MT793X IoT SDK for Firmware Update Developer's Guide

Version: 0.1

Release date: 2021-06-11

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Version History

Version	Date	Description
0.1	2021-06-11	Initial draft

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1   Overview

MediaTek IoT SDK enables firmware over the air (FOTA) update, a widely adopted cost and time efficient solution to update the firmware on connected devices. The purpose of this developer's guide is to provide a complete description on how to deploy FOTA on the NOR flash.

This document guides you through:

- FOTA architecture layout.
- FOTA update on MediaTek IoT development platform.
- FOTA update workflow using the **CLI.**

A complete list of FOTA features for MediaTek IoT development platform is provided below.

- Full image update: The image Flash partition is the partition that can run the firmware directly. In full image update, there is only one image Flash partition in the Flash layout. The FOTA package file is first downloaded to the FOTA Flash partition and is later updated to the image Flash Partition.
- FOTA packaging tool
- FOTA update through Wi-Fi
- Command line operation (example)

Currently, the SDK provides the full image update mechanism and provides source code for customization. The SDK can then be customized to integrate third party solution to provide other (for example, incremental) update mechanisms.

1.1 Feature Support Status on Chips

The MediaTek IoT SDK development platform is an integrated solution with limited availability of FOTA features on each chip. A summary of the supported features is shown in Table 1 FOTA feature support status on chips.

- MediaTek IoT SDK for Wi-Fi: MT7931/MT7933

Table 1 FOTA feature support status on chips

Product Line	Chip	Full image FOTA update	Dual image FOTA update	Update through Bluetooth	Update through Wi-Fi
MT793X	MT7931	V			V
MT793X	MT7933	V			V

1.2 Coverage of This Document

Figure 1 shows the complete cycle of product development and FOTA. This document covers the FOTA related parts, including packing a FOTA package, the download phase, and upgrade phase.

Figure 1 FOTA development and FOTA cycle
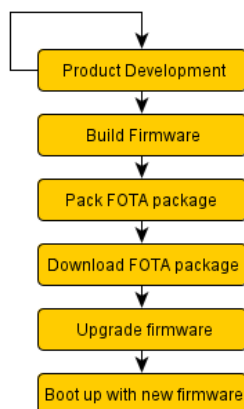
1.3 Architecture Layout of the SDK FOTA Feature

1.3.1 Upgrade over Wi-Fi Overview
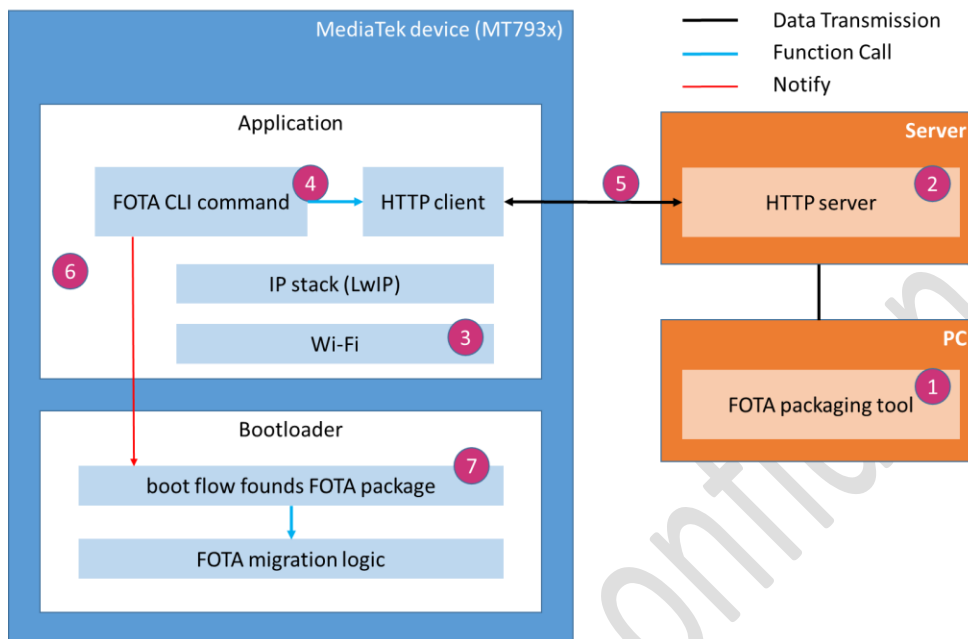
Figure 2 FOTA architecture layout for updating the firmware through Wi-Fi

The steps of updating through Wi-Fi in Figure 2 is illustrated step-by-step below.

1. Step 1 is to pack a FOTA package for upgrading a target device.
2. Keeps the package from step 1 on an HTTP server that target device can access via a Wi-Fi connection.
3. Start to connect to Wi-Fi network and make sure the HTTP server can be accessed.
4. Use CLI command to start a download procedure to fetch the prepared FOTA package into the upgrade space on NOR flash.
5. HTTP client fetches data into NOR flash.
6. Use CLI command to set a flag to notify the status of a new FOTA image is ready.
7. The bootloader receives the notification and calls FOTA migration API to process the update on the target device.

2   Using FOTA Update

2.1   FOTA Packaging Tool

MediaTek provides a FOTA packaging tool that runs on Microsoft Windows to compress data, and generate a checksum and prefix header for the new binary FOTA package file.

During the first phase of the update process, the download phase, under a running application image, the tool fetches the FOTA package file via supported protocol.

The second phase of update process is update phase, where under a running bootloader image, the tool parses the header, validates the package file using the checksum, and identifies where the data should be written.

2.1.1 Using Microsoft Windows Version of the FOTA Packaging Tool

Table 2 FOTA packaging tool's folder content on Windows PC

Folders and Files	Description
atl	Abstract template library, needed by FOTARomPacker.
FOTARomPacker	Source code of FOTARomPacker.
Release\FOTARomPacker.exe	Prebuilt executable of FOTARomPacker.
template_ini\mt7931\FOTARomPacker.ini	A sample config file for generating a FOTA image of an MT7931 RTOS image.
template_ini\mt7933\FOTARomPacker.ini	A sample config file for generating a FOTA image of an MT7933 RTOS image.
FOTARomPacker.sln	Visual Studio 2013 Solution file of FOTA packer. Open this with Visual Studio 2013 to develop/customize.

To use the FOTA packaging tool:

1. Copy the new binary to the top level directory of the extracted FOTA packaging tool folder.

2. Configure the corresponding FOTARomPacker.ini under _ini folder.

a) Set the load path to the line below [General Setting] as shown in Figure 3.

b) Set the binary file's name (File) and the start address (Start_Address) of this binary in the flash.

c) Set the size of the partition where the binary is written.

d) Configure the setting to compress the binary if needed. The LZMA compression is applied if the value of Is_Compressed is true.

3. Execute the FOTARomPacker.exe to generate a FOTA package file at the top level directory of the extracted FOTA packaging tool folder.

For example:

Command
c:
cd \mt793x_fota_rom_packer_win-2021-06-09
Release\FOTARomPacker.exe -i template_ini\mt7931\FOTARomPacker.ini -o **fota-7931.bin** -m 1 –M 8

```
[General·Setting]
Base_Directory=.

[CM4·bin]
File=mt7931an_xip_qfn_bw.sgn
Start_Address=0x18044000
Partition_Size=0x300000
Is_Compressed=true
```

Figure 3 A sample of FOTARomPacker.ini of MT7931

```
[General·Setting]
Base_Directory=.

[CM4·bin]
File=mt7933cv_xip_bga_al.sgn
Start_Address=0x18044000
Partition_Size=0x300000
Is_Compressed=true
```

Figure 4 A sample of FOTARomPacker.ini of MT7933

2.2   FOTA Update Methods

The MT793X currently only supports full image update.

2.2.1   Full Image FOTA Update

This update method is easy to use and does not occupy much flash memory space if a compression algorithm is applied to reduce update package size.

In the full image update, the project is completely rebuilt and a new binary file is generated including all linked object files. There is a reserved space on the NOR Flash to store the new binary. When the new binary file is successfully transferred and stored in the specified address of the reserved space, you can programmatically set a flag as notification to the bootloader and reboot the system.

When the bootloader detects a new binary file on the flash, it replaces the old binary firmware with the new one in the RTOS firmware partition. When the firmware is successful replaced, the system boots up with the new binary.

2.2.1.1. Compile Options for the Full Image FOTA Update

The compile options for the FOTA update are configured in the main project and bootloader project makefiles (`feature.mk`). One of the makefiles is in the main application folder, and the other is in the bootloader project folder that builds the bootloader binary. Only when FOTA options in both of them are enabled, the FOTA feature is enabled.

Configure the following options in PROJECT_DIRECTORY/GCC/`feature.mk` of the main application.

Table 3 FreeRTOS-based main project: feature options

Main application project feature options	
MTK_FOTA_V3_ENABLE	y
MTK_FOTA_V3_FREERTOS_ENABLE	y
MTK_FOTA_V3_CLI_ENABLE	y
MTK_FOTA_V3_HTTP_ENABLE	y

Configure the following options in `bootloader/GCC/feature.mk` of the main application.

Table 4 OS-less bootloader project: feature options

Bootloader project feature options	
MTK_FOTA_V3_ENABLE	y
MTK_FOTA_V3_BOOTLOADER_ENABLE	y
MTK_FOTA_V3_PAYLOAD_LZMA_ENABLE	y

If you are updating the firmware through Wi-Fi, other compile options can be enabled or disabled depending on the required modules for FOTA update on the HDK in the `PROJECT_DIRECTORY/GCC/feature.mk` file, as shown in the following table.

Option	Description	Build RTOS application	Build the bootloader
MTK_LWIP_ENABLE	IP stack support.	y	n
MTK_MINICLI_ENABLE	Needed to have console command line interface.	y	n
MTK_CLI_TEST_MODE_ENABLE	Needed because some commands are available in test mode.	y	n
MTK_MT7933_CONSYS_WIFI_ENABLE	Turn on Wi-Fi hardware support	y	n
MTK_WIFI_PROFILE_ENABLE	Enable Wi-Fi profile	y	n
MTK_WLAN_SERVICE_ENABLE	Enable Wi-Fi service	y	n
MTK_WIFI_EMI_IN_PSRAM	Control the used memory by Wi-Fi FW.	y	n

2.2.1.2 FOTA Buffer Partition Size for the Full Image Update

The FOTA update package data is saved in the FOTA reserved partition. To customize the flash layout, consider saving the storage size for the FOTA reserved partition. Usually the FOTA packaging tool compresses the binary file to reduce the reserved quota size by default, so the reserved storage is 65% of the total size of the target partitions ready to update.

2.3   Suggested Flash Layout Setting for Each Chip with FOTA Enabled

2.2.1   Suggested Flash Layout Setting for the MT7931

On MT7931 RFB, 8 MB is the default hardware configuration. The default partition allocation is shown in Figure 5. As the partition table is subject to change according to requirements, refer to the source code to get the latest allocation.
The partition is described in either "<main project>/GCC/ld/memory.ld", or "<main project>/GCC/mt7933_flash.ld".
If the partition table has been updated, remove previously generated build outputs and rebuild.

Figure 5 MT7931 8-MB default flash partition

2.2.2 Suggested Flash Layout Setting for the MT7933

On MT7933 RFB, 16 MB is the default hardware configuration. The default partition allocation is shown in Figure 6. As the partition table is subject to change according to requirements, refer to the source code to get the latest allocation.

The partition is described in either "<main project>/GCC/ld/memory.ld", or "<main project>/GCC/mt7933_flash.ld".

If the partition table has been updated, remove previously generated build outputs and rebuild.

Figure 6 MT7933 16MB default flash partition

3 FOTA Update Workflow

This chapter provides detailed steps on how to download the FOTA package and update the firmware. Only Wi-Fi is supported currently.

3.1 Update over Wi-Fi Connection

3.1.1 Connecting to a Wi-Fi Network

The HTTP server provides the update file to the HTTP client located on the MT793X. The HTTP client must first connect to a router. The update file can then be transferred from the server to the client.
To automatically connect the RFB to the Wi-Fi access point after boot up, store the router SSID and password on the flash memory of the RFB. The parameters can be saved to the flash either programmatically or through a command line under console.

Wi-Fi initialize command	Description
en	CLI enters test mode (uses test command set)
wifi init	Initialize Wi-Fi module

Wait 5 seconds until Wi-Fi has initialized.

Wi-Fi configuration command	Description
wpa_cli add_network 0	Create network profile 0
wpa_cli set_network 0 ssid '"mediatek"'	Set the SSID of network profile 0 NOTE: Be careful about the single and double quotes.
wpa_cli set_network 0 key_mgmt WPA-PSK	Set the key management of network profile 0
wpa_cli set_network 0 psk '"12345678"'	Set the key of network profile 0 NOTE: Be careful about the single and double quotes.
wpa_cli set_network 0 pairwise CCMP	Set the pairwise cipher suite of network profile 0
wpa_cli set_network 0 group CCMP	Set the group cipher suite of network profile 0
wpa_cli set_network 0 proto RSN	Set the network protocol suite of network profile 0
wpa_cli enable_network 0	Enable network 0
wpa_cli select_network 0	Select network 0 (effectively starts the scan and connection process.
back	CLI returns to normal mode (uses normal command set)

The device starts building a Wi-Fi connection and obtains an IP address in the end.
You should see messages similar to the following on the console.

```
[985755][common][I][ip_ready_callback][123]***********************
[985756][common][I][ip_ready_callback][124]DHCP got IP:192.168.0.100
[985756][common][I][ip_ready_callback][126]***********************
```

3.1.2   FOTA CLI Command

CLI commands are the main interface for interacting with the MT76x7. There are five commands starting with "fota" to identify the FOTA commands, which are followed by the operation that takes one or more parameters, as shown in the following table.

| Operation	Format	Example
Download and write a FOTA package	fota dl <url>	fota dl http://192.168.0.2:8000/fota-7931.bin
Download a FOTA package without writing it into flash.	fota dl <url> dl_only	fota dl http://192.168.0.2:8000/fota-7931.bin dl_only

Set the flag to notify bootloader that a FOTA package is ready.	fota trig set	$ fota trig set
		$ fota status
		info: 1

Clear the flag to notify bootloader there is no FOTA package to be processed.	fota trig clear	$ fota trig clear
		$ fota status
		info: -1

Shows the FOTA status	fota status	After fota download, the status becomes -1.
		$ fota status
		info: -1
		$ fota trig set
		$ fota status
		info: 1
		$ fota trig clear
		$ fota status
		info: -1

3.1.3   Download Workflow

To download the FOTA update, use terminal emulation software, such as PuTTY, secureCRT, HyperTerminal, TeraTerm on your PC. The tool used in this section is TeraTerm. Before running the tool, identify the device port on your PC.

1) Open Windows Control Panel, then click System and:
    a. On Windows 7 and 8, click Device Manager
2) In Device Manager, navigate to Ports (COM & LPT).
3) Connect the RFB to your computer.
4) Four COM devices should appear under Ports (COM and LPT) in Device Manager.

The last one is the default console of RFB. Note the COMx port number of the USB Serial Port; this information is necessary for completing the configuration of TeraTerm.
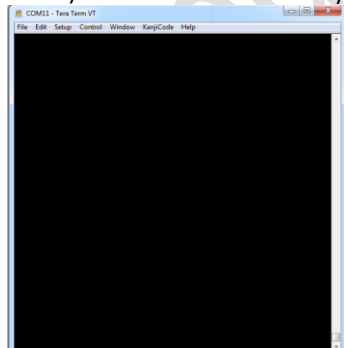
To configure TeraTerm:

1) Launch TeraTerm.
2) Select the COM Port of the device and set the speed to 921600.
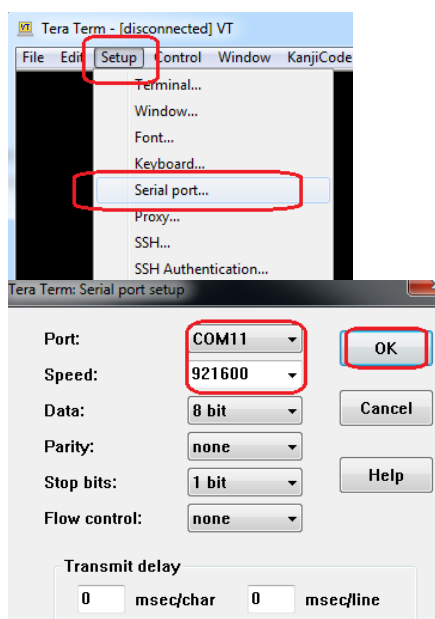
3)   Open the serial port
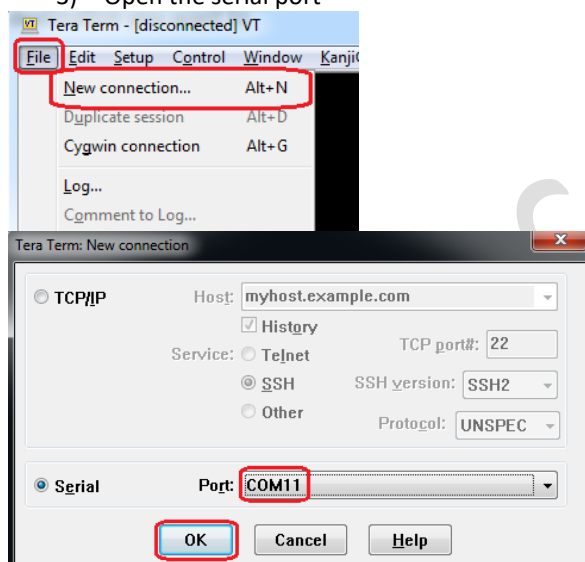
4)   TeraTerm is now ready

Reset/reboot the RFB. In a matter of seconds, the board boots up to ready status. Use CLI command to connect to Wi-Fi access point and perform FOTA.

```
en
wifi init
```

Wait 5 seconds, and continue with these settings.

```
wpa_cli add_network 0
wpa_cli set_network 0 ssid '"mediatek"'
wpa_cli set_network 0 key_mgmt WPA-PSK
wpa_cli set_network 0 psk '"12345678"'
wpa_cli set_network 0 pairwise CCMP
wpa_cli set_network 0 group CCMP
wpa_cli set_network 0 proto RSN
wpa_cli enable_network 0
wpa_cli select_network 0
back
```

If the parameters are set correctly as shown in this section, the RFB successfully connects to the router and a random LAN IP address is allocated to the RFB, which should be similar to "DHCP got IP: 192.168.0.100" as shown in the following example.

If the IP address is not fetched, check the Wi-Fi network setting.

```
***********************
 DHCP got IP:192.168.0.100
***********************
```

When the IP address is ready, assuming the server is an HTTP server with IP address 192.168.0.2, use the following command to start the download phase.

```
fota dl http://192.168.0.100/fota-7931.bin
```

FOTA download command shows download is successful.

```
$ fota dl http://192.168.0.100/fota-7931.bin
url: 1 192.168.0.100 80 fota-7931.bin
fota download success
```

3.1.4   Bootloader Migration Flow

When the download completes successfully, use the reboot command in the terminal emulation software on your PC, or press the reset key on your board to trigger a reboot. When the reboot starts, the bootloader checks whether to perform the firmware update. The workflow of **Update Agent** is shown in Figure 7 FOTA migration flow.
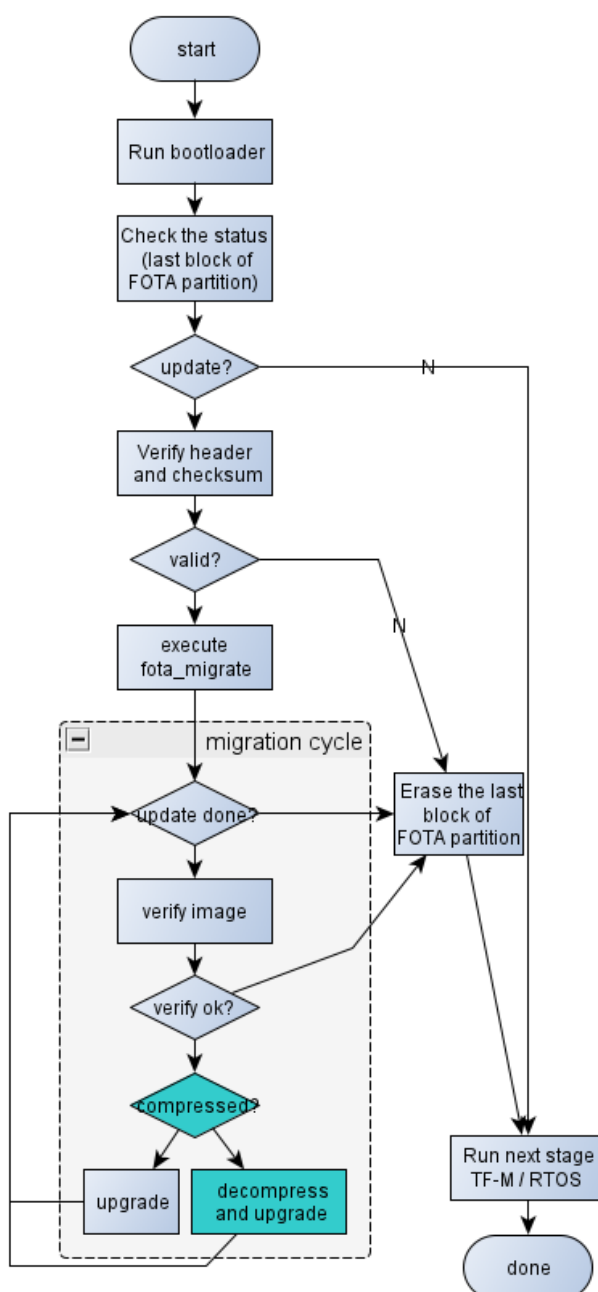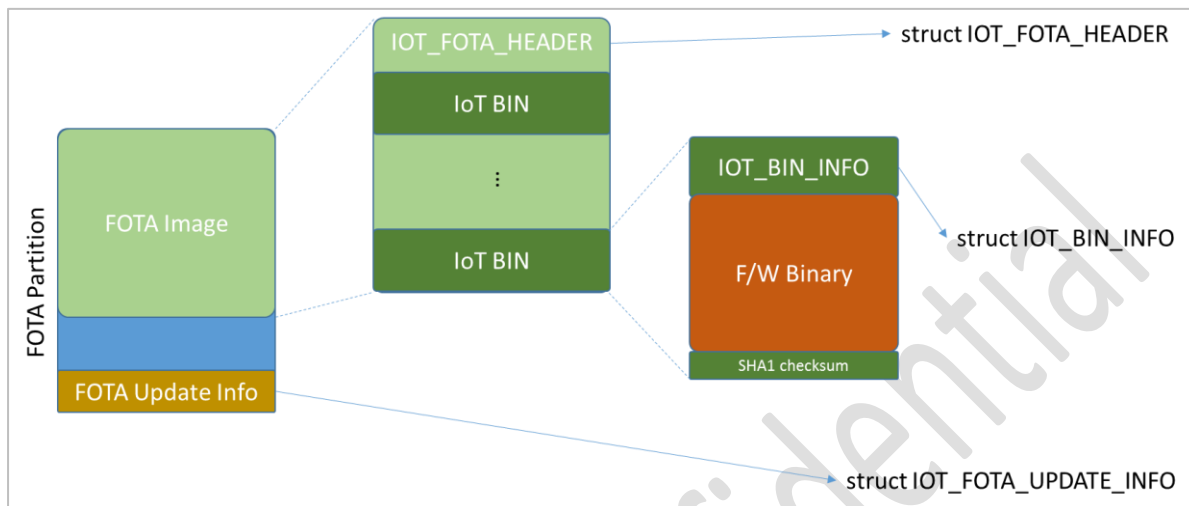

Figure 7 FOTA migration flow

Note: The SDK FOTA upgrade on MT7931/MT7933 does not support upgrading bootloader currently.

4   Key Data Structure and Formats

This chapter lists the key data structures and formats used by FOTA packer and FOTA.

Structure	Description
```typedef struct{ uint32_t m_magic_ver; uint32_t m_bin_num;} IOT_FOTA_HEADER;```	The header structure of a FOTA image. Identify the header and keeps record of the firmware binary entries. Magic number (m_magic_ver) is fixed to 0x004D4D4D. The number of firmware binaries is kept in m_bin_num. There should be 1~N entries in the table of IOT_BIN_INFO type, right next to header.
```typedef struct{ uint32_t m_bin_offset; uint32_t m_bin_start_addr; uint32_t m_bin_length; uint32_t m_partition_length; uint32_t m_sig_offset; uint32_t m_sig_lenth; uint32_t m_is_compressed; uint8_t m_bin_reserved[4];} IOT_BIN_INFO;```	Describes the needed information of a firmware binary. The m_bin_offset is the starting offset of the firmware binary in FOTA partition. The attribute m_bin_start_addr is the starting address of the firmware binary in its target partition of upgrade. The attribute m_bin_length is the length of firmware binary.
```typedef struct _fota_upgrade_info_t{ uint32_t magic; fota_upgrade_state_t state; uint8_treserved[4096 - sizeof(uint32_t) *2];} fota_upgrade_info_t;```	The structure keeps the status of FOTA. The reserved attribute ensures the structure size is 4 KB. One instance of this structure should be written to the last 4 KB of a FOTA partition. Magic number (magic) is fixed to 0x27182818. The status can be interpreted following this enumeration: ```typedef enum{ // no valid image FOTA_UPGRADE_STATUS_NONE = 0xFFFFFFFF, // image is ready FOTA_UPGRADE_STATUS_READY = 0x00000001,```

Structure	Description

	``
	    // upgrade was interrupted
	    FOTA_UPGRADE_STATUS_RUNNING = 0x00000003,
	    // image parse failed
	    FOTA_UPGRADE_STATUS_INVALID = 0x00000005,
	} fota_upgrade_state_t;
	``

5 Appendix A: Acronyms and Abbreviations

The acronyms and abbreviations used in this developer's guide are listed in the following table.

Acronym/Abbreviation	Definition
FOTA	Flash over-the-air; refer to the design/software of updating firmware wirelessly.
HTTP	Hypertext transfer protocol.
TFTP	Trivial file transfer protocol.
NOR flash	NOR logic gates based flash memory
RFB	Reference board; stands for a reference development hardware kit for software development.
CLI	Command line interface of the MT793x; this is where you can test-drive most functions.

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