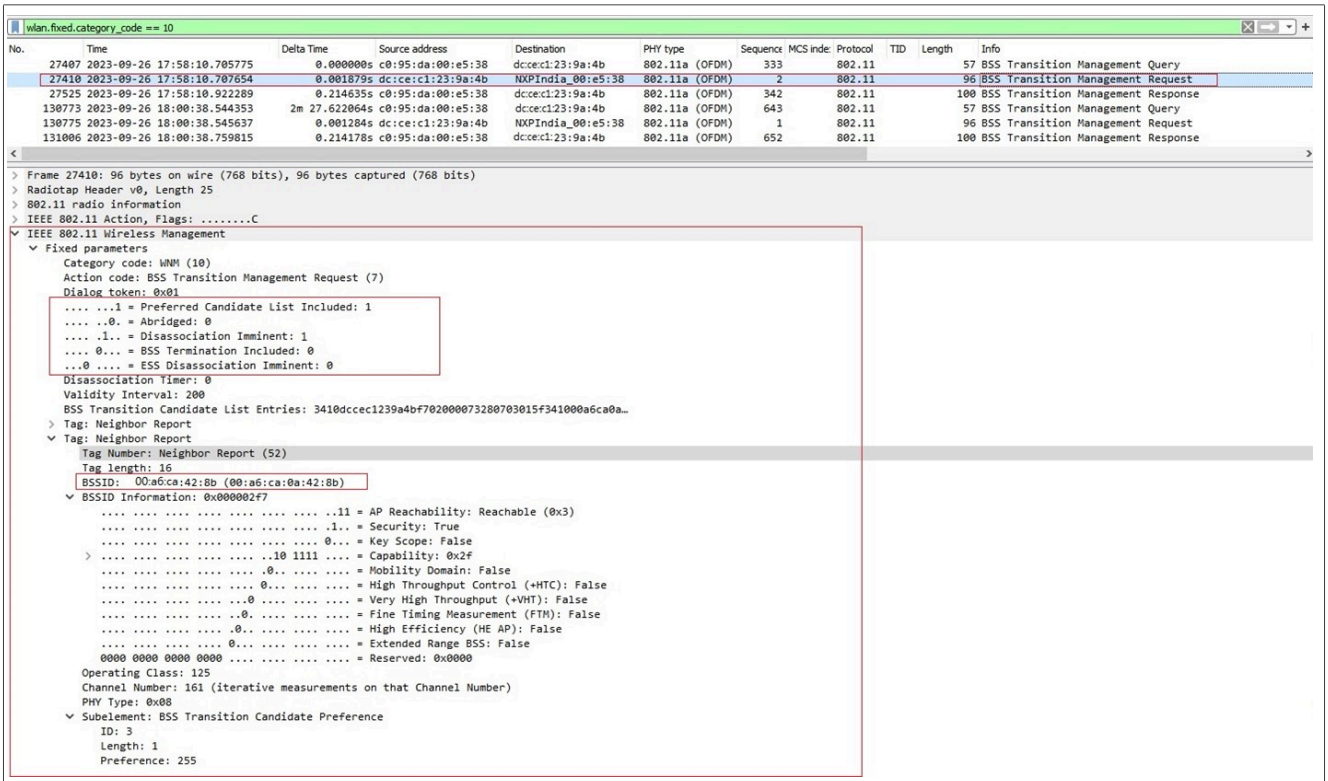

Figure 16. Example of BTM query request from the AP to the STA

Step 4 – STA responds to the request of AP1 to roam to a different AP.

Note: *STA roams using 802.11r. Refer to Section 9.*

Figure 17 shows an example of the STA response to AP 1 with the decision to roam to AP 2.

- STA MAC= c0:95:da:00:e5:38
- AP MAC= dc:ce:c1:23:9a:4b
- BSS Transition Target BSS = 00:a6:ca:42:8b (decides to roam to AP 2)

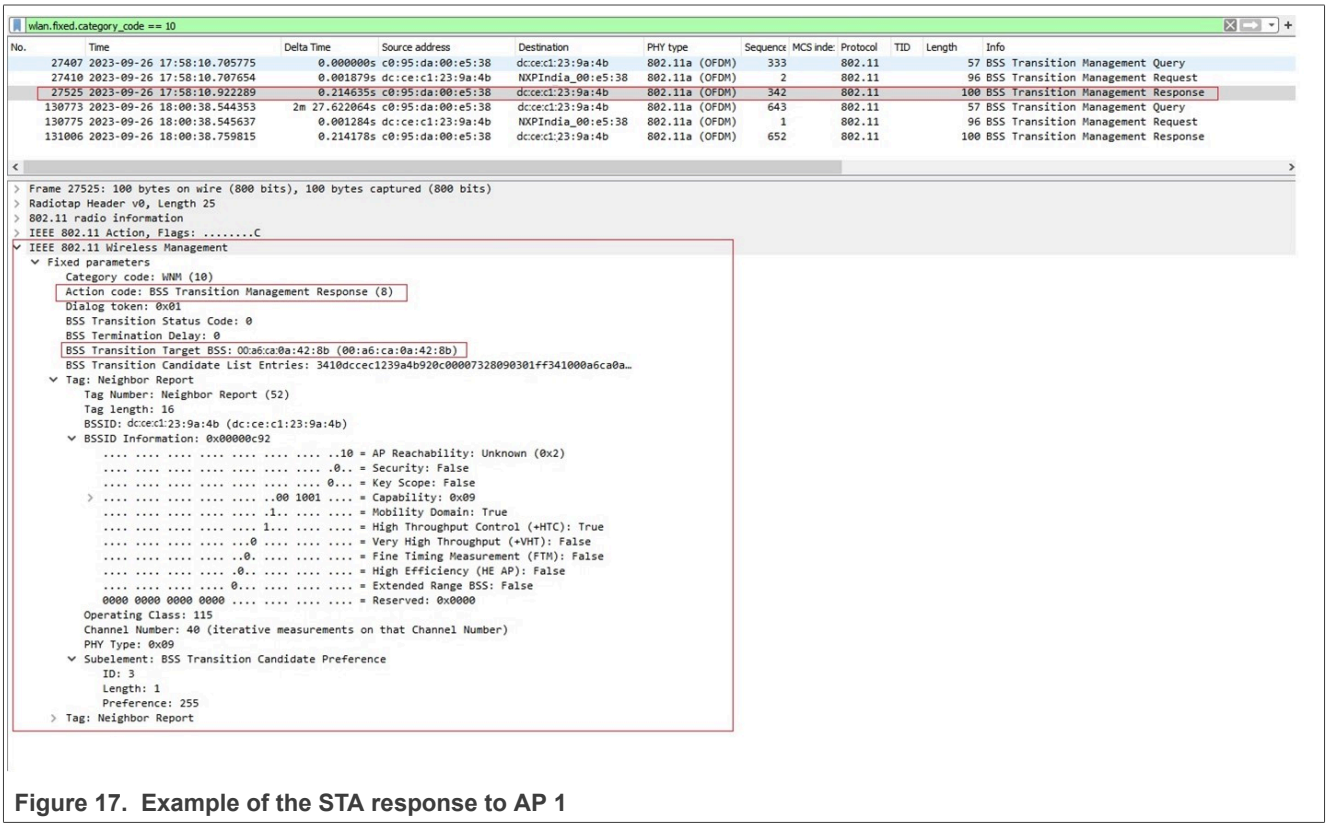

Figure 17. Example of the STA response to AP 1

8 802.11r examples

This section provides an example for over-the-air and over-the-distribution-system (over-the-DS) Fast Transition. A EAPoL key 4-way handshake is not required for FT.

8.1 Over-the-air fast transition (FT)

In Over-the-Air FT, the STA directly communicates with the target AP using IEEE 802.11 FT-Auth and FT-(Re)Association during the FT association flow. The capability for FT is advertised in the Beacon Mobility Domain Information Element of the AP.

In this example, the wireless LAN controller is configured for over-the-air FT. The STA is connected to AP1 at location A. As the STA moves closer to AP2 at location B, the received signal strength from AP1 drops below the set signal threshold. The STA automatically switches to AP2.

wpa_supplicant handles Over-the-Air FT. The following wpa_cli command can also be used to manually trigger Over-the-Air FT.

```
./wpa_cli -i mlan0 ROAM  <MACaddress of Target AP >
```

Figure 18 shows Over-the-Air FT communication. The arrows represent the Over-the-Air FT sequence:

1. Authentication
2. Authentication
3. Reassociation Request
4. Reassociation Response

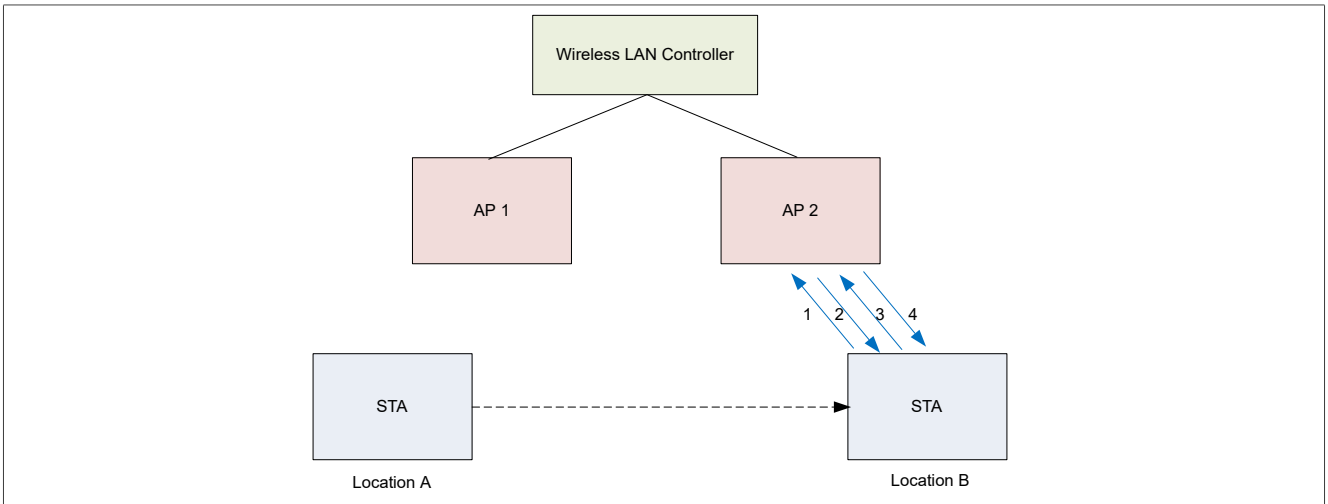

Figure 18. Over-the-air FT communication

Step 1 – Set up the environment (Section 5).

Step 2 – Move STA closer to AP 2 until the signal strength from AP1 is less than the threshold.

Step 3 – STA roams from AP 1 to AP 2, which is also shown on the console.

Command output example:

```
wlan: send out FT auth,wait for auth response
wlan : FT response  target AP 08:XX:XX:XX:2f:90
wlan: FT auth received
Fast BSS Transition use ft-over-air
wlan: Fast Bss transition to bssid 08:XX:XX:XX:2f:90 successfully
```

Figure 19 shows a sniffer capture example of Over-the-Air FT.

- AP 1 MAC= `08:cc:68:b4:2b:a0`
- STA MAC= `00:50:43:22:10:72`
- AP 2 MAC= `08:cc:68:b4:2f:90`
- Over-the-Air Transition sequence of Authentication, Authentication, Reassociation Request, and Reassociation Response.

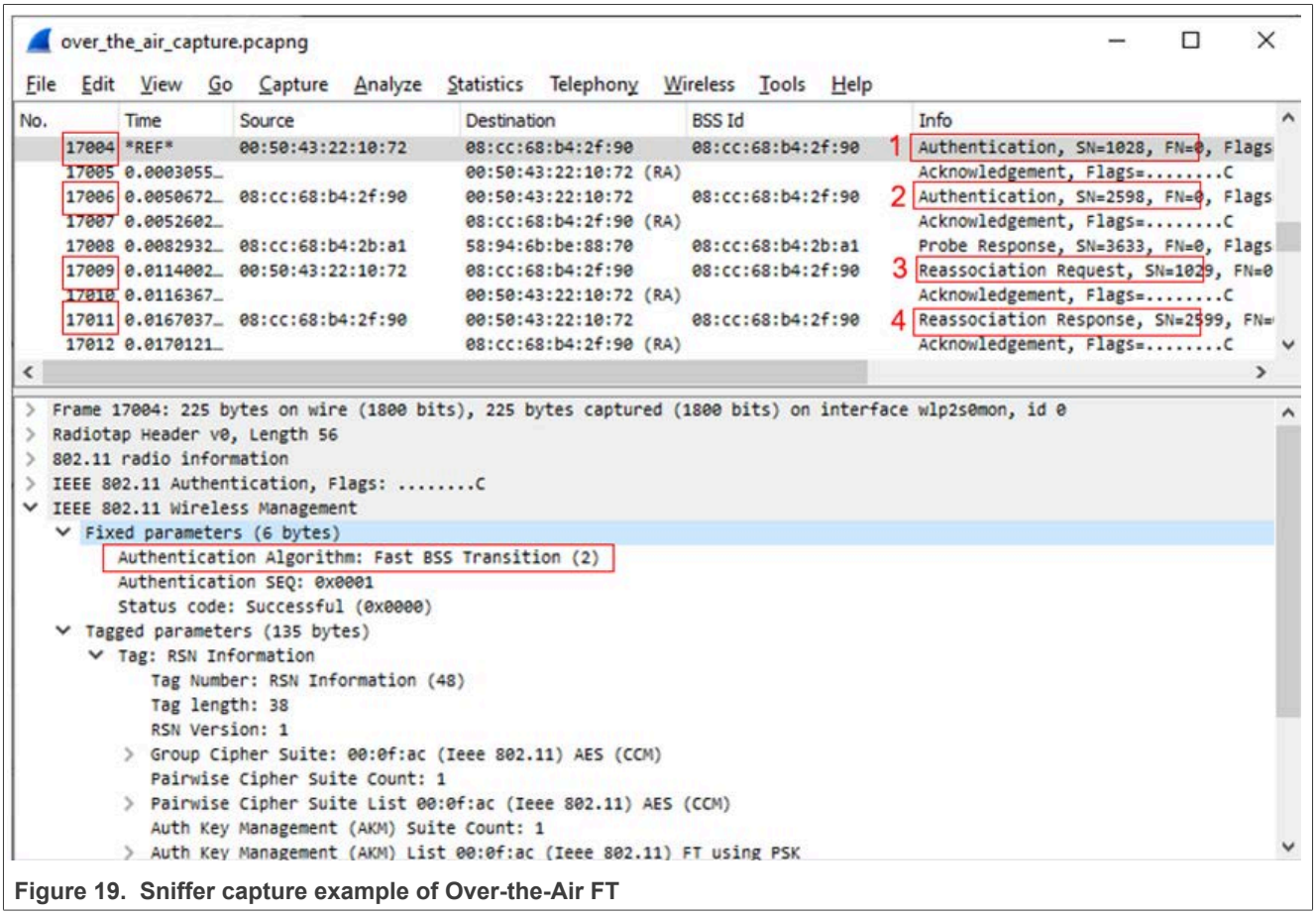

Figure 19. Sniffer capture example of Over-the-Air FT

8.1.1 Over-the-Air FT flow

The Figure 20 shows the interaction between the wpa_supplicant, Wi-Fi driver, and firmware.

The wpa_supplicant commands (in uppercase) are defined in *hostap/src/drivers/nl80211_copy.h*.

For more details about the driver to firmware APIs, refer to [1], [2], [3], and [4].

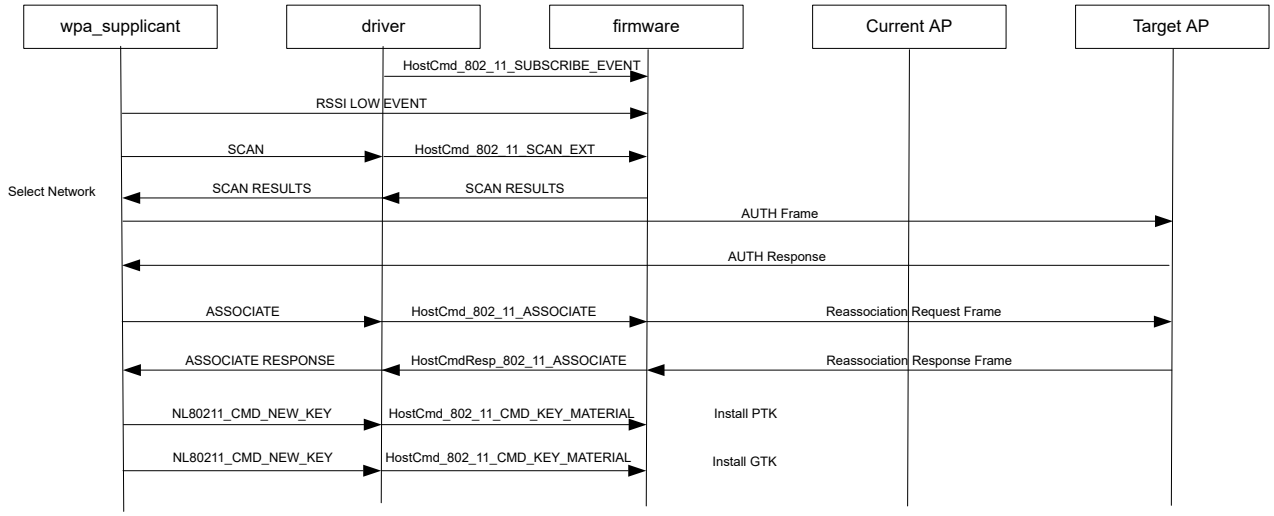

Figure 20. Over-the-Air FT flow

8.2 Over-the-DS fast transition (FT)

In over-the-DS FT, the STA communicates with the target AP through the current AP. STA sends IEEE 802.11 FT action frames to the current AP, which forwards the frames to the target. The capability for FT is advertised in the Beacon Mobility Domain Information Element of the AP.

In this example, the wireless LAN controller is configured for Over-the-DS FT. The STA is connected to AP1 at location A. When the STA moves closer to AP2 at location B, the received signal strength from AP1 drops below the set signal threshold. The STA is triggered to roam to AP 2 when the wpa_supplicant command is issued.

Note: *Open source wpa_supplicant does not support automatic roaming Over-the-DS.*

The command to manually trigger Over-the-DS FT is:

```
./wpa_cli -i mlan0 FT_DS  <MACaddress of Target AP >
```

Figure 21 shows Over-the-DS FT communication. The arrows represent the FT Over-the-DS sequence:

1. Action Frame (Fast Transfer Request)
2. Action Frame (Fast Transfer Response)
3. Reassociation Request
4. Reassociation Response

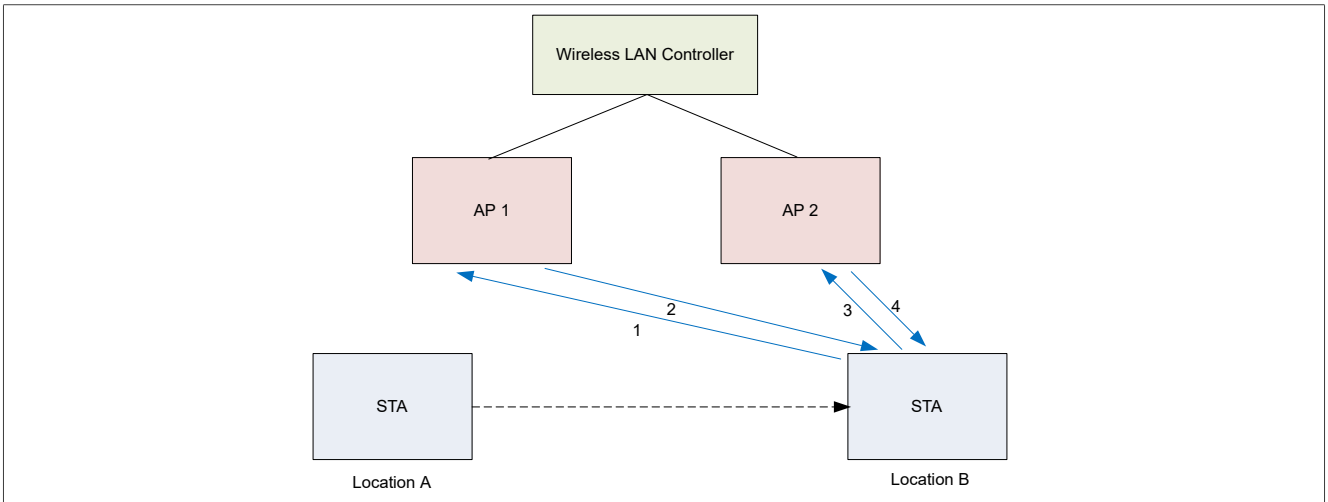

Figure 21. Over-the-DS FT communication

Step 1 – Set up the environment (Section 5).

Step 2 – Move STA closer to AP 2, where the signal strength from AP 1 will be less than the threshold.

Step 3 – Run the `wpa_cli` command to trigger Over-the-DS FT.

```
./wpa_cli -i mlan0 FT_DS  <MACaddress of Target AP >
```

Step 4 – The STA roams from AP 2 to AP 1 (also shown on the console).

Output example:

```
wlan: send out FT request,wait for FT response
wlan : FT response  target AP 08:XX:XX:XX:2f:90
wlan: received FT response
Fast BSS transition to bssid 08:XX:XX:XX:2f:90 successfully
```

Figure 22 shows a sniffer capture example of Over-the-DS FT.

- AP 1 MAC= 08:cc:68:b4:2b:a0
- STA MAC= 00:50:43:22:10:72
- AP 2 MAC= 08:cc:68:b4:2f:90
- Over-the-DS FT sequence of Action, Action, Reassociation Request, and Reassociation Response.

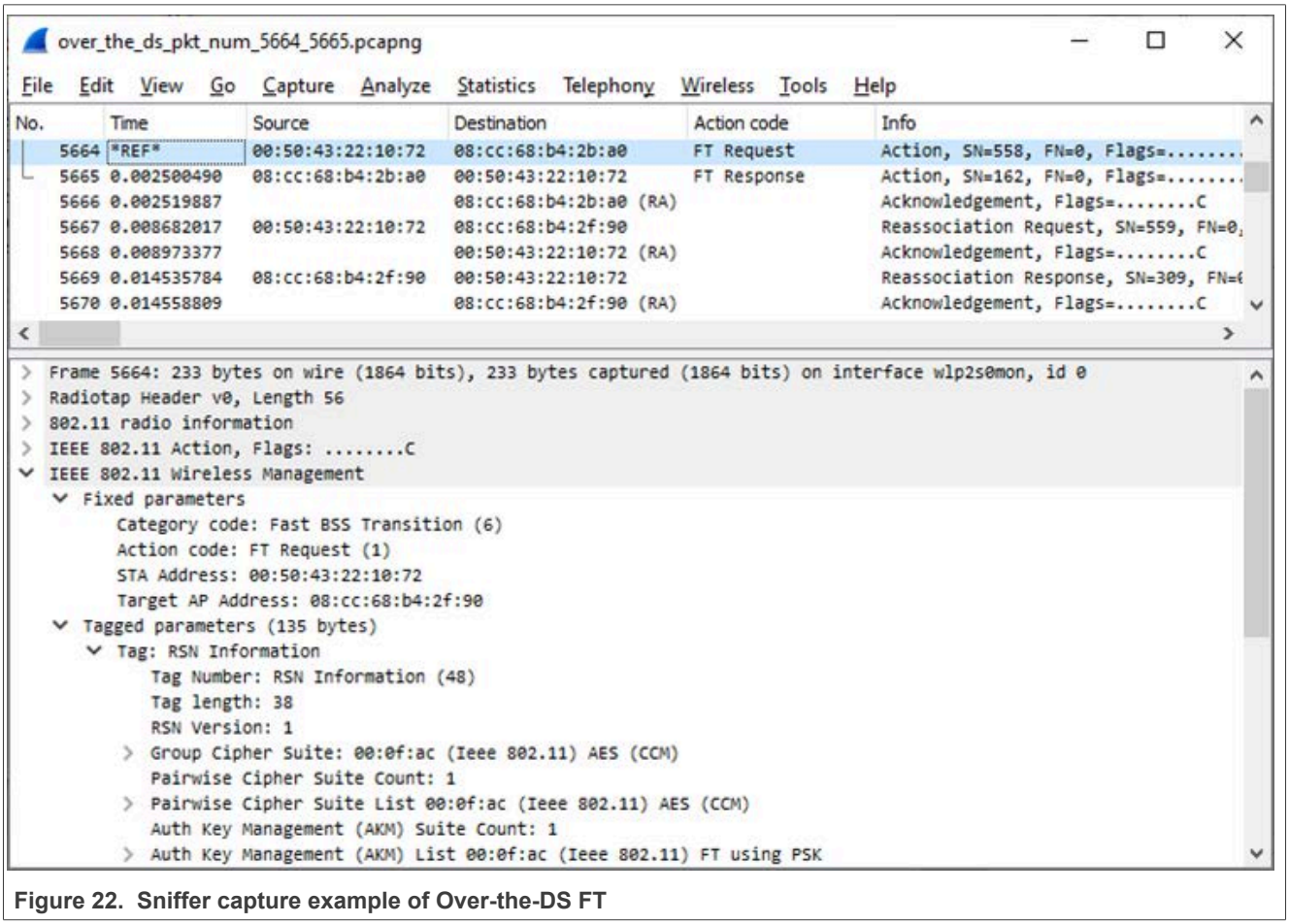

Figure 22. Sniffer capture example of Over-the-DS FT

8.2.1 Over-the-DS FT flow

Figure 23 shows the interaction between the wpa_supplicant, Wi-Fi driver, and firmware.

The wpa_supplicant commands (in uppercase) are defined in *hostap/src/drivers/nl80211_copy.h*.

For more details about the driver to firmware APIs, refer to [1], [2], [3], and [4].

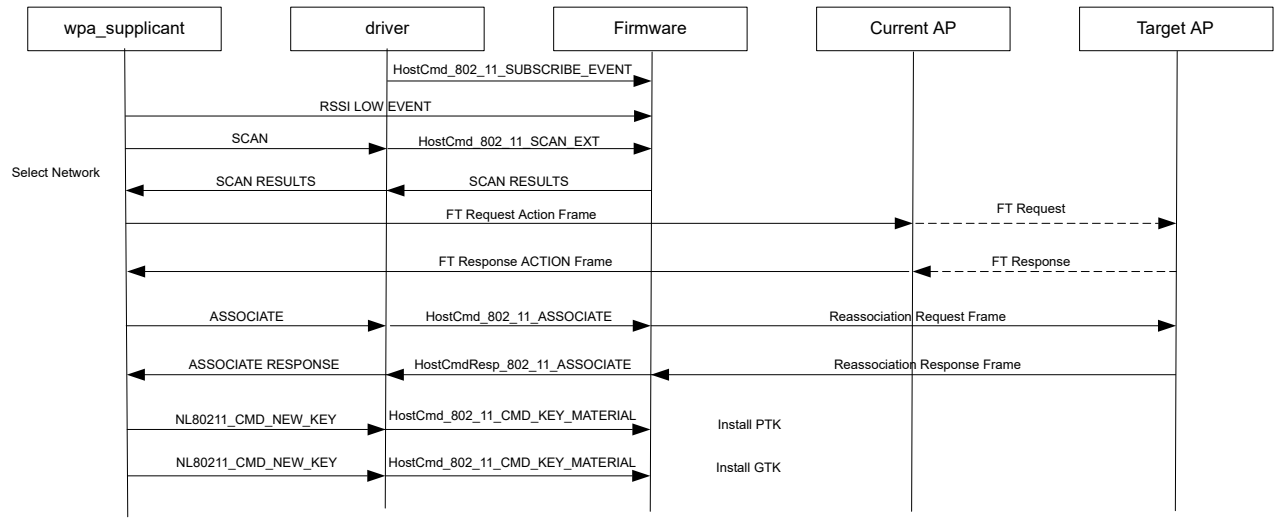

Figure 23. Over-the-DS FT flow

9 Abbreviations

Table 2. Abbreviations

Abbreviation	Description
AP	Access point
bgscan	Background scan
BSS	Basic service set
BTM	BSS transition management
DS	Distribution system
DUT	Device under test
ESS	Extended service set
FT	Fast transition
MLME	MAC sublayer management entity
RRM	Radio resource management
RSSI	Receive signal strength indication
STA	Station
WNM	Wireless network management
wpa_cli	Command line interface for wpa_supplicant

10 References

[1] Application note – AN13296: Embedded Wi-Fi Subsystem API Specification V16 (link)
[2] Application note – AN13297: Embedded Wi-Fi Subsystem API Specification V17 (link)
[3] Application note – AN13538: Embedded Wi-Fi Subsystem API Specification V18 (link)
[4] Application note – AN14314: Embedded Wi-Fi Subsystem API Specification for AW692/AW693 (link)
[5] Webpage – 88W8987: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 5 (802.11ac) + Bluetooth® Solution (link)
[6] Webpage – 88W8997: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 5 (802.11ac) + Bluetooth® Solution (link)
[7] Webpage – 88Q9098: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 6 (802.11ax) + Bluetooth® Automotive Solution (link)
[8] Webpage – 88W9098: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 6 (802.11ax) + Bluetooth® (link)
[9] Webpage – AW611: 2.4/5 GHz Dual-band 1x1 Wi-Fi® 6 (802.11ax) + Bluetooth® Automotive Solution (link)
[10] Webpage – AW690: Wi-Fi® 6 1x1 Concurrent Dual Wi-Fi (CDW) and Bluetooth® Combo SoC (link)
[11] Webpage – AW692: 2x2 Single-band (5 GHz) Concurrent Dual Wi-Fi® 6, 1x1 (2.4 GHz) Wi-Fi 6, and Bluetooth® Combo Solution (link)
[12] Webpage – AW693: 2x2 Dual-band (5-7 GHz), 1x1 (2.4 GHz) Concurrent Dual Wi-Fi 6/6E and Bluetooth Combo Solution (link)
[13] Webpage – IW416: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 4 (802.11n) + Bluetooth® Solution (link)
[14] Webpage – IW611: 2.4/5 GHz Dual-band 1x1 Wi-Fi® 6 (802.11ax) + Bluetooth® Solution (link)
[15] Webpage – IW612: 2.4/5 GHz Dual-Band 1x1 Wi-Fi® 6 (802.11ax) + Bluetooth® + 802.15.4 Tri-radio Solution (link)
[16] Webpage – IW620: 2.4/5 GHz Dual-Band 2x2 Wi-Fi® 6 (802.11ax) + Bluetooth® Solution (link)
[17] Webpage – Linux WPA/WPA2/WPA3/IEEE 802.1X Supplicant (link)

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12 Revision history

Table 3. Revision history

Document ID	Release date	Description
AN14212 v.2.0	13 January 2025	• Changed the access of the document to public. • Supersedes AN13888 – 802.11r and fast transition (FT).
AN14212 v.1.0	22 August 2024	• Initial version

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