

BG96 LwM2M User Guide

LPWA Module Series

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About the Document

History

Revision	Date	Author	Description
1.0	2018-08-20	Sherlock ZHAO	Initial
1.1	2019-07-31	Sherlock ZHAO	<ol style="list-style-type: none">1. Added LwM2M Server configuration, data transfer, registration and deregistration commands.2. Added an example to illustrate LwM2M Client configuration.

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1 Introduction

With the rise of the Internet of Things, more and more terminal devices have been connected to Internet. So the requirement of device management and upgrade becomes urgent.

The emergence of OMA Lightweight M2M (LwM2M) solves this industry problem. LwM2M provides some features to help device vendors to manage their devices, update the firmware, remotely control devices, etc. The main motivation for LwM2M is to define a set of lightweight protocols for a variety of IoT devices, since IoT devices are often very limited resources for embedded terminals, without UI, and come with limited computing and network communication capabilities. It is also because of the huge number of IoT terminals, due to which saving network resources become more important.

This document mainly introduces LwM2M protocol, architecture of OMA LwM2M, and how to use this feature with Quectel BG96 module.

2 General Overview of LwM2M

Open Mobile Alliance (OMA) specifies the application layer communication protocol between a LwM2M Server and a LwM2M Client, located in a LwM2M device. The OMA LwM2M enabler includes device management and service enablement for LwM2M devices.

BG96 provides LwM2M Client on APPS. The LwM2M Client is compliant with *OMA Lightweight Machine to Machine Technical Specification* and supports the following interfaces:

- Bootstrap
- Client Registration
- Device Management and Service Enablement
- Information Reporting

The following figure shows the LwM2M stack on BG96.

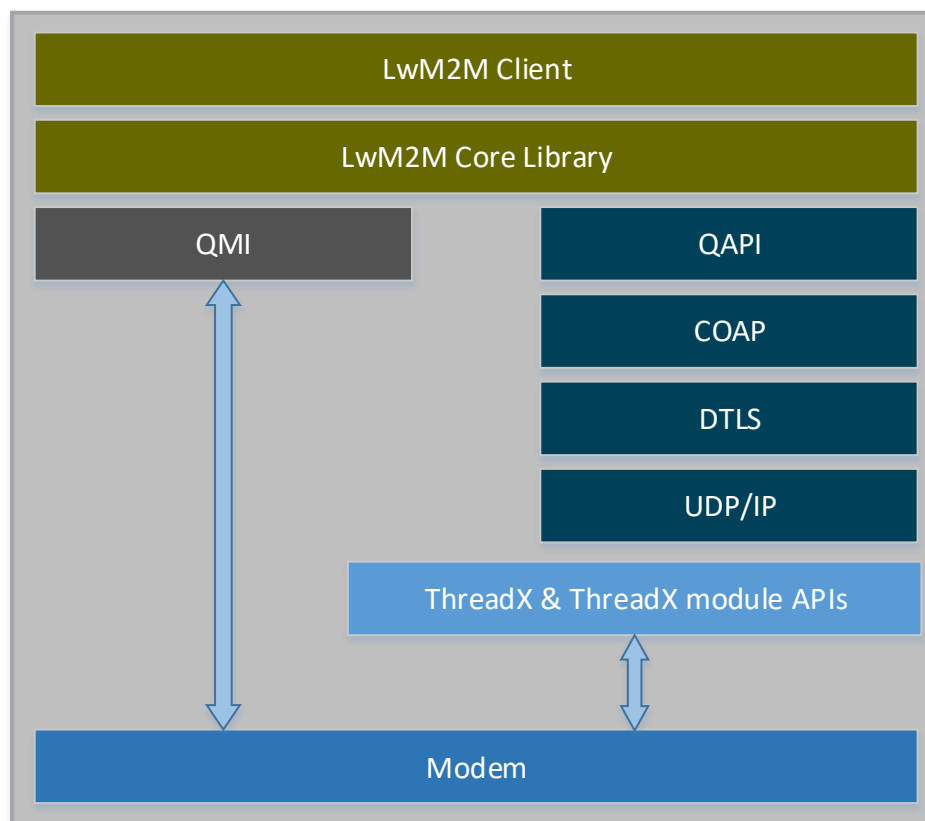


Figure 1: LwM2M Stack on BG96

3 LwM2M on BG96

3.1. LwM2M Interfaces

3.1.1. Bootstrap Interface

The bootstrap interface is used to provision essential information into the LwM2M Client to enable the LwM2M Client to “Register” to one or more LwM2M Servers.

- **Bootstrap Modes Supported by BG96**

There are four bootstrap modes supported by the LwM2M: factory bootstrap, bootstrap from smartcard, client-initiated bootstrap and server-initiated bootstrap. Generally, a LwM2M Client must support at least one bootstrap mode specified in the bootstrap server. Currently, BG96 supports two bootstrap modes in LwM2M: factory bootstrap by default and client-initiated bootstrap.

- **Server and Access Control Configurations**

Information about bootstrap server or other servers, and access control can be configured in *bootstrap.ini* file and preloaded on the device. During the device start-up, the *bootstrap.ini* file is loaded and parsed to get the required information for bootstrapping or registering to the servers. During the client-initiated bootstrap, if disconnection or failure occurs, then retry timers can be triggered as per *lwm2m_cfg* file. The default APN specified in *lwm2m_cfg* file is used for data call setup for bootstrap request.

3.1.2. Client Registration Interface

The client registration interface is used by a LwM2M Client to register to one or more LwM2M Servers, maintain each registration to and de-register from a LwM2M Server.

- **Register**

When registering, the LwM2M Client performs the “Register” operation and provides the properties the LwM2M Server requires to contact the LwM2M Client (e.g., End Point Name); maintain the registration and session (e.g., Lifetime, Queue Mode) between the LwM2M Client and LwM2M Server as well as knowledge of the Objects the LwM2M Client supports and existing Object Instances in the LwM2M Client. The registration is in soft state, with a lifetime indicated by the Lifetime Resource of that LwM2M Server Object Instance.

- **Update**

The LwM2M Client periodically performs an update of its registration information to the registered LwM2M Server(s) by performing the “Update” operation. If the lifetime of a registration expires and without receiving an update from the LwM2M Client, the LwM2M Server removes the registration.

- **Deregister**

Finally, when shutting down or discontinuing use of a LwM2M Server, the LwM2M Client performs a “Deregister” operation.

The Binding Resource of the LwM2M Server Object informs the LwM2M Client of the transport protocol preferences of the LwM2M Server for the communication session between the LwM2M Client and LwM2M Server. The LwM2M Client SHOULD perform the operations with the modes indicated by the Binding Resource of the LwM2M Server Object Instance.

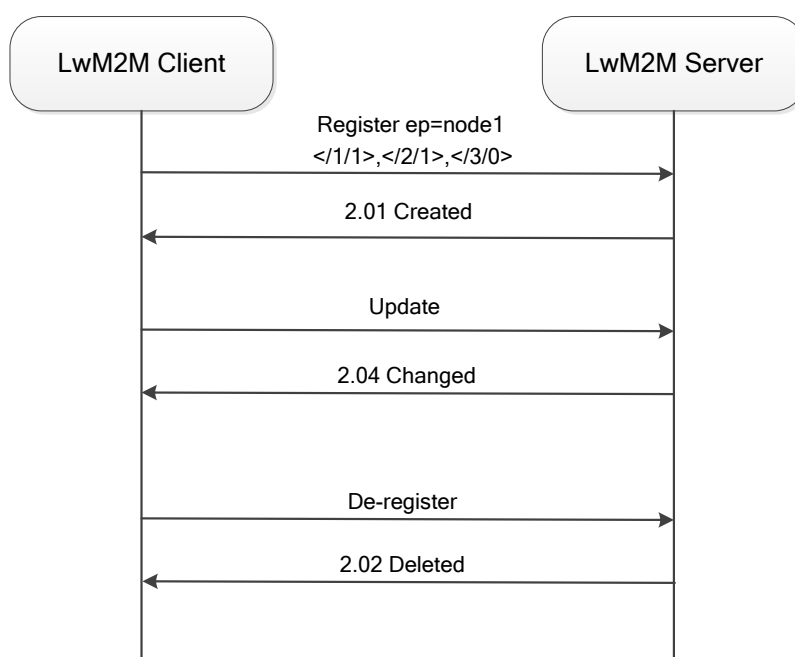


Figure 2: Client Registration Interface Operation Flow

carrier_apn_cfg file allows configuring the APN for the data call connection to each server. In the absence of *carrier_apn_cfg* file, the default APN specified in the *lwm2m_cfg* file is used.

If there is a disconnection or failure in registration, then retry timers can be triggered as per *lwm2m_cfg* file. After a disconnection or device reboot during registration, if the re-registration with server is not required, this setting can be disabled by enabling the parameter **PER_REGSTATUS_FEAT**.

The registration update follows the registration lifetime (as per Resource /1/x/1 value).

3.1.3. Device Management and Service Enablement Interfaces

Device management and service enablement are very important interfaces in LwM2M.

- These interfaces are used by LwM2M Server to access object instances and resources available from the LwM2M Client.
- The interfaces support this access through the use of “Create”, “Read”, “Write”, “Delete”, “Execute”, “Write Attributes”, or “Discover” operations.
- The operations that Resource supports are defined in the Object definition using the Object Template.

The data flow of device management and service enablement is shown as below:

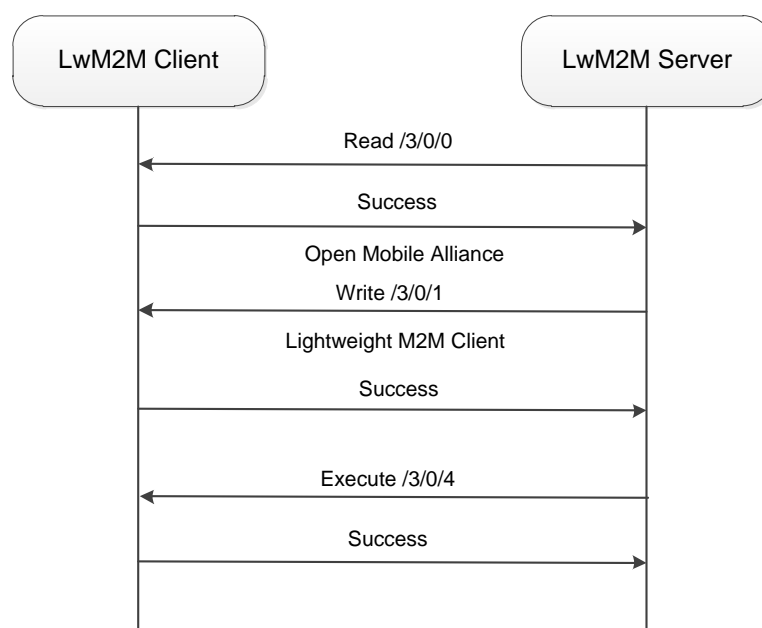


Figure 3: Example Data Flow of Device Management

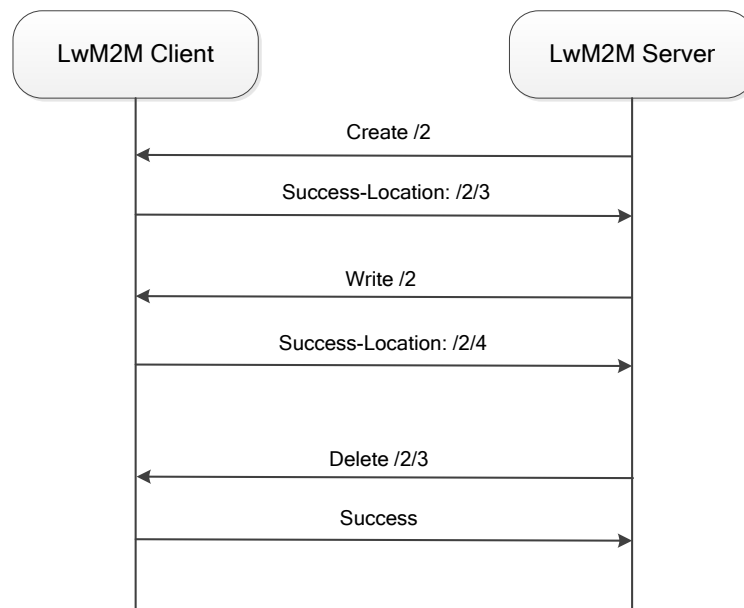


Figure 4: Example Data Flow of Service Enablement

3.1.4. Information Reporting Interface

The information reporting interface is used by a LwM2M Server to observe any changes in a Resource on a LwM2M Client, and receive notifications when new values are available.

- This observation relationship is initiated by sending an “Observe” operation to the LwM2M Client for an Object, an Object Instance or a Resource.
- An observation ends when a “Cancel Observation” operation is performed.

BG96 LwM2M Client supports observation and notification of objects, object instances and resources.

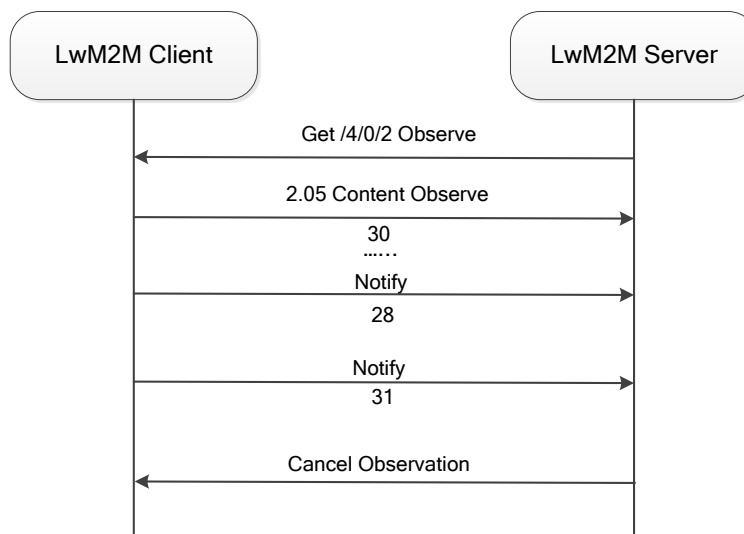


Figure 5: Example Data Flow of Information Reporting

3.2. LwM2M Object

LwM2M Client of BG96 implements the following objects and handles the server requests for them:

- Security object
- Server object
- Access control object
- Device object
- Connectivity monitoring object
- Location object
- Connectivity statistics object

The LwM2M Client of QTI supports the following objects as a pass-through objects:

- Firmware update object
- Software management object
- Device capability management object

The information received for these objects is sent to other registered applications such as DFOTA, which implements these objects and monitors them using LwM2M QAPI.

For example, the LwM2M receives a request for "execute update" on firmware update object. LwM2M Client passes the request to DFOTA application, which is registered to receive the events. When DFOTA application receives the "execute update" message, it processes and applies the image and sends the result to LwM2M Client to forward it to LwM2M Server.

3.3. File Provision and Configuration

The previous chapters provide a simple understanding of LwM2M. BG96 supports LwM2M feature based on CoAP and DTLS protocols. This chapter will introduce how to use this feature on BG96.

Customers just need to modify related configuration files to set the bootstrap server or LwM2M Server address and APN, then the module will connect to the LwM2M Server automatically when the module boots up. LwM2M Server can get all the resources information from the module's LwM2M Client. Presently, BG96 only supports reading/writing of objects.

Related configuration files are shown as below:

Table 1: Configuration Files of LwM2M

Filename	Description
<i>bootstrap.ini</i>	<ul style="list-style-type: none"> Used as factory bootstrap to discover the bootstrap server or other servers. Bootstrap server details for client initiated bootstrap. Can be used to instantiate multiple instances of objects (Security, Server, ACL).
<i>carrier_apn_cfg</i>	This file defined default APN for LwM2M Server connection, as BG96 needs to establish PDN connection first in current network.
<i>lwm2m_app_autostart</i>	LwM2M Client startup script. LwM2M Client will not boot up without this file.
<i>lwm2m_cfg</i>	Contains LwM2M options to control features such as registration retry.
<i>qcli_config</i>	QCLI startup script.

NOTE

If required, the above mentioned files should be preloaded to the folder */data* in BG96. After BG96 reboots, LwM2M Client will run automatically.

3.3.1. bootstrap.ini

bootstrap.ini file contains the object information required for the bootstrapping process. The object information is in JSON format defined in the *OMA Lightweight Machine to Machine Technical Specification*.

Table 2: Format of bootstrap.ini

Attributes	JSON Variable	Mandatory	Description
Base Name	bn	No	The base name string which is prepended to the Name value of the entry for forming a globally unique identifier for resource.
Base Time	bt	No	The base time which the Time values are relative to.
Resource Array	e Array Parameters	Yes	The Resource list as JSON value array according to [SENML] with Array parameter extension (Object Link).
	name n	No	The Name value is prepended by the Base Name value to form the name of the resource instance. The

				<p>resulting name uniquely identifies the Resource Instance from all others.</p> <p>Example:</p> <ul style="list-style-type: none"> if Base Name is "/", the Array entry Name of the Resource is {Object}/{Object Instance}/{Resource}/{Resource Instance} when Base Name is not present, the Array entry Name is the full URI of the requested Resource Instance
Time	t	No		The time of the representation relative to the Base Time in seconds for a notification. Required only for historical representations.
Float Value	v			Value as a JSON float if the Resource data type is Integer, Float, or Time.
Boolean value	bv			Value as a JSON Boolean if the Resource data type is Boolean.
ObjectLink value	ov		One value field is mandatory	Value as a JSON string if the Resource data type is ObjectLink Format.(e.g."10:03")
String value	sv			Value as a JSON string for all other Resource data types. If the Resource data type is opaque the string value holds the Base64 encoded representation of the Resource.

3.3.2. carrier_apn_cfg

The file *carrier_apn_cfg* includes details about the carrier-specific APN used for each server.

Table 3: Items of carrier_apn_cfg

Parameter	Default value	Description
APN_NAME	carrierAPN1	APN to be used for the server with SHORT_SERVER_ID1.
APN_CLASS	2	Class/Category of the APN.
SHORT_SERVER_ID1	102	Short server ID of the server that uses the APN.
BS_IF_REG_FAILS	0	<p>If set to 0, LwM2M Client will not perform bootstrapping on registration failure for this SSID.</p> <p>If set to 1, LwM2M Client will perform bootstrapping on registration failure for this SSID.</p>

Sometimes in order to successfully register to the network and activate the PDN connection, the corresponding APN should be configured according to the current network. After the existing APN

configuration, add a semicolon and then in the next line add a new APN configuration, as shown below:

```
/* Existing APN config */
APN_NAME=vzwadmin
APN_CLASS=2
SHORT_SERVER_ID1=102
; /* New APN config */
APN_NAME=vzwinternet
APN_CLASS=3
SHORT_SERVER_ID1=103
```

3.3.3. lwm2m_cfg

lwm2m_cfg is a LwM2M Client configuration file containing the following configuration information:

Table 4: Items of lwm2m_cfg

Parameter	Default value	Description
APN	-	Default APN to be used if <i>carrier_apn_cfg</i> is not available.
RETRY_TIMEOUT	30	Initial time period (in seconds) to retry data-call if there is a data-call failure.
RETRY_EXPONENT_VAL	2	Value by which timeout for data-call retry has to be increased exponentially.
MAX_RETRY_TIMEOUT	640	Maximum time period (in seconds) for data-call retry.
MAX_NO_RETRIES	5	Maximum number of retry attempts in case of data-call failure.
ACK_TIMEOUT	60	Sleep-ACK timeout value (in seconds). If there is no activity during the period, then DUT goes to sleep.
REG_RETRY_TIMEOUT	60	Initial time period (in seconds) to retry registration, if there is a registration failure.
REG_RETRY_EXPONENT	2	Value by which timeout for registration retry must be increased exponentially.
REG_RETRY_MAXTIMEOUT	480	Maximum time period in seconds for registration retry, if there is a registration failure.
ROAMING_FEAT	1	Determines LwM2M functionality enablement in roaming condition: <ul style="list-style-type: none"> When set to 1, LwM2M functionality is disabled in roaming. When set to 0, LwM2M functionality is

		enabled in roaming.
FER_REGSTATUS_FEAT	0	<p>Determines registration persistence across reboot in LwM2M Client:</p> <ul style="list-style-type: none"> When set to 1, registration persistence is enabled across reboot in LwM2M Client. When set to 0, registration persistence is disabled across reboot in LwM2M Client.
BATTERY_LEVEL_THRESHOLD	20	Battery level less than the threshold mentioned in this configuration value would be considered as low battery by the client.
CARRIER_TYPE	0	<p>Enables carrier specific functionality in the client:</p> <ul style="list-style-type: none"> 0 Default 1 Verizon
REBOOTSTRAP_REG_FAILS_MAX_NO_ATTEMPTS	0	Maximum number of reattempts on bootstrap failure.
REG_EP_NAME	4	<p>EP Name to be used during registration. Please refer to OMA Specifications Section 6.3.1-Endpoint Client Name for more details. Supported values are given below:</p> <ul style="list-style-type: none"> 4 IMEI URN 7 IMEI MSISDN URN
BOOTSTRAP_EP_NAME	7	<p>EP Name to be used during bootstrap. Please refer to OMA Specifications Section 6.3.1-Endpoint Client Name for more details. Supported values are given below:</p> <ul style="list-style-type: none"> 4 IMEI URN 7 IMEI MSISDN URN
BOOT_UP_SLEEP_TIME	5	Sleep time before LwM2M Client operation starts.
GPS_MIN_INTERVAL	3000	The interval (in milliseconds) after which GNSS information is fetched periodically.
GPS_MIN_DISTANCE	1	The change in distance (in meters) after which GNSS information is fetched.

A typical content of *lwm2m_cfg* is shown as below:

```
{
APN=carrier_apn;
RETRY_TIMEOUT=30;
RETRY_EXPONENT_VAL=2;
MAX_RETRY_TIMEOUT=640;
MAX_NO_RETRIES=5;
ACK_TIMEOUT=30;
REG_RETRY_TIMEOUT=60;
```

```
REG_RETRY_EXPONENT=2;
REG_RETRY_MAXTIMEOUT=480;
ROAMING_FEAT=1;
PER_REGSTATUS_FEAT=0;
BATTERY_LEVEL_THRESHOLD=20;
REBOOTSTRAP_REG_FAILS_MAX_NO_ATTEMPTS=5;
CARRIER_TYPE=0;
REG_EP_NAME=4;
BOOTSTRAP_EP_NAME=7;
BOOT_UP_SLEEP_TIME=10;
}
```

NOTE

Customers could not add new resources in the client for customization. Customer's LwM2M Server only gets the resource information supported by BG96 currently.

3.3.4. Security Mode (SSL)

PSK files corresponding to bootstrap server and DIAG server have to be present in `/datatx/ssl`.

And the files should be in the format of `ssid_server.psk` (e.g. `100_server.psk` for Bootstrap Server).

Resource 0/x/2 decides the security mode. Please refer to *OMA Lightweight Machine to Machine Technical Specification* for possible values. For Verizon, security mode should be enabled always for bootstrap and DIAG.

Generate random key using PSKTool with the following steps (PSKTool download path: <https://fossies.org/windows/misc/gnutls-3.5.8-w64.zip/>):

1. Use the following command to generate .psk file. This will generate `101_server.psk` in `/datatx/ssl`.

```
psktool.exe -u iot_app_101 -p 101_server.psk -s 32
```

2. Please check the link below for the tool usage:
https://www.gnutls.org/manual/html_node/psktoolInvocation.html#psktool-Invocation
3. Copy `<short_server_id>_server.psk` file generated in `datatx/ssl/` directory into alternate file systems of BG96.

4 Description of LwM2M AT Command

4.1. AT+QLWM2M Configure LwM2M Client

The command is used to configure the parameters of LwM2M Client before connecting to LwM2M Server.

AT+QLWM2M Configure LwM2M Client	
Test Command AT+QLWM2M=?	Response +QLWM2M: "select", (0-5) +QLWM2M: "cdp", <server>, <port> +QLWM2M: "epns", (0,1)[, <ep_name>] +QLWM2M: "bsmode", (0,1) +QLWM2M: "mbsps", <srvCode>, <seriaNo>, <cnt>, <icci> d>, <module>[, <mac>] +QLWM2M: "register"[, (0,1)] +QLWM2M: "update", <ssid>[, (0,1)] +QLWM2M: "deregister" +QLWM2M: "lifetime", <ssid>, (30-86400) +QLWM2M: "uldata", <objID>, (1-1460), <Data> +QLWM2M: "ulhex", <objID>, (1-1460), <HexData> +QLWM2M: "dltype", (0,1) +QLWM2M: "ippref", (0,1) +QLWM2M: "enable", (0,1) +QLWM2M: "bootstrap", (0-4)[, <instance>] +QLWM2M: "qcli_en", (0,1) +QLWM2M: "psk", (0,1) +QLWM2M: "apn", <apn_name> +QLWM2M: "endpoint", (4,7), (4,7) +QLWM2M: "reset" +QLWM2M: "clean" OK
Write Command Select/query the type of LwM2M Server: AT+QLWM2M="select"[, <server_type> >]	Response If <server_type> is present, select the LwM2M Server to be connected to: OK Or

	<p>ERROR</p> <p>Else query the current configuration: +QLWM2M: "select",<server_type></p> <p>OK</p>
<p>Write Command</p> <p>Configure/query the the LwM2M Server address and port: AT+QLWM2M="cdp",<server>,<port>]</p>	<p>Response</p> <p>If <server> and <port> are present, configure the LwM2M Server address and port: OK Or ERROR</p> <p>Else query the current configuration: +QLWM2M: "cdp",<server>,<port></p> <p>OK</p>
<p>Write Command</p> <p>Configure/query the EP name for LwM2M authentication: AT+QLWM2M="epns",<auto_mode>,<ep_name>]</p>	<p>Response</p> <p>If <auto_mode> and <ep_name> are present, set the EP name for LwM2M authentication: OK Or ERROR</p> <p>Else query the current configuration: +QLWM2M: "epns",<ep_name></p> <p>OK</p>
<p>Write Command</p> <p>Configure/query the bootstrap mode to be/being used: AT+QLWM2M="bsmode",<bs_mode>]</p>	<p>Response</p> <p>If <bs_mode> is present, set the bootstrap mode to be used: OK Or ERROR</p> <p>Else query the current configuration: +QLWM2M: "bsmode",<bs_mode></p> <p>OK</p>
<p>Write Command</p> <p>Configure/query parameters required for LGU+ LwM2M authentication: AT+QLWM2M="mbsps",<srvCode>,<seriaNo>,<cnt>,<iccid>,<module>,<mac>]</p>	<p>Response</p> <p>If all these parameters are present, set the parameters required for LGU+ LwM2M authentication: OK Or ERROR</p>

	<p>Else query the current configuration: +QLWM2M: "mbsps",<srvCode>,<seriaNo>,<cnt>,<iccid>,<module>,<mac></p> <p>OK</p>
<p>Write Command Start LwM2M Client and initiate registration: AT+QLWM2M="register",<reg_mode>]</p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Send "registration update" message to LwM2M Server: AT+QLWM2M="update",<ssid>,<update_mode>]</p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Deregister from LwM2M Server: AT+QLWM2M="deregister"</p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Change registration lifetime of LwM2M Client: AT+QLWM2M="lifetime",<ssid>,<lifetime></p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Send uplink data to the server through a specified resource: AT+QLWM2M="uldata",<objID>,<data_size>,<Data></p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Send hexadecimal uplink data to the server through the specified resource: AT+QLWM2M="ulhex",<objID>,<data_size>,<HexData></p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Configure the preferred format to output the incoming downlink data: AT+QLWM2M="dltype",<data_type></p>	<p>Response OK</p> <p>If there is any error: ERROR</p>
<p>Write Command Configure the preferred PDN type to be used to start data call for LwM2M:</p>	<p>Response OK</p>

AT+QLWM2M="ippref",<ip_type>	If there is any error: ERROR
Write Command Enable/disable LwM2M Client feature: AT+QLWM2M="enable",<enable_value>	Response OK If there is any error: ERROR
Write Command Configure the configuration category: AT+QLWM2M="bootstrap",<category>[,<instance>]	Response OK If there is any error: ERROR
Write Command Enable/disable QCLI: AT+QLWM2M="qcli_en",<qcli_value>	Response OK If there is any error: ERROR
Write Command Configure/query PSK key value: AT+QLWM2M="psk",<psk_operation>	Response OK If there is any error: ERROR
Write Command Configure the APN to be used for the server: AT+QLWM2M="apn",<apn_name>	Response OK If there is any error: ERROR
Write Command Configure the EP name to be used during registration and bootstrap: AT+QLWM2M="endpoint",<reg_epname>,<bs_epname>	Response OK If there is any error: ERROR
Write Command Delete persistent files of LwM2M Client to make all configurations take effect after module resetting: AT+QLWM2M="reset"	Response OK If there is any error: ERROR
Write Command Clean all LwM2M Client configuration files: AT+QLWM2M="clean"	Response OK If there is any error: ERROR

Parameter

<server_type>	This parameter is used to select the type of LwM2M Server to which the LwM2M Client will be connected. 0 Leshan server 1 T-Mobile server 2 LGU+ server 3 Verizon motive server 4 Ericsson server 5 AT&T server
<server>	LwM2M Server address to be accessed to.
<port>	LwM2M Server port number. The range is 0-65535.
<auto_mode>	Whether to automatically generate an EP name. 0 Use the <ep_name> to automatically generate a special EP name based on the rules required by the LGU+. For LGU+ only. 1 Set <ep_name> as EP name for LwM2M authentication.
<ep_name>	EP name. Identify the LwM2M Client on one LwM2M Server (including LwM2M Bootstrap Server). It is provided to the LwM2M Server during registration, and is also provided to the LwM2M Bootstrap Server when executing the bootstrap procedure.
<bs_mode>	Bootstrap mode. 0 Factory bootstrap 1 Client initiated bootstrap
<srvCode>	Service code defined by LGU+.
<seriaNo>	The IMEI number of module.
<cnt>	The phone number of inserted (U)SIM card.
<iccid>	The ICCID number of inserted (U)SIM card.
<module>	Module type.
<mac>	The MAC address of module.
<reg_mode>	Registration mode. 0 Register to the server only once. 1 Register to the server automatically.
<ssid>	Short server ID.
<update_mode>	Whether to send "registration update" message with object lists. 0 Without supported object lists. 1 With supported object lists.
<life_time>	The lifetime of the registration in seconds. The range is 30-86400.
<objID>	The object ID for data transfer. Currently, only object 19, object 10250 and object 26241 are supported. The object 10250 and object 26241 are used only by LGU+.
<data_size>	The length of the uplink data to be sent. The range is 1-1460. Unit: byte.
<Data>	Uplink data to be entered and sent.
<HexData>	The hexadecimal uplink data to be entered and sent.
<data_type>	Preferred format to output the incoming downlink data

	<ul style="list-style-type: none"> 0 Prefer to output the downlink data in text format. 1 Prefer to output the downlink data in hexadecimal format.
<ip_type>	<p>Preference PDN type to be used to start data call for LwM2M.</p> <ul style="list-style-type: none"> 0 Prefer to start IPv4 data call. 1 Prefer to start IPv6 data call.
<enable_value>	<p>Enable/disable LwM2M Client functionality.</p> <ul style="list-style-type: none"> 0 Disable LwM2M Client feature 1 Enable LwM2M Client feature
<category>	<p>Integer type. The configuration category.</p> <ul style="list-style-type: none"> 0 Backup <i>bootstrap.ini</i> file from EFS. If the backup file is not exist in <i>/datatx/factory</i>, the command will response an error. 1 Configure LwM2M registration or bootstrap server address and port <ul style="list-style-type: none"> <instance> LwM2M Server address and port. The format of server address is "coap(s)://server_address:server_port". 2 Specify the lifetime of the registration in seconds. <ul style="list-style-type: none"> <instance> The lifetime of the registration in seconds. The maximum value is 86400. 3 The access mode through which the LwM2M Client is connected to the LwM2M Server. <ul style="list-style-type: none"> <instance> If set to 0, LwM2M Client will connect to registration server. If set to 1, LwM2M Client will try to connect to bootstrap server. 4 Security mode <ul style="list-style-type: none"> <instance> If set to 0, LwM2M Client will use PSK mode. If set to 3, LwM2M Client will use no-security mode.
<qcli_value>	<p>This parameter is used to enable QCLI.</p> <ul style="list-style-type: none"> 0 Disable. 1 Enable
<psk_operation>	<p>If set to 0, the module will use "IMEI:<imei>_QUECTELTMOBILEDDI" as PSK identify and use SHA256 to generate PSK key value automatically. After the command is responded successfully, PSK file will be saved into <i>/datatx/ssl</i> folder. If set to 1, the module can query the PSK key value using currently.</p>
<apn_name>	<p>APN to be used for the server.</p>
<reg_epname>	<p>EP name to be used during registration. Please refer to OMA Specifications Section 6.3.1-Endpoint Client Name for more details. The following are the supported values:</p> <ul style="list-style-type: none"> 4 IMEI URN 7 IMEI MSISDN URN
<bs_epname>	<p>EP Name to be used during bootstrap. Please refer to OMA Specifications Section 6.3.1-Endpoint Client Name for more details. The following are the supported values:</p> <ul style="list-style-type: none"> 4 IMEI URN 7 IMEI MSISDN URN

4.2. Description of LwM2M URCs

LwM2M URCs will be reported to the host when LwM2M Client is in registration, observation and application data transmission.

4.2.1. "+QLWEVENT:" URC for Status Reporting

When the LwM2M Client is in bootstrapping and registration process, this URC will be reported.

" +QLWEVENT:" URC for Status Reporting

+QLWEVENT: <eventID>,<statusStr> Report the current status of LwM2M Client.

Parameter

<eventID>	Integer type. The LwM2M Client status.
<statusStr>	A string to describe LwM2M Client status.

4.2.2. "+QLWOBSERVE:" URC for Observation Notification

When the resource of object 19, object 10250 or object 26241 are observed, this URC will be reported.

" +QLWOBSERVE:" URC for Observation Notification

+QLWOBSERVE: <tokenID>,<uri>,<obs_flag> Observation notification.

Parameter

<tokenID>	The token value of observe CoAP message.
<uri>	Observed URI of client.
<obs_flag>	Observed or not.
	0 Observed
	1 Observation canceled

4.2.3. "+QLWDLDATA:" URC for Incoming Data Notification

When the LwM2M Client has received downlink data from the server, this URC will be reported.

" +QLWDLDATA:" URC for Incoming Data Notification

+QLWDLDATA: <uri>,<data_type>,<data_len>,<data> Downlink data incoming notification.

Parameter

<uri>	Resource for reporting data.
<data_type>	The type of incoming downlink data. 4 Resource value type is string. 5 Resource value type is opaque.
<data_len>	The length of incoming downlink data. Unit : byte.
<data>	The incoming downlink data.

5 Firmware Update (DFOTA)

OMA defines the application layer communication protocol between a LwM2M Server and a LwM2M Client, which is located in a LwM2M device. For BG96, the LwM2M protocol is used to manage device provisioning and is a trigger of a DFOTA procedure. For the DFOTA upgrade on the BG96, firmware update object is provided by the LwM2M specification.

The typical process of DFOTA is illustrated below:

1. Download the firmware image.
2. Trigger the firmware update on the BG96.
3. Boot the flow to apply candidate firmware image.

The LwM2M Client will be notified about the new firmware by the LwM2M Server using Constrained Application Protocol (CoAP). The client sends the indication to registered DFOTA application. DFOTA application downloads the firmware from the server and stores it on file system of BG96. The following diagram shows the key components involved in DFOTA process on BG96.

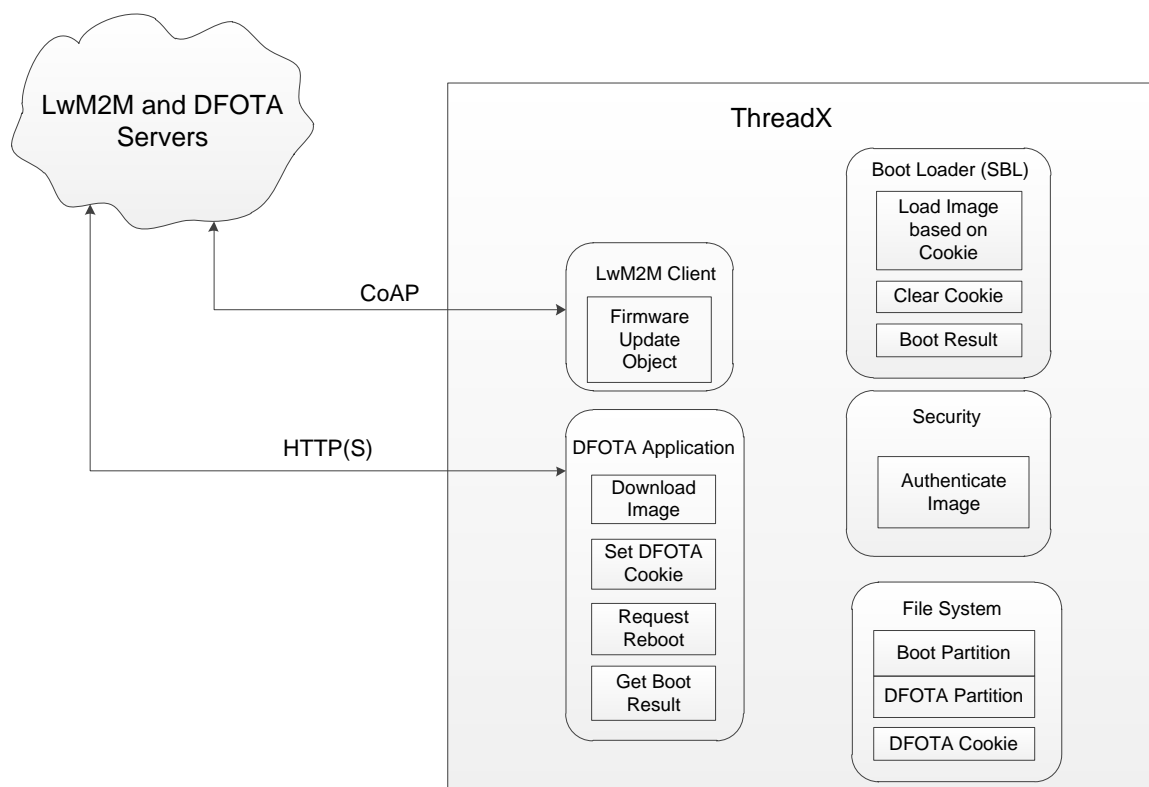


Figure 6: LwM2M Firmware Image Download

About “Firmware Update Object” in LwM2M on BG96, the detailed interaction process between LwM2M Client on BG96 and LwM2M Server will be described as below.

LwM2M Client registers and observes the “Package URI” resource in firmware update object, and then customers will see this object shown in the server after client registering success.

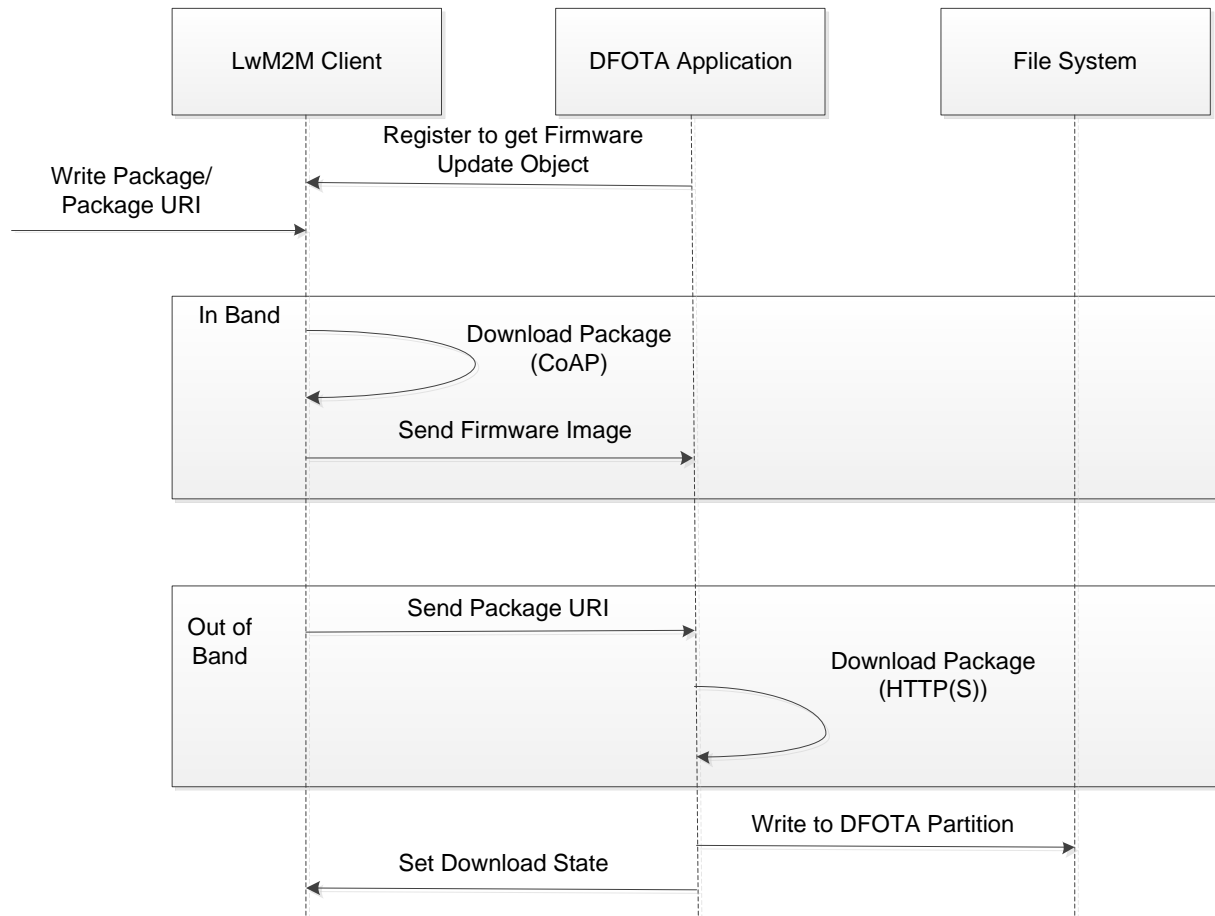


Figure 7: Observe Package URI and Download Firmware

- In “In-Band” mode, the module downloads firmware package from LwM2M Server directly via CoAP protocol, and send downloaded package to DFOTA application. All “firmware update” actions will be done in the application.
- In “Out of Band” mode, the only difference is that the module downloads firmware package from HTTP(S) server to the local.

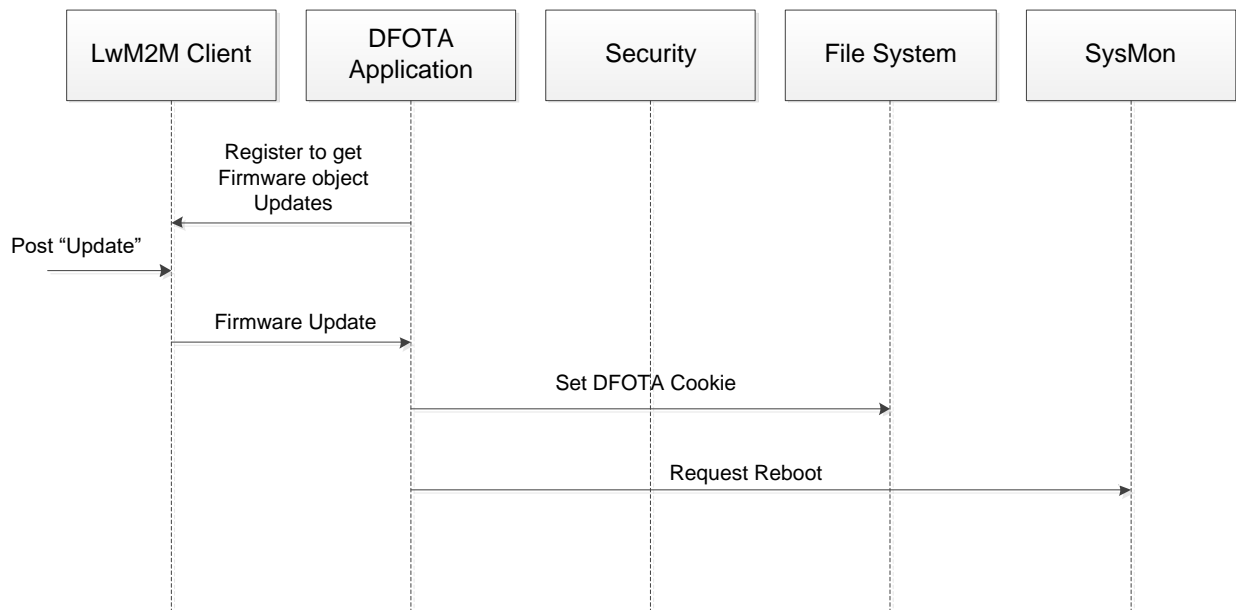


Figure 8: Observe “Update” Resource and Update Event Processing

6 Examples

6.1. LwM2M Feature Test (Leshan Server)

LwM2M feature can be tested on Leshan server. If customers want to test BG96 LwM2M Client on Leshan server, please follow the steps below:

1. *qcli_config*, *bootstrap.ini*, *carrier_apn_cfg*, and *lwm2m_cfg* should be added to alternate file system of BG96, but some files should be modified before adding.

- 1) One sequence of *bootstrap.ini* file should be modified to specify Leshan server address for BG96:

- In Non-Security mode:

```
{ "bn": "/0/1/",  
  "e": [  
    { "n": "0", "sv": "coap://leshan.eclipse.org:5683" },  
    { "n": "1", "bv": false },  
    { "n": "2", "v": 3 },  
    { "n": "10", "v": 102  
  ] }
```

- In Security mode with PSK:

```
{ "bn": "/0/1/",  
  "e": [  
    { "n": "0", "sv": "coaps://leshan.eclipse.org:5684" },  
    { "n": "1", "bv": false },  
    { "n": "2", "v": 0 },  
    { "n": "10", "v": 101  
  ] }
```

- 2) *carrier_apn_cfg* and *lwm2m_cfg* should be modified to offer the correct APN value and class based on the module's network environment. For details, please refer to **Chapter 3.3.2** and **Chapter 3.3.3**.
2. Create a directory named *lwm2m* under */datatx* (*/datatx/lwm2m*) in alternate file system of BG96. If BG96 is connected to Leshan server in security mode, then an additional direction named *SSL* should be created under */datatx* (*/datatx/lwm2m*) and finally add PSK file into this folder.

Please note that if security mode is used while creating connection to Leshan server, then client security configuration should be added in the web interface of the server, according to steps illustrated in the figure below.

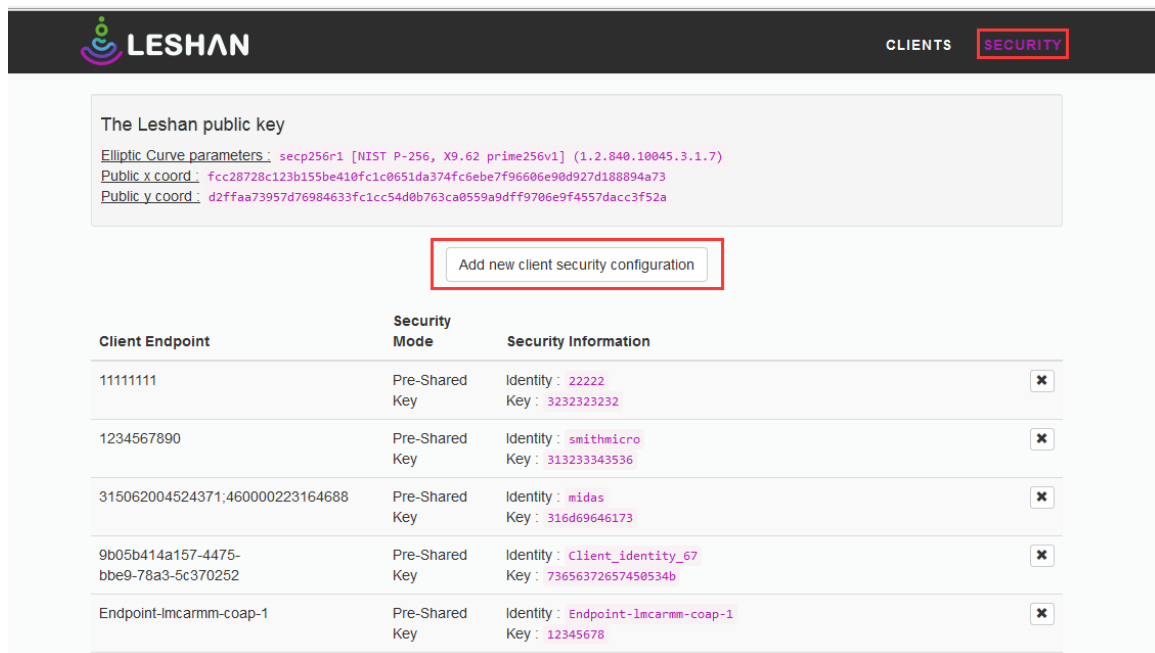


Figure 9: Click “Add New Client Security Configuration” (in SECURITY Tab)

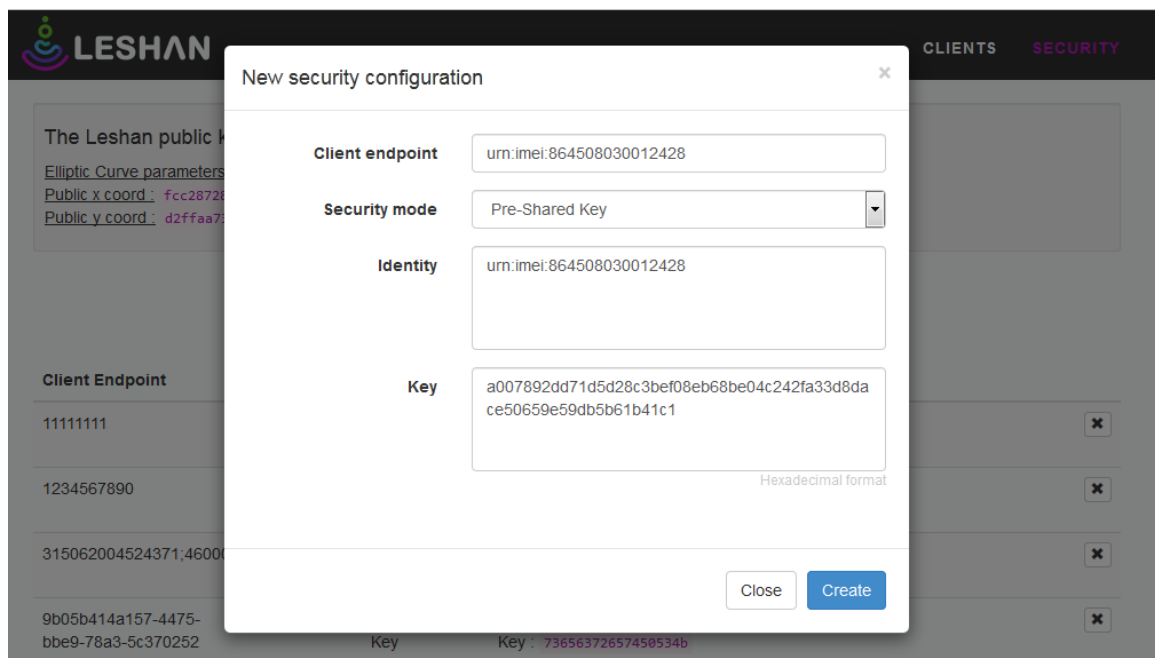


Figure 10: Create “New Security Configuration” on Leshan Server

- After all modified files are loaded into /datatx folder of EFS, the following information can be read through the debug port of BG96 after reboot.

```
Net: Net Registered
dss_netapp: DSS_NetApp Registered
LwM2M_EXT: LwM2M_EXT Registered
```

Command List:

Commands:

1. Help
2. Exit

Subgroups:

3. Net
4. dss_netapp
5. LwM2M_EXT

```
> LwM2M: CLI registered
LwM2M: LwM2M_LOG:Carrier type = 0
LwM2M:
LwM2M: REG EP NAME = 4
LwM2M:
LwM2M: BOOTSTRAP EP NAME = 7
LwM2M:
LwM2M: LwM2M_LOG: bootstrap_name --> urn:imei-msisdh:864508030012428-5755127091
LwM2M:
LwM2M: State: STATE_REGISTER_REQUIRED
LwM2M: State: STATE_REGISTERING
LwM2M: State: STATE_READY
```

When “LwM2M: State: STATE_READY” is shown, it means BG96 has been connected to Leshan server successfully. Leshan server shows the permission for each resource on the webpage. For instance, if customers want to get “Lifetime” resource value, there is only a need to click “**Read**” button on webpage and then “Lifetime” value will be shown. When any resource value needs to be updated, customers only need to click “**Write**” and input a new value.

an.eclipse.org/#/clients

an


 CLIENTS SECURITY				
				Connected clients: 9
Client Endpoint	Registration ID	Registration Date	Last Update	
esp80144c	IXuMRscpzS	Oct 13, 2017 9:38:29 PM	Oct 14, 2017 11:54:51 AM	
TEST_DEVICE_01	Wxt3BSVuBa	Oct 13, 2017 2:04:13 PM	Oct 13, 2017 2:04:13 PM	
urn:imei:864508030012428	QawCCr3e1M	Oct 14, 2017 11:54:19 AM	Oct 14, 2017 11:54:19 AM	
my-smart-watch	Bs5xNg4zTu	Oct 13, 2017 10:12:39 PM	Oct 13, 2017 10:12:39 PM	
TCMR-07654321	4NhEOIAUzU	Oct 14, 2017 6:58:40 AM	Oct 14, 2017 6:58:40 AM	
urn:imei:004402090410378	1x4yl0LBFP	Oct 14, 2017 10:08:11 AM	Oct 14, 2017 10:08:11 AM	
Santiago_Any_132	YCr1OJvnk	Oct 4, 2017 4:29:55 PM	Oct 14, 2017 11:27:56 AM	
urn:imei:004401082034311	fgcdi8AJUv	Oct 13, 2017 11:48:19 PM	Oct 14, 2017 12:58:34 AM	
urn:imei:004401082034279	F0UzYwqY2Q	Oct 13, 2017 3:19:34 PM	Oct 14, 2017 11:54:58 AM	

Figure 11: Online Client on Leshan Server


 CLIENTS SECURITY				
Clients / urn:imei:864508030012428		Multi-value <input type="button" value="TLV"/> Single-value <input type="button" value="TLV"/>		
LwM2M Server / 1				
Instance 1	/1/1	<div> <div>Create New Instance</div> <div> <div>Observe ▶ </div> <div>Read</div> <div>Write</div> <div>Delete</div> </div> </div>		
Short Server ID	/1/1/0	Observe ▶	Read	102
Lifetime	/1/1/1	Observe ▶	Read	300
Default Minimum Period	/1/1/2	Observe ▶	Read	1
Default Maximum Period	/1/1/3	Observe ▶	Read	60
Disable	/1/1/4	Exec		
Disable Timeout	/1/1/5	Observe ▶	Read	86400
Notification Storing When Disabled or Offline	/1/1/6	Observe ▶	Read	true
Binding	/1/1/7	Observe ▶	Read	UQS
Registration Update Trigger	/1/1/8	Exec		

Figure 12: Client Object and Instance on Leshan Server

6.2. LwM2M Client Configuration

```
//Load LGU+ built-in configuration
```

```
AT+QLWM2M="select",2
```

```
OK
```

```
//Configure the server address and port number
```

```
AT+QLWM2M="cdp","xxx.103.233.xxx",5783
```

```
OK
```

```
//Set a specific EP name
```

```
AT+QLWM2M="epns",0,"QUEC"
```

```
OK
```

```
//Set specific LwM2M parameters (for LGU+ server only)
```

```
AT+QLWM2M="mbmps","QUEC","992185","01212345678","904978","LWTHM"
```

```
OK
```

```
//Initiate bootstrapping or registration
```

```
AT+QLWM2M="register"
```

```
OK
```

```
//LGU+ server mode is client initiated bootstrap
```

```
+QLWEVENT: 0,"STATE_INITIAL"
```

```
+QLWEVENT: 1,"STATE_BOOTSTRAP_REQUIRED"
```

```
+QLWEVENT: 2,"STATE_BOOTSTRAPPING"
```

```
+QLWEVENT: 0,"STATE_INITIAL"
```

```
+QLWEVENT: 3,"STATE_REGISTER_REQUIRED"
```

```
+QLWEVENT: 4,"STATE_REGISTERING"
```

```
+QLWEVENT: 5,"STATE_READY"
```

```
//“UL data” resource of “application data container” object (10250) observed by the server
```

```
+QLWOBSERVE: "A88044B83F554A5D","/10250/0/0"
```

```
//Resource of “application firmware” object (26241) observed by the server
```

```
+QLWOBSERVE: "3A6695CDCC9EDC3C", "/26241/0/0"
```

```
//Send data to the server (text mode)
```

```
AT+QLWM2M="uldata",10250,5,"hello"
```

```
OK
```

```
//Send data to the server (hex mode)
```

```
AT+QLWM2M="ulhex",10250,5,"3031323334"
```

```
OK
```

```
//Report incoming data from server
```

```
+QLWDLDATA: "10250/0/1",2,"3031"
```

7 FAQs

In practical application scenarios, customers may encounter some problems. The following are the solutions for some frequently asked questions for reference:

1. **Q:** The module has been registered to the network, but why the LwM2M cannot set up a data call or connect to the server?
A: LwM2M is implemented in APPS side of BG96. If the LwM2M wants to set up a data call and establish a PDN connection, then customers should set a correct APN in *carrier_apn_cfg* and *lwm2m_cfg* for LwM2M according to the current network situation.
2. **Q:** When the LwM2M initialization is complete, why the error message “LWM2M: LWM2M_LOG: Populating Reg EP name: LWM2M_IMEI_MSISDN_URN failed” is displayed on the QCLI debug port?
A: When BOOTSTRAP_EP_NAME or REG_EP_NAME is set as 7 in *lwm2m_cfg*, LwM2M will use IMEI and MSISDN to generate an EP name for connection. If the module cannot query MSISDN from the (U)SIM card successfully or the (U)SIM card does not have a MSISDN, then LwM2M will respond the error when connecting to the server. In such case, please set BOOTSTRAP_EP_NAME or REG_EP_NAME to 4 and test again.
3. **Q:** LwM2M has been connected to LwM2M Server before, but why the server cannot be connected successfully after setting a new LwM2M Server address in *bootstrap.ini* and rebooting?
A: After LwM2M is connected to LwM2M Server, LwM2M will generate some temporary files in */datatx/lwm2m/* in Alternate EFS. These persistent files must be deleted to make the new configurations take effect.

8 Appendix A References

Table 5: Related Documents

SN	Document Name	Remark
[1]	OMA-TS-LightweightM2M-V1_0-20170208-A	OMA Lightweight Machine to Machine Technical Specification
[2]	OMA-AD-LightweightM2M-V1_0-20170208-A	OMA Lightweight Machine to Machine Architecture

Table 6: Terms and Abbreviations

Abbreviation	Description
ACL	Access Control List
APN	Access Point Name
APPS	Application Subsystem
CoAP	Constrained Application Protocol
DFOTA	Delta Firmware Upgrade Over-the-air
DIAG	Diagnostics
DTLS	Datagram Transport Layer Security
DUT	Device Under Test
EFS	Embedded File System
EP	Endpoint
GNSS	Global Navigation Satellite System
HTTP(S)	Hypertext Transfer Protocol (Secure)
IMEI	International Mobile Equipment Identity

LwM2M	Lightweight Machine to Machine
MSISDN	Mobile Station International Subscriber Directory Number
OMA	Open Mobile Alliance
PDN	Public Data Network
QCLI	Qualcomm Command Line Interface
SSID	Short Server Identifier
SSL	Secure Sockets Layer
UI	User Interface
URI	Uniform Resource Identifier
URN	Uniform Resource Name
