

AN13888

802.11r Roaming with Fast Transition (FT)

Rev. 2 — 1 July 2024

Application note

Document information

Information	Content
Keywords	802.11r, roaming, bgscan, wpa_suplicant, fast transition
Abstract	Introduces the types of fast transition and describes how to enable fast transition.



1 Introduction

NXP Wi-Fi radios support IEEE 802.11r roaming implemented with Fast Transition (FT). Fast Transition is faster than normal roaming because it avoids a 4-way handshake when transitioning from one AP to another. This document explains how to enable the two types of fast transition.

1.1 Supported products

The following wireless SoCs support 802.11r:

- 88W8897
- 88W8987
- 88W8997
- 88W9098
- IW416
- IW611
- IW612

Note: Refer to the feature list in the respective product software release package to check that 802.11r is supported.

1.2 References

Table 1. Reference list

Reference type	Description
Web page	Open source wpa_supplicant (link)
Application note	AN13296 - Embedded Wi-Fi Subsystem API specification v16 (link)
Application note	AN13297 - Embedded Wi-Fi Subsystem API specification v17 (link)
Application note	AN13538 - Embedded Wi-Fi Subsystem API specification v18 (link)

1.3 Notation conventions

This document employs the following notation conventions:

- Commands and examples of command outputs are shown in paragraphs with grey background color

```
This is an example of command
```

- Terms related to commands use a monospace font:
 - parameter
 - option
 - command name
- File names, directory names and paths are shown in *italics*:
 - <file name>.<extension>
 - <directory>
 - path/to/directory/and/file

2 Configuration

This section describes how to enable the fast transition feature.

2.1 Driver

When loading the drivers, use the following parameters to enable fast transition:

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

Example of command to load the driver:

```
insmod wlan.ko
insmod sdxxx.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 `drvdbg = 0x20037` is optional and used to log FT messages on `dmesg`.

2.2 wpa_supplicant

Note: *wpa_supplicant* version 2.7 or above is required for Fast Transition.

Step 1 - Enable `IEEE80211R` parameter in `hostap/wpa_supplicant/.config` file

```
CONFIG_IEEE80211R=y
```

Step 2 - Compile `wpa_supplicant`.

```
make
```

Step 3 - Edit `wpa_supplicant.conf` file

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 `key_mgmt` parameter to FT-PSK or FT-EAP.

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

- Set the background scanning parameters, `bgscan`

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

Where:

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:

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

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

Step 4 - Run `wpa_supplicant`.

```
wpa_supplicant -B -Dnl80211 -imlan0 -c/etc/wpa_supplicant.conf
```

3 Types of fast transition

The two types of fast transition are over-the-air and over-the-distribution-system (over-the-DS).

3.1 Over-the-air fast transition

In over-the-air fast transition, the STA directly communicates with the target AP using IEEE 802.11 FT-Auth and FT-(Re)Association during the fast transition association flow.

The capability for fast transition is advertised in the Beacon Mobility Domain Information Element of the AP.

Command to trigger fast transition over-the-air:

```
wpa_cli -i wlan0 ROAM <MAC address of Target AP >
```

3.2 Over-the-DS fast transition

In over-the-DS fast transition, 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 fast transition is advertised in the Beacon Mobility Domain Information Element of the AP.

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

Command to trigger fast transition over-the-DS:

```
wpa_cli -i wlan0 FT_DS <MAC address of Target AP >
```

4 Examples

4.1 Over-the-air fast transition

To test over-the-air fast transition, follow these steps:

Step 1 - Configure the wireless LAN controller for Over-the-Air Fast Transition.

Step 2 - Connect both Access points, AP1 and AP2, to the wireless LAN controller.

Step 3 - Configure the DUT as described in Section 3.1 and 3.2 and connect the DUT to AP1.

Step 4 - Move the DUT closer to AP2 until the signal strength from AP1 is less than the threshold

Step 5 - Check that the sniffer capture has the following Over-the-Air sequence:

1. Authentication
2. Authentication
3. Reassociation request
4. Reassociation response

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

[Figure 1](#) shows an example of over-the-air fast transition set-up. The arrows represents the over-the-air fast transition sequence:

1. Authentication
2. Authentication
3. Reassociation request
4. Reassociation response

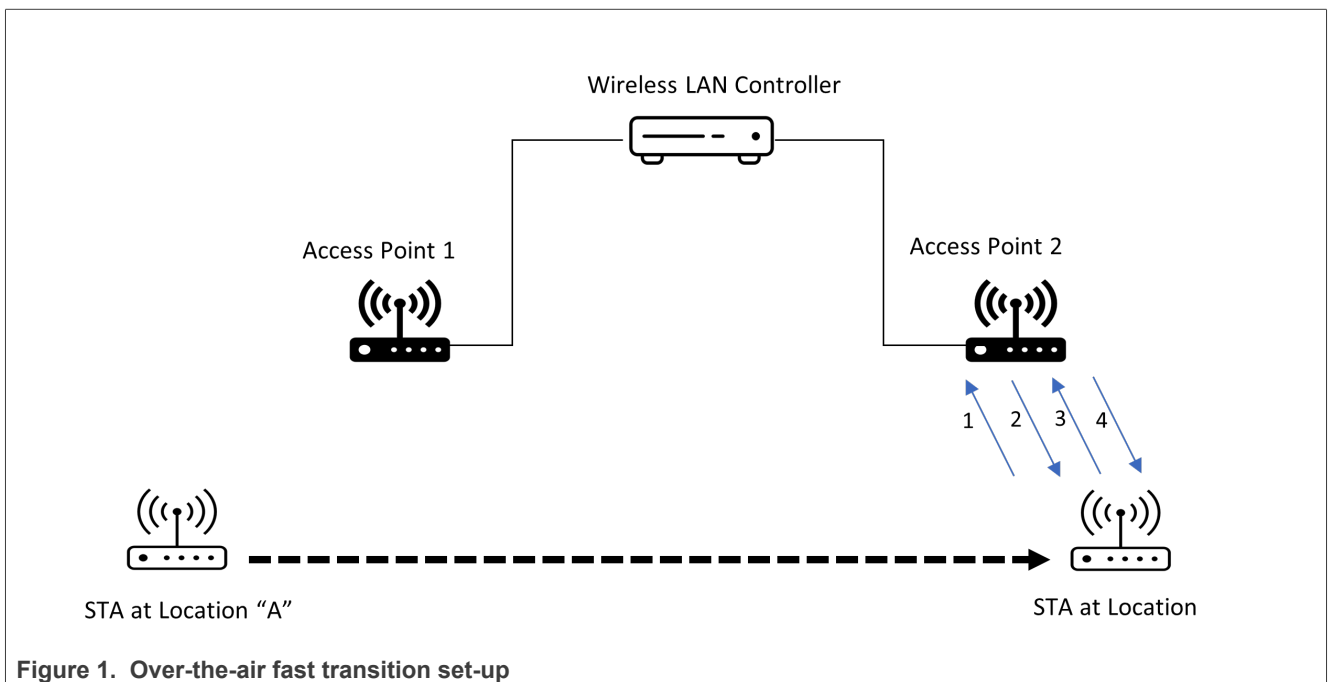


Figure 1. Over-the-air fast transition set-up

Figure 2 shows a screen capture of Over-the-Air Fast Transition in a packet.

- AP1 MAC address of 08:cc:68:b4:2b:a0
- STA MAC address of 00:50:43:22:10:72
- AP2 MAC address of 08:cc:68:b4:2f:90

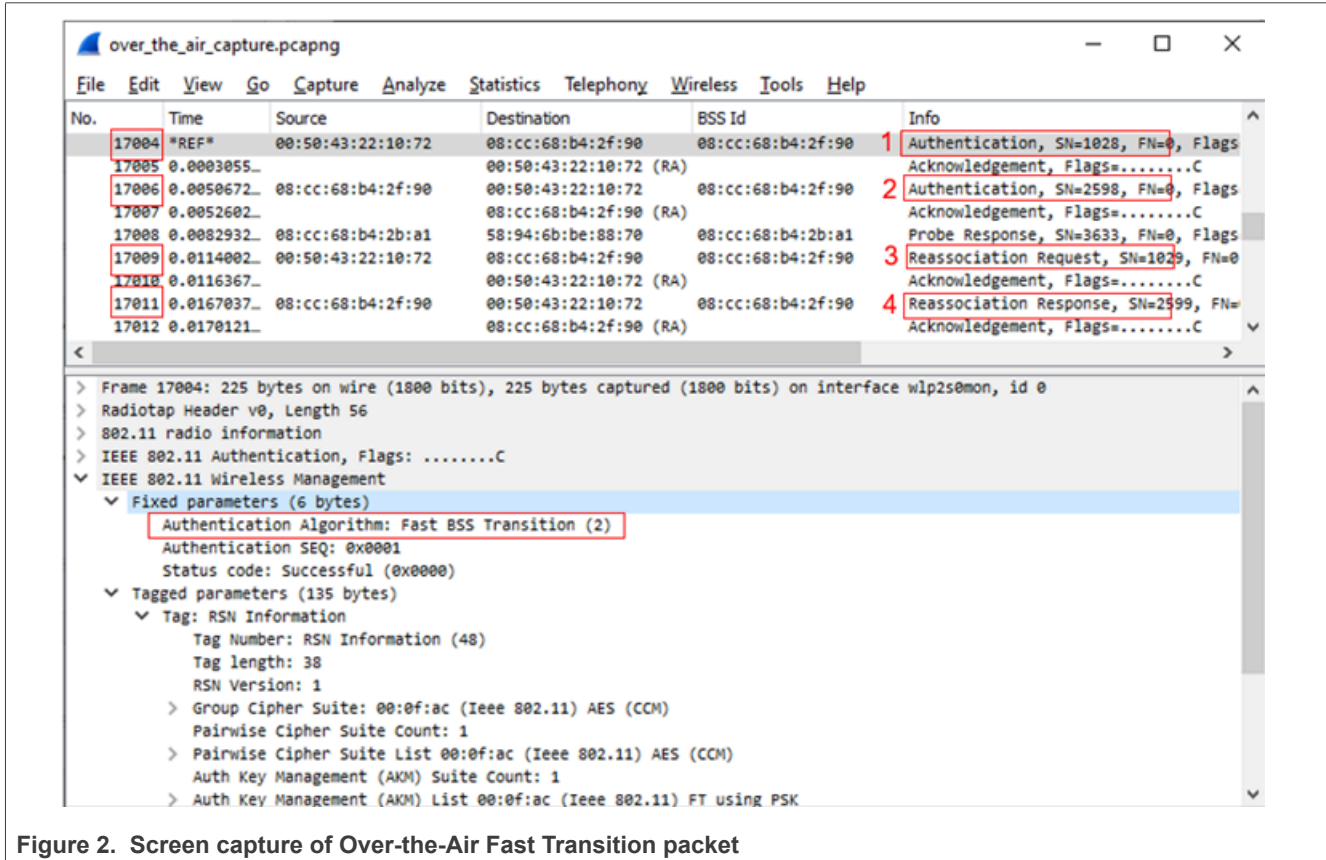


Figure 2. Screen capture of Over-the-Air Fast Transition packet

Example of dmesg log:

```
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
```

4.2 Over-the-DS fast transition

To test over-the-DS fast transition, follow these steps:

Step 1 - Configure Wireless LAN Controller for over-the-DS fast transition.

Step 2 - Connect the access points AP1 and AP2 to the Wireless LAN Controller.

Step 3 - Configure the DUT as described in Section 3.1 and 3.2 and connect the DUT to AP1.

Step 4 - Move the DUT closer to AP2, where the signal strength from AP1 is less than the threshold.

Step 5 - Run `wpa_cli` command to trigger over-the-DS fast transition.

```
wpa_cli -i wlan0 FT_DS <MAC address of Target AP>
```

Step 6 - Check that the sniffer capture has the following over-the-DS fast transition sequence:

1. Action frame (fast transfer request)
2. Action frame (Fast Transfer Response)
3. Reassociation request
4. Reassociation response

In this example, the wireless LAN controller is configured for over-the-DS fast transition. The STA is connected to AP1 at location A. When the STA moves closer to AP2 at location B, the receive signal strength from AP1 drops below the set signal threshold. STA is triggered to switch to AP2 when the `wpa_cli` command is issued ([step 5](#))

[Figure 3](#) shows over-the-DS fast transitions. The arrows represent over-the-DS fast transition sequence:

1. Action frame (fast transfer request)
2. Action frame (fast transfer response)
3. Reassociation request
4. Reassociation response

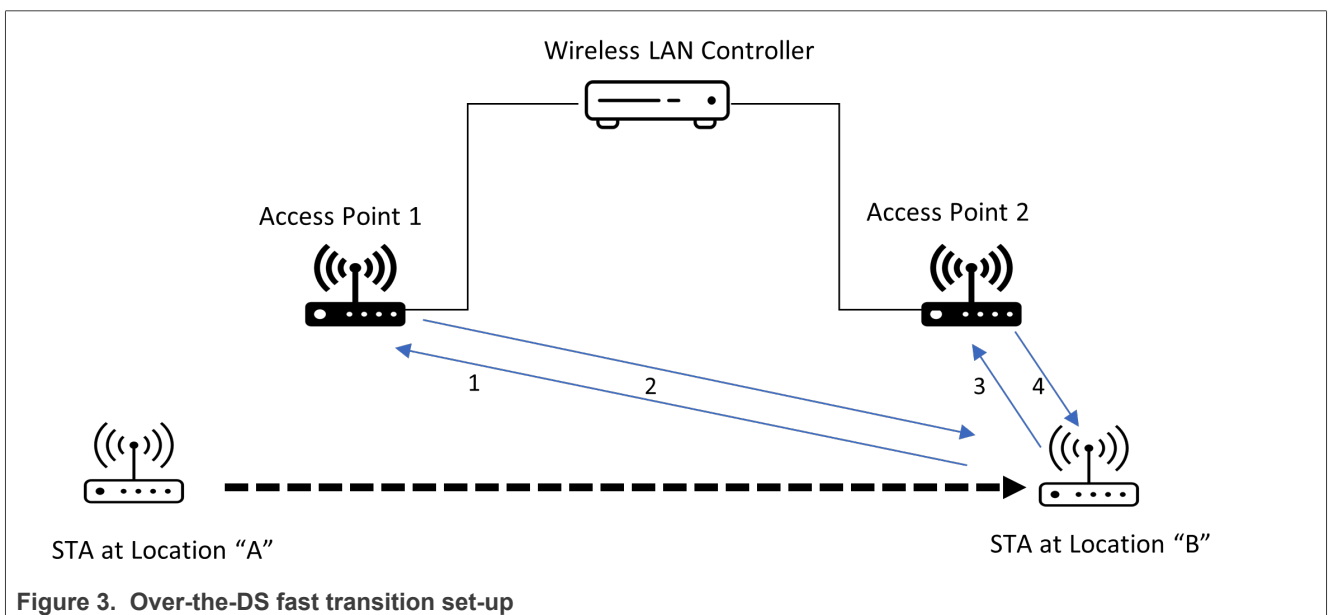


Figure 3. Over-the-DS fast transition set-up

Figure 4 shows a screen capture of over-the-DS fast transition in a packet with:

- AP1 MAC address: 08:cc:68:b4:2b:a0
- STA MAC address: 00:50:43:22:10:72
- AP2 MAC address: 08:cc:68:b4:2f:90

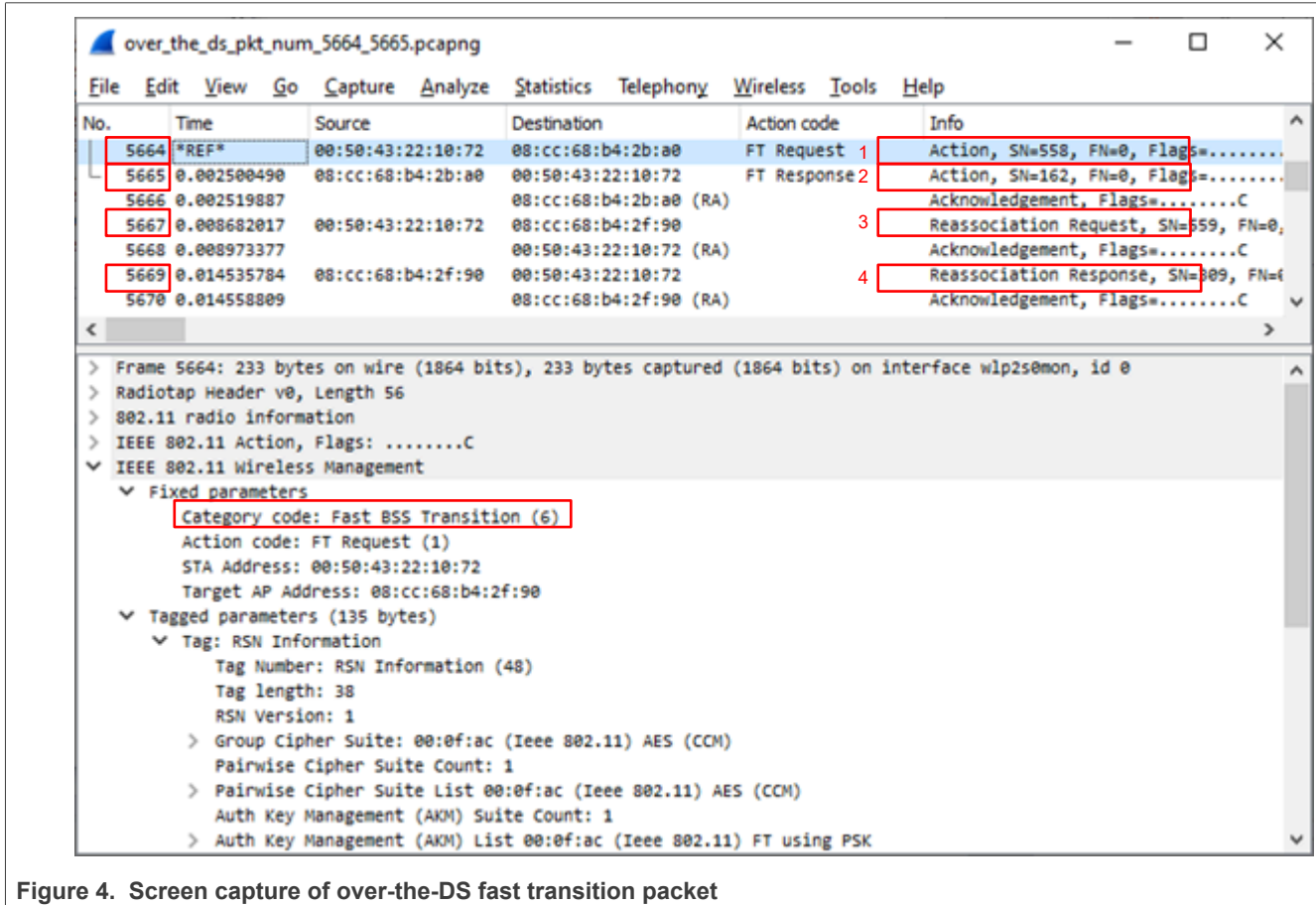


Figure 4. Screen capture of over-the-DS fast transition packet

Example of dmesg log:

```
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
```

5 Fast transition flow

The section includes illustrations of the interaction between wpa_supplicant, the Wi-Fi driver and the firmware.

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

For more details about the driver to firmware APIs, refer to *Embedded Wi-Fi Subsystem API Specifications (Section 1.2)*.

Figure 5 shows the flow for over-the-air fast transition.

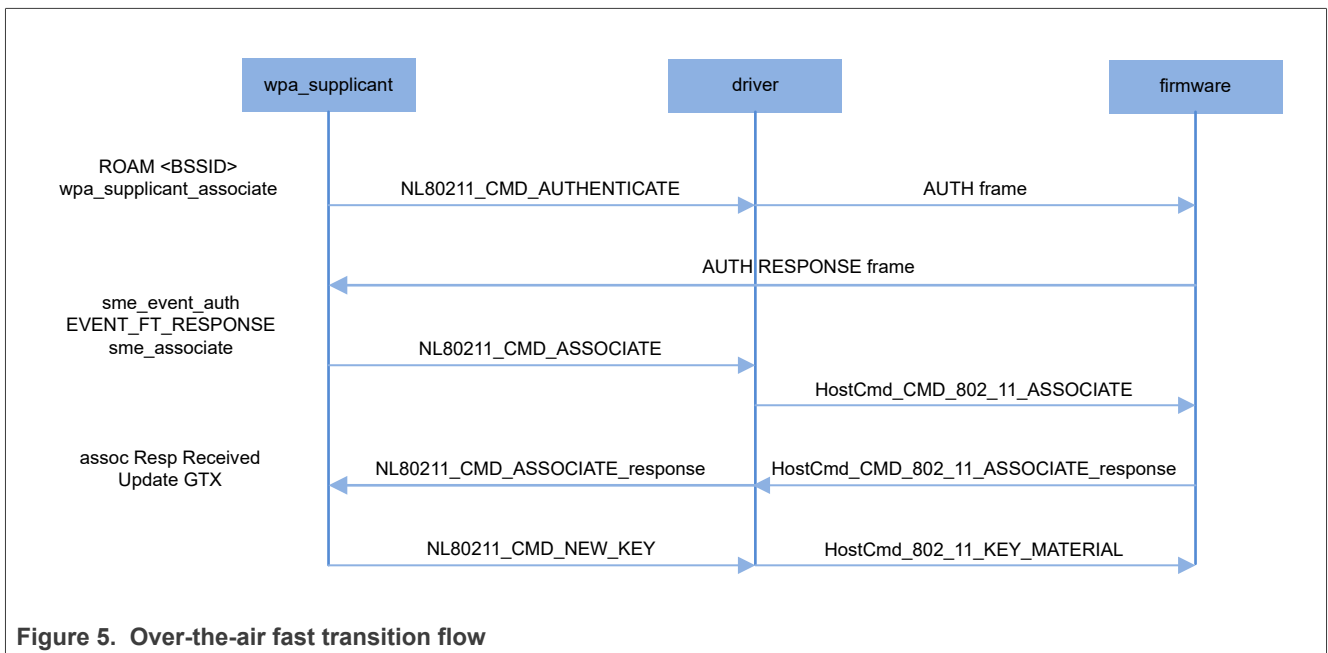
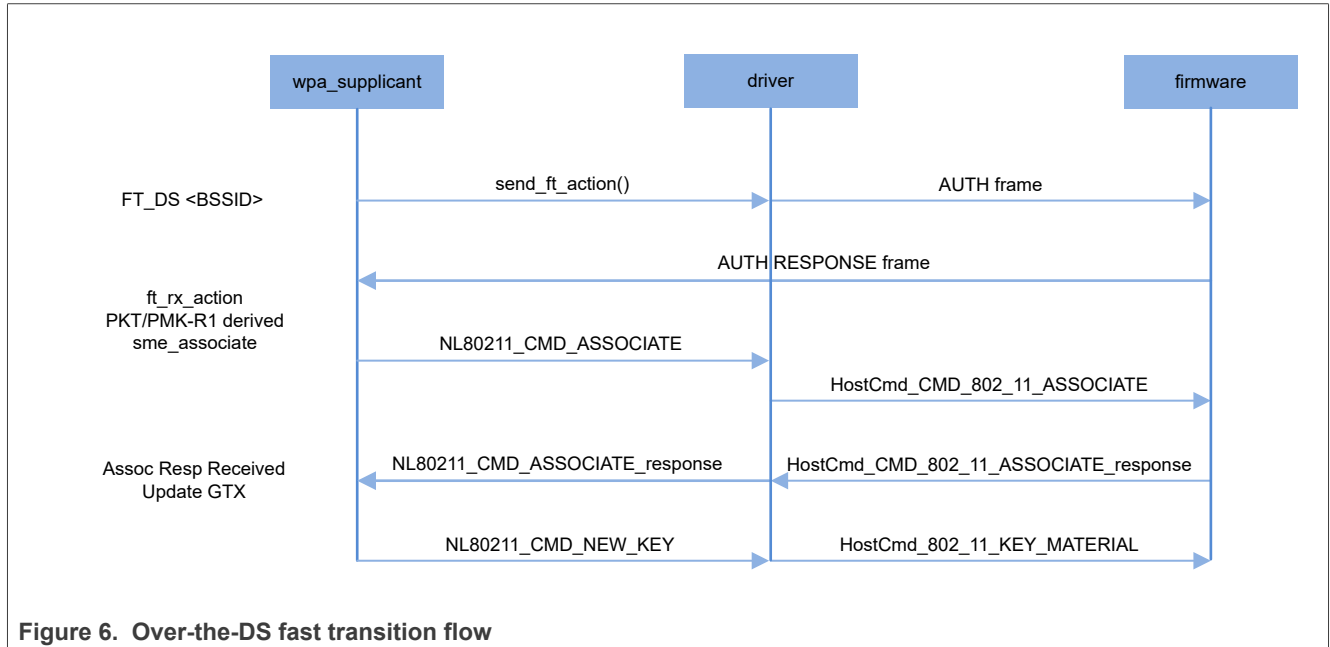


Figure 6 shows the flow for over-the-DS fast transition.



6 Note about the source code in the document

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7 Acronyms and abbreviations

Table 2. Acronyms and abbreviations

Acronym	Definition
AP	Access point
bgscan	Background scan
DS	Distribution system
DUT	Device under test
FT	Fast transition
MLME	Mac layer management entity
RSSI	Receive signal strength indication
STA	Station
wpa_cli	Command line interface to <i>wpa_supplicant</i>

8 Revision history

Table 3. Revision history

Document ID	Release date	Description
AN13888 v.2	01 July 2024	<ul style="list-style-type: none">• Changed the access from confidential to public.
AN13888 v.1	04 August 2023	<ul style="list-style-type: none">• Initial version

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