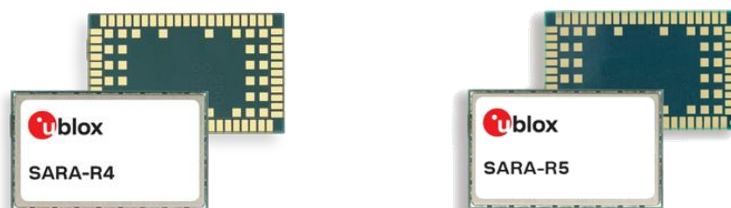# SARA-R4 / SARA-R5 series

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 will cover details on the mandatory objects, an example about extensible object and command options available.

Document information

Title	**SARA-R4 / SARA-R5 series**
Subtitle	LwM2M objects and commands
Document type	Application note
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This document applies to the following products:

Product name	
SARA-R410M	except for "01B", "52B" product versions
SARA-R412M	
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 [7].

Contents

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 [4].

1.1 LwM2M interfaces

The Open Mobile Alliance (OMA) defines the application layer communication between an LwM2M server and an LwM2M client.
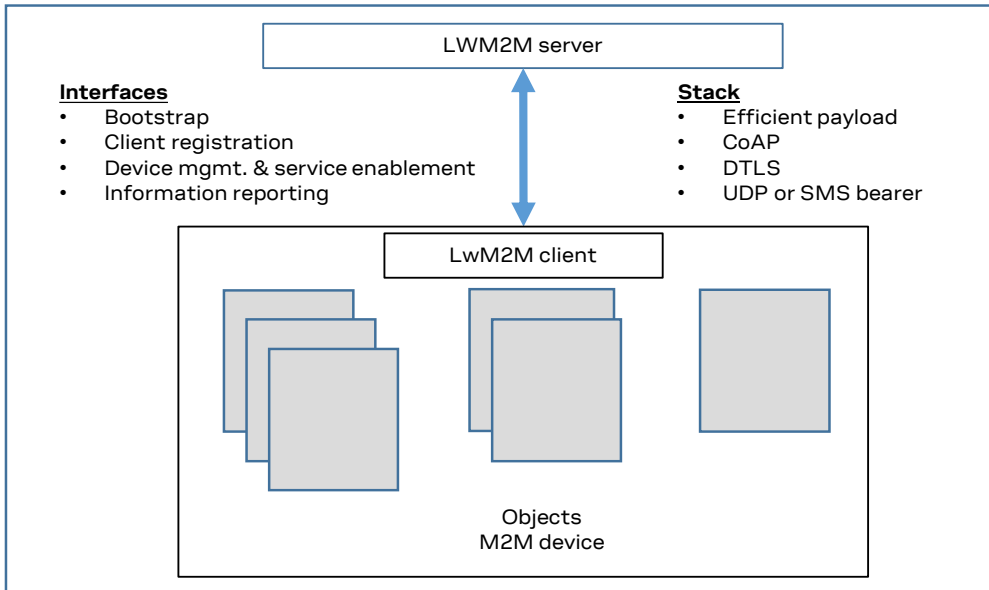
Figure 1: Interfaces between the server and client

- Bootstrap interface: configure servers info, credentials & ACLs
- Client registration interface: informs server about "existence" and supported functionality (e.g., objects, transport bindings)
- Device management and service enablement interface: ability to access object instances and resources
- Information reporting interface: publish/subscribe interaction for observing 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).
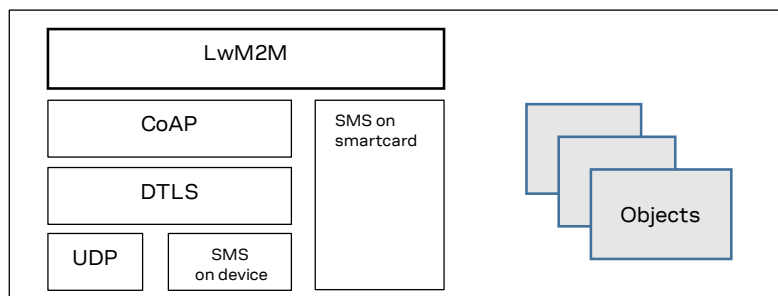
Figure 2: Protocols used in LwM2M

☞ 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 is used to change 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 is used to access 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.
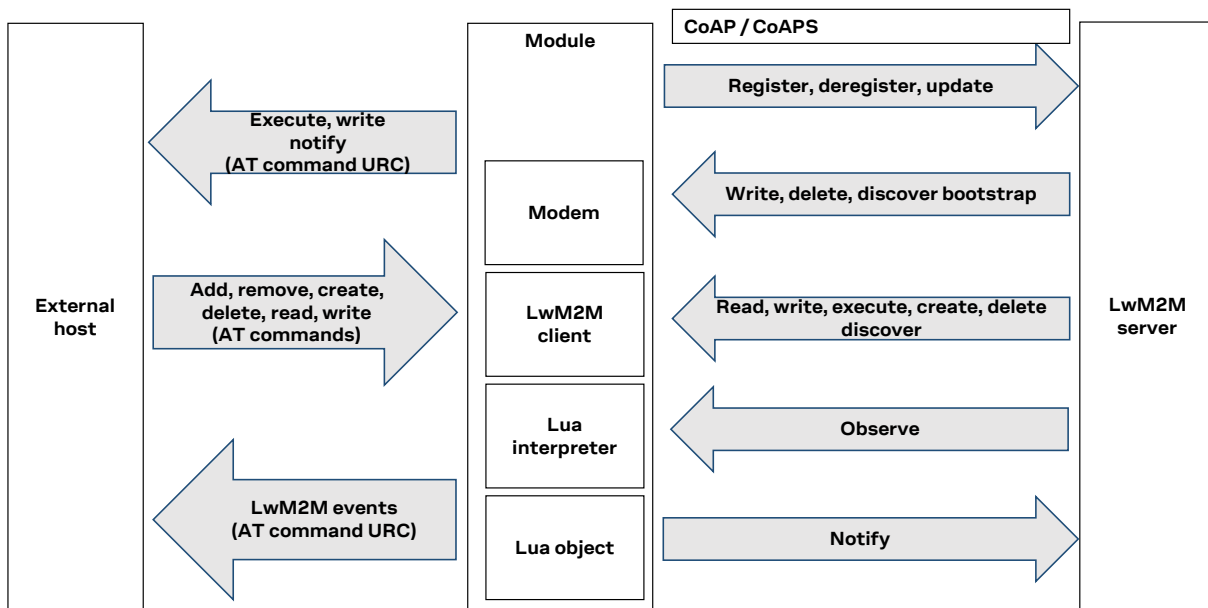
Figure 3: High level architecture

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.
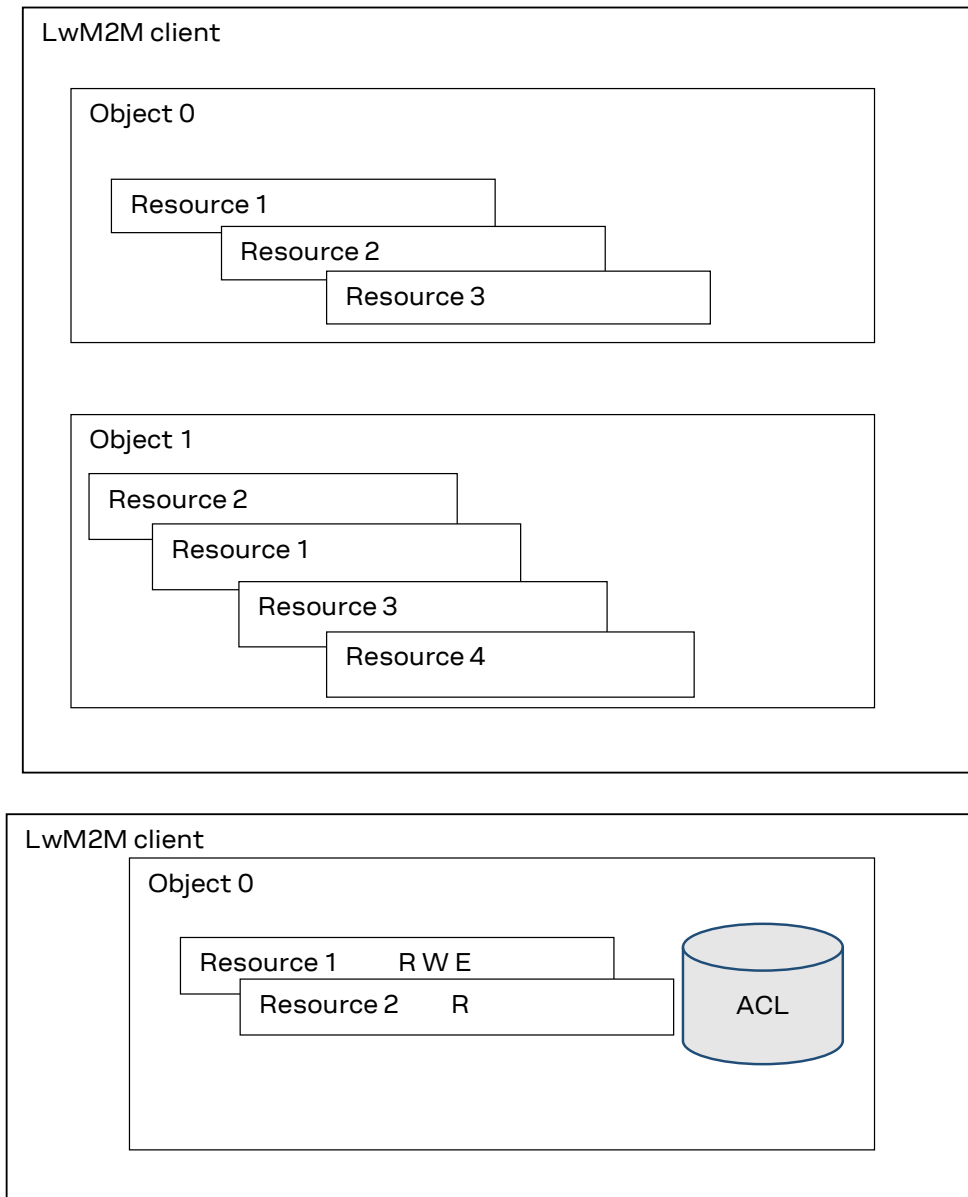
Figure 4: Objects, instances and resources

- 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 Objects supported

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.

Find here below the objects and resources supported by SARA-R4 / SARA-R5 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, 1*, 2*, 3*	* = 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, 1*, 2*, 3*	* = 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

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

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

Object ID	Name	Resources supported	Notes
14	Software Component	0, 2, 5	
16	Portfolio	0, 1*, 2*, 3*	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 3: 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. In addition, some of these resources cannot be populated by an end device even though the Lua object exists in the current builds implying it cannot be used by an end device.

☞ On SARA-R5 series modules and 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 means of the +CGDCONT AT command, the same will be created/deleted in a dedicated Object 11 resource.

☞ On SARA-R5 series modules and on SARA-R410M-02B / SARA-R412M-02B, 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 in compliance with AT&T requirement CDR-IOT-005 [8]. 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 [8]. 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 the 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

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 start using 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. This script can be used 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
   http://www.openmobilealliance.org/tech/profiles/lwm2m/3300.xml

4. 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.

5. 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
   ```

6. 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.

7. The object file can be copied to the module using the steps provided in section 5.3.2 that describes adding objects.

8. Once the object is added to the object table and the module is restarted, the LwM2M client can start using the new object.

9. 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.

10. The server is then able to 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 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.

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[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.

In the following sections there is a description of 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 means of the +UMNOPROF AT command, 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.
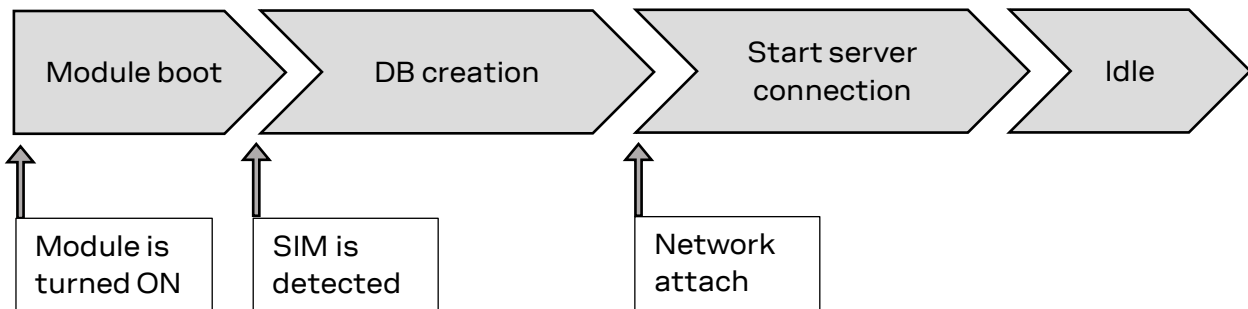
- The module is already provisioned with LwM2M DB aligned to the default MNO profile configuration.
- The module deletes the DB file when swapping the +UMNOPROF profile from one to another. The suggested wait time timings for DB creation are:
  - **SARA-R5 series**:

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

Table 4: 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

For environments with critical time constraints (e.g. module/device production phase), it is possible to skip LwM2M DB creation by activating the LwM2M production mode, in which the LwM2M client will not start and not initialize, so the DB creation is skipped.

The LwM2M production mode is tuned with two different settings in the +ULWM2MCONFIGEXT AT command:

- <production_mode>: 0 - The production mode is disabled.
- <production_mode>: 1 - The production mode is enabled if the inserted SIM matches the <production_sim> parameter.
- <production_sim>: tring parameter of 5 or 6 digits which allows to filter a special SIM used in production, e.g. 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.

Factory-programmed values are <production_mode>: 0 and <production_sim>: "" which means the feature is disabled (LwM2M always starts) in all the <mno> profiles apart from <mno>: 90 (Global) where it is enabled with <production_sim>: "00101". This means that in Global default configuration, LwM2M will not start if a test SIM is inserted.

The changes 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) 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), or 20 (NTT DoCoMo), then only the u-blox server is available by default. In this case no bootstrap is performed.

<MNO>	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)	
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 5: 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 [6].

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> 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 5. This table 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 asking for the module to be awakened 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), 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 respective +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, leading to 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 prior to use.

3.5.2　Custom servers

In all the MNO configurations, apart from undefined / regulatory (+UMNOPROF: 0), GCF-PTCRB (+UMNOPROF: 201) and NTT DoCoMo (+UMNOPROF: 20), the LwM2M client will attempt to connect to the u-blox LwM2M server. This connection will use the general purpose data context, whose connection ID (CID) is 1.

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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 with usage of +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: 60,20,30,4,1,0,"" 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:

- o 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.
- o 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: 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.

☞ On SARA-R5 series in Verizon network this timer value is 60 s.

4   AT commands

For detailed AT command descriptions, see the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].

4.1   Shut-down and start-up

The LwM2M client starts up along with the module.

On SARA-R4 series, the +ULWM2M AT command helps accomplish shutting down and re-initializing the LwM2M client. Here below is provided the sequence to bring it down or to re-initialize the LwM2M client.

Command	Response	Description
Stop LwM2M client		
AT+ULWM2M=1	OK	Stop the LwM2M client. Wait for the URC indicating the shut-down completion.
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 6: SARA-R4: 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.

☞ 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, 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.
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 7: SARA-R5 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 means of 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 SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].)

☞ 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 [6].

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.

4.1.1 SARA-R5 series: 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.

4.2   Viewing 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 of 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 of 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 contents 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, rather 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 means of the AT+CFUN=16 command).

4.3   Registration status and timer

For detailed AT command descriptions, see the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].

☞   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 below 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-R4 series if the SIM card is locked with a PIN, the LwM2M client might not bootstrap and register after boot up. The host should issue the AT+ULWM2MREG=0 command once the SIM is unlocked.

☞ On SARA-R4 series 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 [6].

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. 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 means of the +CFUN AT command.

4.4 Reading and writing to objects

The +ULWM2MREAD and +ULWM2MWRITE AT commands follow the JSON format specified in the OMA technical specification Lightweight M2M [4].

The +ULWM2MREAD AT command can be typically 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 can be used to "Read" an object, object instance, or resource e.g. 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 will need to 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: when reading 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
When reading the specific resource, note that 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 2: when reading the entire object instance of a custom object with only a single resource, which is multi-instance, note that 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 can be used to "Write" 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, so it is possible to issue the command with an empty string, in this way the changes are committed to 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 non-volatile memory

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

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

5 Operational examples

For detailed AT command descriptions, see the SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].

5.1 Adding an additional server to the client

By default, the module will communicate with server ID 721 which belongs to u-blox as this is defined in the bootstrap object. For testing purposes, an additional server instance can be created for the client to communicate with for e.g. a demo Leshan server. In the following example CoAP / CoAPS URL of a test Leshan server is used.

The +ULWM2MCREATE AT command can be used to accomplish "Adding an additional server". The format used for the +ULWM2MCREATE AT command is in a JSON format as defined in the OMA technical specification Lightweight M2M [4]. Notice 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 will be added.

5.1.1 Creating the security object instance

Follow one of the steps listed below to create the security object (i.e. either without DTLS or with DTLS). The added instance can be deleted using the +ULWM2MDELETE AT command (for more details, 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 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\"}]}",12 3`	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 command to assign the owner of the object instance in the associated ACL object instance.

☞ In addition, the 256 bit AES encryption is used locally to encrypt the locally stored information on module's LwM2M operations. The key is generated per module and stored in the module.

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[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 USECMNG; for additional info about the +USECPRF AT command, see SARA-R5 series AT commands manual [6].

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 allows to delete the created instances. The below command deletes the instance of security object and server object that were created previously. The AT+ULWM2MDEREG=123 command deregisters the module from the server 123 which could 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 for setting the server connection preferences for the LwM2M client and the security feature. The configuration specifies the PDP identifier, connection type, and whether or not to use security. When creating a new server, after having issued the +ULWM2MCREATE AT command as described in section 5.1.2 for the server and security object, also issue the +ULWM2MCONFIG AT command to set the server connection preferences. The module can obtain a PSK using the security feature as well. For more details, see u-blox security data suite application note [4].

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
		  It should be noted 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 here means the device will not use security feature to obtain PSK.

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

☞ If the <usec_psk>=0 in an LwM2M configuration file entry for a particular 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.

☞ If the <usec_psk>=1 for a particular LwM2M server, the PSK and PSK identifier will be generated internally by the uSec application. In this case, new PSK and PSK identifier values are created prior to each full LwM2M registration attempt and are stored in the associated security object instance. In the table in section 5.1.1 {"n":"3","sv":"MzUyNzUzMDk1Nzg3NjE4"} and {"n":"5","sv":"q83v"} need not be issued in the command discussed.

☞ An LwM2M server must use the u-blox uCSP service to validate the credentials. For more details, see u-blox security data suite application note [4].

☞ On SARA-R4 series all LwM2M and FOTA communication for SoftBank and DoCoMo MNO profiles has to be done with PDN context identifier 2, which cannot be viewed or edited using the +CGDCONT AT command.

5.1.5 Restart and check 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 SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].

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		
	+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 SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].

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 has to 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, like once an hour or once a day or so depending on the end application.

☞ 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 SARA-R4 series AT commands manual [1] / SARA-R5 series AT commands manual [6].

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		
	+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: generic sensor

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 [6].

☞ 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",	Object ID /3300 is no longer present in the list of objects.

Command	Response	Description
	"/14/4","/14/5","/14/6","/14/7", "/14/0","/16","/0/1" OK	
Delete the object file		
AT+UDELFILE="object_generic_sen sor.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_conn ectivity.lua","object_connectivity _monitoring.lua","object_connectiv ity_statistics.lua","object_device .lua","object_firmware_update.lua" ,"object_location.lua","object_lwm 2m_access_control.lua","object_lwm 2m_security.lua","object_lwm2m_ser ver.lua","object_lwm2m_software_co mponent.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_sen sor.lua", 11668,"XLWM2M" > [Send data]	OK	Adding generic sensor Lua object file.
AT+ULSTFILE=0,"XLWM2M"	+ULSTFILE: "object_apn_connection_ profile.lua","object_cellular_conn ectivity.lua","object_connectivity _monitoring.lua","object_connectiv ity_statistics.lua","object_device .lua","object_firmware_update.lua" ,**"object_generic_sensor.lua"**,"obje ct_location.lua","object_lwm2m_acc ess_control.lua","object_lwm2m_sec urity.lua","object_lwm2m_server.lu a","object_lwm2m_software_componen t.lua","object_portfolio.lua" OK	List all of the object Lua files.
AT+ULWM2MADD="object_generic_se nsor.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.

☞ On SARA-R5 series, 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 and will fail to initialize.

☞ **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.

  o **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.
  o **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.
  o **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\":\"/330 0/0\",\"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","/1 4/2","/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.

  o **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.

o **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.

o **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":"Temperat ure"},{"n":"5751","sv":""},{"n":"5 604","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.
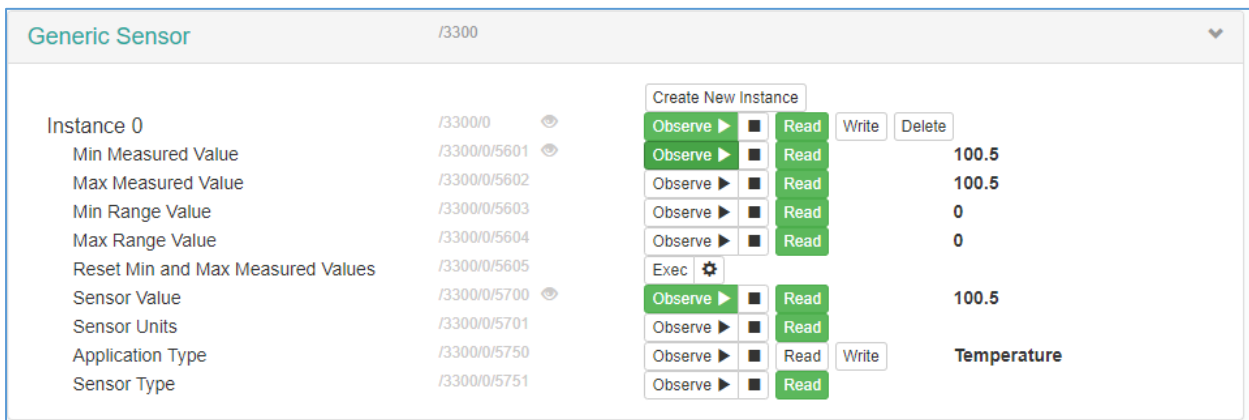
Figure 5: Generic sensor instance on an LwM2M server

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 for performing actions.

In the below code snippet from the sample object_generic_sensor.lua, a function **lua_send_urc** is used to send a URC notification when a resource's "App" type 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
```

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

Command	Response	Description
AT+ULWM2MCREATE="{\"bn\":\"/330 0/0\",\"e\":[{\"n\":\"5750\",\" sv\":\"Temperature\"}]}",123	OK	Adding the "App" type of temperature to 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 which will 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: 16, 19, 23, 24, 25, 42 • Low/high: 0/1 • Time: 0-10000 ms (0: to be left asserted) • 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-Execute permissions have to 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 are provided permission for the newly added server ID 123 to be able to execute actions on the device object to give it the capability 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":7 21}]}` `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 for 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 as soon as 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:
    ```
    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.

Appendix

A   Leshan overview

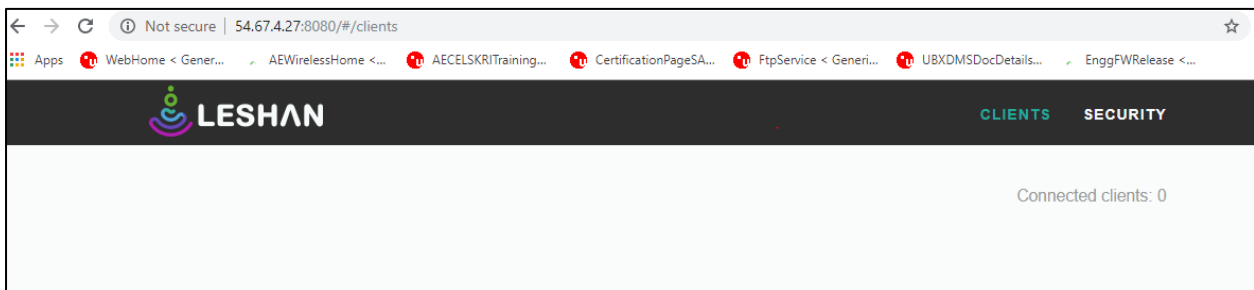**Download a Leshan demo server on Ubuntu**

- 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 be able 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 given as ABCDEF, whereas in the +ULWM2MCREATE AT command a value of q83v is the base64-encoded format of the HEX string 0xAB,0xCD,0xEF.
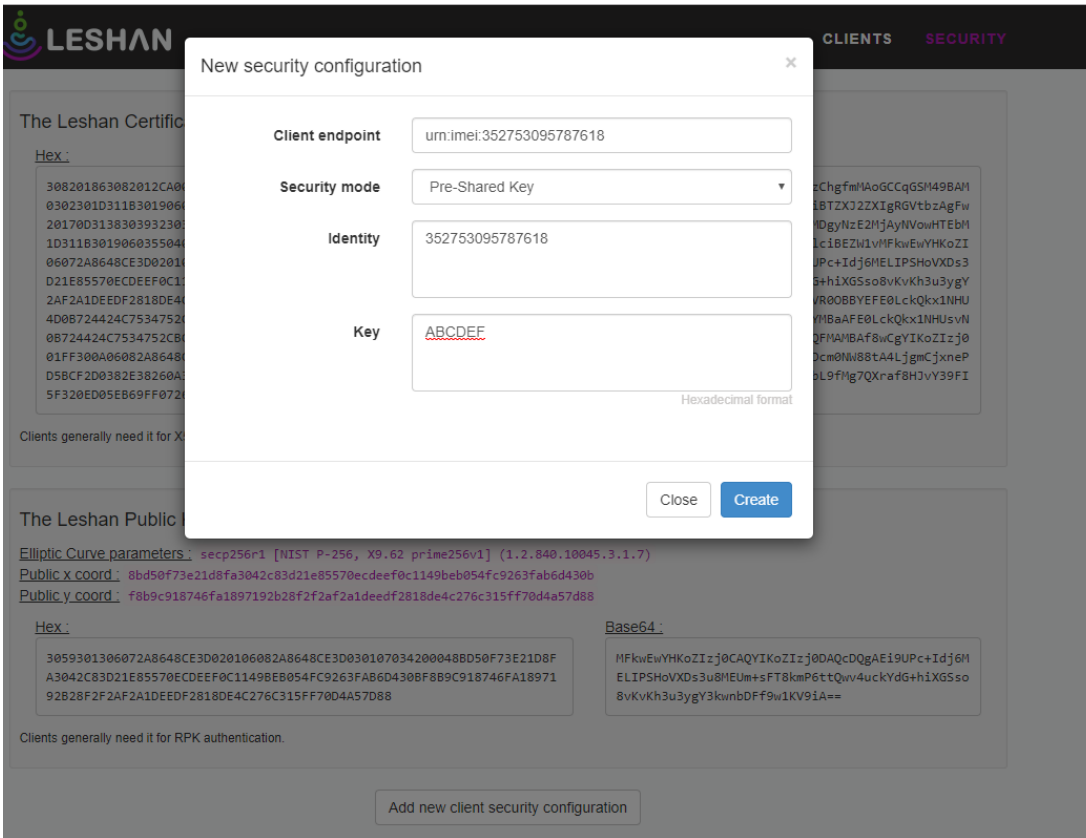
Reading objects using Leshan

Clicking on the **Read** button allows the Leshan server to be able to read the object values from the client.

Modifying 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 up again.
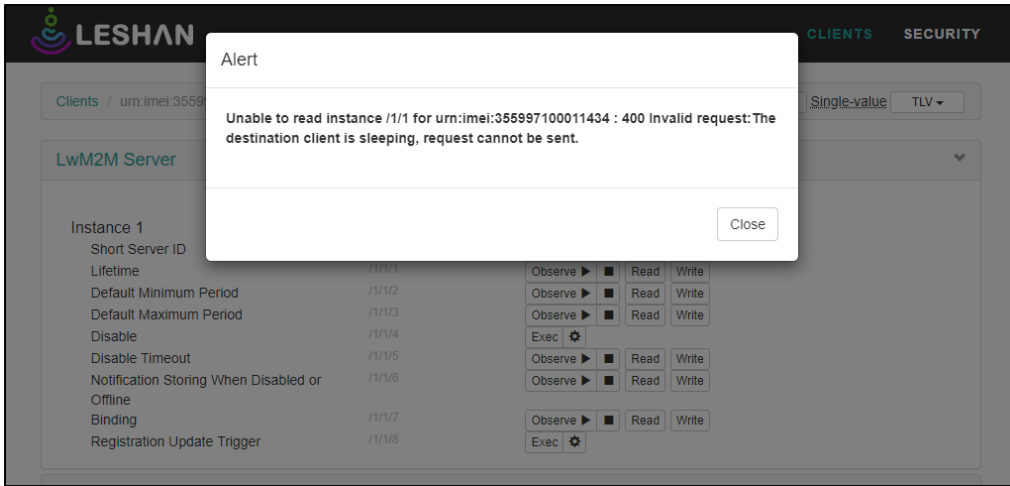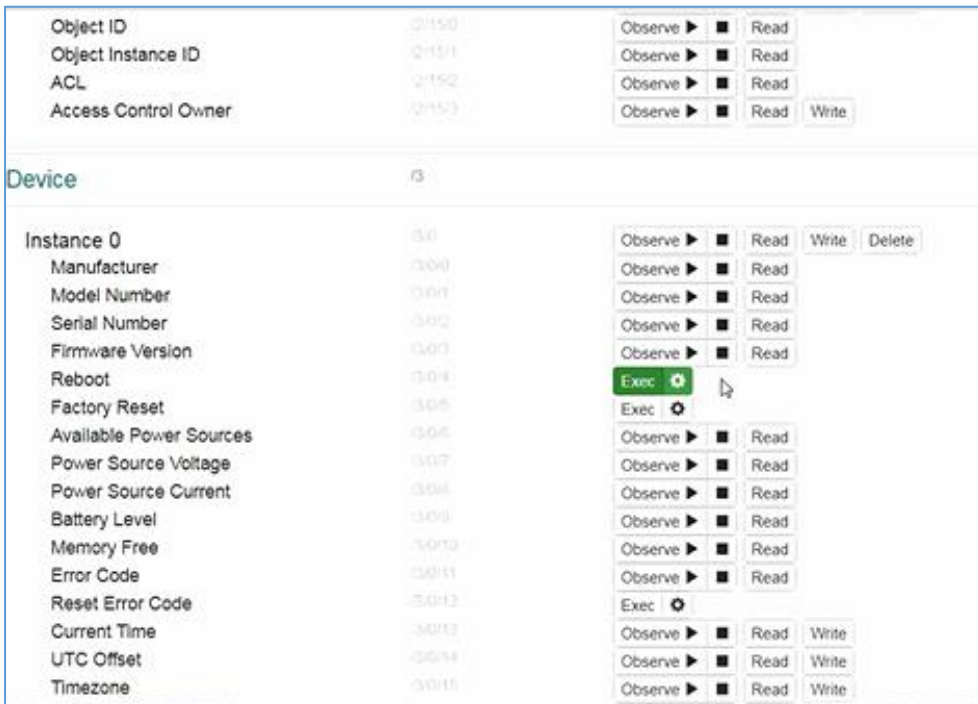
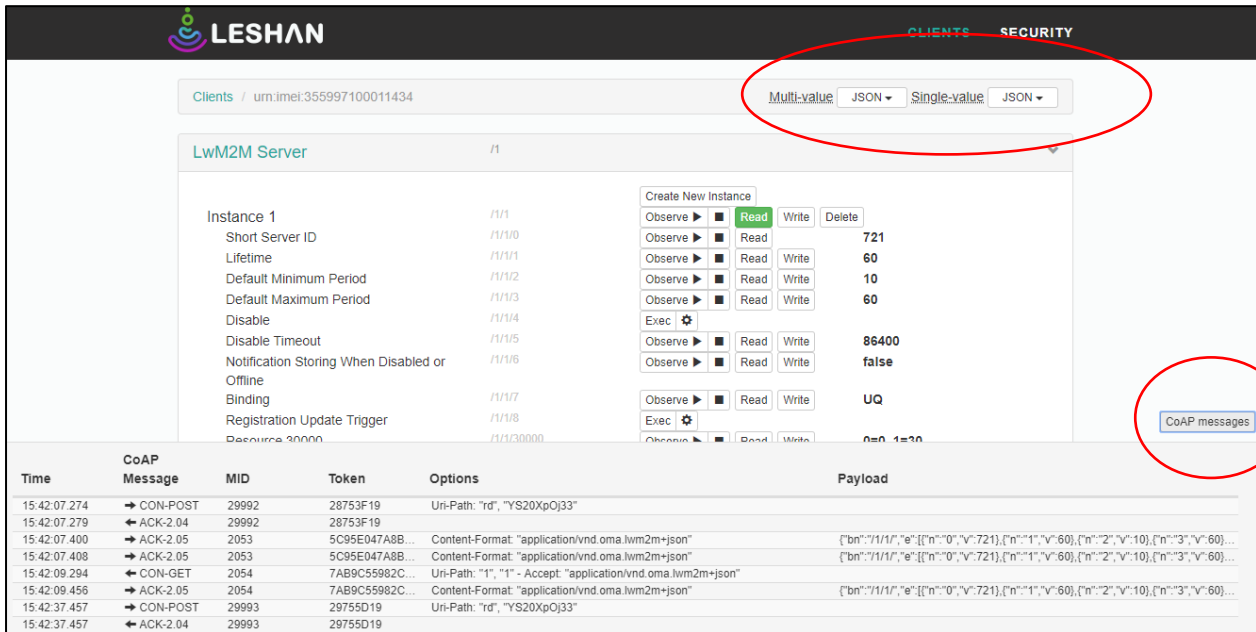For more details, see section 5.2.

To reboot the client

For more details, see section 5.6.

Under the "Device" object as shown in the below picture, click on the **Exec**.

CoAP messaging on Leshan

The Leshan web application has the ability to display the CoAP messages going across the client and server. These can be used for debugging purposes.

B   Installing Lua on a Linux machine

The below procedure can be used 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 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

Table 8: Explanation of the abbreviations and terms used

Related documentation

[1] u-blox 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] OMA technical specification Lightweight M2M, V1_0-20170208-A
[5] u-blox security data suite application note, UBX-19030037
[6] u-blox SARA-R5 series AT commands manual, UBX-19047455
[7] u-blox SARA-R4 series firmware update with uFOTA, FOAT and EasyFlash application note, UBX-17049154
[8] AT&T device requirements document n. 13340

☞ For regular updates to u-blox documentation and to receive product change notifications, register on our homepage (www.u-blox.com).

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

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