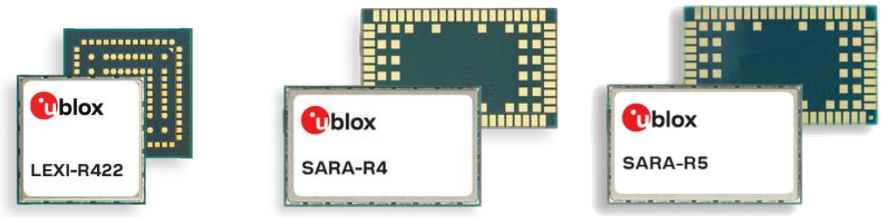
LEXI-R4 / SARA-R4 / SARA-R5 series

LwM2M objects and commands

Application note



Abstract

u-blox cellular modules offer LwM2M options to achieve a few mandatory objects, extensible object, and Firmware Over The Air update (uFOTA). This application note covers details on the mandatory objects, an example about extensible object and available com

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This document applies to the following products:

Product name	
LEXI-R422	
SARA-R410M	Except for "01B", "52B" product versions
SARA-R412M	
SARA-R422	
SARA-R422M8S	
SARA-R422M10S	
SARA-R422S	
SARA-R5 series	

☞ SARA-R410M-02B-00, SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R412M-02B-00, SARA-R412M-02B-01, and SARA-R412M-02B-02 support the LwM2M feature only for the uFOTA service. For more details, see the SARA-R4 series firmware update with uFOTA, FOAT and EasyFlash application note [9].

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1 LwM2M overview and architecture

Lightweight machine-to-machine (LwM2M) is a secure, efficient, and deployable client-server protocol for managing resource constrained devices on a variety of networks. The module implements the LwM2M client and sits in between the server and the host application. The u-blox client implementation is compliant with LwM2M OMA TS version 1.0 [7].

1.1 LwM2M interfaces

The Open Mobile Alliance (OMA) defines the application layer communication between an LwM2M server and an LwM2M client.

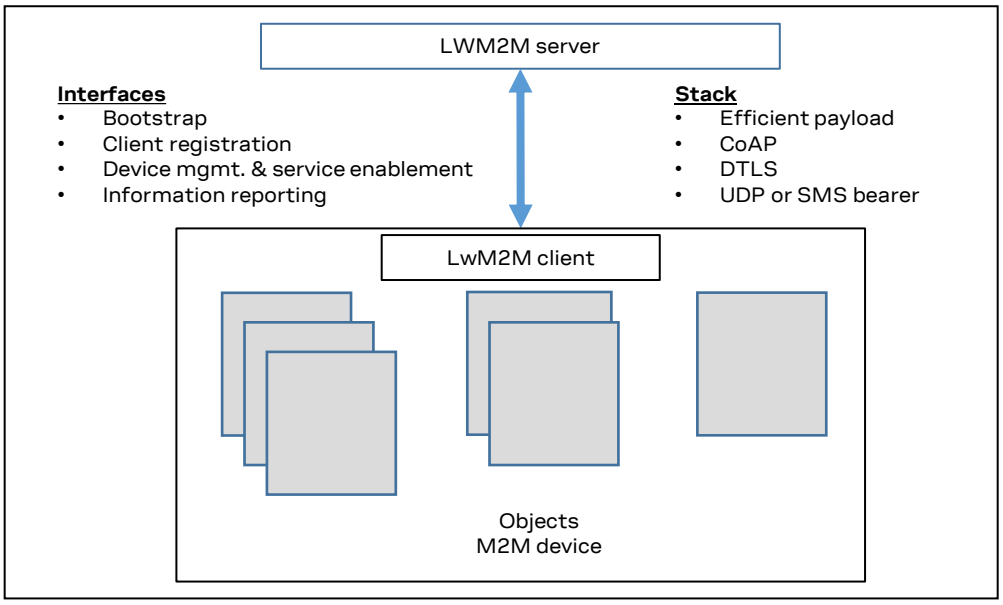


Figure 1: Interfaces between the server and client

- Bootstrap interface: to configure servers' info, credentials & ACLs
- Client registration interface: to inform server about "existence" and supported functionality (e.g., objects, transport bindings)
- Device management and service enablement interface: to access object instances and resources
- Information reporting interface: to publish/subscribe interaction to monitor changes in resources

The LwM2M client connects to the server using the CoAP protocol. For secure connections it uses DTLS with the Pre-Shared Key (PSK).

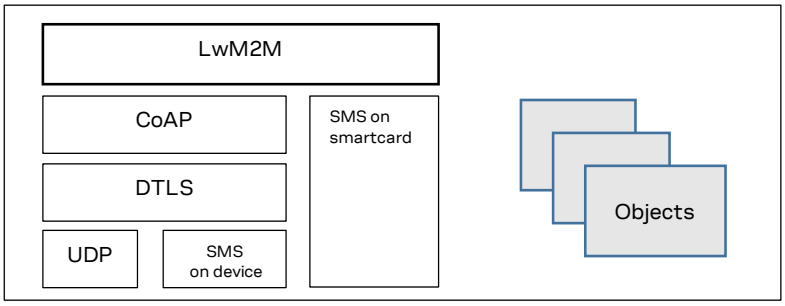


Figure 2: Protocols used in LwM2M

☞ The SMS on device/smart card is not implemented in SARA-R4 series.

1.2 High level LwM2M client architecture

The LwM2M architecture on the module consists of the modem, LwM2M client, Lua interpreter and the Lua objects.

An external host or LwM2M server with permission can access the object instances and resources provided by the LwM2M client. A “Write” operation changes the value of a resource, the values of an array of resources instances, or the values of multiple resources of an object instance. A “Read” operation accesses the value of a resource, an array of resource instances, an object instance or all the object instances of an object.

LwM2M objects are implemented as Lua scripts. The scripts can be modified to perform custom actions in response to LwM2M operations. For example, an "Execute" operation from an LwM2M server could be used to send a URC to the external host to trigger a specific action.

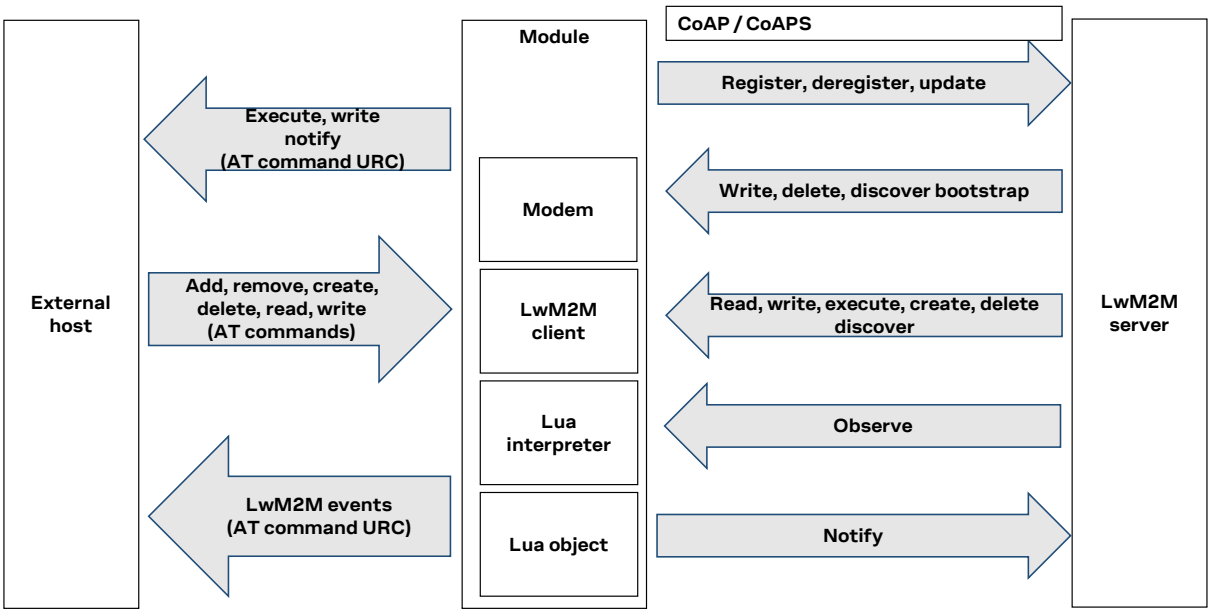


Figure 3: High level architecture

1.3 Objects and resources

LwM2M uses a simple flat data model consisting of object instances and their constituent resources that can be addressed using consistent URI scheme across clients.

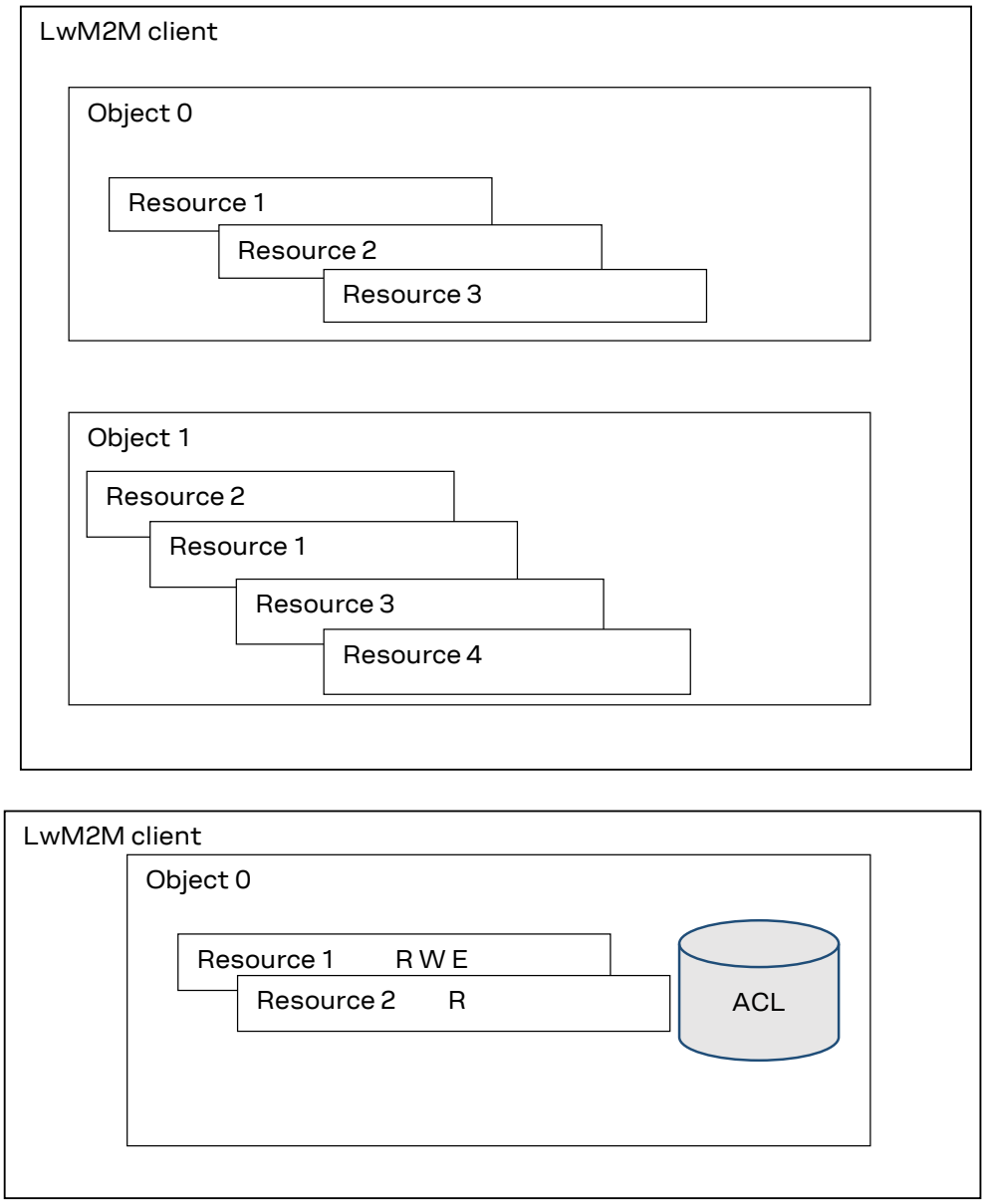


Figure 4: Objects, instances, and resources

- An object can have multiple instances and is a collection of resources.
- A resource is an atomic piece of information that can be read, written, or executed.
- Access control lists (ACLs) define which operations on a given object instance are allowed for which LwM2M server(s).
- A resource can be of the type: string, integer (8 – 64 bit), float, boolean, time, ObjLnk, none
- Objects/Resources are accessed with simple URI like /{ObjectID}/{ObjectInstance}/{ResourceID} Ex: /3/0/1 = 3 – Device Object, 0 – Instance of Object, 1 –Manufacturer

2 Objects and categories

For more details on LwM2M and categories, see http://www.openmobilealliance.org/wp/OMNA/LwM2M/LwM2MRegistry.html.

Category	URN	Object ID	Description
oma-label	urn:oma:lwm2m:oma:<id>:<version>	0 - 1023	Objects produced by OMA. Only OMA can use this range
ext-label	urn:oma:lwm2m:ext:<id>:<version>	2048 - 10240	Objects registered by 3rd party standards organizations or alliances
x-label	urn:oma:lwm2m:x:<id>:<version>	10241 - 26240 26241 – 32768 32769 - 42768	Objects registered by companies or individuals. Objects Produced by Vendors to re-use Block of objects reserved by vendors (Max 50). Private range, Objects will not be published

2.1 Supported objects

LwM2M objects are implemented as Lua scripts which act as the container for the objects, object instances, and resources. The Lua objects are generated using the XML provided by OMA and customized for the module. For more details, see section 4.1.1.

Table 1, Table 2, Table 3, and Table 4 show the objects and resources supported by different series modules.

Object ID	Name	Resources supported by SARA-R410M-02B / SARA-R412M-02B	Notes
0	Security	0, 1, 2, 3, 5, 9, 10, 11, 30000**	** = Only supported in Verizon configuration
1	Server	0, 1, 2, 3, 4, 5, 7, 8, 16, 17, 18, 30000**	** = Only supported in Verizon configuration
2	Access Control	0, 1, 2, 3	
3	Device	0, 1, 2, 3, 4, 5, 6*, 7*, 8*, 9*, 10, 11*, 12*, 13*, 14*, 15*, 16, 17, 18* ,19, 20*, 21, 22*, 30000**	* = Data written by end device ** = Only supported in Verizon configuration
4	Connectivity Monitoring	0, 1, 2, 3, 4, 5, 7*, 8, 9, 10, 30000**	* = Data written by end device ** = Only supported in Verizon configuration
5	FW Update	1, 2, 3, 5, 7, 8, 9	Only via uFOTA / Verizon server
6	Location	0, 1, 2, 3, 4, 5, 6	Data written by end device
7	Connectivity Statistics	0, 1, 2, 3, 4, 5, 6, 7 ,8	
10	Cellular Connectivity	4, 5, 9	
11	APN Connection Profile	0, 1, 3, 9, 10, 11, 12, 24, 25	
14	Software Component	0, 2, 5	
15	Device Capability Management	0, 1, 2, 3, 4, 5, 6, 7	Data written by end device
16	Portfolio	0	Data written by end device
3300	Generic Sensor	5601, 5603, 5604, 5605, 5607, 5700, 5701, 5750, 5751	Data written by end device
10241	Host Device Information	5905, 5906, 5907, 5908	Data written by end device
10262	Interval Data Delivery	0, 1, 2, 3	Data written by end device
10299**	Host Device	0, 1, 2*, 3, 4, 5*, 6	* = Data written by end device
10308	AT&T Extended Connectivity	1, 2, 3, 7, 8	Only supported in AT&T configuration

Table 1: LwM2M objects, SARA-R4 "02B" product versions

Object ID	Name	Resources supported by SARA-R410M-63B-00 / SARA-R410M-73B-00 / SARA-R410M-83B-00	Resources supported by SARA-R410M-63B-01 / SARA-R410M-73B-01 / SARA-R410M-83B-01	Notes
0	Security	0, 1, 2, 3, 5,	0, 1, 2, 3, 5, 10, 11	
1	Server	0, 1, 7, 8	0, 1, 2, 3, 4, 5, 7, 8	
2	Access Control	0, 1, 2, 3	0, 1, 2, 3	
3	Device	0, 1, 2, 3, 4, 6*, 7*, 8*, 9*, 11*, 16, 17	0, 1, 2, 3, 4, 5, 6*, 7*, 8*, 9*, 10, 11*, 12*, 13*, 14*, 15*, 16, 17, 18* ,19, 20*, 21, 22*	* = Data written by end device
4	Connectivity Monitoring	0, 1, 2, 3, 4, 5, 7, 8	0, 1, 2, 3, 4, 5, 7*, 8, 9, 10	* = Data written by end device
5	FW Update	1, 2, 3, 5, 9	1, 2, 3, 5, 7, 8, 9	Only via uFOTA server
6	Location	0, 1, 2, 3, 4, 5, 6	0, 1, 2, 3, 4, 5, 6	Data written by end device
7	Connectivity Statistics	2, 3, 6, 7, 8	2, 3, 4, 5, 6, 7 ,8	
14	Software Component	-	0, 2, 5	
15	Device Capability Management	-	0, 1, 2, 3, 4, 5, 6, 7	Data written by end device
16	Portfolio	-	0	Data written by end device
3300	Generic Sensor	0	0, 5601, 5603, 5604, 5605, 5607, 5700, 5701, 5750, 5751	Data written by end device
10241	Host Device Information	-	5905, 5906, 5907, 5908	Data written by end device
10262	Interval Data Delivery	-	0, 1, 2, 3	Data written by end device
10299	HostDevice	-	0, 1, 2, 3, 4, 5, 6	Data written by end device

Table 2: LwM2M objects, SARA-R4 "63B", "73B", "83B" product versions

Object ID	Name	Resources supported by LEXI-R4 / SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S	Notes
0	Security	0, 1, 2, 3, 5, 9, 10, 11, 30000**	** = Only supported in Verizon configuration by SARA-R422-01B, SARA-R422S-01B and SARA-R422M10S
1	Server	0, 1, 2, 3, 4, 5, 7, 8, 16, 17, 18, 30000**	** = Only supported in Verizon configuration by SARA-R422-01B, SARA-R422S-01B and SARA-R422M10S
2	Access Control	0, 1, 2, 3	
3	Device	0, 1, 2, 3, 4, 5, 6*, 7*, 8*, 9*, 10, 11*, 12*, 13*, 14*, 15*, 16, 17, 18 ,19, 20*, 21, 22*, 30000**	* = Data written by end device ** = Only supported in Verizon configuration by SARA-R422-01B, SARA-R422S-01B and SARA-R422M10S
4	Connectivity Monitoring	0, 1, 2, 3, 4, 5, 7, 8, 9, 10, 30000**	** = Only supported in Verizon configuration by SARA-R422-01B, SARA-R422S-01B and SARA-R422M10S
5	FW Update	1, 2, 3, 5, 8, 9	Only via uFOTA server
6	Location	0, 1, 2, 3, 4, 5, 6	Data written by end device
7	Connectivity Statistics	0, 1, 2, 3, 4, 5, 6, 7 ,8	
10	Cellular Connectivity	4, 5, 9	
11	APN Connection Profile	0, 1, 3, 9, 10, 11, 12, 24, 25	
14	Software Component	0, 2, 5	
15	Device Capability Management	0, 1, 2, 3, 4, 5, 6, 7	Data written by end device
16	Portfolio	0	Data written by end device
3300	Generic Sensor	5601, 5603, 5604, 5605, 5607, 5700, 5701, 5750, 5751	Data written by end device
10241	Host Device Information	5905, 5906, 5907, 5908	Data written by end device
10262	Interval Data Delivery	0, 1, 2, 3	Data written by end device
10308	AT&T extended connectivity	1, 2, 3, 7, 8	Only supported in AT&T configuration by SARA-R422-01B, SARA-R422S-01B and SARA-R422M10S

Table 3: LwM2M objects, LEXI-R4 / SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S

Object ID	Name	Resources supported	Notes
0	Security	0, 1, 2, 3, 5, 9, 10, 11, 30000**	** = Only supported in Verizon configuration
1	Server	0, 1, 2, 3, 4, 5, 7, 8, 10, 16, 17, 18, 30000**	** = Only supported in Verizon configuration
2	Access Control	0, 1, 2, 3	
3	Device	0, 1, 2, 3, 4, 5, 6*, 7*, 8*, 9*, 10, 11*, 12, 13, 14*, 15*, 16, 17, 18 ,19, 20*, 21*, 22*, 30000**	* = Data written by end device ** = Only supported in Verizon configuration
4	Connectivity Monitoring	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 30000**	** = Only supported in Verizon configuration
5	FW Update	1, 2, 3, 5, 6, 7, 8, 9, 10**	** = Only supported in Verizon configuration
7	Connectivity Statistics	0, 1, 2, 3, 4, 5, 6, 7 ,8	
11	APN Connection Profile	0, 1, 3, 24	Not supported in Verizon configuration
14	Software Component	0, 2, 5	
16	Portfolio	0	Only supported in AT&T configuration; Data written by end device
10308	AT&T extended connectivity	1, 2, 3, 7, 8, 9	Only supported in AT&T configuration

Table 4: LwM2M objects, SARA-R5 series modules

☞ The client recognizes these objects and provides access to some of the objects. It is up to the individual product on how these objects get populated. There are some object resources that cannot be populated by the host, even though these Lua object exists in the module's firmware, and therefore they cannot be used by an end device.

☞ On SARA-R410M-02B / SARA-R412M-02B, in all the +UMNOPROF AT command configuration except for the Verizon configuration (+UMNOPROF: 3), the Object 11 "APN connection profile" is synchronized with APNs defined/displayed via the +CGDCONT AT command. In this way when creating/deleting an APN by the +CGDCONT AT command, the same will be created/deleted in a dedicated Object 11 resource.

☞ On SARA-R5 series modules and on SARA-R422-01B / SARA-R422S-01B / SARA-R422M10S, only in AT&T configuration, the Object 11 "APN connection profile" is synchronized with APNs defined/displayed via the +CGDCONT AT command. In this way when creating/deleting an APN by the +CGDCONT AT command, the same will be created/deleted in a dedicated Object 11 resource. On SARA-R5 "00B" product versions, in all the +UMNOPROF AT command configuration except for the Verizon configuration (+UMNOPROF: 3), the Object 11 "APN connection profile" is synchronized with APNs defined/displayed via the +CGDCONT AT command.

☞ On SARA-R5 series modules, on SARA-R410M-02B / SARA-R412M-02B and on SARA-R422-01B / SARA-R422S-01B / SARA-R422M10S, in AT&T configuration (+UMNOPROF: 2) the APN "attm2mglobal" must NOT be deleted from the +CGDCONT list, since the deletion of this APN will prevent LwM2M connectivity. This is compliant with AT&T requirement CDR-IOT-005 [10]. If an APN is disabled setting the Object 11 resource 3 to "false", then the APN activation will be locally rejected by the AT interface. If the disabled APN is used for attaching the module, it will be automatically

replaced with “attm2mglobal”. This complies with the AT&T requirement CDR-DVM-4559 [10]. On SARA-R510S-00B-00, SARA-R510M8S-00B-00, and SARA-R500S-00B-00 the automatic replacement is not available, so a disabled APN will result in the module not being able to attach.

☞ On SARA-R5 series modules, time resource /3/0/13 is automatically updated and aligned to the module time.

☞ On SARA-R4 series modules, time resource /3/0/13 shall be updated by the end device.

☞ On SARA-R510M8S-00B-00, SARA-R510S-00B-00, SARA-R500S-00B-00 the object 14 "Software component" and resource /5/0/10 are not supported.

2.2 Custom or extensible LwM2M object

☞ Only SARA-R5 product versions 00B, 01B, 61B, and 71B support Lua, related Lua features, and .lua definition files described in this document

Customers might want to use an LwM2M object that can be used with their end product. The objects are based on Lua scripts https://www.lua.org/. The customer should follow these steps to generate an object and use it on the module:

1. The customer requests u-blox for assistance in creating custom/extensible objects[1].
2. u-blox support will provide the **lwm2m_object_generator.lua** Lua script. Use this script to generate a Lua object that can run with the u-blox LwM2M client.
3. The customer downloads an OMA compliant XML file describing the LwM2M object. For example, the following link is for the generic sensor object: object ID 3300: Generic Sensor
4. http://www.openmobilealliance.org/tech/profiles/lwm2m/3300.xml
5. The customer installs the Lua software to use the script provided. For details on how to install Lua on a Linux machine, see appendix B.
6. The customer can run the **lwm2m_object_generator.lua** Lua script providing the XML file as an argument as shown below. For example, the below command will generate the object file object_generic_sensor.lua.

```
# lua  lwm2m_object_generator.lua   3300.xml
```

7. Once the object is generated, the customer makes the necessary customizations (i.e. URC notification / generating a pulse) based on their requirements. See section 6 for details on available functions.
8. The object file can be copied to the module using the steps provided in section 5.3.2 that describes adding objects.
9. Once the object is added to the object table and the module is restarted, the LwM2M client can start using the new object.
10. If the LwM2M client is already registered, a registration update message is sent to the server(s) to indicate to the server(s) that the object now exists on the LwM2M client device.
11. The server can then perform operations on that object and its resources (read, write, create, execute, write attribute, delete, or discover). An instance of the object can be created, and resources can be populated.

☞ On SARA-R5 series for product types that do support LUA, the “Compiled Lua” or “Lua Bytecode” format is not supported. All Lua files must be in plain text, readable Lua code, as generated by the **lwm2m_object_generator.lua** Lua script.

[1] u-blox will also provide a service that requires a non-recurring expense (NRE) where the customer can request u-blox to create the customized or extensible object by providing their requirements and OMA compliant xml.

3 LwM2M impact on module functionality

LwM2M, as embedded application:

- Autonomously activates PDN and makes data traffic. MNO servers will use dedicated APN, while user-specific servers, like u-blox LwM2M server, will use user data.
- Affects PSM. If LwM2M is performing data traffic, the PSM will be inhibited, to allow for connectivity.
- Affects power consumption.

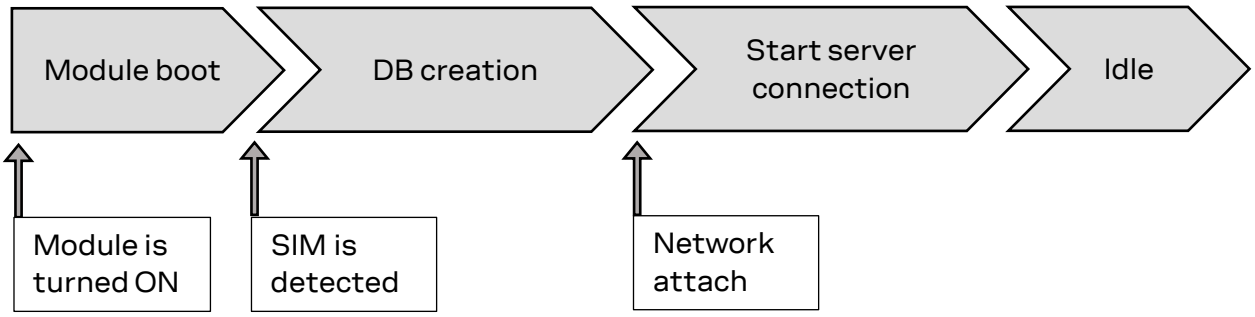
The following sections describe the main LwM2M procedures and their timings.

☞ The undefined / regulatory profile (+UMNOPROF: 0) and the GCF-PTCRB profile (+UMNOPROF: 201) do not support LwM2M feature.

☞ Section 3.2 refers to the factory-programmed configuration. It is possible for the LwM2M server/user to add/delete/modify the server's number and connectivity timings.

3.1 LwM2M start sequence: DB creation

At the first boot after MNO change by the +UMNOPROF AT command, and if LwM2M is enabled by default, then the LwM2M client proceeds with the creation of the LwM2M database. This operation impacts module functionality and requires the host processor to not interfere with it.



- The module is already provisioned with LwM2M DB aligned to the default MNO profile configuration.
- The module deletes the DB file when swapping the +UMNOPROF profile from one to another. The suggested wait time for DB creation are:
  - **SARA-R5 series**:

Target <MNO>	DB creation time (s)	Suggested wait time (s)
90	5	10
100	5	10
2	7	10
3	13	20

Table 5: SARA-R5 series DB creation time

The timings above consider time span from the module boot to the LwM2M initialization complete. The SIM must be inserted with PIN disabled.
URCs for initialization status information can be enabled, see section 4.1.1.

  - **SARA-R4 series**: the suggested wait time for SARA-R4 series is 10 s for all supported MNO profiles.
- LwM2M client is not functional during the DB file creation, which is a one-time operation.
- It is highly recommended to not remove power or reboot the module during the DB file creation.
- The DB can be erased via the AT+ULWM2M=2 command. At the next reboot, the timings above are applied.

3.2 SARA-R5 series: LwM2M production mode

By default, LwM2M client is disabled on the factory programmed MNO profile 90 (global). Different MNO profiles can be factory configured with LwM2M client enabled by default. For details, see the Mobile Network Operator profiles section in the appendix of SARA-R5 series AT commands manual [1].

For environments with critical time constraints (e.g. module/device production phase), it's possible to skip LwM2M DB creation by activating the LwM2M production mode, in which the LwM2M client will not star.

The LwM2M production mode is tuned with two parameters of the +ULWM2MCONFIGEXT AT command:

- <production_mode>:
  - When set to 0: The production mode is disabled.
  - When set to 1: The production mode enabled if inserted SIM matches the <production_sim> parameter.
- <production_sim>: String parameter of 5 or 6 digits which filters a special SIM used in production. For example, if set to "00101", all the SIMs with IMSI starting by "00101" will not produce any LwM2M activity. An empty string ""means the feature is disabled.

For MNO profile 90 (Global), the factory-programmed values are:

- <production_mode>=1
- <production_sim>="00101"

This means with the default configuration, the LwM2M client will not start if a test SIM is inserted.

For all other MNO profiles, the factory-programmed values are:

- <production_mode>=0
- <production_sim>=""

This means the production mode is disabled, and therefore if LwM2M was not disabled, it will always start.

The changes of above settings apply to the current selected MNO profile only. Reboot the module to apply the settings.

☞ LwM2M production mode shall be used for simulated and/or controlled environments, not in the field. If enabled, it will stop LwM2M functionality and prevent LwM2M-based services including FOTA. LwM2M is also a mandatory requirement for MNO certifications.

☞ On SARA-R510S-00B-00, SARA-R510M8S-00B-00 and SARA-R500S-00B-00 the LwM2M production mode feature and +ULWM2MCONFIGEXT parameters <production_mode> and <production_sim> are not supported.

3.3 Basic functionality

When active, the client attempts to perform a client-initiated bootstrap (only in Verizon Wireless (+UMNOPROF: 3), AT&T (+UMNOPROF: 2), AT&T FirstNet (+UMNOPROF: 206), AT&T 2-4-12 (+UMNOPROF: 198), NTT DoCoMo (+UMNOPROF: 20), T-Mobile (+UMNOPROF: 5) configurations). If the bootstrap was already successfully performed, the client would trigger registration to the available servers.

☞ In NTT DocoMo (+UMNOPROF: 20) LwM2M is disabled by factory-programmed configuration. Issue the AT+ULWM2M=4 command to activate the LwM2M client.

The LwM2M client can connect to multiple servers and it does so with a frequency established by the life-time. This parameter depends on the operator and is set in the bootstrap process, which is performed only once, the first time the LwM2M client is activated.

Based on the supported operators, namely AT&T (Including Firstnet and 2-4-12 profiles), Verizon and NTT DoCoMo, the operator's bootstrap server configures one (AT&T, NTT DoCoMo) or more (Verizon) operating servers to which the LwM2M client then connects periodically before the respective life time expires (it does it a little more than life-time / 2).

In addition to the operator-configured servers, the u-blox server is always present. If the selected MNO profile is different from 2 (AT&T), 206 (AT&T FirstNet), 198 (AT&T 2-4-12), 3 (Verizon), 5 (T-Mobile), or 20 (NTT DoCoMo), then only the u-blox server is available by default. In this case no bootstrap is performed.

MNO profile	Server	SSID	Lifetime	CID/APN	Notes
2 (AT&T), 198 (AT&T 2-4-12), 206 (AT&T FN)	Device Management	3	24 h	attm2mglobal	Connect at each reboot
3 (Verizon)	Device Management	102	30 d	VZWADMIN	Connect at each reboot
3 (Verizon)	Diagnostic	101	24 h	VZWADMIN	Connect at each reboot
3 (Verizon)	Repository	1000	24 h	Internet (CID 1 by default)	
5 (T-Mobile)	Device Management	1	24 h	lwm2m.iot.t-mobile.com:5684	
20 (NTT DoCoMo)	Device Management	123	24 h	dcmiot.net	
4 (Telstra), 28 (Softbank)	u-blox LwM2M	721	14 d	Internet (CID 1 by default)	
2 (AT&T), 3 (Verizon), 19 (Vodafone), 21 (Telus), 28 (SoftBank), 31 (Deutsche Telekom) 33 (VIVO), 39 (SKT), 43 (Rogers), 44 (Claro Brasil), 45 (TIM Brasil), 46 (Orange France), 90 (Global), 100/101 (Standard EU) 102 (Standard JP), 198 (AT&T 2-4-12), 206 (AT&T FirstNet)	u-blox LwM2M	721	24 h	Internet (CID 1 by default)	

Table 6: servers present in LwM2M database after bootstrap, and their lifetime.

☞ For the complete list of supported MNO profiles, see the +UMNOPROF AT command description in the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

First-time bootstrap

The first time the LwM2M client is turned on, it will bootstrap and connect to the operational servers.

This procedure applies to any change of MNO profile, if the LwM2M client is active (+ULWM2M: 0) the selected configuration is different from undefined / regulatory (+UMNOPROF: 0) or GCF-PTCRB (+UMNOPROF: 201).

☞ The MNO profile change via the +UMNOPROF AT command must be done with the module in an offline state (+COPS: 2 or +CFUN: 0 or +CFUN: 4). If the module is not offline, the MNO switch may lead to inconsistent LwM2M configuration.

Module already bootstrapped

After bootstrap, the LwM2M client connects to servers following the lifetime timing. The number of servers and the APN/CID used follows Table 6, which also reports the MNO profiles where the connection to MNO servers is also triggered at each reboot, in compliance with MNO requirements.

3.4 LwM2M and power saving mode

If there are no active connections or FW upgrades in progress, the LwM2M client allows the module to enter power saving mode (PSM) without awaking the module at the end of the life-time of the servers to which it is registered. The first time the module wakes up for reasons independent of LwM2M, the LwM2M client will restart and will check the current time. If the life-time of one of the servers to which it is registered has expired, then it will connect to that server.

Therefore, if the life-times configured by the operator's bootstrap server are high, the LwM2M client is not invasive and does not prevent entry into PSM.

When the device exits the PSM, the LwM2M client will automatically perform registration update to Verizon (+UMNOPROF: 3), AT&T (+UMNOPROF: 2 or +UMNOPROF: 198), AT&T FirstNet (+UMNOPROF: 206) and NTT DoCoMo (+UMNOPROF: 20) servers. No activity will be performed in other +UMNOPROF configurations.

☞ On SARA-R5 series the <reg_update_boot> parameter of the +ULWM2MCONFIG AT command causes the device to connect to the servers at every power-on regardless of the life-time expiration. The <reg_update_boot> is set by default to 1 in AT&T and Verizon configuration. In +ULWM2MCONFIG the <reg_upd_at_PSM_exit> parameter applies to the PSM case but is not supported by SARA-R510S-00B-00, SARA-R510M8S-00B-00, or SARA-R500S-00B-00 where the device will obey the <reg_update_boot> when exiting from PSM.

3.5 Configuration of APNs and PDNs in LwM2M

3.5.1 Operator-specific servers

When in AT&T (including FirstNet and AT&T 2-4-12), T-Mobile, Verizon, or NTT DoCoMo MNO configuration, LwM2M will by default connect to MNO-specific servers. Operators prescribe the usage of a dedicated APN for those, namely:

- **Verizon**: Class 2 APN “VZWADMIN” is activated and used for connection to Bootstrap, Device Management (DM) and Diagnostic server. This APN is hardcoded in the VZW APN table and it is not possible to delete or change it.
- **AT&T**: AT&T APN “attiotfirstnet.fn” when FirstNet MNO profile is selected (+UMNOPROF: 206), otherwise AT&T APN “attm2mglobal” is used. It is stored by default in LwM2M object /11/0. Even if this resource and its +CGDCONT entry can be deleted and changed by the user, removing this APN is generally prohibited. If the user or application processor re-defines or removes this APN, LwM2M functionality in AT&T will be disrupted, causing AT&T certification invalidation.
- **NTT DoCoMo**: DoCoMo APN “dmiot.net” is used. It is configured to CID 2. The user or application processor is expected by carrier to configure CID 1 before use. User must define this PDN with FOTA APN information (APN name, IP type, authentication type, username, password) depending on the used NTT DoCoMo UICC. If the APN matches the value configured at CID 1 (Attach EPS bearer), the FOTA client will use CID 1 instead, to avoid multiple PDN activation with same APN.
- **Softbank**: no Softbank-specific server is contacted in Softbank configuration; FOTA relies on u-blox’ LwM2M and FOTA servers. However, the MNO requires the module to use dedicated PDN settings to contact the u-blox server used for uFOTA.
    - On SARA-R4 series all LwM2M and FOTA communication for Softbank MNO profile is done with PDN context identifier 2. The user must define this PDN with FOTA APN information (APN name, IP type, authentication type, username, password) depending on the used Softbank UICC. If the APN matches the value configured at CID 1 (Attach EPS bearer), the FOTA client will use CID 1 instead to avoid multiple PDN activation with same APN.
    - On SARA-R5 series the LwM2M and FOTA PDN must be configured (APN name, IP type, authentication type, username, password) by the user by the +ULWM2MFOTAAPN AT

command. The user must also configure attach APN by editing the CID by the +CGDCONT AT command. These data are maintained across FOTA updates since the "APN sync" of the +ULWM2MCONFIGEXT configuration is set.

- **T-Mobile:** CID 1 is used for connection towards T-Mobile bootstrap and Device Management (DM) servers. This will use billable APN, customer shall check with the MNO if a dedicated APN is available upon UICC subscription, define a new PDP with the +CGDCONT AT command and configure accordingly the correct CID on the +ULWM2MCONFIG AT command.

☞ On SARA-R410M-63B-00 and SARA-R410M-63B-01 in Softbank or NTT DoCoMo configuration the CID 2 cannot be viewed or edited using the +CGDCONT AT command.

3.5.2 Custom servers

The connection to u-blox uFOTA LwM2M server, when enabled in the current MNO profile, will use by default the general-purpose data context, whose connection ID (CID) is 1.

LEXI-R422 / SARA-R422-00B / SARA-R422S-00B / SARA-R422M8S

The LwM2M client always uses connection profile ID (CID) 1 (for more details, see the +CGDCONT AT command in the SARA-R4 series AT commands manual [1]) and this setting cannot be changed (the <cid> parameter of the +ULWM2MCONFIG AT command is not effective). In case a private APN is being provisioned, the user shall use the +CGDCONT AT command to:

- Set the CID 1to be used for general internet data APN so the LwM2M connectivity is granted,
- Set any connection profile (CID) different from 1 to be used for private APN.

SARA-R5 series

It is possible for the user to set the general-purpose CID to be used for internet data, and even to configure a certain context identifier to be used by each server. The configuration is done by the +ULWM2MCONFIG and +ULWM2MCONFIGEXT AT commands:

Command	Response	Description
		The +ULWM2MCONFIG read command shows the CIDs being used by each server.
AT+ULWM2MCONFIG?	+ULWM2MCONFIG: 721,0,1,255,1,0,0,40,0,0,2 +ULWM2MCONFIG: 101,0,1,1,0,1,0,240,0,0,2 +ULWM2MCONFIG: 102,1,1,1,0,1,0,240,0,1,2 +ULWM2MCONFIG: 1000,0,1,255,0,0,0,240,0,0,2 OK	The 721 and 1000 servers are set to <cid>: 255, which means they will use the CID reported in the +ULWM2MCONFIGEXT read command.
AT+ULWM2MCONFIGEXT?	+ULWM2MCONFIGEXT: 90,20,30,4,1,0,"",0,0,0,0 OK	The CID is 1. This is the general data CID commonly used at attach, but a different CID can be inserted. It can be also possible to define a special CID for each server via the +ULWM2MCONFIG set command.

☞ On SARA-R510S-00B-00, SARA-R510M8S-00B-00, and SARA-R500S-00B-00 <cid>=255 is not supported in the set command.

☞ Note that:

- Servers 101 and 102 do not use CID 1 since they are proprietary Verizon servers. Same applies to server 3 in AT&T. These will use dedicated APNs.
- If a certain CID is indicated for usage with a certain server, the CID must be at least defined in the +CGDCONT AT command entries.

3.5.2.1 Global configuration

In the global profile configuration (+UMNOPROF: 90) the default general purpose CID is 1, which matches the Attach EPS bearer.

☞ On SARA-R5 series it is possible to configure a CID to a value other than 1 via the +ULWM2MCONFIGEXT AT command with the <GeneralDataCid> parameter.

3.5.2.2 AT&T configuration

AT&T generally adopts the attach CID as a multipurpose APN. The default configuration is 1, which may be still changed as above. Configuration changes do not apply to AT&T-specific servers (SSIDs 0, 1, 3). This holds for AT&T FirstNet and AT&T 2-4-12.

3.5.2.3 Verizon configuration

Verizon IMS-less devices must consider the attach CID as internet data. It is still possible to point a certain server to a different CID, using configuration above. Configuration changes do not apply to VZW-specific servers (SSIDs 101,102).

3.5.3 SARA-R5 series, LEXI-R4 series and SARA-R422-01B / SARA-R422S-01B / SARA-R422M10S: server-based disable and roaming activity

It is possible to selectively disable a LwM2M server with the +ULWM2MCONFIG AT command, with the <server_disabled> parameter. This allows server configuration such that no data may be sent to it in certain conditions:

- <server_disabled>: 0 - the server is always enabled
- <server_disabled>: 1 - the server is always disabled
- <server_disabled>: 2 - the server is disabled only when the module is in roaming cell conditions

To avoid additional costs due to data traffic in roaming conditions, it is possible to configure LwM2M to allow server connections only when in Home network.

Factory-programmed configuration allows LwM2M connections to all the available servers, apart from Verizon Wireless (+UMNOPROF: 3) where the client will perform no activity (including FOTA) when in roaming.

☞ Disabling a server is not recommended as it will prevent LwM2M-based services including FOTA. LwM2M is also a mandatory requirement for MNO certifications.

☞ On SARA-R510S-00B-00, SARA-R510M8S-00B-00, and SARA-R500S-00B-00 <server_disabled> parameter of the +ULWM2MCONFIG AT command is not supported.

3.6 Connection tear down timings

LwM2M client will tear down the CID being used for connection in 90 s after the latest successful sent message. This is a pre-defined value suggested for keeping client reachable from the server.

LwM2M session and its tear down time are helpful for host application design when considering the use of the following features:

- Use of power save mode. See section 3.4 for more details.
- Managing when to start PPP/DUN call.
- PDP context state for 2G.

For more details on LwM2M topics related to PPP and 2G context, see corresponding LEXI-R4 / SARA-R4 or SARA-R5 development application development guide [4], [5], [6] and LEXI-R4 / SARA-R4 firmware update application note [9].

LwM2M data activity does not delay shutdown such as with +CPWROFF, nor when changing the CFUN mode functionality of MT from full, where device may be registered to a network, then swhiching to in Airplane mode. Also, it does not delay disabling the LwM2M client through +UWM2M command.

☞ Fore SARA-R5 series and SARA-R422-01B / SARA-R422S-01B / SARA-R422M10S in Verizon network, this timer value is 60 s.

☞ For SARA-R410M-02B-01, SARA-R410M-02B-02, SARA-R412M-02B-01, SARA-R412M-02B-02, LwM2M teardown PDN usage is up to 186 s for CAT-M1, 2G RAT, and up to 90 s for NB-IoT.

3.7 Enabling LwM2M client and uFOTA

On certain product versions, for specific MNO profiles, the LwM2M client or uFOTA server is not enabled by default. Thus, after setting and activating the MNO profile, the LwM2M client may need to be enabled. Also, the uFOTA server may need to be enabled if the host device is to support uFOTA FW delta updates. To see if the LwM2M client and uFOTA is enabled by default for a specific MNO profile, see the "Mobile Network Operator profiles" section in the appendix in the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

After setting and then activating the desired MNO profile, the default LwM2M and uFOTA setting for the MNO profile can be checked to see if it is enabled or not.

Command	Response	Description
Stop LwM2M client		
AT+ULWM2M?	+ULWM2M: 0 OK	Upon boot, read +ULWM2M to check the <activation_mode> parameter of LwM2M client. In this example the response is 0, meaning enabled.
AT+ULWM2MCONFIG?	+ULWM2MCONFIG: 721,0,1,255,1,0,0,0,40,0,0,0 OK	Verify if uFOTA is enabled. In this example the parameters: <server_id>: 721 <server_disabled>:0 This indicates uFOTA server ID 721 is enabled.

If MNO profile 2 (AT&T) or 206 (AT&T FirstNet) has LwM2M disabled, it can be enabled with the following steps, with the option to enable uFOTA too.

Command	Response	Description
Enabling LwM2M client on MNO profile 2 (AT&T) or 206 (FN) and optionally enabling uFOTA		
AT+ULWM2M=0	OK	Enable LwM2M client.
AT+CFUN=4	OK	Set module to Airplane mode
AT+CFUN=16	OK	Reset the module.
AT+ULWM2MCONFIG= 0,0,1,2,0,0,0,0,0,0,0,0	OK	Enable AT&T server setting: <server_id>: 0, <server_disabled>=0
AT+ULWM2MCONFIG=3,1,3,1,0,1,1,0,40,0,0,0	OK	Enable AT&T server setting: <server_id>: 3, <server_disabled>=0
AT+ULWM2MCONFIG=721,0,1,1,1,0,0,0,0,0,0,0	OK	Optional step: If uFOTA service is desired, enable uFOTA setting: <server_id>: 721, <server_disabled>=0

Command	Response	Description
Enabling LwM2M client on MNO profile 2 (AT&T) or 206 (FN) and optionally enabling uFOTA		
AT+CFUN=16	OK	Reset the module.
AT+CFUN=1	OK	Exit Airplane by enabling online mode.

If an MNO profile has uFOTA disabled, it can be enabled with the following steps.

Command	Response	Description
Enable uFOTA on MNO profile 3 (VZW) or 5 (TMO)		
AT+ULWM2MCONFIG=721,0,1,3,1,0,0,0,0,0,0,0	OK	Enable uFOTA setting: <server_id>: 721, <server_disabled>=0
AT+CFUN=16	OK	Reset the module
Enable uFOTA on all other MNO profiles		
AT+ULWM2M=0	OK	Enable LwM2M client.
AT+CFUN=16	OK	Reset the module
AT+ULWM2MCONFIG=721,0,1,1,1,0,0,0,0,0,0,0	OK	Enable uFOTA setting: <server_id>: 721, <server_disabled>=0
AT+CFUN=16	OK	Reset the module

For the above guidelines to enable LwM2M client and/or uFOTA server, note that all configurations are persistent except:

- For modules that support the Backup & Restore feature, in the event of a Restore, configurations change to the setting on the Backup copy:
  - To allow restore at desired configuration, configure Backup action after the LwM2M client has been set (see the +UBKUPDATA AT command). For more details, see corresponding application development guide [4], [5], [6].
- MNO profile change via the +UMNOPROF AT command, then the settings will reset the default MNO profile configuration. This is also valid for re-setting the same MNO profile already configured.
- In LEXI-R422 / SARA-R422 the LwM2M client reset by AT+ULWM2M=2 will also reset the +ULWM2MCONFIG settings. So, if any server was enabled and LwM2M client is reset, the changes must be re-submitted.
- FW update may reset settings to the target FW defaults.
  - Check target FW release notes for details and actions required.
  - If LwM2M client is disabled in the target FW, it is required to enable LwM2M client again via AT+ULWM2M=0 command. This will allow the FW update process (uFOTA) to conclude properly.

4 AT commands

For detailed AT command descriptions, see the LEXI-R4 / SARA-R4 series AT commands manual [1] and SARA-R5 series AT commands manual [8].

4.1 Shut-down and start-up

The LwM2M client starts up along with the module.

On SARA-R410M and SARA-R412M, the +ULWM2M AT command shuts down and restore e the LwM2M client to factory-programmed settings. See example sequences in Table 7.

Command	Response	Description
Stop LwM2M client		
AT+ULWM2M=1	OK	Stop the LwM2M client. Wait for the URC indicating the shut-down completion. If reset or shutdown is needed, wait for 4 sec after OK before doing so.
AT+CFUN=15	OK	Reset the module and restart the LwM2M client. Wait for the URC that indicates the process is up.
Restore LwM2M client		
AT+ULWM2M=2	OK	Stop the LwM2M client and return to factory-programmed settings. Wait for the URC that indicates the shut-down completion.
AT+CFUN=15	OK	Reset the module to restart the LwM2M client.

Table 7: SARA-R410M and SARA-R412M stop and restore LwM2M client procedure

☞ In the undefined (+UMNOPROF: 0) configuration, the LwM2M client does not start regardless of the +ULWM2M AT command configuration.

☞ For factory SARA-R410M-02B-01 and SARA-R410M-02B-02 modules, these products are not certified for AT&T's LwM2M specification and therefore their IMEI are not added to AT&T's AVS LwM2M database system. If these products shall be upgraded to SARA-R410M-02B-04 by FW flash with EasyFlash tool, and they would be used on AT&T with either MNO profile 2, 198 or 206, then LwM2M client must be disabled with AT+ULWM2M=1 upon each boot, or persistently once with AT+ULWM2M2=1,1. Disabling the LwM2M client would prevent the device from trying to connect with AT&T bootstrap sever, which would fail , since the IMEI is not populated by the AVS database server. See appendix D for more details.

☞ On SARA-R410M-63B the +ULWM2M AT command supports two additional <activation_mode> parameter values, <activation_mode>=3 and <activation_mode>=4, to disable and enable communication with the NTT DoCoMo LwM2M server when the NTT DoCoMo MNO profile is activated. These parameter settings are persistent across power cycles.

On SARA-R5 series and LEXI-R422 / SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S, the AT+ULWM2M=0 and AT+ULWM2M=1 commands save the enabled flag in NVM, while the AT+ULWM2M=2 AT command performs a reset of the LwM2M client.

Command	Response	Description
Disable LwM2M client		
AT+ULWM2M=1	OK	Disables the LwM2M client. The setting will be effective after reboot.

Command	Response	Description
AT+CFUN=16	OK	Reboot the module.
Enable LwM2M client		
AT+ULWM2M=0	OK	Enables the LwM2M client. The setting will be effective after reboot.
AT+CFUN=16	OK	Reboot the module to restart the LwM2M client.
Restore LwM2M client		
AT+ULWM2M=2	OK	Erases the persistent data of the LwM2M client. A reboot is needed.
AT+CFUN=16	OK	Reboot the module to restart the LwM2M client.

Table 8: SARA-R5 and LEXI-R422 / SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S stop and restore LwM2M client procedure

☞ In the regulatory (+UMNOPROF: 0) and the GCF-PTCRB (+UMNOPROF: 201) configurations, the LwM2M client does not start regardless of the +ULWM2M AT command configuration.

☞ Changing the MNO profile (followed by a module reboot by the +CFUN AT command) back and forth also re-initializes the LwM2M client to the factory-programmed settings for the MNO profile. (For more details, see the +UMNOPROF command in LEXI-R4 / SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].)

☞ On SARA-R4 ”02B”, "63B", "73B", "83B" product versions additional steps of changing the MNO profile back and forth needs to be done to complete a factory-programmed reset if the +ULWM2MCONFIG AT command was used previously as described in section 5.1.4. i.e., AT+UMNOPROF=0 followed by AT+CFUN=15 and AT+UMNOPROF=<previously configured profile> followed by another AT+CFUN=15.

☞ On SARA-R5 series: the LwM2M client keeps separate configuration sets for AT&T (+UMNOPROF: 2), Verizon (+UMNOPROF: 3) and for all other cases. If the +ULWM2MCONFIG or +ULWM2MCONFIGEXT AT commands have been previously issued, the MNO switch via +UMNOPROF AT command will select another set of configurations, but it does not erase the previous configuration. If an MNO is selected back and forth, the same configuration will be restored at the same MNO.

URCs indicate the readiness state of the LwM2M client. The +ULWM2MSTAT AT command can be used to turn on the URC, which will show up when the state changes. For detailed descriptions of the status codes, see the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Turn on the URC (enabled by default).
AT+ULWM2MSTAT=0	OK	Turn off the URC.
URCs		
	+ULWM2MSTAT: 4,7	LwM2M process has shut down.
	+ULWM2MSTAT: 4,0	LwM2M process up and ready.

☞ On SARA-R5 series the LwM2M client status URC (<event>=4) is not supported.

4.1.1 SARA-R5 series and LEXI-R422 / SARA-R422: LwM2M client initialization URCs

It is possible to enable +ULWM2MSTAT URCs for LwM2M client initialization complete status (<event>=5). This is done by setting the <verbosity_mask> parameter in the +ULWM2MSTAT command.

Command	Response	Description
AT+ULWM2MSTAT=1,2	OK	Turn on the URC (Client initialization only).
AT+ULWM2MSTAT=1,3	OK	Turn on the URC (Client initialization and activity).
URCs		
	+ULWM2MSTAT: 5,1	LwM2M initialization started
	+ULWM2MSTAT: 5,2	LwM2M initialization finished
	+ULWM2MSTAT: 5,3	LwM2M initialization stopped due to production mode

☞ On SARA-R510S-00B-00, SARA-R510M8S-00B-00, and SARA-R500S-00B-00 the <verbosity_mask> parameter and the <event>=5 are not supported.

4.1.2 SARA-R5 series and LEXI-R422 / SARA-R422: LwM2M server connection status URCs

It is possible to enable +ULWM2MSTAT URCs for LwM2M server connection status (<event>=6). This is done by setting the <verbosity_mask> parameter in the +ULWM2MSTAT command.

Command	Response	Description
AT+ULWM2MSTAT=1,4	OK	Turn on the URC (server connection status only).
URCs		
	+ULWM2MSTAT: 6,721,0, "coaps://ucsplwm2m.services.u-blox.com:5684"	LwM2M server connection created
	+ULWM2MSTAT: 6,721,1, 1254,4588	LwM2M server connection suspended
	+ULWM2MSTAT: 6,721,2, "coaps://ucsplwm2m.services.u-blox.com:5684"	LwM2M server connection resumed
	+ULWM2MSTAT: 6,721,3, 715,443	LwM2M server connection closed

☞ On SARA-R510S-00B-00, SARA-R510M8S-00B-00, and SARA-R500S-00B-00 the <verbosity_mask> parameter and the <event>=6 are not supported.

☞ On SARA-R510S-00B-01, SARA-R510M8S-00B-01, and SARA-R500S-00B-01 the <event>=6 is not supported.

☞ On LEXI-R422 / SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S the <server_connection_status>=1 (connection suspended), 2 (connection restored) parameter values are not supported.

4.2 View existing objects

Command	Response	Description
AT+ULWM2MLIST="/"	+ULWM2MLIST: "/1/1","/2/1","/2/2","/2/3","/2/4","/2/5","/2/6","/2/7","/2/8","/2/9","/2/10","/2/11","/2/12","/2/0","/3/0","/4/0","/5/0","/6","/7","/10","/11/0","/14/1","/14/2","/14/3","/14/4","/14/5","/14/6","/14/7","/14/0","/16","/0/1","/3300" OK	List all the objects and object instances on the device. The response /3300 means this object has no instances yet but the object ID is available for use.

Command	Response	Description
AT+ULSTFILE=0,"XLWM2M"	+ULSTFILE: "object_apn_connection_profile.lua","object_cellular_connectivity.lua","object_connectivity_monitoring.lua","object_connectivity_statistics.lua","object_device.lua","object_firmware_update.lua","object_generic_sensor.lua","object_location.lua","object_lwm2m_access_control.lua","object_lwm2m_security.lua","object_lwm2m_server.lua","object_lwm2m_software_component.lua","object_portfolio.lua" OK	List all the objects and object instances on the device. ☞ For SARA-R5 series, see the note below.
AT+ULSTFILE=2,"object_generic_sensor.lua","XLWM2M"	+ULSTFILE: 11479 OK	List file size of an object.
AT+ULSTFILE=1,"XLWM2M"	+ULSTFILE: 9994240 OK	List available space. This is an estimated size. Practical usable space could be smaller based on bad blocks or flash memory conditions.
AT+URDFILE="object_generic_sensor.lua", "XLWM2M"	+URDFILE: "object_generic_sensor.lua",11479, <contents of the file> OK	Display the file contents.
AT+URDBLOCK="object_generic_sensor.lua",0,186,"XLWM2M"	+URDBLOCK: "object_generic_sensor.lua",186, <contents of the file> OK	Display a file content based on offset and length.

☞ On SARA-R5 series default object definitions are embedded in the firmware, so they cannot be listed as normal files. They can only be listed by the +ULWM2MLIST AT command. But they can be redefined if a corresponding Lua object definition file is stored with the XLWM2M tag and the AT+ULWM2M=2 command is issued. The filenames must be exactly "object_device.lua", "object_lwm2m_security.lua", "object_lwm2m_server.lua", "object_lwm2m_access_control.lua", "object_apn_connection_profile.lua", "object_connectivity_monitoring.lua", "object_connectivity_statistics.lua", "object_portfolio.lua", "object_firmware_update.lua", "object_att_connectivity_extension.lua". Any change of these internal objects will be effective after a reset of the client (with e.g. AT+ULWM2M=2, AT+UDELFILE="object.db","LWM2M" or by switching to a different MNO profile, followed by a module reset by the AT+CFUN=16 command).

☞ On SARA-R5 series for product types that do support LUA, the “Compiled Lua” or “Lua Bytecode” format is not supported. All Lua files must be in plain text, readable Lua code, as generated by the lwm2m_object_generator.lua Lua script.

4.3 Registration status and timer

For detailed AT command descriptions, see the LEXI-R4 / SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

☞ The last registration time for each server is maintained in persistent storage, to calculate the need of a registration update by comparing it with the current time and the server lifetime. Changing the module time would affect this calculation. A forced registration might be needed.

4.3.1 Registration query and forcing a registration

The LwM2M client will register with the list of servers that have been configured in the "Server" object. The +ULWM2MREG AT command can be used to check the status on the registration if URCs are turned off. It may also report information that are not available via URC, such as a server being in "update needed" state.

Command	Response	Description
AT+ULWM2MREG?	+ULWM2MREG: 721,2,86281 OK	Server ID 721 is successfully registered (<status>=2) and the client will register once again in 86281 s.
Force a registration		
AT+ULWM2MREG=123	OK	Force a registration to server ID 123.
Force the bootstrap and registration		
AT+ULWM2MREG=0	OK	Force a bootstrap and attempt registration on all configured servers.

☞ The +ULWM2MREG read command might respond with an error result code while the LwM2M process are coming up after a reset. It could take ~60 s after a restart to respond back without an error result code.

☞ An error result code may be provided while trying to force the registration if the module has not registered previously.

☞ On SARA-R410M and SARA-R412M if the SIM card is locked with a PIN, the LwM2M client might not properly configure since it will not be able to retrieve SIM information. This is most relevant in VZW configuration (+UMNOPROF: 3) where the SIM information is used to build UE endpoint name. It is then recommended to insert the SIM PIN, if enabled, within 10 s from module boot.

☞ On SARA-R410M and SARA-R412M if the module boots up to +CFUN: 4 initially, the LwM2M client does not bootstrap and register. The host should issue the AT+ULWM2MREG=0 command once the AT+CFUN=1 command has been issued.

4.3.2 Registration URC

URCs have been added to indicate the registration state of the LwM2M client. The +ULWM2MSTAT AT command can be used to turn on the URC which will show up every ~60 s. For detailed descriptions of the status codes, see the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

Command	Response	Description
AT+ULWM2MSTAT=1	OK	Turn on the URC (disabled by default).
AT+ULWM2MSTAT=0	OK	Turn off the URC.
URCs		
	+ULWM2MSTAT: 1,721,3	Event 1 is a registration status.

Command	Response	Description
		Status 3 means registration failed with the u-blox server with server ID 721.
	`+ULWM2MSTAT: 1,721,2`	Status 2 means registration success with the u-blox server with server ID 721.
	`+ULWM2MSTAT: 2,721,86305`	Event 2 means registration interval. Re-registration will happen in 86305 s to u-blox server with server ID 721.

☞ On SARA-R4 “63B”, “73B”, “83B” product versions the +ULWM2MSTAT URC is enabled by default.

☞ The u-blox LwM2M server is not supported when NTT DoCoMo MNO profile is activated. LwM2M DM and FOTA is done with the DoCoMo LwM2M server.

4.3.3 Forcing a deregistration

The LwM2M client can be instructed to de-register with the list of servers that have been configured in the “Server” object. The below command can be used to force deregistration from a server, or deregistration from all servers using option 0.

Command	Response	Description
Force a de-registration		
`AT+ULWM2MDEREG=123`	`OK`	Force a deregistration from server ID 123.
Force a de-registration from all servers		
`AT+ULWM2MDEREG=0`	`OK`	Force a de-registration from all servers configured.

☞ Once the deregistration has taken place, it is not possible to re-register again unless the module is reset by the +CFUN AT command.

4.4 Disable, limit, or remove the u-blox LwM2M server

To prevent periodic connection (24 h default lifetime) to u-blox LwM2M server (SSID 721), but shutting down the LwM2M client with the +ULWM2M AT command is not an option for the host application at boot-up, then it is possible to:

- Alter the LwM2M server configuration using +ULWM2MCONFIG command
- Extend the lifetime
- Remove the server from LwM2M client DB.

The server is mainly used for uFOTA functionality.

☞ This action will limit or block uFOTA functionality, it will be not possible to deliver FOTA updates managed via LwM2M.

The following sequence show how to alter the LwM2M server configuration to disable the target server.

Command	Response	Description
AT+ULWM2MCONFIG?	721,0,1,255,1,0,0,0,40,0,0,0 OK	Read LwM2M configuration. Here u-blox server SSID 721 <server_disabled> is value 0, which indicates it is enabled..
AT+ULWM2MCONFIG=721,0,3,255,1,0,0,0,40,0,0,1	OK	Disable u-blox uFOTA server SSID 721. It can be re enabled again, as described in section 3.7
AT+ULWM2MCONFIG?	+ULWM2MCONFIG: 721,0,3,255,1,0,0,0,40,0,0,1 OK	Read configuration to confirm last parameter <server_disabled> is set correctly to 1.
AT+CFUN=16	OK	Reboot the module for new setting to take effect. On SARA-R41 series use AT+CFUN=15 to reboot.

Here is a list of the server object URIs across different products objects needed to target to delete the u-blox LwM2M server.

Product	MNO profile	Server Object URI <uri>	Description
SARA-R410M / SARA-R412M	2 (AT&T), 3 (Verizon), 198 (AT&T 2-4-12), 206 (FirstNet)	/1/721	Applicable to any VZW and AT&T-related profile
	20 (NTT DoCoMo)	N.A.	Not applicable to DoCoMo profile since u-blox server is already not present by default
	Others <mno>	/1/1	
SARA-R422-00B / SARA-R422S-00B / SARA-R422M8S	Any	/1/1	
LEXI-R422 / SARA-R5 / SARA-R422-01B / SARA-R422S-01B / SARA-R422M10S	Any	/1/10	

The server object is deleted with following sequence:

Command	Response	Description
Check for the desired server Object instance to be deleted		
AT+ULWM2MLIST="/"	"<list_of_uris>"	List of all objects and objects' instances' <uri>'s
Delete the server Object instance		
AT+ULWM2MDELETE="<uri>"	OK	Delete server <uri> as per table above
Wait at least 40s		
AT+CFUN=15	OK	Reboot to apply the new configuration
Confirm server Object instance deleted		
AT+ULWM2MLIST="/"	"<list_of_uris>"	List of all objects and objects' instances' <uri>'s

Command	Response	Description
		Confirm target server <uri> deleted

The lifetime is modified with following sequence:

Command	Response	Description
Check server lifetime value		
AT+ULWM2MREAD="<uri>"	+ULWM2MREAD: {"bn":"<uri>","e":[{"n":"0","v":721},{"n":"1","v":<lifetime value>}	Use appropriate value for <uri> e.g. /1/10 Confirm present lifetime value for server ID 721
Write server lifetime		
AT+ULWM2MWRITE="{\"bn\":\"<uri>\",\"e\":[{\"n\":\"1\",\"v\":2592000}]}"	OK	Lifetime changed for <uri> as per table above. Set to suggested 30d
Wait at least 40s		
AT+CFUN=15	OK	Reboot to apply the new configuration
Confirm updated server lifetime value		
AT+ULWM2MREAD="<uri>"	+ULWM2MREAD: {"bn":"<uri>","e":[{"n":"0","v":721},{"n":"1","v":2592000}	Use appropriate value for <uri> e.g. /1/10 Confirm applied lifetime value to server ID 721

Upon deletion of the server instance or changing of the server lifetime, the client will perform a registration update to the listed servers, to notify the change. Registration update success is not mandatory for the change to apply.

The new configuration is saved in the NVM. The change can be reverted with any of the following:

- Re-bootstrap via the AT+ULWM2M=2 command
- Re-bootstrap via server command
- MNO profile change by the +UMNOPROF AT command

4.5 Read and write to objects

The +ULWM2MREAD and +ULWM2MWRITE AT commands follow the JSON format specified in the OMA technical specification Lightweight M2M [7].

The +ULWM2MREAD AT command can be used to:

- To read the registration timer for an LwM2M server
- To read the previous value of a sensor resource

As shown in the examples below, the +ULWM2MREAD AT command reads an object, object instance, or resource. Fox example, to read the entire object "/3300/0", which is the generic sensor object.

Command	Response	Description
Reading an instance		
AT+ULWM2MREAD="/3300/0"	+ULWM2MREAD: {"bn":"/3300/0","e":[{"n":"5700","sv":"25"},{"n":"5701","sv":"Celsius"},{"n":"5601","sv":"25"},{"n":"5602","sv":"25"},{"n":"5750","sv":"Temperature"}]} OK	Read the object instance 0 for the object 3300.
Reading a resource		
AT+ULWM2MREAD="/3300/0/5601"	+ULWM2MREAD: {"bn":"/3300/0/5601/","e":[{"n":"5601","v":0}]} OK	Read the object instance 0's resource 5601 for the object 3300.

☞ There is a character limit of 1040 characters per line. Hence if there is an object with a lot of data, the resources can be read one at a time like the above example.

☞ **For application developers:** the parsing of the +ULWM2MREAD information text response must be handled appropriately, because JSON permits multiple configurations for URI formatting. The "ID structure" returned by the +ULWM2MREAD AT command might vary based on the query and the object itself. See the examples below for how the “bn” field varies.

Command	Response
Example 1: Read the entire object instance, the base name appears as /object/object instance of the portfolio object:	
AT+ULWM2MREAD="/16/0"	+ULWM2MREAD: {"bn":"/16/0/","e":[{"n":"0/1","sv":"test2"},{"n":"0/0","sv":"test"},{"n":"3","v":0}]} OK
Example 2: Read the specific resource, the base name appears as /object/object instance/resource:	
AT+ULWM2MREAD="/16/0/0"	+ULWM2MREAD: {"bn":"/16/0/0/","e":[{"n":"1","sv":"test2"},{"n":"0","sv":"test"}]} OK
Example 3: Read the entire object instance of a custom object with only a single resource, which is multi-instance, the base name appears as /object/object instance/resource:	
AT+ULWM2MREAD="/33056/0"	+ULWM2MREAD: {"bn":"/33056/0/1/","e":[{"n":"1","v":0}]} OK

The +ULWM2MWRITE AT command allows an external host to change the value of a resource, the values of an array of resource instances, or the values of multiple resources from an object instance.

The +ULWM2MWRITE AT command can be typically used to:

- Change the lifetime timer for the LwM2M server
- Write a measurement from a sensor object
- Updating the device location in the location object
- Writing an error code to the device

As shown in the example below, the +ULWM2MWRITE AT command writes to the object instance’s resource. For example, to write to the object Instance “/3300/0” resource “5700”, which could be the generic sensor’s object temperature. The contents are in general not immediately saved in non-volatile memory (NVM), so it is possible to issue the command with an empty string, in this way the changes are committed to the file system and it is safe to turn off the module.

Command	Response	Description
AT+ULWM2MWRITE="{\"bn\":\"/3300/0\",\"e\":[{\"n\":\"5700\",\"v\":100.5}]}"	OK	Write to an object 3300 instance 0’s resource 5700 the value of 100.5.
AT+ULWM2MWRITE=""	OK	Save changes in NVM

☞ On SARA-R510M8S-00B-00, SARA-R510S-00B-00, and SARA-R500S-00B-00 the AT+ULWM2MWRITE="" command is not supported.

☞ On LEXI-R4 / SARA-R4 series modules the AT+ULWM2MWRITE="" command is not supported.

4.6 AT&T ODIS functionality

SARA-R410M / SARA-R412M and SARA-R422-01B / SARA-R422S-01B / SARA-R422M10S and SARA-R5 modules in +UMNOPROF: 2 configuration are certified for AT&T LwM2M DM. This means they also comply with AT&T requirement "<CDR-DVM-1600> Local Read and Write Access to Host Device Details for an IoT Module".

Modules support the +ODIS AT command which populates host device information in LwM2M Host Device Object 10241. The command is present only when AT&T MNO profile is selected by the +UMNOPROF AT command.

Host device information contains default values of factory-programmed configuration, as required by AT&T. According to AT&T:

<CDR-DVM-1602> Device Initiated Alert Upon Change to Host Device Detail: [...] The IoT module with a LWM2M client will automatically notify and report the change to the Host Device (ODIS) details inside the LWM2M Portfolio Object if there is a pre-existing Observe command on the LWM2M server.

The +ODIS settings are persistent upon power cycles. However, they need to be re-configured by host application in the following cases:

- Factory reset by the AT+UFACTORY=2,x command (where supported)
- LwM2M client reset by AT+ULWM2M=2 command
- FW update, all methods excluding uFOTA (FW update via LwM2M client)
- MNO profile change by the +UMNOPROF AT command

Command	Response	Description
`AT+ODIS?`	`+ODIS: "HMAN0","HMOD0","HSW0"` `OK`	Get ODIS factory-programmed values
`AT+ODIS="TestID1","TestMAN1","TestMOD1","TestSW1"`	`OK`	Configure ODIS information with custom data. Notice that the first parameter (Host Device ID) is not readable
`AT+ODIS?`	`+ODIS: "TestMAN1","TestMOD1","TestSW1"` `OK`	Get custom ODIS data.

5 Operational examples

5.1 Adding an additional server to the client

By default, the module communicates with u-blox server (ID 721) as defined in the bootstrap object. For testing purposes, an additional server instance can be created for the client, for example, a demo Leshan server. The following examples use CoAP / CoAPS URL of a test Leshan server.

The +ULWM2MCREATE AT command can be used to accomplish “Adding an additional server”. The +ULWM2MCREATE AT command uses JSON format as defined in the OMA technical specification Lightweight M2M [7]. Note that if the JSON data contains embedded double quotes, they must be properly escaped with a backslash character "\".

To add a new server, a “Security” object instance and “Server” object instance needs to be created and configured. In addition, a security configuration needs to be applied. In this example a demo Leshan server hosted by the u-blox support team is added.

5.1.1 Creating the security object instance

Follow one of the steps listed below to create the security object, without or with DTLS. The added instance can be deleted using the +ULWM2MDELETE AT command, see section 5.1.3.

☞ For details, see http://www.openmobilealliance.org/tech/profiles/LWM2M_Security-v1_0.xml.

Command	Response	Description
Add a new “Security” object instance for CoAP		
`AT+ULWM2MCREATE="{\"bn\":\"/0/2/\",\"e\":[{\"n\":\"0\",\"sv\":\"coap://54.193.4.219:5683\"},{\"n\":\"1\",\"bv\":false},{\"n\":\"2\",\"v\":3},{\"n\":\"10\",\"v\":123}]}",123`	`OK`	• coap://54.193.4.219:5683 is the demo Leshan server CoAP URL. • "false" indicates that it is not a bootstrap server • "v":3 indicates its non-secure • 123 is the short server ID • The server ID 123 is specified again in the +ULWM2MCREATE AT command to assign the owner of the object instance in the associated ACL object instance.
Add a new “Security” object instance for CoAPS (DTLS)[2]		
`AT+ULWM2MCREATE="{\"bn\":\"/0/2/\",\"e\":[{\"n\":\"0\",\"sv\":\"coaps://54.193.4.219:5684\"},{\"n\":\"1\",\"bv\":false},{\"n\":\"2\",\"v\":0},{\"n\":\"3\",\"sv\":\"MzUyNzUzMDk1Nzg3NjE4\"},{\"n\":\"10\",\"v\":123},{\"n\":\"5\",\"sv\":\"q83v\"}]}",123`	`OK`	• coaps://54.193.4.219:5684 is a demo Leshan server CoAPS URL. • "false" indicates that it is not a bootstrap server • "v":0 indicates its secure • MzUyNzUzMDk1Nzg3NjE4 is the base64 version of 352753095787618 [i.e. IMEI] • :123 is the short server ID • q83v is the base64 format of the HEX string 0xAB,0xCD,0xEF • The server ID 123 is specified again in the +ULWM2MCREATE AT command to assign the owner of the object instance in the associated ACL object instance.

[2] See appendix A for details on how to add a PSK to the Leshan server

☞ The +ULWM2MREAD AT command cannot be used to read the "/0" object as it is a security object and hence the PSK cannot be seen via the AT command.

☞ In SARA-R5 series modules the DTLS cipher suites will be added automatically. The used cipher suites (CS) will be the ones supported by Certificates and security profiles manager (CSPM); for additional info about the +USECPRF AT command, see SARA-R5 series AT commands manual [8].

5.1.2 Creating the server object instance

☞ For more details, see http://www.openmobilealliance.org/tech/profiles/LWM2M_Server-v1_0.xml.

Command	Response	Description
`AT+ULWM2MCREATE="{\"bn\":\"/1/2/\",\"e\":[{\"n\":\"0\",\"v\":123},{\"n\":\"1\",\"v\":300},{\"n\":\"2\",\"v\":10},{\"n\":\"3\",\"v\":60},{\"n\":\"5\",\"v\":86400},{\"n\":\"6\",\"bv\":false},{\"n\":\"7\",\"sv\":\"UQ\"}]}",123`	`OK`	123 is the short server ID. 300 is the life timer (registration timer) value.

5.1.3 Deleting an Instance of an object

The +ULWM2MDELETE AT command deletes an instances of a LwM2M object. The below command deletes the instance of a security object and a server object. The AT+ULWM2MDEREG=123 command deregisters the module from the server 123 (server ID 123 used as an example), which must be done prior to deleting the instances as shown below.

Command	Response	Description
`AT+ULWM2MDELETE="/0/2"`	`OK`	Deleting instance of an object.
`AT+ULWM2MDELETE="/1/2"`	`OK`	

☞ Reboot the module after having executed the above steps.

5.1.4 Security configuration

In addition to the above steps the below configuration step is needed to set the server connection preferences for the LwM2M client and the security feature. The configuration specifies the PDP identifier, connection type. When creating a new server, after the +ULWM2MCREATE AT command is issued (see section 5.1.2), issue the +ULWM2MCONFIG AT command to set the server connection preferences.

Command	Response	Description
`AT+ULWM2MCONFIG=123,0,1,1,0`	`OK`	• Server ID 123 is being configured here. • bootstrap_on_failure: 0 means false here and the device will not attempt bootstrap after a failed registration • pdn_type : 1 means IPv4 • pdn_context_id : 1 is the cid Note that the value for this parameter is the index returned by `+CGDCONT: 1,"IP","phone","10.0.0.1",0,0,0,0` • usec_psk: 0

☞ Reboot the module to re-initialize for client/server to pick up the above changes.

☞ For each LwM2M server, provide the PSK and PSK identifier as Base64 encoded values and write the associated LwM2M security object instance.

☞ On SARA-R410M-02B and SARA-R412M-02B <usec_psk> must be 0.

5.1.5 Restarting and checking URCs

The following example shows the URCs with the new server ID 123 (make sure to toggle the DTR line for the URCs). For detailed URC descriptions, see the LEXI-R4 / SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

Command	Response	Description
SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B		
	`+ULWM2MSTAT: 1,123,2`	Indicates successful registration.
	`+ULWM2MSTAT: 2,123,204`	Timer counting down.
SARA-R5 / SARA-R410M-02B / SARA-R412M-02B / LEXI-R422/ SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S		
	`+ULWM2MSTAT: 1,123,3`	Indicates successful registration.
	`+ULWM2MSTAT: 2,123,204`	Timer counting down.

If the above 2 steps are successfully performed, the device's IMEI would be seen on the LwM2M server's client page.

5.2 Modifying the registration update timer

For detailed AT command descriptions, see LEXI-R422 / SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

Every time the module connects to the LwM2M server, it maintains the connection only for ~30 s and this cannot be modified. However, changing the life timer to a smaller value like 180 s (it must be greater than 90 s at a minimum due to COAP transmit wait time) will get the client to communicate more often and hence while testing, the objects can be read more often from the server.

The registration timer of server "/1/2" which was the new server ID 123 created in the previous section was configured with 300 s. In the below example, it has been modified to 180 s.

Command	Response	Description
`AT+ULWM2MWRITE="{\"bn\":\"/1/2/\",\"e\":[{\"n\":\"1\",\"v\":180}]}"`	`OK`	Change the registration timer to 180 s.

☞ Shorter timers mean communicating with the server more often. Hence the above change to shorter timer is only for a testing purpose. In a production deployment the registration timer would probably be longer, e.g., once an hour or once a day, depending on the end application.

☞ On SARA-R4 series Softbank MNO profile does not allow writing to the registration timer. The default is 2 weeks.

The below URCs might be received after entering the above command. For detailed URC descriptions, see the LEXI-R4 / SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

Command	Response	Description
SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B		
	`+ULWM2MSTAT: 1,123,2`	Indicates successful registration.
	`+ULWM2MSTAT: 2,123,90`	New registration timer counting down.
SARA-R5 / SARA-R410M-02B / SARA-R412M-02B / LEXI-R422/ SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S		

Command	Response	Description
SARA-R410M-63B / SARA-R410M-73B / SARA-R410M-83B		
	`+ULWM2MSTAT: 1,123,3`	Indicates successful registration.
	`+ULWM2MSTAT: 2,123,90`	New registration timer counting down.

To force a registration update (using short server ID), see section 4.3.

5.3 Adding a new object / instance / resource

The example shown below is for the "Generic Sensor" object. For detailed AT command descriptions, see the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [8].

☞ This object is already present on the SARA-R4 "63B", "73B", "83B" product versions. The object can be deleted and reloaded for testing purposes.

☞ On SARA-R5 series, the "Compiled Lua" or "Lua Bytecode" format is not supported. All Lua files must be in plain text, readable Lua code.

5.3.1 Removing objects/instances

The +ULWM2MREMOVE AT command removes an object from the LwM2M object table, along with any existing instances from the memory. The Lua object file on the device file system is not removed and can be deleted using the +UDELFILE AT command.

An object that has been removed from the LwM2M object table cannot have a create operation performed. In the below example, the object_generic_sensor 3300 is removed and in the later sections the object is added again as an example.

Command	Response	Description

`AT+ULWM2MLIST="/"`	`+ULWM2MLIST: "/1/1","/2/1","/2/2",`
	`"/2/3","/2/4","/2/5","/2/6",`
	`"/2/7","/2/8","/2/9","/2/10",`
	`"/2/11","/2/12","/2/0","/3/0",`
	`"/4/0","/5/0","/6","/7","/10",`
	`"/11/0","/14/1","/14/2","/14/3",`
	`"/14/4","/14/5","/14/6","/14/7",`
	`"/14/0","/16","/0/1","/3300"`
	`OK`
		Object ID /3300 is present in the list of objects.

`AT+ULWM2MREMOVE="/3300"`	`OK`	Remove object ID /3300
List the objects and object instances		

`AT+ULWM2MLIST="/"`	`+ULWM2MLIST: "/1/1","/2/1","/2/2",`
	`"/2/3","/2/4","/2/5","/2/6",`
	`"/2/7","/2/8","/2/9","/2/10",`
	`"/2/11","/2/12","/2/0","/3/0",`
	`"/4/0","/5/0","/6","/7","/10",`
	`"/11/0","/14/1","/14/2","/14/3",`
	`"/14/4","/14/5","/14/6","/14/7",`
	`"/14/0","/16","/0/1"`
	`OK`
		Object ID /3300 is no longer present in the list of objects.

Delete the object file		
`AT+UDELFILE="object_generic_sensor.lua","XLWM2M"`	`OK`	Remove the Lua object file from the module.

Command	Response	Description
AT+ULSTFILE=0,"XLWM2M"	+ULSTFILE: "object_apn_connection_profile.lua","object_cellular_connectivity.lua","object_connectivity_monitoring.lua","object_connectivity_statistics.lua","object_device.lua","object_firmware_update.lua","object_location.lua","object_lwm2m_access_control.lua","object_lwm2m_security.lua","object_lwm2m_server.lua","object_lwm2m_software_component.lua","object_portfolio.lua" OK	List all the object Lua files on the file system.

☞ On SARA-R5 series modules the object definitions embedded in the FW cannot be deleted.

5.3.2 Adding objects

☞ For more details, see http://www.openmobilealliance.org/tech/profiles/lwm2m/3300.xml.

Contact u-blox support for getting this sample Lua object. The sample Lua provided by u-blox support will have some additional code snippets which use features like GPIO and URC for notification.

Add an object to the LwM2M object table before to perform some "Create" or "Delete" operations. The +ULWM2MADD AT command adds an object that has been copied to the device file system to the LwM2M object table.

Command	Response	Description
AT+UDWNFILE="object_generic_sensor.lua", 11668,"XLWM2M" > [Send data]	OK	Adding generic sensor Lua object file.
AT+ULSTFILE=0,"XLWM2M"	+ULSTFILE: "object_apn_connection_profile.lua","object_cellular_connectivity.lua","object_connectivity_monitoring.lua","object_connectivity_statistics.lua","object_device.lua","object_firmware_update.lua",**"object_generic_sensor.lua"**,"object_location.lua","object_lwm2m_access_control.lua","object_lwm2m_security.lua","object_lwm2m_server.lua","object_lwm2m_software_component.lua","object_portfolio.lua" OK	List all the object Lua files.
AT+ULWM2MADD="object_generic_sensor.lua"	OK	Load the Lua object to start using it.

☞ It is recommended to pre-validate the custom Lua file before storing it in module. Tools like LUAC are available for free on the web to compile the Lua script and confirm it will be functional when loaded by the resident LwM2M client.

☞ If the +ULWM2MADD AT command returned an error result code, then the file has to be removed from the file system (via the AT+ULWM2MDELETE=<filename>,"XLWM2M" AT command) otherwise the LwM2M client will attempt to load it at next boot, it will fail to initialize and will exit.

The successful client initialization can be checked with the command AT+ULWM2MLIST="/".

On LEXI-R422 / SARA-R422 / SARA-R422S / SARA-R422M8S / SARA-R422M10S the URCs showed at next boot in case of error will be the following:

URCs	Description
`+ULWM2MSTAT: 5,1`	LwM2M initialization started
`+ULWM2MSTAT: 4,6`	LwM2M client exit

If the file is not removed from the file system, the LwM2M client will not start.

☞ **For application developers:** applications should limit the addition/deletion of objects during the operational lifetime of a module. Objects are expected to be instantiated and then written to and read from.

- **Data usage:** addition and deletion of an object triggers a communication between the client and the LwM2M servers. The client controls this activity per the OMA standard.
- **Memory:** adding objects uses up memory resources on the module. The memory is finite and in addition to LwM2M there are other processes that run on the module like uFOTA, security etc. Hence it is not possible to provide an estimate on how many objects can be created during operations. It is recommended to not perform bulk addition of new objects but to add and test every single object.
- **Error:** the +ULWM2MADD AT command might respond with an OK final result code and not report an error result code when it has failed to add the object to the memory due to a lack of resources on the module.

5.3.3 Creating an object instance

The +ULWM2MCREATE AT command allows to create an object instance and make the given server ID the owner of the object (has full permissions to the object).

In the below example a new instance of the generic sensor object instance is created, and server ID 123 is made the owner of it. In addition, a resource 5750 is also being set to App type “Temperature”.

☞ All the LwM2M servers that the client registers to are aware of all object instances, though they may not have permissions on a given instance.

Command	Response	Description
`AT+ULWM2MCREATE="{\"bn\":\"/3300/0\",\"e\":[{\"n\":\"5750\",\"sv\":\"Temperature\"}]}",123`	`OK`	Create an object instance and populate it with some resources. The server ID is 123 specifies the owner of the object instance. 5750 is a resource for the object 3300’s instance 0 and it represents “Temperature”. See section 4.4 for the +ULWM2MNOTIFY URC that might be received after running this command.
`AT+ULWM2MLIST="/"`	`+ULWM2MLIST: "/1/1","/2/1","/2/2","/2/3","/2/4","/2/5","/2/6","/2/7","/2/8","/2/9","/2/10","/2/11","/2/12","/2/0","/3/0","/4/0","/5/0","/6","/7","/10","/11/0","/14/1","/14/2","/14/3","/14/4","/14/5","/14/6","/14/7","/14/0","/16","/0/1","/3300/0"` `OK`	List all the object and Instances to verify that /3300/0 being listed.

☞ **For application developers**: applications should limit the creation/deletion of object instances and should not do this too often. Objects are resources that are written to or read from.

- **Data usage:** creation and deletion of an object on the LwM2M client triggers communication between the client and the LwM2M servers. The client controls this activity per the OMA standard.

- **Memory:** memory is finite and creating an object instance uses up memory resources on the module, which is shared with other background processes like uFOTA, security etc. It is recommended to not perform bulk creation of new object instances but to create and test every single object instance.
- **Error:** the +ULWM2MCREATE AT command might respond with an OK and report an error result when it has failed to add an instance to the memory due to a lack of resource on the module.

5.3.4 Writing and reading a value to a resource

Command	Response	Description
Write a value to one of the resources		
AT+ULWM2MWRITE="{\"bn\":\"/3300/0\",\"e\":[{\"n\":\"5700\",\"v\":100.5}]}"	OK	Write the value of 100.5 to a resource.
Read all resources of the instance		
AT+ULWM2MREAD="/3300/0"	+ULWM2MREAD: {"bn":"/3300/0/","e":[{"n":"5601","v":100.5},{"n":"5602","v":100.5},{"n":"5603","v":0},{"n":"5700","v":100.5},{"n”:"5701","sv":""},{"n":"5750","sv":"Temperature"},{"n":"5751","sv":""},{"n":"5604","v":0}]} OK	Read all the resources of instance 0 of object ID 3300.
URC		
	+ULWM2MSTAT: 3,123,/3300/0/5700	This URC might be seen if the LwM2M server is registered for observing. Specifically, event 3 is a notification that the client is triggering the conditions to send the current value to the server.

Figure 5: Generic sensor instance on an LwM2M server

The generic sensor object instance should start populating with data on the LwM2M server. Since server ID 123 was associated with the “Generic Sensor Object” instance, the presence of the instance can be visually verified on the previously mentioned Leshan server.

5.4 +ULWM2MNOTIFY URC

The +ULWM2MNOTIFY URC can be used by the external host to performe actions.

In the below code snippet from the sample object_generic_sensor.lua, in the object_generic_sensor.write() method a call to the **lua_send_urc** function is used to send a URC notification when the "Application Type" resource (ID=5750) is set.

```
if res == RES_O_APPLICATION_TYPE then
msg = string.format("Application type changed in sensor %d", inst)
lua_send_urc(string.len(msg), msg)
end
```

☞ On SARA-R510M8S-00B, SARA-R510S-00B, SARA-R500S-00B the syntax of the lua_send_urc function is different as it accepts only the string argument, without the string length:

```
msg = string.format("Application type changed in sensor %d", inst)
lua_send_urc(msg)  -- pass only the string
```

For example, after executing the following +ULWM2MCREATE AT command, a URC will be seen.

Command	Response	Description
AT+ULWM2MCREATE="{\"bn\":\"/3300/0\",\"e\":[{\"n\":\"5750\",\"sv\":\"Temperature\"}]}",123	OK	Writing the "Application type" (resource 5750) will trigger a URC to notify.
URC		
	+ULWM2MNOTIFY: Application type changed in sensor 0	

5.5 Generic sensor object accessing a GPIO pin

☞ The LwM2M pulse feature is not supported by SARA-R5 series modules.

For detailed AT command descriptions, see the SARA-R4 series AT commands manual [1].

The +UGPIOC and +ULWM2MPULSE AT commands can be used to configure and operate a GPIO.

In the below code snippet from the object_generic_sensor.lua, a function **lua_send_pulse** is used to send a signal to id 16 of the GPIO.

```
if res == RES_M_SENSOR_VALUE then
lua_send_pulse(16)
```

In the below example the +ULWM2MWRITE AT command is issued to turn on a GPIO pin and make it go high for a few seconds according to +ULWM2MPULSE setting. This can be visually verified on an evaluation board.

Command	Response	Description
AT+UGPIOC=16,25	OK	The GPIO 1 is configured to take an LwM2M pulse.
AT+ULWM2MPULSE=?	+ULWM2MPULSE: 16,25,0,0,0 OK	Query the GPIO which is working with LwM2M.
AT+ULWM2MPULSE=16,1,3000,1	OK	Configure the +ULWM2MPULSE to go high for 3 s and persist on the module reboot. Allowed settings: • GPIO pins identifier: SARA-R4 16,19, 23, 24, 25, 42 LEXI-R4 14,15,16,17,18 ,29 • Low/high: 0/1 • Time: 0-10000 ms (0: to be left asserted)

Command	Response	Description
		• Persist: 0/1
`AT+ULWM2MWRITE="{\"bn\":\"/3300/0\",\"e\":[{\"n\":\"5700\",\"v\":100.5}]}"`	`OK`	To trigger the GPIO using the +ULWM2MWRITE command which will call the code snippet below. On an EVK, the LED for the GPIO should turn green.

5.6 Reset the module from an LwM2M server

The access control list object ID 2 can be used to specify the permissions for a server to execute actions on an object: For more details, see

http://www.openmobilealliance.org/tech/profiles/LWM2M_Access_Control-v1_0_3.xml.

For example, the device object ID 3 has a resource ID 4 to reboot the module: http://www.openmobilealliance.org/tech/profiles/LWM2M_Device-v1_0_3.xml

Each instance of the access control object corresponds to one object instance's permissions. Resource ID 0 specifies the object ID, and resource ID 1 specifies the object instance ID. If an object instance does not have default access permissions configured, read-write-xecute permissions must be explicitly added for the new server ID.

Permissions are granted at the object instance level. A server may not be granted permissions only to specific resources in an object instance. For example, granting server ID 123 execute permissions on object instance /3/0 can allow the server to perform factory reset (/3/0/ 5) as well as reboot (/3/0/4).

In the below example, permission is given to the newly added server ID 123. The remote server can now execute actions on the device object to be able to reboot the module.

Command	Response	Description
AT+ULWM2MREAD="/2/1"	+ULWM2MREAD: {"bn":"/2/1/","e":[{"n":"0","v":3},{"n":"1","v":0},{"n":"2/721","v":15},{"n":"3","v":721}]} OK	Read the object ID 2 which is the access control list object.
AT+ULWM2MWRITE="{\"bn\":\"/2/1/\",\"e\":[{\"n\":\"2/123\",\"v\":15}]}"	OK	Give permission to server ID 123 to reboot the module. (15 is read-write-execute)
AT+ULWM2MREAD="/2/1"	+ULWM2MREAD: {"bn":"/2/1/","e":[{"n":"0","v":3},{"n":"1","v":0},{"n":"2/123","v":15},{"n":"2/721","v":15},{"n":"3","v":721}]} OK	To read the object again to verify that the ACL object is modified.

A re-registration could be forced for the above to take effect immediately.

After the above steps, the LwM2M server can execute a reboot on the client.

The module should reset once it receives the execute command from the LwM2M server.

6 Registered functions

The following C functions are registered with the LwM2M client and are available to be used in the object scripts.

- lua_send_urc
  - See the section 5.4
  - Sample usage (for SARA-R4 series modules):

```
if res == RES_O_APPLICATION_TYPE then
msg = string.format("Application type changed in sensor %d", inst)
lua_send_urc(string.len(msg), msg)
end
```

- lua_send_pulse
  - See the section 5.5
  - Sample usage:

```
if res == RES_M_SENSOR_VALUE then
lua_send_pulse(16)
```

- lua_modem_get_imei
  - Sample usage:

```
-- returns the device’s imei as a string
local imei = lua_modem_get_imei()
```

- lua_modem_get_msisdn
  - Sample usage:

```
-- returns the device's msisdn as a string
local msisdn = lua_modem_get_msisdn()
```

- lua_modem_get_carrier_id
  - Sample usage:

```
-- returns the carrier id as in integer
local carrier_id = lua_modem_get_carrier_id()
if carrier_id == lwm2m_carrier_id.LWM2M_CARRIER_SOFTBANK then
-- do something
end
```

```
Note: Carrier Id definitions are defined in lwm2m_defs.lua
 Contact u-blox support if this Information is needed.
```

- lua_system_reboot
  - Sample usage:

```
-- stops the LwM2M Client and resets the device
lua_system_reboot()
```

- lua_system_factory_reset
  - Sample usage:

```
-- resets the device to the default profile; requires a reboot
lua_system_factory_reset()
```

☞ SARA-R5 series modules do not support the lua_send_pulse function.

7 Supported data formats

LwM2M u-blox implementation dynamically supports both TLV and JSON data formats for incoming / outgoing packets. A server may want to configure for TLV instead of JSON for relatively faster and light data transfer.

The LwM2M client logic is as follows:

- The LwM2M client signals JSON format support in the Register (COAP POST) message.
- The client also supports TLV format for data write/read.
- The client generally responds to data read with the same format (TLV or JSON) as the one received in the read (COAP GET) request.

Exceptions:

- If the COAP GET contains an ACCEPT option, the response will be returned with the format contained in ACCEPT option. Examples:
  - GET request:

```
Constrained Application Protocol, Confirmable, GET, MID:56891
   01.. .... = Version: 1
   ..00 .... = Type: Confirmable (0)
   .... 1000 = Token Length: 8
   Code: GET (1)
   Message ID: 56891
   Token: 324d7685225c6dad
 > Opt Name: #1: Uri-Path: 3
 > Opt Name: #2: Uri-Path: 0
 v Opt Name: #3: Accept: application/vnd.oma.lwm2m+json
      Opt Desc: Type 17, Critical, Safe
      0110 .... = Opt Delta: 6
      .... 0010 = Opt Length: 2
      Accept: application/vnd.oma.lwm2m+json
   [Uri-Path: /3/0]
```

  - Response to GET:

```
Constrained Application Protocol, Acknowledgement, 2.05 Content, MID:56891
   01.. .... = Version: 1
   ..10 .... = Type: Acknowledgement (2)
   .... 1000 = Token Length: 8
   Code: 2.05 Content (69)
   Message ID: 56891
   Token: 324d7685225c6dad
 > Opt Name: #1: Content-Format: application/vnd.oma.lwm2m+json
   End of options marker: 255
 v Payload: Payload Content-Format: application/vnd.oma.lwm2m+json, Length: 541
      Payload Desc: application/vnd.oma.lwm2m+json
      [Payload Length: 541]
   [Uri-Path: /3/0]
   [Request In: 58]
   [Response Time: 39.690148270 seconds]
JavaScript Object Notation: application/vnd.oma.lwm2m+json
 v Object
    > Member: bn
    > Member: e
```

- If the COAP GET is done in plain text, and the read is for an entire Object, an entire Object instance, or in general for more than one instance, the response will be returned in JSON format.

Appendix

A Leshan overview

Download a Leshan demo server on Ubuntu

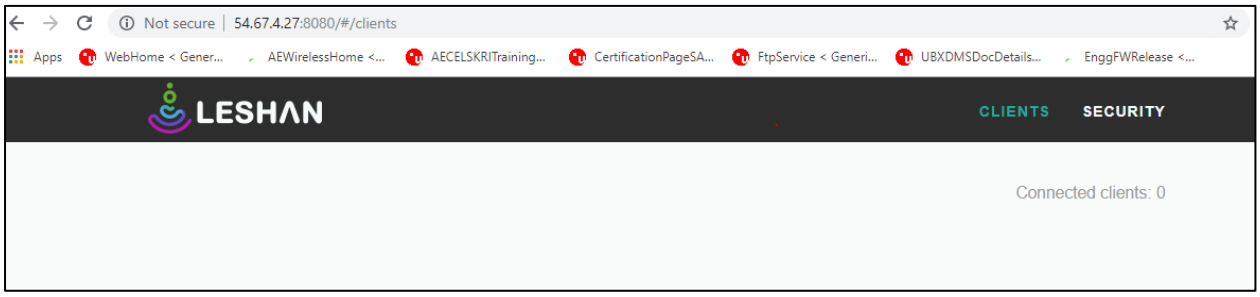
- Wget https://hudson.eclipse.org/leshan/job/leshan/lastSuccessfulBuild/artifact/leshan-server-demo.jar

Start up a demo server

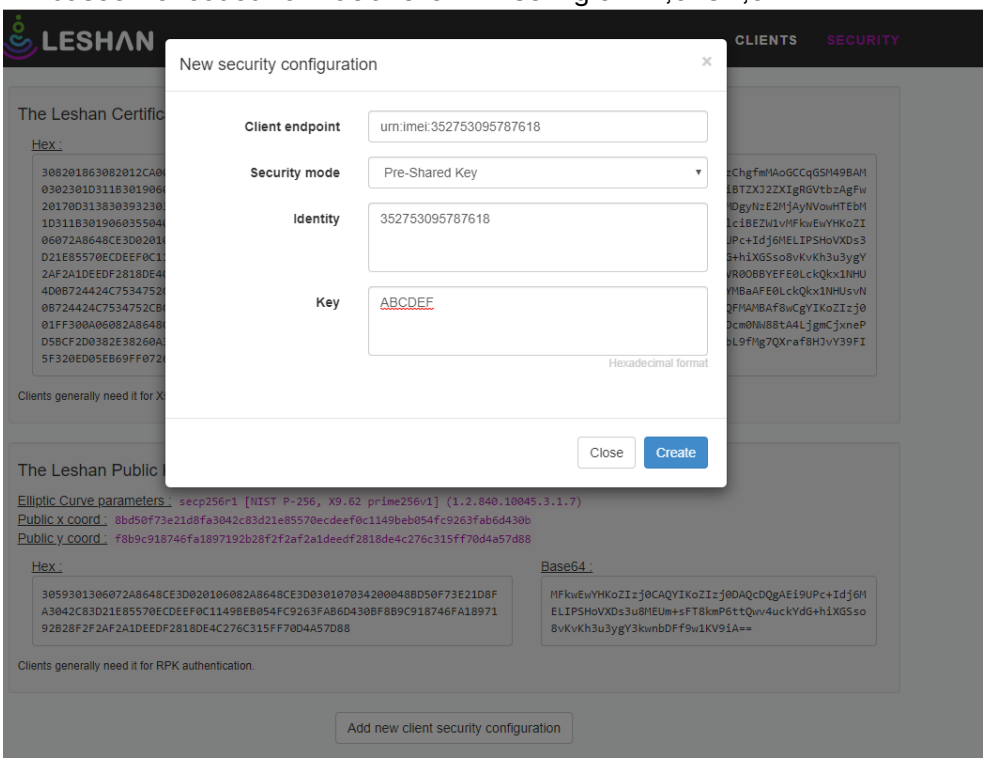
- java -jar ./leshan-server-demo.jar

Access using: http://<IP of server>:8080

- For an external client to communicate to the Leshan server, the CoAP port 5683 and CoAPS port 5684 need to be accessible via UDP.



- Point the device to the Leshan server. For more details, see section 5.1.
- If using CoAPS, created a PSK for the client on the Leshan server.
- The key here is “ABCDEF”, whereas in the +ULWM2MCREATE AT command a value of q83v is the base64-encoded format of the HEX string 0xAB,0xCD,0xEF.

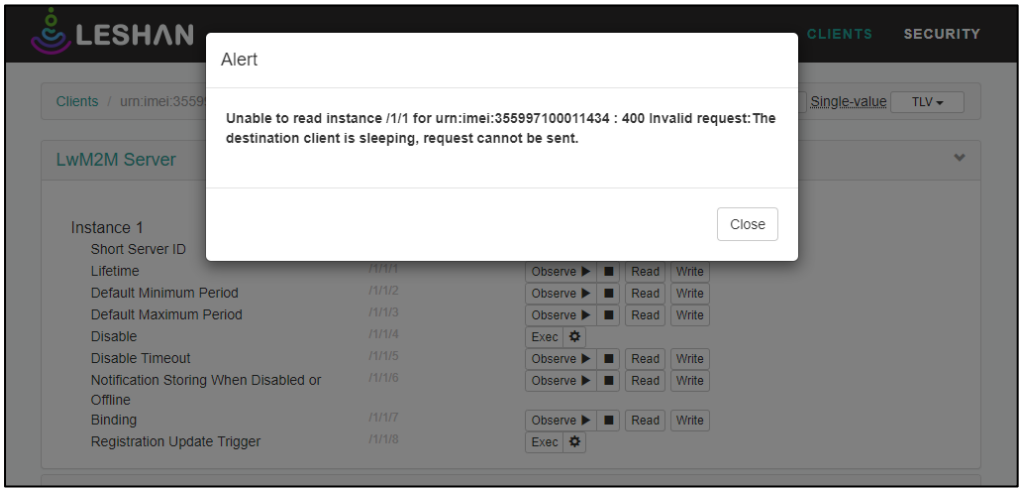


Read objects using Leshan

Click **Read,** the Leshan server reads the object values from the client.

Modify registration timer

An error can occur on a Leshan server when trying to read an object. This is because of the life timer and the finite window of ~30 s during which the connection is open. The life timer counts down to 0 and then this contact window opens again.

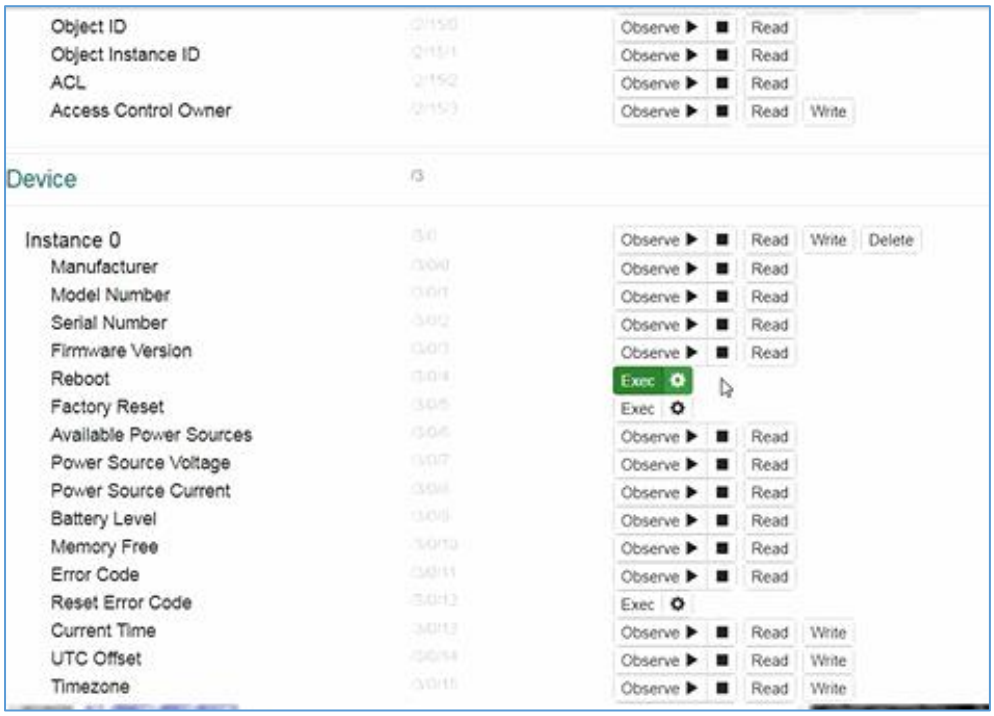


For more details, see section 5.2.

Reboot the client

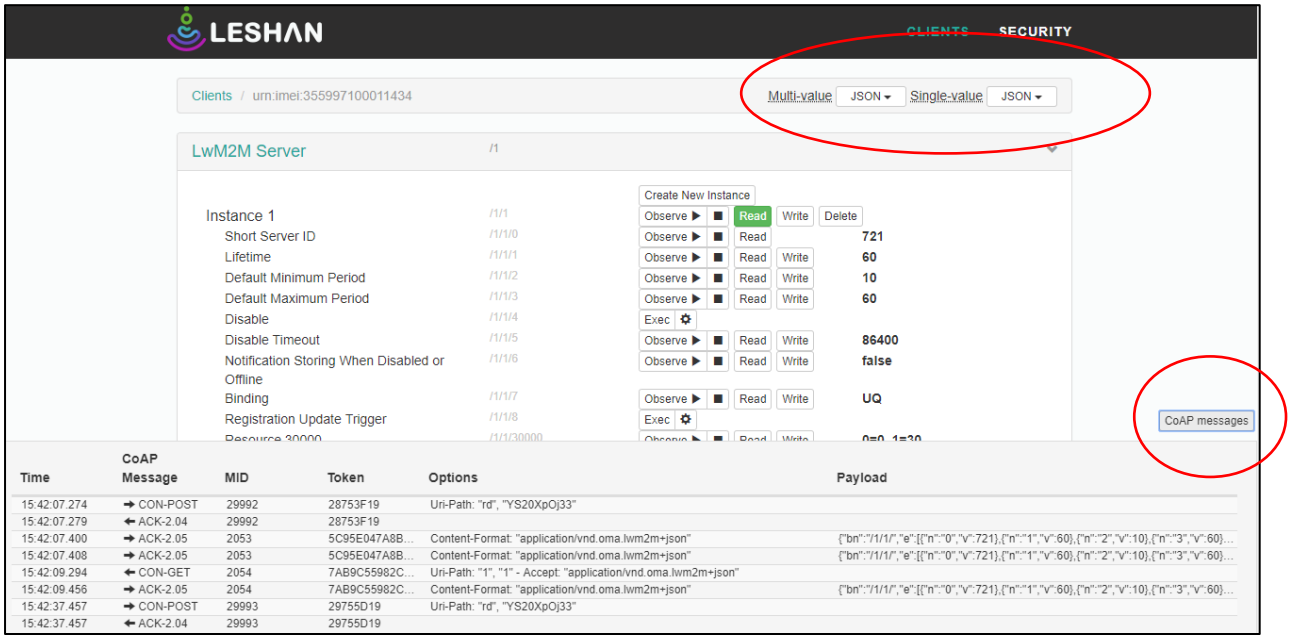
For more details, see section 5.6.

Under the “Device” object as shown in the below picture, click **Exec**.



CoAP messaging on Leshan

The Leshan web application can display the CoAP messages going across the client and server. It’s useful for debugging.



B Installing Lua on a Linux machine

Follow the procedure below to install Lua on Ubuntu.

```
wget https://www.lua.org/ftp/lua-5.3.5.tar.gz
sudo apt-get install make
sudo apt-get install gcc
sudo apt-get install libreadline-dev
gunzip lua-5.3.5.tar.gz
tar -xvf lua-5.3.5.tar
cd lua-5.3.5/src
make linux test
```

- Use the binary file “lua” for running
- See section 2.2

C Verizon-Motive certification

Verizon certification activity requires the user to substitute manually the default Verizon LwM2M bootstrap server (pre-configured in Verizon MNO profile / +UMNOPROF: 3), with the Motive test one. This task can be achieved by the procedure described below.

Deregister the module from the MNO network and delete LwM2M objects database. Configures the URC reporting status for LwM2M client. Reboot the module.

Command	Response	Description
AT+CFUN=4	OK	De-register the module.
AT+ULWM2M=2	OK	Delete LwM2M objects database.
AT+ULWM2MSTAT=1,7	OK	Configure the URC reporting status for LwM2M client. The syntax of this command differs according to the product type. Refer to AT commands manual for details.
AT+CFUN=16	OK	Reboot the module.

After the module reboot, wait for the LwM2M client to complete the initialization process.

URCs	
+ULWM2MSTAT: 5,1	LwM2M client initialization process started.
+ULWM2MSTAT: 5,2	LwM2M client initialization process finished.

Replace the Verizon LwM2M bootstrap server URL with the Motive test one, persists the configuration and set the module to full functionality.

Command	Response	Description
AT+ULWM2MWRITE="{\"bn\":\"/0/0/\",\"e\":[{\"n\":\"0\",\"sv\":\"coaps://ddocdpboot.do.motive.com:5684\"}]}"	OK	Replace Verizon LwM2M bootstrap server URL with the Motive test one.
AT+ULWM2MWRITE=""	OK	Force the LwM2M client to persist immediately the new configuration. The Motive bootstrap test server will be used until the LwM2M objects database is deleted.
AT+CFUN=1	OK	Set the module to full functionality.

The bootstrap process is then started against Motive LwM2M bootstrap server.

URCs	
+ULWM2MSTAT: 6,100,0,"ddocdpboot.do.motive.com:5684"	The connection to Motive LwM2M bootstrap server is created.
+ULWM2MSTAT: 0,100,11	The bootstrap process is initiated.
+ULWM2MSTAT: 0,100,12	The bootstrap process is pending.
+ULWM2MSTAT: 6,100,3,282,606	The connection to Motive LwM2M bootstrap server is closed.
+ULWM2MSTAT: 0,100,14	The bootstrap process is finished.

To restore the default Verizon LwM2M bootstrap server, delete the LwM2M objects database and reboot the module.

Command	Response	Description
AT+ULWM2M=2	OK	Delete LwM2M objects database.
AT+CFUN=16	OK	Reboot the module.

D Disabling LwM2M on SARA-R41 series

☞ This appendix section applies to: SARA-R410M-02B-03, SARA-R410M-02B-04, SARA-R412M-02B-03, SARA-R412M-02B-04. These product types are certified for AT&T LwM2M. For any related AT&T MNO profile, they do have LwM2M enabled, which may be required by MNO to be disabled. For details on MNO profiles, see SARA-R4 series AT commands manual [1]

If an active MNO profile selected has LwM2M enabled, and the MNO carrier should require it to be disabled, then it can be done with +ULWM2M command.

To disable LwM2M do the following upon each boot-up

Command	Response	Description
		Device boots up
AT+ULWM2M=1	OK	Shutdown LwM2M client for this session. If reset or shutdown is needed, wait for 4 sec after OK before doing so.

If PSM is enabled, and AT+ULWM2M=1 is applied to stop the LwM2M client, then when the module enters the PSM sleep mode and then later exits the sleep state, the LwM2M client will once again initialize and resume due to its volatile setting. For more details see SARA-R4 series AT commands manual [1] and SARA-R4 series Application development guide [4]. If desired to disable the LwM2M client again, a subsequent AT+ULWM2M=1 command is then necessary when the client resumes.

☞ Disabling LwM2M persistently is not supported on SARA-R410M-02B-03, SARA-R412M-02B-03.

To disable LwM2M persistently.

Command	Response	Description
		Device boots up
AT+ULWM2M=1,1	OK	Shutdown LwM2M client. Client is now disabled persistently. If reset or shutdown is needed, wait for 4 sec after OK before doing so.

For SARA-R410M-02B-03, SARA-R412M-02B-03. when booting-up the module in offline mode such as in airplane mode (+CFUN: 4), then to avoid a potential conflict with LwM2M leading to an unexpected module reboot, it is recommended to set disable LwM2M before exiting the airplane mode by setting the module to full functionality to MT (+CFUN: 1). Following exit, reboot the module to restore LwM2M client.

Command	Response	Description
		Device boots up in airplane mode.
AT+CFUN?	+CFUN: 4 OK	Confirm device is in airplane mode.
AT+ULWM2M=1	OK	Shutdown LwM2M client for this session. If reset or shutdown is needed, wait for 4 sec after OK before doing so.
AT+CFUN=1	OK	Set MT to full functionality from airplane mode.
AT+CFUN=15	OK	Reboot the module this way LwM2M will resume upon boot.

E Disabling LwM2M for AT&T on SARA-R5 series

☞ This appendix applies to SARA-R500S / SARA-R510S / SARA-R510M8S products of type numbers 00B-00, 00B-01, 00B-02, and 01B-00. These type numbers are certified for AT&T LwM2M.

For any related AT&T MNO profile that have LwM2M enabled, it may be required by AT&T MNO to disable them. For details on MNO profiles, see SARA-R5 series AT commands manual [8]. To disable the support for AT&T LwM2M servers (and optionally u-blox uFOTA), apply the following AT command sequence.

Command	Response	Description
AT+ULWM2MCONFIG=0,0,3,1,0,0,0,0,40,0,0,1	OK	Disable AT&T server SSID 0
AT+ULWM2MCONFIG=1,1,3,1,0,1,1,0,40,0,0,1	OK	Disable AT&T server SSID 1
AT+ULWM2MCONFIG=3,1,3,1,0,1,1,0,40,0,0,1	OK	Disable AT&T server SSID 3
AT+ULWM2MCONFIG=721,0,3,255,1,0,0,0,40,0,0,1	OK	Optionally disable u-blox uFOTA server SSID 721 if uFOTA is not used. It can be re enabled again, as described in section 3.7
AT+ULWM2MCONFIG?	+ULWM2MCONFIG: 0,0,3,1,0,0,0,0,40,0,0,1 +ULWM2MCONFIG: 1,1,3,1,0,1,1,0,40,0,0,1 ULWM2MCONFIG: 3,1,3,1,0,1,1,0,40,0,0,1 +ULWM2MCONFIG: 721,0,3,255,1,0,0,0,40,0,0,1 OK	Read configuration to confirm last parameter <server_disabled> is set correctly to 1.
AT+ULWM2M=1	OK	Note that switching MNO profiles will override this setting (LwM2M client enabled/disabled) but won't affect the servers setting.
AT+CFUN=16	OK	Reboot the module for new setting to take effect.

F Glossary

Abbreviation	Definition
3GPP	3rd Generation Partnership Project
ACL	Access Control List
APN	Access Point Name
AT	AT Command Interpreter Software Subsystem, or attention
CID	Context ID
CoAP	Constrained Application Protocol
DB	Database
FOTA	Firmware Over The Air
IMEI	International Mobile Equipment Identity
IP	Internet Protocol
NRE	Non Recurring Expense
PSK	Pre-Shared Key
TX	Transmission
UDP	User Datagram Protocol
uFOTA	u-blox FOTA
UL	Uplink
URC	Unsolicited Result Code

Related documentation

[1] u-blox LEXI-R4 / SARA-R4 series AT commands manual, UBX-17003787
[2] u-blox SARA-R4 series data sheet, UBX-16024152
[3] u-blox SARA-R4 series system integration manual, UBX-16029218
[4] u-blox SARA-R41 series application development application note, UBX-18019856
[5] u-blox LEXI-R4 / SARA-R42 series application development application note, UBX-20050829
[6] u-blox SARA-R5 series application development application note, UBX-20009652
[7] OMA technical specification Lightweight M2M, V1_0-20170208-A
[8] u-blox SARA-R5 series AT commands manual, UBX-19047455
[9] u-blox LEXI-R4 / SARA-R4 series firmware update with uFOTA, FOAT and EasyFlash application note, UBX-17049154
[10] AT&T device requirements document n. 13340
[11] u-blox LEXI-R4 series data sheet, UBX-22020834
[12] u-blox LEXI-R4 series system integration manual, UBX-23007449

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Revision history

Revision	Date	Name	Comments
R01	20-Dec-2019	skri/sgod	Initial release
R02	11-Jun-2020	skri	Updated sections 3.4, 4.3.2, 4.3.3
R03	26-Nov-2020	acom/acam/ skri	Extended the document applicability to SARA-R5 series modules. Added section “LwM2M impact on module functionality”
R04	26-Feb-2021	skri / acom	Extended the document applicability to SARA-R410M-02B-03 and SARA-R412M-02B-03
R05	23-May-2022	aoli	Extended the document applicability to SARA-R422, SARA-R422M8S and SARA-R422S
R06	24-Nov-2022	aoli	Extended the document applicability to SARA-R422-01B, SARA-R422M10S and SARA-R422S-01B
R07	24-Nov-2023	clee	Extended the document applicability to LEXI-R422 series
R08	21-Dec-2023	clee	Added Appendix section “Disabling LwM2M for AT&T on SARA-R5 series”
R09	27-Feb-2024	clee	Extended the document applicability to SARA-R520

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