

BG95&BG77 DFOTA

Application Note

LPWA Module Series

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Our aim is to provide customers with timely and comprehensive service. For any assistance, please contact our company headquarters:

Quectel Wireless Solutions Co., Ltd.

Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China 200233

Tel: +86 21 5108 6236

Email: info@quectel.com

Or our local office. For more information, please visit:

<http://www.quectel.com/support/sales.htm>

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About the Document

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1 Introduction

Quectel BG95 and BG77 modules support DFOTA function, which allows customers to update the firmware over the air.

Before firmware updating, a delta firmware package which contains only the differences between the source and the target firmware versions has to be obtained. By this way, the amount of data transmitted and the time taken can be reduced.

This document mainly describes how to update the firmware of Quectel BG95 and BG77 modules via DFOTA which can be triggered by either **AT+QFOTADL** command or LwM2M protocol.

2 Trigger DFOTA with AT Command

2.1. Firmware Update Procedure

The following chart illustrates the DFOTA procedure triggered with AT command, when the firmware package is stored on HTTP(S)/CoAP(s) server.

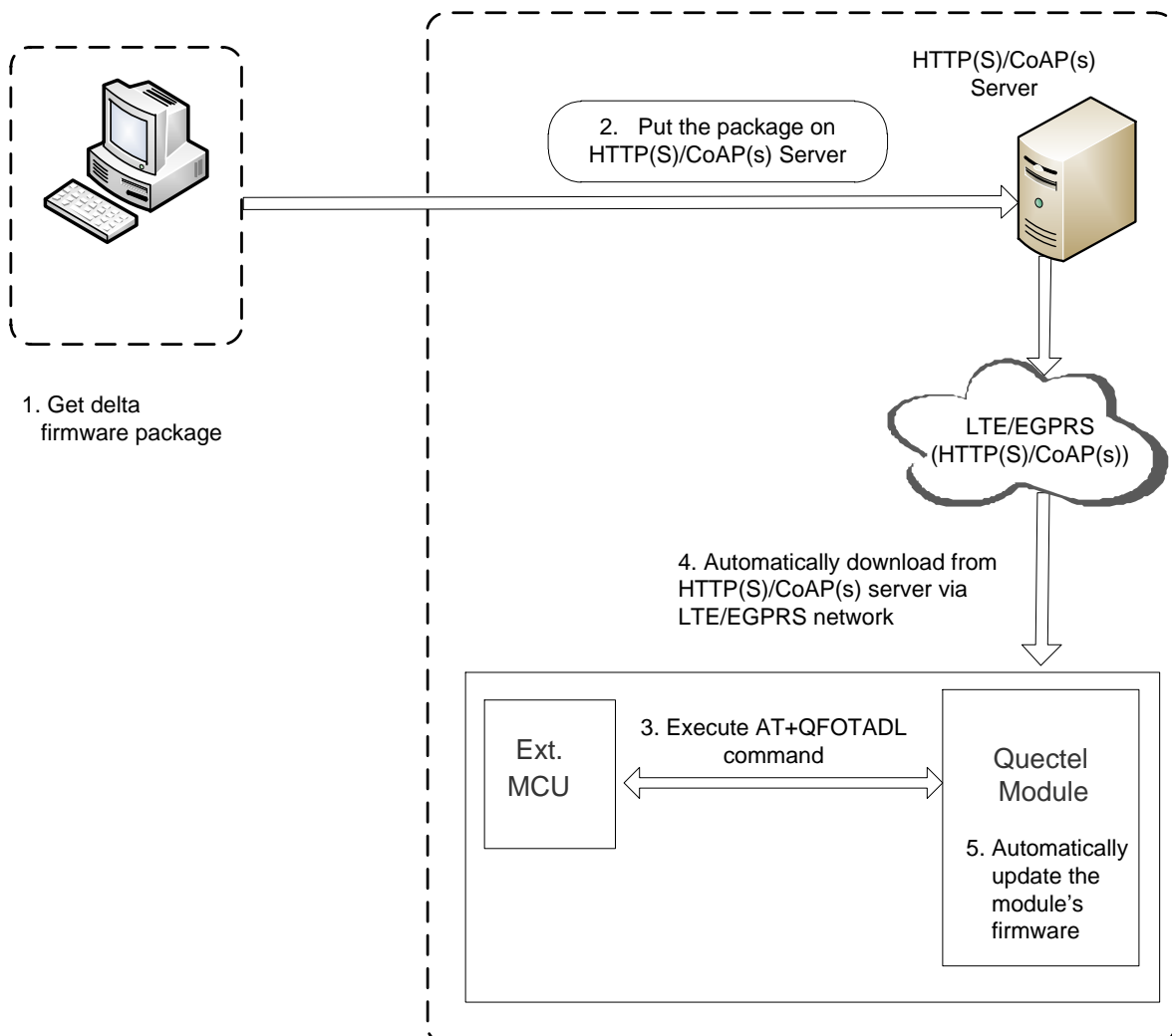


Figure 1: DFOTA Procedure (Triggered with AT Command)

As shown in the above figure, the following steps need to be performed to update the firmware when the firmware package is stored on HTTP(S)/CoAP(s) server:

- Step 1:** Get the delta firmware package from Quectel.
- Step 2:** Put the delta package on HTTP(S)/CoAP(s) server.
- Step 3:** Execute **AT+QFOTADL** command.

After executing **AT+QFOTADL** command, the module will automatically download the package from HTTP(S)/CoAP(s) server via LTE/EGPRS network (**Step 4**) and automatically update the firmware of the module (**Step 5**).

2.1.1. Get Delta Firmware Package

Before updating, please check the source firmware version with **ATI** command and confirm the target firmware version, and then send the two firmware versions to Quectel or the module supplier so as to get a delta package.

2.1.2. Put Delta Package on HTTP(S)/CoAP(s) Server

- Step 1:** Please set up an HTTP(S)/CoAP(s) server before using DFOTA function. (Quectel does not provide such servers.)
- Step 2:** Put the delta firmware package on the server, and record the storage path.
- Step 3:** The module will get the delta package from the path after executing corresponding AT command.

2.1.3. Check APN Setting

Please check whether the APN is set properly after putting the delta firmware package on the HTTP(S)/CoAP(s) server. For instance, the APN for Telstra (U)SIM card should be "**Telstra.internet**", and the relevant AT commands are listed below:

- Query DFOTA APN: **AT+QCFGEXT="fota_apn"**
- Set DFOTA APN: **AT+QCFGEXT="fota_apn",0,"Telstra.internet"**

2.1.4. Check Network Status

After APN setting is confirmed, please check whether the data network is registered before firmware updating.

The relevant AT commands are listed below:

- **AT+CSQ:** Query signal quality
- **AT+CREG?** or **AT+CGREG?:** Query network registration status

- **AT+COPS?**: Query the registered operator

For more details about the above commands, please refer to *document [1]*.

2.1.5. Execute AT Command to Update the Firmware

After APN setting and network status are confirmed, execute the **AT+QFOTADL** command, and then the module will download the firmware package from the HTTP(S)/CoAP(s) server over the air and update the firmware automatically. For more details, please refer to *Chapter 3*.

2.1.6. Description of AT Command Mode and Data Mode

The COM port of BG95/BG77 module has two working modes: AT command mode and data mode. In AT command mode, the inputted data via COM port will be treated as AT commands. In data mode, it will be treated as data.

Inputting **+++** or pulling up MAIN_DTR (**AT&D1** should be set first) can make the COM port exit data mode. To prevent the **+++** from being misinterpreted as data, the following sequence should be followed:

- 1) Do not input any character within 1 s or longer before inputting **+++**.
- 2) Input **+++** within 1 s, and no other characters can be inputted during the time.
- 3) Do not input any character within 1 s after **+++** has been inputted.

When **AT+QFOTADL="COM:",<file_size>,<timeout>** is executed, the COM port enters data mode. If **+++** is inputted or MAIN_DTR is pulled up before the command response is returned normally, then the port will exit data mode forcibly and also the command will be interrupted immediately.

2.2. Description of DFOTA Related AT Commands

2.2.1. AT+QFOTADL Update Firmware via DOFTA

This command enables automatic firmware update for module via DFOTA. After executing the command, the module will automatically download the package from HTTP(S) server. After the package download is finished, the module will automatically update the firmware. If firmware is updated successfully, the module will reboot, otherwise it will return an error and exit DFOTA.

AT+QFOTADL Update Firmware via DOFTA

Test Command	Response
AT+QFOTADL=?	OK

NOTE

All AT commands take effect immediately unless otherwise specified.

2.2.1.1. AT+QFOTADL=<HTTP_URL> Update Firmware When Delta Package is Stored on HTTP(S)

Server

If the delta firmware package is stored on an HTTP(S) server, **AT+QFOTADL=<HTTP_URL>** command should be executed to enable automatic firmware update via DFOTA. Then the module will download the delta package from the HTTP(S) server over the air and update the firmware automatically.

AT+QFOTADL=<HTTP_URL> Update Firmware When Delta Package is Stored on HTTP(S) Server

Write Command AT+QFOTADL=<HTTP_URL>	Response OK +QIND: "FOTA", "HTTPSTART" +QIND: "FOTA", "DOWNLOADING", <percent> +QIND: "FOTA", "DOWNLOADING", <percent> ... +QIND: "FOTA", "HTTPPEND", <HTTP_err> +QIND: "FOTA", "RESETTING" +QIND: "FOTA", "START" +QIND: "FOTA", "UPDATING", <percent> +QIND: "FOTA", "UPDATING", <percent> ... +QIND: "FOTA", "END", <update_err> If there is any error: +CME ERROR: <err>
Maximum Response Time	300 ms
Validity	Invalid after powering down.

Parameter

<HTTP_URL>	String type. The maximum length is 700 bytes. It should be started with "HTTP://" or "HTTPS://", for example: "HTTP://<HTTP_server_URL>:<HTTP_port>/<HTTP_file_path>".
<HTTP_server_URL>	String type. The IP address or domain name of the HTTP(S) server.
<HTTP_port>	Integer type. The port number of the HTTP(S) server. The default value is 80.

	The range is 1-65535.
<HTTP_file_path>	String type. The file name in HTTP(S) server.
<HTTP_err>	Integer type. The HTTP(S) error code. 0 means updated successfully. Any other value means an error. Please refer to Chapter 5 for more details.
<percent>	Integer type. The download or update progress in percentage.
<update_err>	Integer type. 0 means updated successfully. Any other value means an error during updating process. Please refer to Chapter 5 for more details.
<err>	An error code relating to ME. Please refer to Chapter 5 for more details.

NOTES

- In DFOTA mode, only the APP works normally and the modem is not loaded. In this mode, the main UART cannot receive AT commands anymore, and can only report URCs at fixed baud rate of 115200 bps. Additionally, the USB port cannot be used either.
- After successful "**DOWNLOADING**" process, the module will be reset and enter DFOTA mode. After successful "**UPDATING**" process, the module will restart again and start up in normal mode.
- If the module is powered down during "**UPDATING**" process, the module will automatically enter DFOTA mode and re-update again when power up next time.
- (1) If SSL certificates are needed while downloading the firmware package from an HTTPS server, then they should be uploaded to /datatx in APP EFS, and must be renamed in accordance with the following rules:
 - The root certificate must be renamed into *fota_cacert.pem*;
 - The client certificate must be renamed into *fota_client_cert.pem*;
 - The private key must be renamed into *fota_client_key.pem*.
- (2) Certificate upload methods:
 - Quectel QEFS Explorer tool can be used to upload the certificates. For more details about the tool, please refer to **document [2]**.
 - AT+QFUPL** command can also be used to upload the certificates. For more details about the command, please refer to **document [3]**.

2.2.1.2. AT+QFOTADL=<CoAP_URL> Update Firmware When Delta Package is Stored on CoAP(s) Server

If the delta firmware package is stored on a CoAP(s) server, **AT+QFOTADL=<CoAP_URL>** command should be executed to enable automatic firmware update via DFOTA. Then the module will download the delta package from the COAP(s) server over the air and update the firmware automatically.

AT+QFOTADL=<CoAP_URL> Update Firmware When Delta Package is Stored on CoAP(s) Server

Write Command	Response
AT+QFOTADL=<CoAP_URL>	OK

	<pre>+QIND: "FOTA","COAPSTART" +QIND: "FOTA","COAPEND",<CoAP_err> +QIND: "FOTA","RESETTING" +QIND: "FOTA","START" +QIND: "FOTA","UPDATING",<percent> +QIND: "FOTA","UPDATING",<percent> ... +QIND: "FOTA","END",<update_err></pre> <p>If there is any error: +CME ERROR: <err></p>
Maximum Response Time	300 ms
Validity	Invalid after powering down.

Parameter

<CoAP_URL>	String type. The maximum length is 700 bytes. It should be started with "CoAP://" or " CoAPS://", for example: " CoAP://<CoAP_server_URL>:< CoAP_port>/< CoAP_file_path> ".
<CoAP_server_URL>	String type. The IP address or domain name of the CoAP(s) server.
<CoAP_port>	Integer type. The port number of the CoAP(s) server. The default value is 80. The range is 1-65535.
<CoAP_file_path>	String type. The file name in CoAP(s) server.
<CoAP_err>	Integer type. The CoAP(s) error code. 0 means updated successfully. Any other value means an error. Please refer to Chapter 5 for more details.
<percent>	Integer type. The update progress (percentage).
<update_err>	Integer type. 0 means updated successfully. Any other value means an error during updating process. Please refer to Chapter 5 for more details.
<err>	An error code relating to ME. Please refer to Chapter 5 for more details.

2.2.1.3. AT+QFOTADL="COM:",<file_size>,<timeout> Upload Delta Package to Flash

The command is used to upload delta package to the NAND flash. If the delta package has existed on the NAND flash, it will be overwritten when a new package is uploaded.

After executing this command and **CONNECT** returns, the module will switch to data mode. When the uploaded data reaches **<file_size>**, or there is no any data inputted when **<timeout>** reaches, it will exit data mode automatically. During data transmission, inputting **+++** or pulling up MAIN_DTR can make the module exit data mode, and more details are provided in **Chapter 2.1.6**.

AT+QFOTADL="COM:",<file_size>,<timeout> Upload Delta Package to Flash

Write Command AT+QFOTADL="COM:",<file_size>[,<timeout>]	Response CONNECT TA switches to the data mode (transparent access mode), and the binary data of file can be inputted. When the total size of the inputted data reaches <file_size> (unit: byte), TA will return to command mode and reply the following codes: +QFOTADL: <upload_size>,<check_sum> OK If there is any error: +CME ERROR: <err>
Maximum Response Time	300 ms
Validity	Invalid after powering down.

Parameter

<file_size>	Integer type. The file size expected to be uploaded. Unit: byte.
<timeout>	Integer type. The time waiting for data to be inputted to USB/UART. The default value is 5. Unit: seconds.
<upload_size>	Integer type. The file size that has been uploaded. Unit: byte.
<check_sum>	The checksum of the uploaded data.
<err>	Integer type. 0 means updated successfully. Any other value means an error. Please refer to Chapter 5 for more details.

NOTES

- <file_size>** cannot exceed 6 Mbytes.
- <check_sum>** is a 16 bit checksum based on bitwise XOR.
If the number of the characters is odd, set the last character as the high 8 bit, and the low 8 bit as 0, and then use an XOR operator to calculate the checksum. **+++** sequence will cause TA to end the command and switch to command mode. However, the data previously uploaded will be preserved into the file.
- When executing the command, the data must be entered after **CONNECT** is returned.

2.2.1.4. AT+QFOTADL=<para1>,<para2> DFOTA Extended Functions

This command supports several extended functions with different parameters, such as trigger DFOTA update operation with local DFOTA firmware package, get DFOTA firmware package information, and delete DFOTA firmware package.

AT+QFOTADL=<para1>[,<para2>] DFOTA Extended Functions

Write Command AT+QFOTADL=<para1>[,<para2>]	<p>Response</p> <p>If <para2> is omitted and <para1>=3, return the current DFOTA update trigger mode +QFOTADL: <para1>,<para2></p> <p>OK</p> <p>If <para2> is omitted and <para1>=4, return the size of local DFOTA package +QFOTADL: <para1>,<para2></p> <p>OK</p> <p>If <para2> is omitted and <para1>=5, delete the DFOTA package OK</p> <p>If <para2> is present and <para1>=3, configure DFOTA update trigger mode OK</p> <p>If there is any error related to ME functionality: +CME ERROR: <err></p> <p>If there is any other error: ERROR</p>
Maximum Response Time	10 s
Validity	Invalid after powering down.

Parameter

<para1>	<p>Integer type.</p> <p>1 Start update</p> <p>2 Reserved</p> <p>3 Configure whether to trigger DFOTA update immediately after DFOTA</p>
---------	---

	package is download
	4 Get the size of local DFOTA package
	5 Delete the local DFOTA package
<para2>	if <para1>=3, 0 Trigger DFOTA update triggered manually with AT+QFOTADL=1 . 1 DFOTA update triggered automatically after package downloaded.
	if <para1>=4, <para2> represents the size of local DFOTA package.
<err>	Integer type. 0 means updated successfully. Any other value means an error. Please refer to Chapter 5 for more details.

2.2.2. AT+QCFGEXT="fota_apn" Configure IP Family and APN for DFOTA

The command is used to configure the IP family type and APN for DFOTA.

AT+QCFGEXT="fota_apn" Configure IP Family and APN for DFOTA	
Write Command AT+QCFGEXT="fota_apn",<IP_type>,<APN>,[<username>,<password>]	Response +QCFGEXT: "fota_apn",<IP_type>,<APN>,<username>,<password> OK If there is any error: ERROR
Maximum Response Time	300 ms
Validity	Remain valid after powering down.

Parameter

<IP_type>	Integer type. IP family type. 0 IPv4 address family 1 IPv6 address family 2 IPv4 and IPv6 address family
<APN>	String type. Access point name.
<username>	String type. Username of the selected APN.
<password>	String type. Password of the selected APN.

3 Trigger DFOTA with LwM2M

3.1. Firmware Update Procedure

OMA defines the application layer communication protocol between a LwM2M server and a LwM2M client, which is located in a LwM2M device. For BG95 and BG77 modules, the LwM2M protocol is used to manage device provisioning and is a trigger of a DFOTA procedure. For the DFOTA update on BG95/BG77, firmware update object is provided by the LwM2M specification.

The following are the typical DFOTA steps with LwM2M:

1. Write “Package”/“Package URI” to trigger the download of firmware image, so that the DFOTA application downloads the firmware image from LwM2M server automatically.
2. Post “Update” to trigger firmware update on BG95/BG77, so that the DFOTA application finishes firmware update automatically with the candidate firmware image.

The LwM2M client will be notified about the new firmware by the LwM2M server using CoAP(s). The client sends the indication to registered DFOTA application. DFOTA application downloads the firmware from the server and stores it on the file system of BG95/BG77. The following figure shows the key components involved in LwM2M DFOTA process on BG95/BG77.

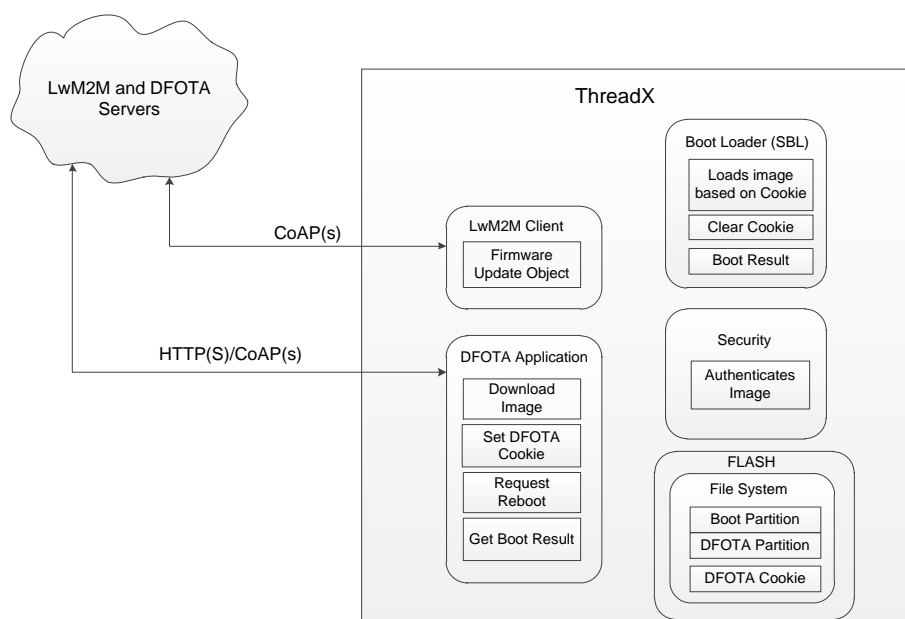


Figure 2: LwM2M Firmware Image Download

3.1.1. Download Firmware Image

About "Firmware Update Object" in LwM2M, the detailed interaction process between LwM2M client and LwM2M server will be described as below.

The LwM2M client should register and observe the "Package URI" resource in Firmware Update Object, customers will see this object showed in the server after the client is registered successfully.

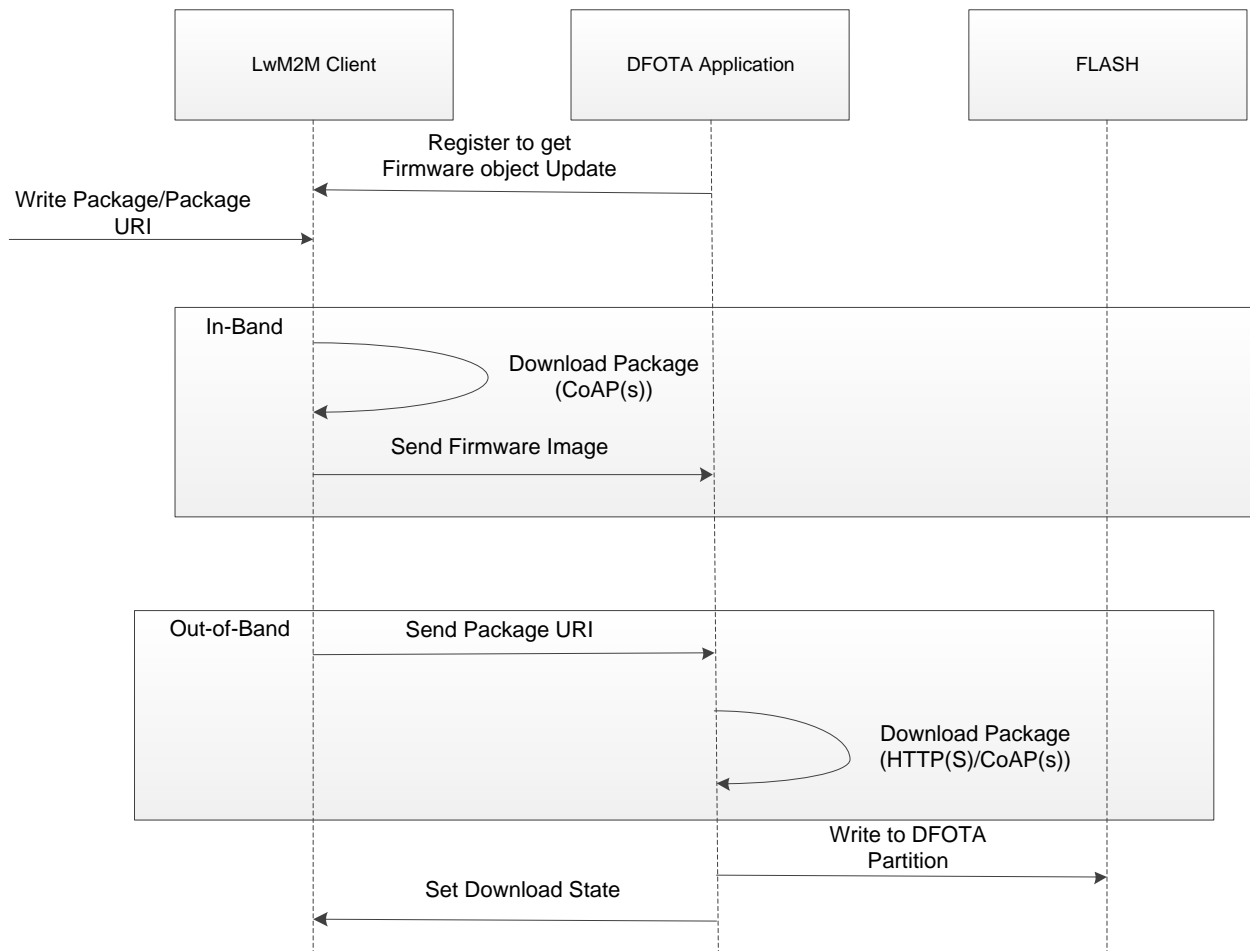


Figure 3: Observe Package URI and Download Firmware Call Flow

NOTE

In in-band mode, the module will download firmware package from LwM2M server directly via CoAP(s) protocol and send downloaded package to DFOTA application. All "firmware update" actions will be done in the application. But in out-of-band mode, the module will download firmware package from HTTP(S)/CoAP(s) server to the local.

3.1.2. Update Firmware

The LwM2M server should observe the “State” resource in Firmware Update Object. If the “State” changed to “Downloaded”, “Update” resource will be executed to trigger firmware update process.

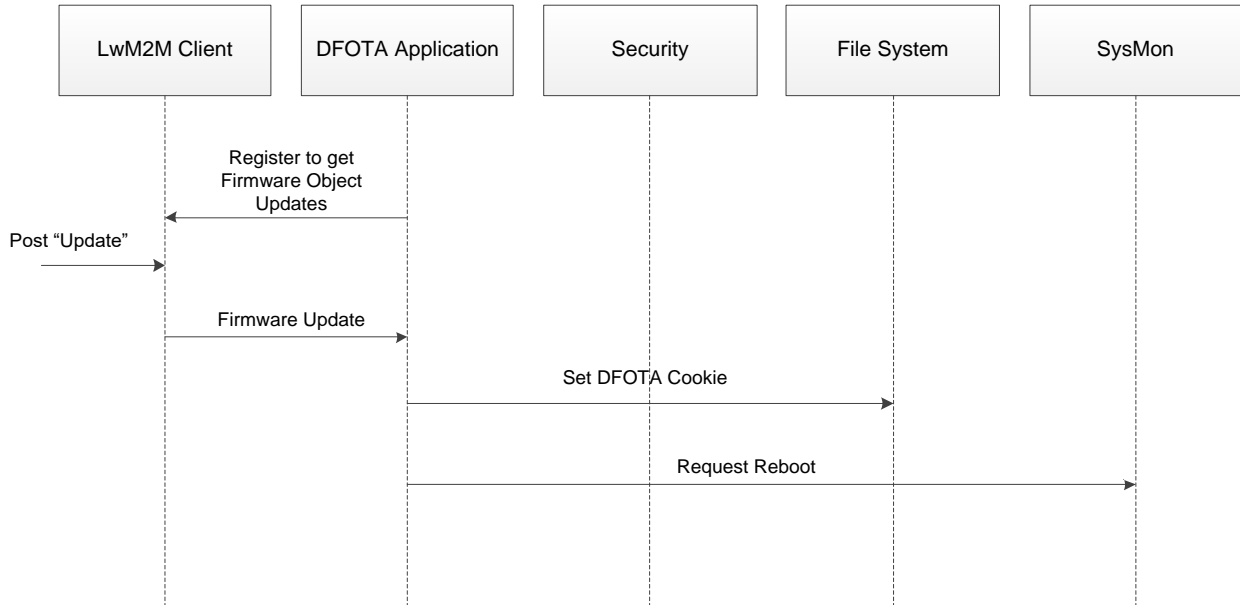


Figure 4: Observe "Update" Resource and Update Event Processing Call Flow

3.2. URC of Firmware Update with LwM2M

3.2.1. Download Progress URCs

3.2.1.1. In-Band Mode

When DFOTA firmware update is triggered in LwM2M in-band mode, the following URCs will be outputted to notify the download progress.

+LWM2M: "FOTA", "DOWNLOADING" Notify the Download Progress

URC Format:

+LWM2M: "FOTA", "DOWNLOADING", "START" Notify the start of download process.

URC Format:

+LWM2M: "FOTA", "DOWNLOADING", "COMPLETED" Notify the completion of download process.

3.2.1.2. Out-of-Band HTTP(S) Mode

When DFOTA firmware update is triggered in LwM2M out-of-band HTTP(S) mode, the following URCs will be outputted to notify the download progress.

+QIND: "FOTA", "HTTP" Notify the Download Progress

URC Format: +QIND: "FOTA", "HTTPSTART"	Notify the start of download process.
URC Format: +QIND: "FOTA", "DOWNLOADING", <percent> ...	Notify the download progress in percentage.
URC Format: +LWM2M: "FOTA", "DOWNLOADED", <HTTP_err>	Notify the result of download operation.

Parameter

<percent>	Integer type. The download progress in percentage.
<HTTP_err>	Integer type. The HTTP(S) error code. 0 means downloaded successfully. Any other value means an error. Please refer to Chapter 5 for more details.

3.2.1.3. Out-of-Band CoAP(s) Mode

When DFOTA firmware update is triggered in LwM2M out-of-band CoAP(s) mode, the following URCs will be outputted to notify the download progress.

+QIND: "FOTA", "COAP" Notify the Download Progress

URC Format: +QIND: "FOTA", "COAPSTART"	Notify the start of download process.
URC Format: +LWM2M: "FOTA", "DOWNLOADED", <CoAP_err>	Notify the result of download operation.

Parameter

<CoAP_err>	Integer type. The CoAP(s) error code. 0 means downloaded successfully. Any other value means an error. Please refer to Chapter 5 for more details.
------------	---

3.2.2. Update Progress URCs

3.2.2.1. Start Updating

+QIND: "FOTA", "START" Start Updating

URC Format:

+QIND: "FOTA", "START"

Notify the start of updating.

3.2.2.2. Updating Progress

+QIND: "FOTA", "UPDATING", <percent> Updating Progress

URC Format:

+QIND: "FOTA", "UPDATING", <percent>

Notify the updating progress in percentage.

Parameter

<percent> Integer type. The updating progress in percentage.

3.2.2.3. Updating Finished

+QIND: "FOTA", "END", <err> Updating Finished

URC Format:

+QIND: "FOTA", "END", <err>

Notify the completion of updating.

Parameter

<err> Integer type.
0 means updated successfully. Any other value means an error.
Please refer to **Chapter 5** for more details.

4 Example

4.1. Update Firmware from HTTPS Server by DFOTA

```
//Update firmware when delta firmware package is stored on an HTTPS server.
//The HTTPS server address is "https://www.quectel.com:100/update.zip".
AT+CSQ;+CEREG?;+CGREG?;+COPS?           //Query network status
+CSQ: 26,99

+CEREG: 0,1

+CGREG: 0,4

+COPS: 0,0,"Telstra Mobile Telstra",8

OK

//Execute AT+QFOTADL command to enable automatic firmware update via DFOTA, and then the
module will start to download the delta package and update firmware automatically.

AT+QFOTADL="https://www.quectel.com:100/update.zip"
OK
+QIND: "FOTA","HTTPSTART"
+QIND: "FOTA","DOWNLOADING",5%
...
+QIND: "FOTA","HTTPEnd",0                   //Finish downloading the package from HTTPS server.
+QIND: "FOTA","RESETTING"                  //The module will be reset and then enter DFOTA mode
+QIND: "FOTA","START"
+QIND: "FOTA","UPDATING",1%
+QIND: "FOTA","UPDATING",2%
...
+QIND: "FOTA","UPDATING",100%
+QIND: "FOTA","END",0                       //Finish updating the firmware.
```

5 Summary of Error Codes

The error code indicates an error related to mobile equipment or network. The details about **<HTTP_err>**, **<CoAP_err>**, **<update_err>** and **<err>** are described in the following tables.

Table 1: Summary of <HTTP_err>/<CoAP_err> Codes

<HTTP_err>/ <CoAP_err>	Meaning
0	Download successful
701	Unknown error
702	Server connection failed
703	Request failed
704	Download timeout
705	URL error
706	File not exist
707	Write data to file failed
708	Downloaded file is too large
710	Downloaded package check failed

Table 2: Summary of <update_err> Codes

<update_err>	Meaning
0	Updated successfully
504	Firmware update failed
505	Update package not exist
506	Update package check failed

511	Package is mismatched with the current firmware
512	DFOTA unknown error

Table 3: Summary of <err> Codes

<err>	Meaning
590	Input parameter invalid
591	DFOTA is ongoing

6 Appendix A References

Table 4: Related Documents

SN	Document Name	Remark
[1]	Quectel_BG95&BG77_AT_Commands_Manual	BG95/BG77 AT commands manual
[2]	Quectel_BG95&BG77_QEFS_Explorer_User_Guide	User guide for QEFS Explorer tool
[3]	Quectel_BG95&BG77_FILE_Application_Note	BG95/BG77 FILE application note

Table 5: Terms and Abbreviations

Abbreviation	Description
APN	Access Point Name
CoAP(s)	Constrained Application Protocol (Secure)
DFOTA	Delta Firmware Upgrade Over-the-Air
FOTA	Firmware Over-the-Air
EGPRS	Enhanced General Packet Radio Service
HTTP(S)	Hyper Text Transport Protocol (Secure)
IP	Internet Protocol
LTE	Long Term Evolution
LPWA	Low Power Wide Area
LwM2M	Lightweight Machine to Machine
OMA	Open Mobile Alliance
URC	Unsolicited Result Code
URI	Uniform Resource Identifier