SARA-R4 / SARA-R5

Internet applications development guide

Application note

Abstract

This document provides detailed examples of how to use AT commands to develop IP applications in SARA-R4 / SARA-R5 series modules.

Document information

Title	**SARA-R4 / SARA-R5**	
Subtitle	Internet applications development guide	
Document type	Application note	
Document number	UBX-20032566	
Revision and date	R05	28-Sep-2022
Disclosure restriction	C1-Public	

This document applies to the following products:

Product name	Notes
SARA-R4 series	Except for SARA-R404M, SARA-R410M, SARA-R412M
SARA-R5 series	

u-blox or third parties may hold intellectual property rights in the products, names, logos and designs included in this document. Copying, reproduction, modification or disclosure to third parties of this document or any part thereof is only permitted with the express written permission of u-blox.

The information contained herein is provided "as is" and u-blox assumes no liability for its use. No warranty, either express or implied, is given, including but not limited to, with respect to the accuracy, correctness, reliability and fitness for a particular purpose of the information. This document may be revised by u-blox at any time without notice. For the most recent documents, visit www.u-blox.com.

Contents

1 Introduction

This document provides guidance for using IP related applications in SARA-R4 and SARA-R5 series modules. It includes examples of AT commands to interface with the u-blox cellular modules for network connectivity and IP protocols use. It reports examples for any applications relying on the IP stack (sockets, MQTT, MQTT-SN, HTTP, FTP, CoAP, SSL/TLS).

In the first section, the packet switched (PS) data connection is described with context definition and procedure to obtain a valid IP address from the network. Then, it provides information on security aspects useful to manage and configure a secure data connection.

Table 1 shows a summary of the documentation available for u-blox cellular modules. We recommend, as a starting point, to read the application development guide app note [8], [11] which reports extremely relevant information guidance for developing applications that interface with the u-blox cellular modules. Moreover, it contains details to complete the network registration process, which is a mandatory precondition to activate a PS data connection and use any internet application.

	Document name	Notes
Application integration	Application development guide app note [8], [11]	This should be the first document to read when working on an application for cellular modules
	FW update app note [14][15]	FW update procedures (uFOTA, FOAT, FOTA, +UFWINSTALL, EasyFlash)
	Internet applications development guide app note	**This document.**
	Security suite web page [13]	IoT-as-a-Service features (local encryption, E2E encryption, E2E symmetric KMS, Chip-to-Chip, Zero Touch Provisioning)
	GNSS implementation app note [16]	Implementation of the GNSS interface, hybrid positioning and timing information in u-blox SARA-R5 and SARA-R4 series modules
	LwM2M objects and commands app note [10]	How to use LwM2M protocol stack to interact with the LwM2M server.
	Mux implementation app note [12]	Usage of multiplexer with cellular modules
	EVK user guide[4], [8]	Starting guide for the evaluation kit
Reference documentation	Data sheet [1], [4]	Use these documents as hardware integration and AT commands API reference
	System integration manual [2], [6]	
	AT commands manual [3], [7]	
Product release documents	Sample delivery note / Information note	Delivered with every FW release

Table 1: SARA-R4 / SARA-R5 product documentation scheme

Considering the growing interest in internet-related applications, the second part of this document provides complete examples and relevant notes to introduce the so-called "IP" applications that are built with our SARA-R4 / SARA-R5 series modules. The module structure of these applications is reported in Figure 1and Figure 2.

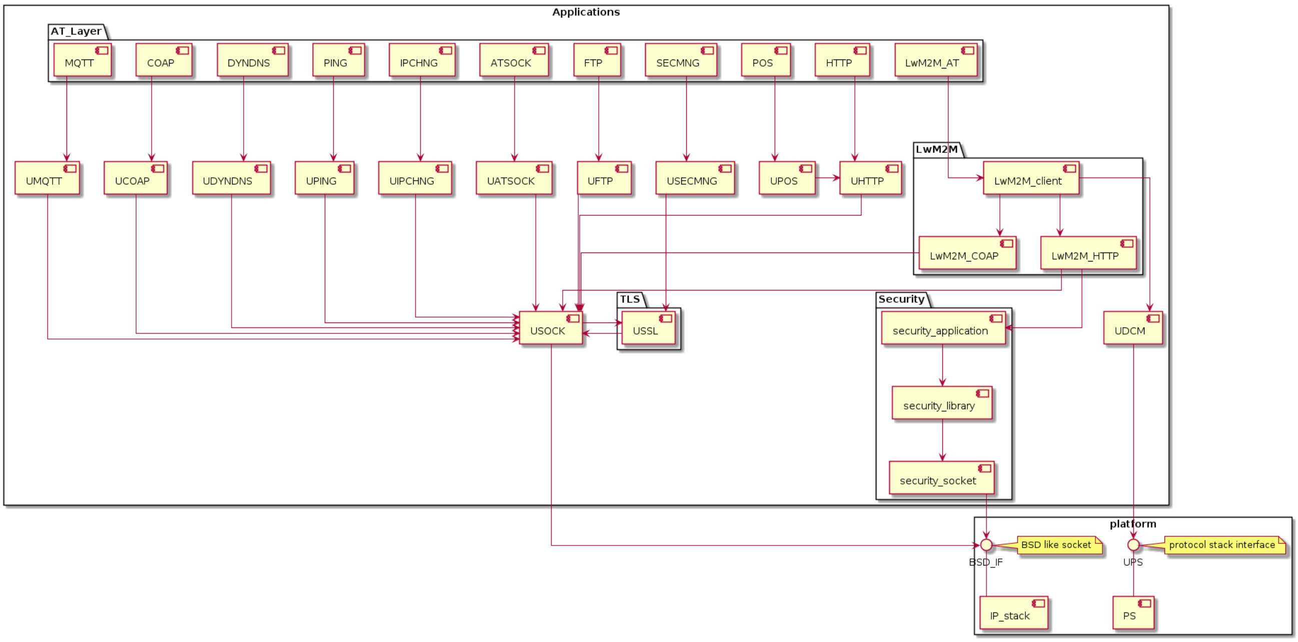


Figure 1: SARA-R5 "IP" applications

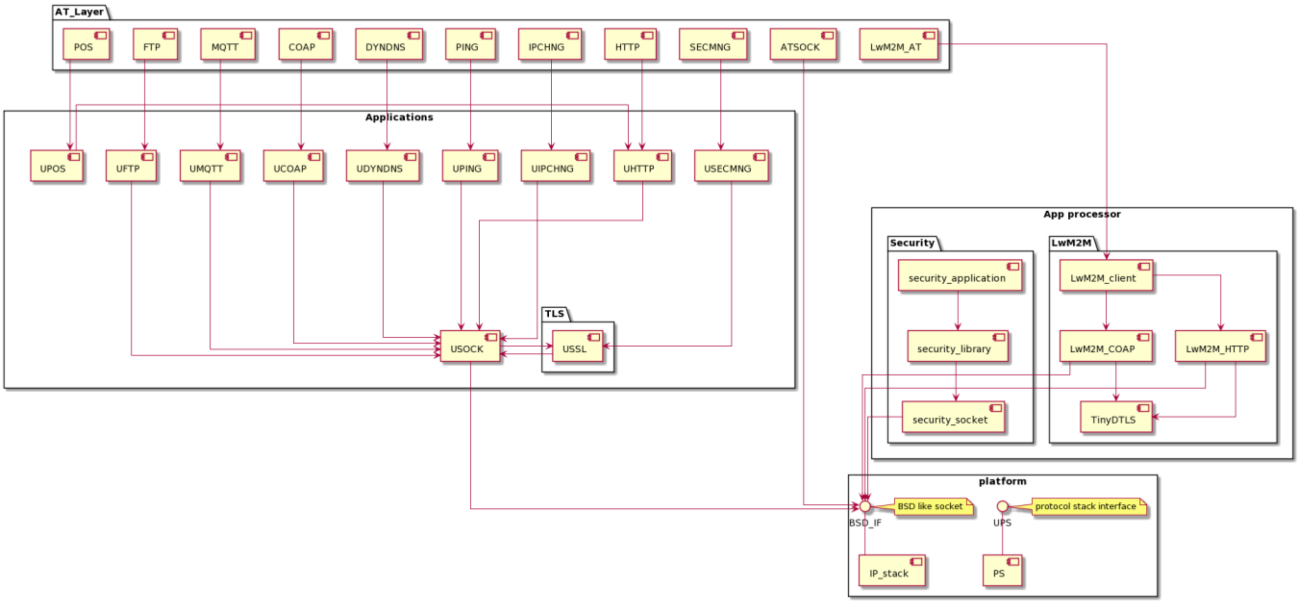


Figure 2: SARA-R422 "IP" applications

In conclusion, use as reference documentation the data sheet [1], [4], the system integration manual [2], [6] and the AT commands manual [3], [7] for a detailed AT command descriptions.

The following symbols are used to highlight important information within this document:

☞ An index finger points out key information pertaining to module integration and performance.

⚠ A warning symbol indicates actions that could negatively impact or damage the module.

2 PS data connection

Ensure the module is correctly registered to the network before executing all the procedures and examples reported in this document. Steps to complete the network registration operation can be found in the "Network registration" section of the application development guide [8], [11].

2.1 PDP contexts

Packet-switched services rely on the Packet Data Protocol (PDP). The PDP context is a data structure that contains the subscriber's session information. Two types of PDP context are defined:

- "external" PDP context: IP packets are built by the Data Terminal Equipment (DTE), the module's IP instance runs the IP relay function only.
- "internal" PDP context, or PSD profile: the PDP context (relying on the module's embedded TCP/IP stack) is configured, established, and handled via the data connection management AT commands.

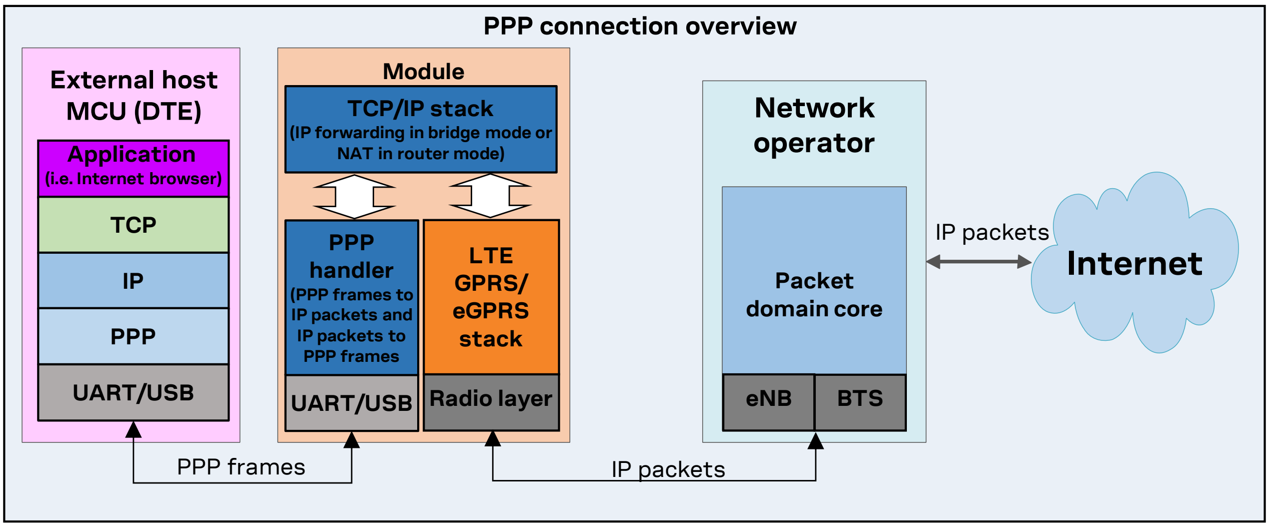


Figure 3: Example of external context structure

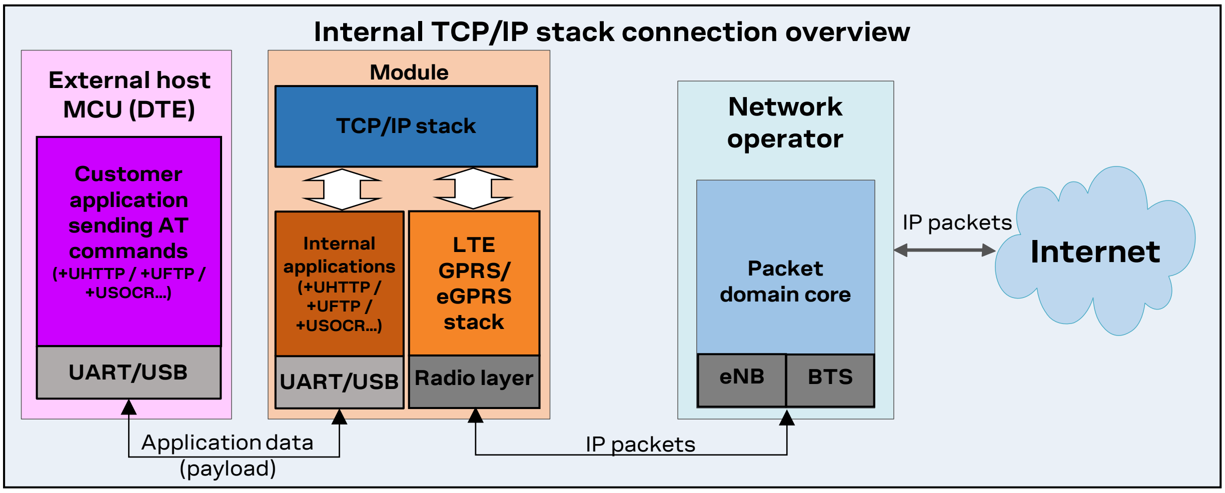


Figure 4: Example of internal context structure

Networks offer connectivity to different IP domains (internet or intranet) selected by specifying the Access Point Name (APN) at PDP context activation.

☞ In LTE RAT, if the APN name is not specified, an anchor APN (e.g., “admin”) can be assigned by the network to the module, along with an IP address which Port filtering feature may give no actual connectivity. Check the APN name to use with your mobile network operator.

For further details on the APN configuration, see the “Network registration” section of the application development guide [8], [11].

Each PDP context defined has a related identifier called “context ID” (CID):

- On SARA-R5 series it is possible to define up to 12 PDP contexts (<cid> from 0 to 11) where 7 of them can be active.
- On SARA-R4 series it is possible to define up to 8 PDP contexts (<cid> from 0 to 7) where 4 of them can be active.

<cid>=1 is mapped to the initial default EPS bearer (primary PDP context, established during the LTE attach procedure).

2.2 MTU configuration

2.2.1 MTU in IPv4

The MTU configuration is stored in the MNO profiles and its configuration depends on specific network operator requirements. The configuration modes can be:

- Fixed value.
- Request in PCO the MTU size during PDP activation and use the network assigned value. If the network does not assign any value, the fixed value is used as a fallback.
- Allow the MTU configuration via the +CGDCONT AT command.

☞ The default values vary depending on the current MNO profile loaded via the +UMNOPROF AT command.

2.2.2 MTU in IPv6

The MTU configuration is stored in the MNO profiles and its configuration depends on specific network operator requirements. The configuration modes can be:

- Fixed value.
- From the router advertisement (RA) during SLAAC. If the MTU is not present in the RA, the fixed value is used as a fallback.

☞ The default values vary depending on the current MNO profile loaded via the +UMNOPROF AT command.

2.3 Socket and PDP context activation

The following example reports all the AT commands necessary to activate a PDP context by starting from the power-up of the modules and the control of the pre-existing settings.

Network settings verification

Command	Response	Description
`AT+CFUN=0`	`OK`	Turn off radio functionality. ☞ While setting the network profile and parameters, the radio functionality must be turned off.
`AT+UMNOPROF=100`	`OK`	Set the MNO profile for usage in Europe (LTE bands 3, 8, 20). The MNO profiles are sets of modem configurations specific for MNO/regions. This setting is stored in NVM and its configuration shall be performed only at the first boot or after the module is flashed.
`AT+CFUN=16`	`OK`	Reboot of the module to make the new setting effective.

`AT+UMNOPROF?`	`+UMNOPROF: 100`
	`OK`
		Verifying that the new profile has been set.

`AT+CFUN=0`	`OK`	Turn off radio functionality.
`AT+CGDCONT=1,"IPV4V6","apn_name"`	`OK`	Define the PDP context 1 with PDP type "IPV4V6" and APN "apn_name" of the MNO.

Check network registration: LTE radio access technology

Command	Response	Description
`AT+CFUN=1`	`OK`	Turn on radio functionality.

`AT+COPS?`	`+COPS: 0,0,"Nutaq Cat-M1 Network",7`
	`OK`
		Verify if module is currently registered to the network.
		☞ Issue `AT+COPS=0` if the `+COPS` read command returns `+COPS: 2`.

`AT+CGDCONT?`	`+CGDCONT: 1,"IP","apn_name","100.108.232.233",0,0,0,0,0,0`
	`OK`
		Return IPv4 address (in this case, only IPv4 address is assigned by the network).
		☞ When mapping the external context to an internal PSD profile, the application must make sure that the same protocol type is set (e.g., in this example, using the `AT+UPSD=0,0,0` command).

Check network registration: GPRS/eGPRS radio access technology

Command	Response	Description
`AT+CFUN=1`	`OK`	Turn on radio functionality.

`AT+COPS?`	`+COPS: 0,0,"Nutaq Network",3`
	`OK`
		Verify if module is currently registered to the network.
		☞ Issue `AT+COPS=0` if the `+COPS` read command returns `+COPS: 2`.

`AT+CGACT=1,1`	`OK`	Activate PDP context 1.

`AT+CGDCONT?`	`+CGDCONT: 1,"IP","apn_name","100.108.232.233",0,0,0,0,0,0`
	`OK`
		Return IPv4 address (in this case, only IPv4 address is assigned by the network).
		☞ When mapping the external context to an internal PSD profile, the application must make sure that the same protocol type is set (e.g., in this example, using command `AT+UPSD=0,0,0`).

Profile activation: SARA-R5

Command	Response	Description
`AT+UPSD=0,0,0`	`OK`	Set the PDP type to IPv4 referring to the output of the +CGDCONT read command.
`AT+UPSD=0,100,1`	`OK`	Profile #0 is mapped on CID=1.
`AT+UPSDA=0,3`	`OK`	Activate the PSD profile #0: the IPv4 address is already assigned by the network. ☞ Only one profile can be activated at the same time. The PDP context activation on more than one profile at the same time is not supported.
	`+UUPSDA: 0,"100.108.232.233"`	This URC indicates that the PSD profile #0 has been successfully activated and the IPv4 assigned to the activated PDP context.

Profile configuration and activation: SARA-R4

Command	Response	Description
`AT+UPSD=0,0,0`	`OK`	Set the PDP type to IPv4 referring to the output of the +CGDCONT read command.
`AT+UPSD=0,100,1`	`OK`	Profile #0 is mapped on CID=1. ☞ Always issue the AT+UPSD=0,100,<cid> command on used context <cid> after the +CGDCONT AT command returns that the context is active with a valid IP address. This activates the PS data connection and allows applications to work properly.

☞ On SARA-R4 series modules it is recommended to always issue the AT+CGACT=1,<cid> command when PDP at <cid> isto be used by application processor, even if the PDP context is already active. IP embedded applications (such as BIP, USEC or LwM2M) may activate it and if the PDP is used by the external processor without AT+CGACT=1,<cid>, the PDP may be de-activated without any notification and external application will lose connectivity.

2.3.1 Mapping IP protocol type

☞ SARA-R4 series modules do not support the IP protocol mapping feature.

When an external context is mapped to an internal PSD profile (e.g., by using the +UPSD AT command option 100) make sure to set the same protocol type (either “IP”, “IPV6”, or “IPV4V6”) both for the context and the profile before the PSD profile activation.

⚠ For SARA-R5 "00B" product version, what matters is the protocol type set when issuing the +CGDCONT set command, and not what is provided as the response of the +CGDCONT read command, which could be different. In the opposite manner, for SARA-R5 "01B" product version and onwards, the internal PSD profile must set a protocol type exactly as read in the +CGDCONT AT command after registration to the network.

☞ On SARA-R5 "00B" product version the default protocol type for external contexts (defined by means of the +CGDCONT AT command) is IPV4V6, while for internal PSD profiles it is IP (v4).

☞ On SARA-R5 "01B” product version the default protocol type for external contexts (defined by means of the +CGDCONT AT command) is IPV4V6, while for internal PSD profiles it is IPV4V6, IPv4 preferred (e.g., AT+UPSD=0,0,2).

☞ If the network supports both IPv4 and IPv6, it is recommended to keep the IPV4V6 setting when defining a new PDN connection via AT commands. Thus, when an LTE attach or PDP context activation is performed, usually both IPv4 and IPv6 IP addresses are assigned in this case so the specified IP type issued in the +UPSD command will be used by the module internet applications (socket, HTTP, FTP, etc.).

The following table shows all possible examples and the +UPSD AT command to correctly map an external context to an internal PSD profile:

External context setting (+CGDCONT)	+UPSD configuration
`"IPV4V6"`	`AT+UPSD=0,0,2` or `AT+UPSD=0,0,3`
`"IP"`	`AT+UPSD=0,0,0`
`"IPV6"`	`AT+UPSD=0,0,1`
Note that the mapping is always done with `AT+UPSD=0,100,1` command.	

If the protocol mapping type is wrong, the profile activation will report the `+CME ERROR: IP type configuration mismatch` error result code.

2.4 Other relevant AT commands

2.4.1 Ping command +UPING

The ping command is the common method to know if a remote host is reachable on the internet.

The ping functionality is based on the ICMP protocol. The ping command sends an ICMP echo request to the remote host and waits for its ICMP echo reply. If the echo reply packet is not received, it might mean that the remote host is not reachable. The ping command could be used also to measure e.g. the round trip time (RTT, the time needed by a packet to go to the remote host and come back) and the time to live (TTL, it is a value to understand how many gateways a packet has gone through).

The +UPING AT command allows the user to execute a ping command from the module to a remote peer. The results of the ping command execution are notified by these URCs:

- +UUPING: reports the +UPING AT command result when no error occurred.
- +UUPINGER: raised if an error occurs while processing the +UPING AT command.

For further details on the +UPING AT command and its possible errors, see the AT commands manual [3], [7].

⚠ Some network operators may disallow ICMP packets traffic on their network, this means that the +UPING AT command may not work.

⚠ Some remote hosts might not reply to ICMP echo requests for security reasons (e.g., firewall settings).

⚠ Some remote hosts might not reply to ICMP echo requests if the data size of the echo request is too big.

⚠ If a remote peer does not reply to an ICMP echo request, it does not mean that for sure the peer cannot be reached in another way.

☞ The command is not supported in context using the IPv6 protocol type.

Command	Response	Description
`AT+UPING="www.google.com"`	`OK`	Ping request.
	`+UUPING: 1,32,"www.google.com","216.58.206.68",115,62`	URC ping responses.

Command	Response	Description

	`+UUPING: 2,32,"www.google.com" ,"216.58.206.68",115,53`
	`+UUPING: 3,32,"www.google.com" ,"216.58.206.68",115,53`
	`+UUPING: 4,32,"www.google.com" ,"216.58.206.68",115,53`	

2.4.1.1 Notes

- If the +UUPING URC reports <rtt>=-1 the timeout is elapsed (no response received).
- If the first +UUPING URC reports <rtt>=-2 the TTL used in the ping request is too low.
- Some network operators may return an ICMP time exceeded message when the remote host is not reachable. In those cases, the first +UUPING URC reports <rtt>=-1 and the subsequent +UUPING URC reports <rtt>=-2.

2.4.2 DNS resolution +UDNSRN

Using the +UDNSRN AT command it is possible to translate a domain name to an IP address or an IP address to a domain name by using an available DNS. There are two available DNSs, primary and secondary. The network usually provides them after a PS data activation. They are automatically used in the resolution process if available. The resolver will use first the primary DNS, and if there is no answer, the second DNS.

Command	Response	Description

`AT+UDNSRN=0,"www.google.com"`	`+UDNSRN: "216.239.59.147"`
	`OK`
		DNS resolution request.

☞ SARA-R5 series modules have an internal DNS cache, entries timeout is set according to the TTL received in the DNS response. Moreover, the cache is cleared when the PDN is deactivated or the module enters the PSM.

☞ In case the application is not subjected to low power consumption constraints, use either the +UPING or the +UDNSRN AT command to verify that the module is registered with the network, and a PS data connection is activated before start using any IP application.

☞ Some NB-IoT network operators do not support ePCO container. Therefore, using ePCO in the attaching of such a network will result in a lack of DNS capabilities. For NB-IoT networks that are known to not support ePCO, it is recommended to disable the ePCO feature using the +UCFGCIOT AT command. Additional details on this matter are available in SARA-R5 series application development guide [9] and SARA-R4 series application development guide [11].

3 Data security

☞ The section does not apply to SARA-R422 modules.

3.1 Certificates manager +USECMNG

The +USECMNG AT command manages SSL/TLS certificates and private keys with the following functionalities:

- Import of certificates and private keys
- List and information retrieval of imported certificates and private keys
- Removal of certificates and private keys
- MD5 calculation of imported certificate or private key

For additional details on this AT command, the number and the format of the certificates, and the private keys accepted, see the AT commands manual [3], [7].

☞ The SSL/(D)TLS connection with server and/or mutual authentication can be successfully performed using the following key size:

- for Rivest-Shamir-Adleman (RSA) keys at least 2048-bits;
- for Elliptic Curve Digital Signature Algorithm (ECDSA) keys at least 192-bits.

The same limitation applies also to the keys used in the generation of certificates.

The following table reports a complete example of the +USECMNG AT command for performing a mutual authentication using certification authority (CA) certificate, client certificate and client private key.

Command	Response	Description

`AT+USECMNG=1,0,"ca_cert","ca_cert.crt"`	`+USECMNG: 1,0,"ca_cert","d10137cee624f cee624418db5eaa"`
	`OK`
		Import the CA certificate from the file "ca_cert.crt" stored in the file system.

`AT+USECMNG=1,1,"client_cert","client_cert.crt"`	`+USECMNG: 1,1,"client_cert","b137ce 137ce5edd6723d8b13"`
	`OK`
		Import the client certificate from the file "client_cert.crt" stored in the file system.

`AT+USECMNG=1,2,"client_key","client_key.key"`	`+USECMNG: 1,2,"client_key","087ab34c9aa03fbce5edd6723d8b8e05"`
	`OK`
		Import the client private key from the file "client_key.key" stored in the file system.

`AT+USECMNG=3`	`CA,"ca_cert","An MQTT broker","2032/10/18 08:23:32"`
	`CC,"client_cert","A client certificate","2032/06/22 12:34:48"`
	`PK,"client_key"`
	`OK`
		List all imported certificates or private keys.

3.2 Profile configuration +USECPRF

The +USECPRF AT command configures the security profiles used for the following SSL/TLS/DTLS connection properties:

- Certificate validation level
- Minimum SSL/(D)TLS version
- Cipher suites to be proposed: legacy, IANA nomenclature, list of cipher suites
- Certificate to be used for server and mutual authentication
- Expected server hostname, when using certificate validation level 1, 2 or 3

- Password for the client private key, if it is password protected
- Pre-shared key used for connection
- Server name indication (SNI)
- Server certificate pinning
- Pre-shared key generated by Root of Trust (RoT)
- (D)TLS session resumption.

For additional details on this AT command and all the related configurations, see the AT commands manual [3], [7].

Command	Response	Description
`AT+USECPRF=0`	`OK`	Reset (set to factory-programmed value) all the parameters of security profile #0. ☞ We recommend issuing the reset as the first command to erase all previously stored values.
`AT+USECPRF=0,0,1`	`OK`	Enable certificate validation without URL integrity check for profile #0. The server certificate will be verified with a specific trusted certificate or with each of the imported trusted root certificates.
`AT+USECPRF=0,2,3`	`OK`	Select legacy cipher suite for profile #0.
`AT+USECPRF=0,3,"ca_cert"`	`OK`	Select trusted root certificate internal name for profile #0.
`AT+USECPRF=0,5,"client_cert"`	`OK`	Select trusted client certificate internal name for profile #0.
`AT+USECPRF=0,6,"client_key"`	`OK`	Select trusted client key internal name for profile #0.
`AT+USECPRF=0,10,"<SNI_address>"`	`OK`	Configure the server name indication. ☞ Some servers require this configuration to correctly perform the secure connection.

3.2.1 Cipher suites

A cipher suite is a set of algorithms and protocols used in the SSL/(D)TLS handshake to negotiate the security setting for the secure connection. The cipher suite for the TLS protocol mainly consists of:

- Key Exchange Algorithm: determines the way symmetric keys are exchanged (RSA, DH, ECDH, DHE, ECDHE, PSK).
- Authentication/ Digital Signature Algorithm: determines how server authentication and client authentication (if required) are performed (RSA, ECDSA, DSA, etc.).
- Bulk Data Encryption: determines which symmetric key algorithm is used to encrypt the actual data (AES, CHACHA20, Camellia, ARIA, etc.). The Bulk Data Encryption is defined by an algorithm, its strength, and operating mode (block cipher mode or stream cipher mode).
- Message Authentication Code (MAC) algorithm: Determines the method that the connection should use to perform data integrity checks (SHA, SHA-256, SHA-384, POLY1305, etc.).

A cipher suite can be defined with a string representing a named combination of the algorithms and protocol:

$$\text{TLS\_}\left\{\begin{array}{c}\text{Key}\\\text{Exchange}\end{array}\right\}\text{\_}\left\{\begin{array}{c}\text{Authentication/}\\\text{Digital Signature}\end{array}\right\}\text{\_WITH\_}\left\{\begin{array}{c}\text{Bulk Data}\\\text{Encryption}\end{array}\right\}\text{\_}\left\{\begin{array}{c}\text{Message}\\\text{Authentication Code}\end{array}\right\}$$

As an example, for the TLS 1.0, TLS 1.1, and TLS 1.2 protocols, the following paragraph shows each part of the cipher suite string **TLS_RSA_WITH_AES_256_CBC_SHA:**

- Key Exchange Algorithm: **RSA**.
- Authentication/ Digital Signature Algorithm: **RSA**.
- Bulk Data Encryption: **AES_256_CBC**.
- Message Authentication Code (MAC) Algorithm: **SHA**.

The Authenticated Encryption with Associated Data (AEAD) bulk ciphers are able to perform authentication and encryption of the message. For the AEAD bulk ciphers in the string representation the Bulk Data Encryption part and Message Authentication Code part are merged.

If the remote server does not support one of these cipher suites selected in the security profile settings, the handshake fails, and module will be unable to connect to the server.

3.2.1.1 TLS 1.3 cipher suites

The section does not apply to SARA-R5 "00" product versions and to SARA-R422 / SARA-R422M8S / SARA-R422S / SARA-R422M10S modules.

The TLS 1.3 protocol introduces several changes to increase the security level. In comparison to the TLS 1.2, it has mainly:

- eliminated Block ciphers (CBC) and non-AEAD ciphers;
- dropped the support for older SSL ciphers (DSA, SHA, Weak Elliptic Curves, RSA Key Exchange, Static Diffie-Hellman (DH, ECDH)).

In the TLS 1.3:

- RSA or ECDSA are used as Authentication/ Digital Signature Algorithm;
- DHE or ECDHE are used as Key Exchange mechanism.

The string representing the cipher suite for the TLS 1.3 protocols has been reduced as follows:

TLS_{ Bulk Data Encryption }_{ Message Authentication Code }

where for the Bulk Data Encryption is used an AEAD cipher, while the Message Authentication Code, in particular the Hash-based Message Authentication Code used in the previous TLS versions, has been substituted by the HMAC-based Key Derivation Functions (HKDF)

As an example, for the TLS 1.3 protocol, the following paragraph shows each part of the cipher suite string **TLS_AES_256_GCM_SHA384**:

- Bulk Data Encryption: **AES_256_GCM** - AEAD bulk cipher;
- Message Authentication Code: **SHA384** – HKDF.

A list of available cipher suite is maintained in the section: "Cipher suite applicability" of the AT commands manual [3], [7].

3.3 Complete example

Command	Response	Description
Step1: Import a trusted root certificate using the stream of byte similar to the +UDWNFILE AT command		
`AT+USECMNG=0,0,"ThawteCA",1516`	`>`	Start the data transfer using the stream of byte. ☞ Differently from the example in section 3.1, in this case the certificate is transferred as a stream of byte and it is not stored in the SARA-R5 file system.

`-----BEGIN CERTIFICATE-----`
`MIIEIDCCAwigAwIBAgIQNE7VVyDV7exJ9C/OjVaMaA==`
`-----END CERTIFICATE-----`
	`+USECMNG: 1,0,"ThawteCA","8ccadc0b22cef5be72ac411a11a8d812"`
	`OK`
		Input PEM formatted trusted root certificate data bytes. Output MD5hash string of the stored trusted root certificate DER.

Step 2: List all available certificates and private key		

`AT+USECMNG=3`	`CA, "ThawteCA","thawte Primary Root CA","2036/07/17"`
	`OK`
		List all available certificates and private keys.

Step 3: Set the security profile 2 validation level to a trusted root		
`AT+USECPRF=2,0,1`	`OK`	Security profile 2 has the validation level set to a trusted root.
Step 4: Set the security profile 2 trusted root certificate to the CA certificate imported as "ThawteCA"		
`AT+USECPRF=2,3,"ThawteCA"`	`OK`	Security profile 2 will use the CA certificate imported as "ThawteCA" for server certificate validation.
Step 5: Use the configured USECMNG profile 2 with the UHTTP application		
`AT+UHTTP=0,1,"www.ssl_tls_test_server.com"`	`OK`	Configure the UHTTP server name.
`AT+UHTTP=0,6,1,2`	`OK`	Enable the SSL/TLS for the UHTTP profile #0 and specify the SSL/TLS security profile #2.
`AT+UHTTPC=0,1,"/","https.resp"`	`OK`	Execute the HTTP GET command.
	`+UUHTTPCR: 0,1,1`	HTTP GET URC response.

☞ Due to the significant memory fingerprint of an SSL/TLS connection, the number of concurrent SSL/TLS connections is limited. The +USECMNG AT command and the underlying SSL/TLS infrastructure allows 4 concurrent SSL/TLS connections (i.e., 4 HTTPS requests or 2 HTTPS and 2 FTPS requests).

☞ SARA-R422S / SARA-R422M8S / SARA-R422M10S modules do not support server certificate pinning, pre-shared key generated by Root of Trust (RoT), and the configuration of the cipher suites via list of cipher suites.

3.4 (D)TLS session resumption

This section reports some details and examples on the use of the (D)TLS session resumption feature, a useful approach that speeds up the handshake negotiation process.

The session resumption allows the caching of TLS/DTLS session information and hence can be used to shorten the handshake procedure when consequential sessions must be established with the same server. The RFC 5077 specification [22] of the session resumption provides 2 concepts:

- **Session ID**: the connection properties (IP address /port) in the resumed session need to be the same as in the suspended session. The server in this case has a cache where tracks the IP address /port /session ID. This concept is also called server-side stateful session resumption in the sense that the server should keep a per-client session state.

- **Session Ticket**: the connection properties (IP address /port) do not need to be the same. In this case, the module needs to keep the *session ticket* so for the server there is less work. This concept is also called server-side stateless session resumption and does not require the server to keep the per-client session state. This allows servers to handle a large number of transactions from different users, the sessions can be cached for a long time, load balancing of the requests can be performed across different servers, and the possibility to run server instances on an embedded platform with little memory.

The session resumption with session ID is performed within the following steps:

1. acquiring the session ID:
   - the client sends in the Client Hello message the session ID length equal to 0.
   - the server responds in the Server Hello message with the session ID and the session ID length (not equal to 0).
   - the client should store the session ID and the session ID length to reuse them.
   - the server should store the session information (session ID, session ID length, connection properties) to accept session resumption from the client.
2. reusing previous session:
   - the client sends in the Client Hello message the session ID and session ID length (not equal to 0).
   - the server responds in the Server Hello message with the same session ID and session ID length if it accepts the session resumption. In this case, no certificate or key information is exchanged during abbreviated TLS handshake and previously negotiated keys are re-used. If the previous session is not accepted the server replies in the Server Hello with a new session ID and session ID length, and then certificates and new session keys must be exchanged.

Since the session resumption is enabled, the URC will be displayed every time a secure connection is performed. Once the session data of the URC are not equal to the session data already set, it means that the server does not accept the session resumption. In this case, the complete handshake has been performed and the new session data has been displayed. The new session data needs to be set again.

☞ The session resumption feature configuration and secure session data are not stored in the NVM, and the session data is displayed via URC. Therefore, the session can be restored after waking up from PSM mode or a module reboot only if the session data is stored by the user application.

☞ SARA-R5 and SARA-R422S / SARA-R422M8S / SARA-R422M10S modules do not support stateless session resumption.

3.4.1 (D)TLS session resumption examples

The following session presents two examples of session resumption. In the first example the session data is not encrypted, while in the second example the session resumption data is encrypted with a local encryption feature provided by the RoT.

3.4.1.1 Example: session data not encrypted

Phase 1: acquiring the session data

Command	Response	Description
Step 1: Preparation steps		
		AT command sequence to ensure Internet connectivity.
		Required +USECMNG AT commands to handle the certificates/keys.

Command	Response	Description
		Required +USECPRF AT commands to configure the security profile <profile_id>.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP – HTTP client).
Step 2: Enable the session resumption		
`AT+USECPRF=<profile_id>,13,0,1`	`OK`	Enable the session resumption for the security profile <profile_id>.
Step 3: Set the session resumption type		
`AT+USECPRF=<profile_id>,13,1,0`	`OK`	Set the session resumption type for the security profile <profile_id>.
Step 4: Associate the application profile to the security profile		
`AT+UHTTP=<app_profile>,6,1,<profile_id>`	`OK`	The application profile <app_profile> is associated to the security profile <profile_id>.
Step 5: Execute HTTP GET request		
`AT+UHTTPC=<app_profile>,1,"/index.html","response_file"`	`OK`	Perform HTTP GET request.
	`+UUSECPRF: <profile_id>,13,1,0`	URC with session resumption type. ☞ The session resumption type should be stored to be reused for the resumption on the next session.
	`+UUSECPRF: <profile_id>,13,2,<session_id_base64>,<master_secret_base64>`	URC with session resumption data. ☞ The session resumption data should be stored to be reused for the resumption on the next session.
	`+UUHTTPCR: <app_profile>,1,1`	HTTP GET URC response.

Phase 2: reusing previous session

Command	Response	Description
Step 1: Preparation steps		
		AT command sequence to ensure Internet connectivity.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP).
Step 2: Enable the session resumption		
`AT+USECPRF=<profile_id>,13,0,1`	`OK`	Enable the session resumption for the security profile <profile_id>.
Step 3: Set the session resumption type		
`AT+USECPRF=<profile_id>,13,1,0`	`OK`	Set the session resumption type for the security profile <profile_id>.
Step 4: Set the session resumption data		
`AT+USECPRF=<profile_id>,13,2,<session_id_base64>,<master_secret_base64>`	`OK`	Set the session resumption data for the security profile <profile_id>.
Step 5: Associate the application profile to the security profile		
`AT+UHTTP=<app_profile>,6,1,<profile_id>`	`OK`	The application profile <app_profile> is associated to the security profile <profile_id>.

Command	Response	Description
Step 6: Execute HTTP GET request		
`AT+UHTTPC=<app_profile>,1,"/index.html","response_file"`	`OK`	Perform HTTP GET request.
	`+UUSECPRF: <profile_id>,13,1,0`	URC with session resumption type. ☞ If the displayed session type is not equal to the session type already set, the session has not been resumed. The new session type should be set.
	`+UUSECPRF: <profile_id>,13,2,<session_id_base64>,<master_secret_base64>`	URC with session resumption data. ☞ If the displayed session data is not equal to the session data already set, the session has not been resumed. The new session type should be set.
	`+UUHTTPCR: <app_profile>,1,1`	HTTP GET URC response.

3.4.1.2 Example: session data encrypted with local encryption

Phase 1: acquiring the session data

Command	Response	Description
Step 1: Preparation steps		
		AT command sequence to ensure Internet connectivity.
		Required +USECMGN AT commands to handle the certificates/keys.
		Required +USECPRF AT commands to configure the security profile <profile_id>.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP – HTTP client).
Step 2: Enable the session resumption		
`AT+USECPRF=<profile_id>,13,0,1`	`OK`	Enable the session resumption for the security profile <profile_id>.
Step 3: Set the session resumption type		
`AT+USECPRF=<profile_id>,13,1,10`	`OK`	Set the session resumption type for the security profile <profile_id>.
Step 4: Associate the application profile to the security profile		
`AT+UHTTP=<app_profile>,6,1,<profile_id>`	`OK`	The application profile <app_profile> is associated to the security profile <profile_id>.
Step 5: Execute HTTP GET request		
`AT+UHTTPC=<app_profile>,1,"/index.html","response_file"`	`OK`	Perform HTTP GET request.
	`+UUSECPRF: <profile_id>,13,1,10`	URC with session resumption type. ☞ The session resumption type should be stored to be reused for the resumption on the next session.
	`+UUSECPRF: <profile_id>,13,12,<encrypted_session_data>,<enc_session_data_size>`	URC with encrypted session resumption data. ☞ The session resumption data should be stored to be reused for the resumption on the next session.
	`+UUHTTPCR: <app_profile>,1,1`	HTTP GET URC response.

Phase 2: reusing previous session

Command	Response	Description
Step 1: Preparation steps		
		AT command sequence to ensure Internet connectivity.
		Required AT commands to configure application profile <app_profile> (in the example the application will be +UHTTP).
Step 2: Enable the session resumption		
AT+USECPRF=<profile_id>,13,0,1	OK	Enable the session resumption for the security profile <profile_id>.
Step 3: Set the session resumption type		
AT+USECPRF=<profile_id>,13,1,10	OK	Set the session resumption type for the security profile <profile_id>.
Step 4: Set the encrypted session resumption data		
AT+USECPRF=<profile_id>,13,12,<encrypted_session_data>,<enc_session_data_size>	OK	Set the encrypted session resumption data for the security profile <profile_id>.
Step 5: Associate the application profile to the security profile		
AT+UHTTP=<app_profile>,6,1,<profile_id>	OK	The application profile <app_profile> is associated to the security profile <profile_id>.
Step 6: Execute HTTP GET request		
AT+UHTTPC=<app_profile>,1,"/index.html","response_file"	OK	Perform HTTP GET request.
	+UUSECPRF: <profile_id>,13,1,10	URC with session resumption type. ☞ If the displayed session type is not equal to the session type already set, the session has not been resumed. The session type should be update.
	+UUSECPRF: <profile_id>,13,12,<encrypted_session_data>,<enc_session_data_size>	URC with encrypted session resumption data. ☞ If the displayed session data is not equal to the session data already set, the session has not been resumed. The session data should be updated.
	+UUHTTPCR: <app_profile>,1,1	HTTP GET URC response.

4 Dial-up network (PPP)

The module can perform dial-up network (DUN) connections supporting the Point-to-Point Protocol (PPP). The PPP connection is established between the host (e.g., Windows device) and the DCE.

When a data call is initiated by the D* AT command, the module switches to the PPP mode just after the CONNECT intermediate result code. If a PDN connection is not active on the specific CID, it will be activated.

For all CIDs but the CID=1 in LTE (the initial default EPS bearer, which is configurable via AT commands), the host can control the authentication parameters and the MTU (maximum transmission unit) size directly through PPP.

☞ If the network throughput is less than the data sent from the host to the module (which is limited by the radio resources assigned by the network to the transmission in the uplink), then packet data loss may occur, even with hardware flow control enabled. To avoid this issue, do either or both:

- reduce the baud rate used on the serial COM port.
- slow down data transfer load by adding pauses between data payloads or breaking up their payload and adding delay.

4.1 Basic setup

☞ The module must be attached to the network and the APN must be properly configured into the PDP context before starting the dial-up.

Command	Response	Description
`ATD*99***1#`		Perform the dial-up on the PDP context on CID=1.

Using the dial command for establishing PPP connection, `ATD*99***1#`, the '1' in this example refers to the first active PDP context returned by the +CGDCONT read command.

4.1.1 Router mode (IPv4 only)

☞ SARA-R4 series modules do not support the router mode.

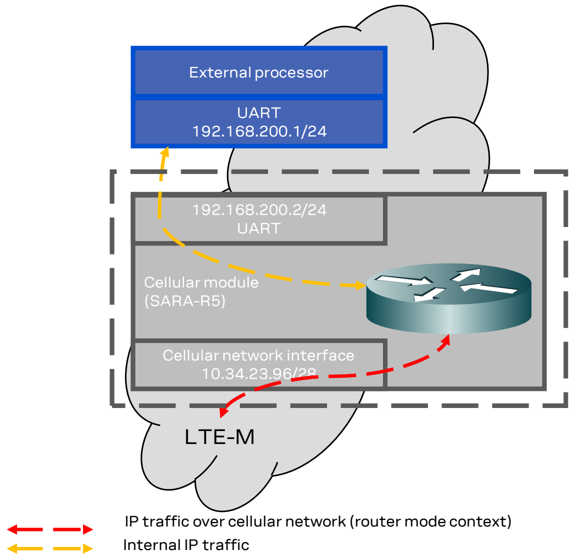


Figure 5: Scheme of a possible router mode configuration

In the router mode configuration, the module will act as a router and a private network between the host device and the module is created. The module will automatically route the traffic of the host to the outside network of the MNO.

The IP addresses in the private network created are hardcoded private addresses of C-type class. The network is defined accordingly with the context ID number:

- 192.168.200 + <cid_id_number>.1 for the external host processor.
- 192.168.200 + <cid_id_number>.2 for the SARA-R5 cellular module.

4.1.2 Bridge mode

☞ SARA-R5 series modules do not support the bridge mode.

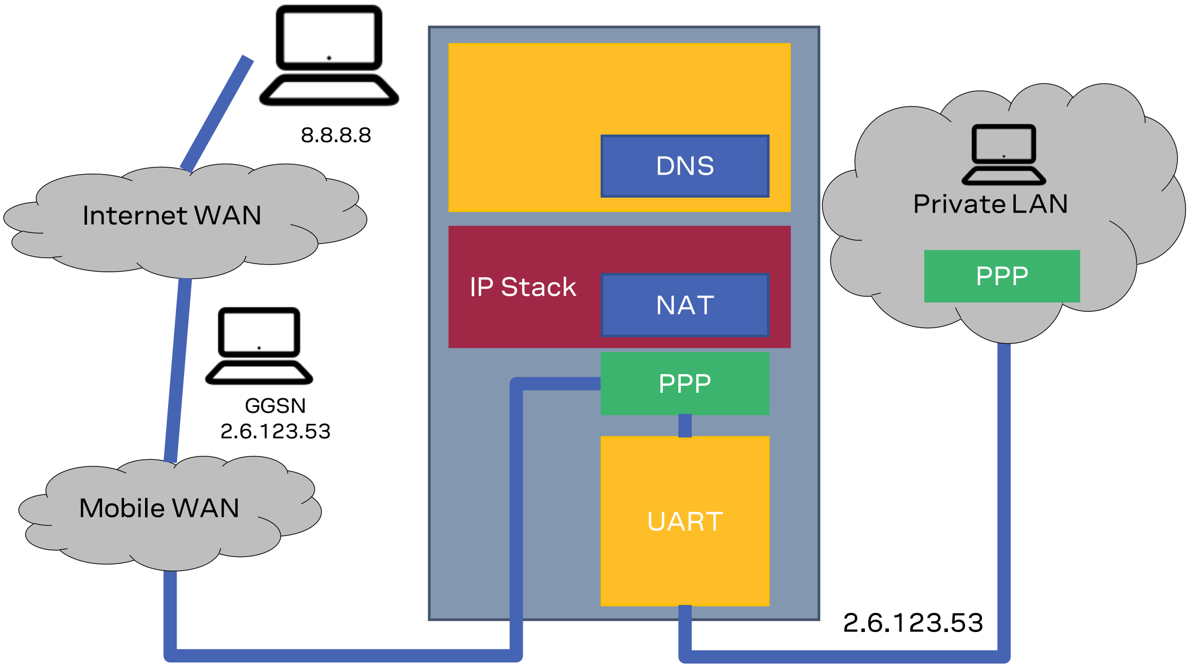


Figure 6: Example of a bridge mode configuration

The application processor gets the module IP address that was previously assigned by the network during the PDN activation.

The module acts as a transparent data pipe and the internal TCP/IP stack is not involved.

Differently, in IPv6 the application processor gets the global address via SLAAC, RSs are forwarded to the MNO routers which reply with corresponding RAs. The application processor's IPv6 address is in the same network (i.e., same global prefix) of the module's one, but the IIDs differ (i.e., two distinct IPv6 addresses are assigned); for example "`2A0B:AD40:1:102A:2A0B:AD40:1:102A`" and "`2A0B:AD40:1:102A:90A1:5CFC:3CC9:7301`".

4.1.3 NAT and port forwarding configurations (IPv4 only)

☞ The section does not apply to SARA-R4 series module.

Two main Network Address Translation (NAT) types are supported: full-cone NAT (also called static NAT) and symmetric NAT.

- In the full-cone NAT configuration, all the data traffic received on the public IP/port is redirected to the internal IP/port. This configuration can be useful when the host application needs to deal with several listening ports or when the listening port number is unknown in advance (e.g., calculated in runtime or received as a configuration parameter during an already existing connection). Full-cone NAT is currently available for PPP interfaces only, and it shall be configured before the PPP link establishment. By default, the full-cone NAT is disabled for all the module contexts.

- With symmetric NAT, it is possible to fine tune which incoming connection on the public interface shall be redirected to the internal IP/port. This NAT configuration adds a layer of security because all the incoming connections on unexpected ports are blocked and filtered out by NAT rules, so these connection attempts will never reach the host application. Symmetric NAT can be configured in both NCM and PPP interfaces.

☞ On SARA-R5 "00B" product versions, the full-cone NAT is not supported.

☞ Full-cone NAT setting is not persistent and need to be enabled every time before the dial-up initialization.

The configuration of the NAT and the port forwarding can be done using the +UPORTFWD AT command. The command permits to define rules for configuring the port forwarding of the PPP interface.

For additional details and examples on the use of NAT configuration and port forwarding, see the +UPORTFWD AT command description in the SARA-R5 AT commands manual [3].

4.1.4 PPP and IPv6

On the contrary to IPv4, IPv6 does not offer private addressing or NAT features. By design, IPv6 allows each node in the network to obtain its own IPv6 global address (i.e., an address reachable from any other host on the internet) via the StateLess Address AutoConfiguration (SLAAC) procedure.

With PPPv6 the PPP server (i.e., the module) does not directly provide any global IPv6 address to the PPP client (DTE), and it is up to the PPP client to start the SLAAC procedure with the network sending a Router Solicitation (RS) message. The network then replies with a Router Advertisement (RA) packet containing the IPv6 address prefix to be used by the DTE to generate its own IPv6 global address. At the end of the procedure, the DTE and the module will own two different IPv6 addresses sharing the same IPv6 address prefix, and both the peers will be reachable from the internet.

Once the IPv6 address is generated, the DTE will be able to perform data traffic and the module will act as a transparent data pipe (it will just forward IPv6 packet to/from the network). This behavior is very similar to the PPP bridge mode for IPv4, the only difference is that DTE and the module will own two different IPv6 addresses. The DTE will be exposed to any incoming connection from the internet, there will not be any filtering because of incoming data.

4.1.5 PPP over multiple PDP contexts

Optionally, a second PDP context can be set up for PPP if used with multiplexer (i.e., in multiplexing mode, MUX) over the UART interface. In such a configuration, the socket type data calls established by AT commands and internal embedded calls are only routed through the default context CID=1.

☞ If a MUX configuration is adopted, it is recommended to use two channels, one for the control by AT interface and URCs messages, and the second for the PPP itself. For additional details on the use of MUX, see the specific application note [12].

☞ A different and unique APN is required per PDP context.

In the below example there are two PDP contexts defined and activated. The second context on CID=2 may be utilized by PPP. Do not activate the second context manually, instead establishing and terminating the PPP session on CID=2 will automatically activate and deactivate it. In the example the second PDP context has been activated by the PPP session.

Example of a second PDP context for PPP dial-up connection:

```
+CGDCONT: 1,"IP","APN1","166.130.71.189",0,0,0,0
+CGDCONT: 2,"IPV4V6","APN2","10.117.32.103 38.0.3.128.178.65.129.209.0.0.0.74.87.68.176
.1",0,0,0,0
```

For more details on multiple PDP contexts, see the AT commands manual [3], [7].

4.2 Terminate cellular packet data connection

The PPP data session can be terminated by one of the following events:

- a DTR hardware transition of the pin from ON to OFF;
- sending an LCP “Terminated request”;
- sending the string “+++” in the AT interface (see the “Circuit 108/2 behavior &D” section of the AT commands manual [3], [7] for further details on “+++” different behaviors).

When using MUX and PPP combined, toggling the DTR line does not terminate the PPP session and return the device to the command mode. In this configuration, it is recommended that the host terminates the PPP session, which can be done by sending LCP_TERM REQ. Another method to terminate the PPP session is to send a MSC MUX frame for logical DTR de-assert.

☞ In SARA-R4 series modules, issue the AT+CVHU=0 command to make ATH over Online Command Mode (OLCM) work, according to 3GPP requirements. If the module has a DUN/PPP activated and is in OLCM, the command deactivates the PPP and the associated PDP context (if possible).

4.3 Port filtering feature for embedded IP applications

☞ SARA-R5 series modules do not support the port filtering functionality and +UEMBPF AT command.

The PPP link between the network and the DTE is normally exclusive for other traffic sources inside the module, meaning that any incoming IP packet will be directed to the DTE by default. This will prevent correct functionality of embedded IP applications such as:

- Bearer Independent Protocol (BIP), used for UICC provisioning and SIM OTA sessions.
- Lightweight Machine-to-Machine client (LwM2M), used for uFOTA and MNO-based device management.
- u-blox Security Client (USEC), used for internal module security provisioning.
- Any other internal application as UPSD, UFTP, MQTT, and CoAP.

To overcome this, the +UEMBPF (Embedded port filtering) AT command and functionalities are available in the module and enabled by factory-programmed value.

☞ On SARA-R42 “00B” product versions, +UEMBPF functionality is not enabled. It is disabled by factory-programmed setting with an empty port range to be customized when applied.

The command requires a port range which will be used as source port for any TCP/UDP traffic sourced from embedded applications. Given that any DL external traffic targeting these ports will not be routed to DTE, the input port range must be outside the range commonly used by DTE via the PPP session. By default, the port range is “9999-19999” in the SARA-R42 “01B” product versions.

See Figure 7 for a scheme of the functionality. The command is required only if a dial-up connection is used. For a complete syntax description, see the SARA-R4 series AT commands manual [7].

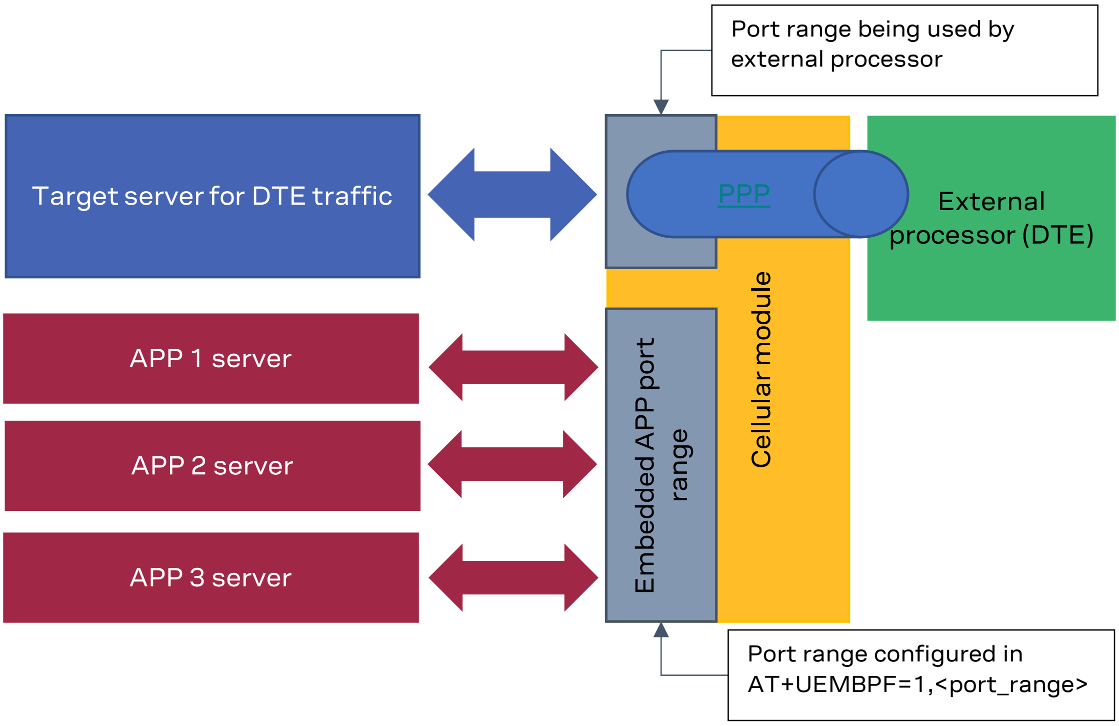
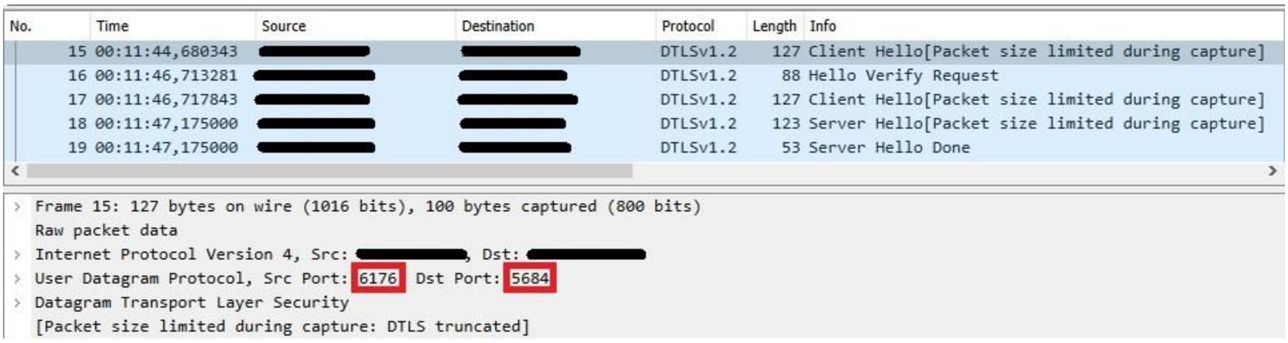

Port range being used by external processor
Target server for DTE traffic
PPP
External processor (DTE)
APP 1 server
APP 2 server
APP 3 server
Embedded APP port range
Cellular module
Port range configured in AT+UEMBPF=1,<port_range>

Figure 7: Scheme of a possible router mode configuration

4.3.1 Example: +UEMBPF with PPP & LwM2M client handling

The reported port filtering feature configures the port range from which the embedded applications will pick the source port when opening the socket. Normally the source port is picked randomly by the modem IP stack, while the destination port is protocol-dependent and server-dependent. See below example, where the `AT+UEMBPF=1,"6000-6200"` command is set and LwM2M performs a connection to server "lwm2m-fota.services.u-blox.com:5684".

LwM2M, which server expects traffic to UDP port 5684, picks source port UDP 6167 which is indeed inside the configured range.



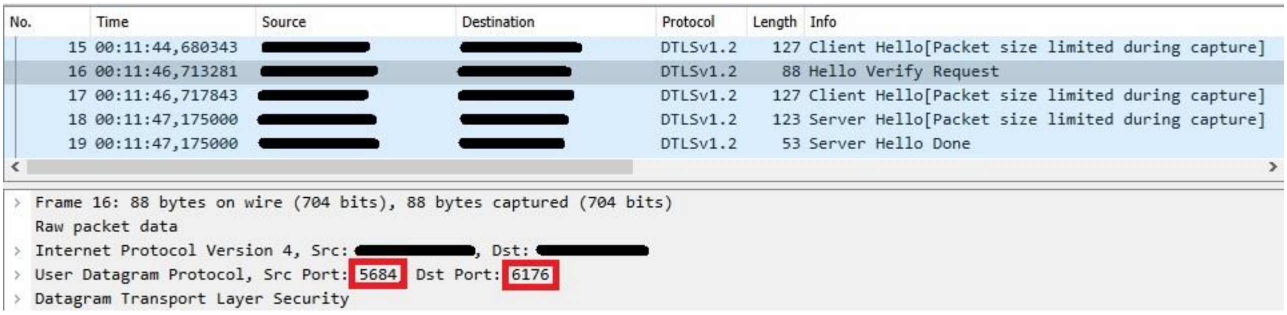
```
No.   Time              Source       Destination  Protocol  Length Info
   15 00:11:44,680343   [redacted]   [redacted]   DTLSv1.2  127 Client Hello[Packet size limited during capture]
   16 00:11:46,713281   [redacted]   [redacted]   DTLSv1.2   88 Hello Verify Request
   17 00:11:46,717843   [redacted]   [redacted]   DTLSv1.2  127 Client Hello[Packet size limited during capture]
   18 00:11:47,175000   [redacted]   [redacted]   DTLSv1.2  123 Server Hello[Packet size limited during capture]
   19 00:11:47,175000   [redacted]   [redacted]   DTLSv1.2   53 Server Hello Done

> Frame 15: 127 bytes on wire (1016 bits), 100 bytes captured (800 bits)
  Raw packet data
> Internet Protocol Version 4, Src: [redacted], Dst: [redacted]
> User Datagram Protocol, Src Port: 6176 Dst Port: 5684
> Datagram Transport Layer Security
  [Packet size limited during capture: DTLS truncated]
```

Figure 8: Outgoing traffic from module to LwM2M server

Accordingly, the range configured via +UEMBPF AT command is not linked to a specific protocol/server/client.

Moreover, in general, the command configures filtering for incoming packets. This means that any incoming packet which has destination port inside the configured range, will be directed to the embedded applications instead of the PPP DTE.

Continuing to look at the example, outgoing packet has src=6176, dst=5684. The incoming then has src=5684, dst=6176.



```
No.   Time              Source       Destination  Protocol  Length Info
   15 00:11:44,680343   [redacted]   [redacted]   DTLSv1.2  127 Client Hello[Packet size limited during capture]
   16 00:11:46,713281   [redacted]   [redacted]   DTLSv1.2   88 Hello Verify Request
   17 00:11:46,717843   [redacted]   [redacted]   DTLSv1.2  127 Client Hello[Packet size limited during capture]
   18 00:11:47,175000   [redacted]   [redacted]   DTLSv1.2  123 Server Hello[Packet size limited during capture]
   19 00:11:47,175000   [redacted]   [redacted]   DTLSv1.2   53 Server Hello Done

> Frame 16: 88 bytes on wire (704 bits), 88 bytes captured (704 bits)
  Raw packet data
> Internet Protocol Version 4, Src: [redacted], Dst: [redacted]
> User Datagram Protocol, Src Port: 5684 Dst Port: 6176
> Datagram Transport Layer Security
```

Figure 9: Incoming traffic from LwM2M server to module

This packet's destination port is independent of the configured filtering range, so it will be directed to the LwM2M client.

This means that the DTE will not receive any packet with destination port inside that range: referring the provided example, when using a source port inside the selected interval (i.e., "6000-6200") to send packets, their response will never be routed to DTE, but to embedded applications.

Thus, the range to be configured in +UEMBPF AT command must be outside the source port range being used by DTE via PPP.

Command	Response	Description
`AT+UEMBPF=1,"6000-6200"`	`OK`	Embedded port filtering configuration.

Command	Response	Description
`AT+CFUN=16`	`OK`	Module reboot to apply from the following power up the desired settings.

`AT+UEMBPF?`	`+UEMBPF: 1,"6000-6200"`
	`OK`
		Embedded port filtering configuration check after the applied reboot.

☞ In general, it is advisable to always apply the +UEMBPF AT command in scenarios in which a dial-up connection is referred. Basically, it could be enough to configure in this command a limited set of ports (at least 50 ports, e.g., "6000-6050") to be reserved for the embedded applications. In particular, these ports will be used by the internal IP applications (e.g., LwM2M client, security services, etc.) and they will not be functional for data traffic related to the PPP DTE, so some proper tuning could be needed at the user side.

5 TCP/UDP internal stack

☞ Verify that the module is registered with the network and a PS data connection is activated. Make sure to follow the steps in section 2 before using the AT commands in this section.

☞ For UDP it is highly recommended to use +USOST and +USORF AT commands instead of +USOCO, +USOWR and +USORD AT commands.

☞ The use of +USOST and +USORF AT commands is recommended without the use of the +USOCO AT command. Precisely, the +USOCO AT command is compatible only with +USORD and +USOWR AT commands.

5.1 Socket connect

Command	Response	Description

`AT+USOCR=6`	`+USOCR: 0`
	`OK`
		TCP socket creation. In this example socket #0 is created.
		The information text response returns the created socket identifier (in this case #0). If a new socket is created (without closing the already existent), a new socket identifier will be returned.

`AT+USOCR=17`	`+USOCR: 1`
	`OK`
		Create another socket (in this case the socket is UDP and its identifier is 1).

`AT+USOCL=1`	`OK`	Close socket #1. The socket #1 is free.

`AT+UDNSRN=0,"ftp.u-blox.com"`	`+UDNSRN: "195.34.89.241"`
	`OK`
		DNS resolution of the URL "ftp.u-blox.com".

`AT+USOCO=0,"195.34.89.241",7`	`OK`	Connect socket #0 to port 7 of a remote host with IP address 195.34.89.241. **The connection is now uniquely associated to the socket. The socket is now ready for read/write operations.**

`AT+USOCO=0,"195.34.89.241",7`	`ERROR`
	`+UUSOCL: 0`
		If the connection is not successfully performed, an error result code is returned and the socket used for the connection attempt is closed. The notification is provided by +UUSOCL URC.

5.2 Socket listening

Command	Response	Description

`AT+USOCR=6`	`+USOCR: 0`
	`OK`
		TCP socket creation with ID #0.

`AT+USOLI=0,1099`	`OK`	Set the socket in listening mode on port 1099. ⚠ The ability to reach the opened port on the server depends also on the network operator. Some network operators do not allow incoming connection on opened TCP/UDP port.

	`+UUSOLI: 1,"151.9.34.66",399`
	`12,0,"151.9.34.74",1099`
		When a connection request arrives from a remote host, a new socket is created with the first integer identifier available. In this example the socket ID is #1. The +UUSOLI URC indicates:
		• **1**: the new socket created. Incoming data from the established connection will be received on this socket. Data to be sent must be written into this socket

Command	Response	Description
		• **151.9.34.66**: IP of the remote server • **39912**: service port • **0**: listening socket. It is the socket identifier specified with the +USOLI AT command • **151.9.34.74**: module IP address • **1099**: listening port assigned to the connection. Configured with the +USOLI AT command Socket #1 is now ready for reading/writing data.
	`+UUSORD: 1,18`	18 bytes of incoming data over the previously established connection. ☞ The incoming data will always be sent on the related socket.

5.3 Socket write (+USOWR)

5.3.1 Binary mode

Command	Response	Description
`AT+USOWR=0,2`	`@`	Request to write 2 data bytes into socket #0. Wait "@" symbol indicating the data prompt is now open (AT commands are not allowed in data prompt). After the @ prompt reception, wait for a minimum of 50ms before sending data.

`12`	`+USOWR: 0,2`
	`OK`
		Write data bytes.
		It is not allowed to write fewer bytes than previously specified with AT+USOWR command.
		If more bytes are written than the threshold, the remaining bytes will be truncated.
		The interface is blocked until all bytes are written.
		If the final result code is returned then the data is sent to a lower level of the protocol stack. **This is not a notification of an acknowledgment received from the remote host data bytes that have been sent to.**

5.3.2 Base syntax

Command	Response	Description

`AT+USOWR=0,2,"12"`	`+USOWR: 0,2`
	`OK`
		Write 2 data bytes data on socket #0.
		If the final result code is returned then the data is sent to a lower level of the protocol stack. **This is not an acknowledgment from the remote host where the data bytes were sent.**
		☞ Some characters are not allowed in base syntax mode. For the allowed characters, see the AT commands manual [3], [7].

5.3.3 Queue FULL

Command	Response	Description
`AT+USOWR=0,2,"12"`	`ERROR`	If the socket buffer is full, then the data bytes inserted in data prompt will be discarded: this may happen if the network is congested or if network coverage is lost. **In this case an error result code is returned.** ☞ For SARA-R5 series the TCP socket queue size is set to 8 kB. ☞ For SARA-R4 series the TCP socket queue size is set to 16 kB.

`AT+USOCTL=0,10`	`+USOCTL: 0,10,4`
	`OK`
		In case of an error result code, it is recommended to query the state of TCP connection associated to the socket to verify the socket is still connected.
		The third parameter of the information text response is the state; if its value is 4, it means the connection is established.

`AT+USOCTL=0,11`	`+USOCTL: 0,11,0`
	`OK`
		It is also possible to query for TCP outgoing unacknowledged data of the socket (this command is valid only for TCP socket).
		In this case, 0 bytes of data is unacknowledged.
		☞ For SARA-R5 series the <param_id>=11 is not supported.

5.4 Socket operations with "Keep Alive" option

☞ In "Keep Alive" mode, the module periodically sends dummy TCP packets to prevent the network from closing the inactive context. The network operator may close inactive TCP connections without notification to the module.

Command	Response	Description

`AT+USOCR=6`	`+USOCR: 0`
	`OK`
		Create a TCP socket #0.

`AT+USOSO=0,65535,8,1`	`OK`	Enable the "keep alive" option. This socket option enables the module to send dummy IP packets to keep the connection alive. • **0**: socket number to be set to enable keep alive option • **65535**: specifies socket level option • **8**: specify the "Keep Alive" option • **1**: enable the keep alive (set to 0 to disable it)
`AT+USOSO=0,6,2,30000`	`OK`	Set the inactivity timeout after which the module will start to send "keep alive" packets. • **0**: socket number to be set to enable keep alive option • **6**: specifies TCP level option • **2**: specifies option TCP "keep idle" timer option • **30000**: the module will send dummy TCP packets every 30000 ms ☞ The set of “keep idle” time option is not supported in SARA-R4 series module.

Default configured values are reported in the following table.

☞ Among the reported values, only the keep alive idle time is configurable with the +USOSO AT command in SARA-R5 series modules.

Parameter	Description	SARA-R4	SARA-R5
Keep alive idle time	Time (in seconds) the connection needs to remain idle before TCP starts sending keepalive probes.	7200 s	7200 s
Keep alive interval	Time (in seconds) between individual keepalive probes.	75 s	75 s
Maximum number of keep alive probes	Maximum number of keepalive probes TCP should send before dropping the connection.	9	8

5.5 Socket read (+USORD)

First scenario

Command	Response	Description
	`+UUSORD: 0,2`	The remote server sends 2 data bytes on socket #0. A URC is returned indicating the socket on which the data is received and the total amount of data received.

`AT+USORD=0,2`	`+USORD: 0,2,"ar"`
	`OK`
		Read data. The data is returned between quotation marks.

Second scenario

Command	Response	Description
	`+UUSORD: 0,30`	The remote server sends 30 data bytes on socket #0. If a socket buffer is empty, the +UUSORD URC indicates a TCP packet has been received from the remote host the socket is connected to and the amount of data bytes of the packet.

`AT+USORD=0,10`	`+USORD: 0,10,"hfgyrhgfty"`
	`OK`
		Read only part of data (in this example 10 bytes of data are read).
		Data is returned between quotation marks.

	`+UUSORD: 0,20`	The +UUSORD URC indicates the total amount of data bytes stored in the buffer after the last +USORD AT command execution. In this example 20 bytes are stored in the buffer.

Third scenario

Command	Response	Description
	`+UUSORD: 0,30`	The remote server sends 30 data bytes on socket #0. If a socket buffer is empty +UUSORD URC indicates a TCP packet has been received from the remote host the socket is connected to and the amount of data bytes of the packet.

`AT+USORD=0,10`	`+USORD: 0,10,"hfgyrhgfty"`
	`OK`
		Only part of the data bytes (10 bytes in this example) is read.

Command	Response	Description
		The data is returned between quotation marks.
	`+UUSORD: 0,25`	The remote server sent more data after the first part was received. The +UUSORD URC indicates the total amount of data bytes stored the buffer after the last +USORD AT command execution. In this example 25 bytes are stored in the buffer.

`AT+USORD=0,10`	`+USORD: 0,10,"hfgbchs7[o"`
	`OK`
		Only part of the data bytes (10 bytes in this example) is read.
		Data is returned between quotation marks.

	`+UUSORD: 0,34`	The remote server sent more data. The +UUSORD URC indicates the total amount of data bytes stored the buffer after the last +USORD AT command execution. In this example 34 bytes are stored in the buffer.

`AT+USORD=0,34`	`+USORD: 0,34,"jghfbv74ksHDFUEçpjè0’@èpyujfnvhfyù"`
	`OK`
		All the bytes are read.

`AT+USORD=0,0`	`+USORD: 0,0`
	`OK`
		Verifies how much unread data is in the buffer. In this example 0 bytes are in socket #0.

Fourth scenario

Command	Response	Description
	`+UUSORD: 0,30`	The remote host sends 30 bytes of data on the socket #0. If a socket buffer is empty the +UUSORD URC indicates a TCP packet has been received from the remote host the socket is connected to and the amount of data bytes of the packet.

`AT+USORD=0,10`	`+USORD: 0,10,"hfgyrhgfty"`
	`OK`
		Only part of the data bytes (10 bytes in this example) is read.
		Data is returned between quotation marks.

	`+UUSORD: 0,25`	The remote server sent other data after the first data bytes had been received. The +UUSORD URC indicates the total amount of data bytes stored the buffer after the last +USORD AT command execution. In this example 25 bytes are in the buffer.
		The remote host closes the TCP connection associated to socket #0.
`AT+USOWR=0,3`	`@`	Request to write 3 data bytes into the socket #0. Wait for "@" symbol indicating the data prompt is now open. After the @ prompt reception, wait for a minimum of 50 ms before sending data.

`123`	`+USOWR: 0,0`
	`OK`
		Write data. After the last byte the data prompt is closed.
		☞ It is not allowed to write fewer bytes than previously specified with +USOWR AT command.
		☞ If more bytes are written with respect to the threshold, the remaining bytes will be truncated.
		The interface is blocked until all bytes are written.

Command	Response	Description
		The +USOWR: 0,0 URC indicates 0 bytes have been sent to the remote host. **This means the TCP connection is now closed.**

`AT+USORD=0,25`	`+USORD: 0,25,"23dfgt5uhj89ikdftevlpazwe"`
	`OK`
		Read the remaining data bytes still stored in the buffer of socket #0.

	`+UUSOCL: 0`	The URC indicates the TCP connection associated to socket #0 is now closed and socket #0 is cleared.

5.6 Socket write (+USOST)

Command	Response	Description

`AT+USOCR=17`	`+USOCR: 0`
	`OK`
		UDP socket creation. In this example the socket #0 is created.
		The information text response returns the new socket identifier (in this example #0). If a new socket is created, a new socket identifier will be returned.

`AT+USOCR=17,12000`	`+USOCR: 0,12000`
	`OK`
		The local port to be used for data sending can be configured during the UDP socket creation.
		In this example the socket #0 is created and bound with port 12000. Data written on socket #0 will be sent from this specific port.

`AT+UDNSRN=0,"ftp.u-blox.com"`	`+UDNSRN: "195.34.89.241"`
	`OK`
		DNS resolution of the URL "ftp.u-blox.com".

`AT+USOST=0,"195.34.89.241",7,2`	`@`	Request to write 2 bytes of data into socket #0 specifying IP address and UDP port of the remote host UDP packet has to be sent to. Wait for "@" symbol indicating the data prompt is now open (AT commands are not allowed in data prompt).

`12`	`+USOST: 0,2`
	`OK`
		Write data. After the last data byte is written, the prompt is closed.
		☞ It is not allowed to write fewer bytes than previously specified with +USOST AT command.
		☞ If more bytes are written with respect to the threshold, the remaining bytes will be truncated.
		The interface is blocked until all bytes are written
		The final result code is returned. This means the data is sent to a lower level of the protocol stack. This is not an acknowledgment, UDP is a connectionless protocol.

5.7 Socket read (+USORF)

SARA-R5 series

Command	Response	Description
	`+UUSORD: 0,2`	A UDP packet with 2 data bytes has been received.

`AT+USORF=0,2`	`+USORF: 0,"195.34.89.241",7,2,"12"`
	`OK`
		Read data.
		The information text response indicates:
		• Read socket identifier
		• Remote IP address
		• Remote UDP port

Command	Response	Description
		• Number of read data bytes • Read data bytes (between quotation marks)
	`+UUSORD: 0,20`	UDP packet with 20 data bytes has been received from the remote server.

`AT+USORF=0,10`	`+USORF: 0,"195.34.89.241",7,2,`
	`"1234567890"`
	`OK`
		Read 10 data bytes.

	`+UUSORD: 0,10`	The +UUSORD URC indicates that 10 bytes are still unread.
		The remote host sends a UDP packet with 20 data bytes.

`AT+USORF=0,10`	`+USORF: 0,"195.34.89.241",7,2,`
	`"1234567890"`
	`OK`
	
	`+UUSORD: 0,20`
		Read the remaining 10 data bytes of the previous packet. The URC indicates 20 data bytes have been received and are still stored in the socket buffer.
		☞ After the first URC has been returned, a second URC is returned (only after a reading operation) indicating:
		• If a reading operation of a packet is not finished it will provide the remaining data of the specific packet
		• Otherwise it will provide the number of data bytes of packets stored in the socket buffer

SARA-R4 series

Command	Response	Description
	`+UUSORF: 0,2`	A UDP packet with 2 data bytes has been received.

`AT+USORF=0,2`	`+USORF: 0,"195.34.89.241",7,2,`
	`"12"`
	`OK`
		Read data.
		The information text response indicates:
		• Read socket identifier
		• Remote IP address
		• Remote UDP port
		• Number of read data bytes
		• Read data bytes (between quotation marks)

	`+UUSORF: 0,20`	UDP packet with 20 data bytes has been received from the remote server.

`AT+USORF=0,10`	`+USORF: 0,"195.34.89.241",7,2,`
	`"1234567890"`
	`OK`
		Read 10 data bytes.

	`+UUSORF: 0,10`	The +UUSORF URC indicates that 10 bytes are still unread.
		The remote host sends a UDP packet with 20 data bytes.

`AT+USORF=0,10`	`+USORF: 0,"195.34.89.241",7,2,`
	`"1234567890"`
	`OK`
	
	`+UUSORF: 0,20`
		Read the remaining 10 data bytes of the previous packet. The URC indicates 20 data bytes have been received and are still stored in the socket buffer.
		☞ After the first URC has been returned, a second URC is returned (only after a reading operation) indicating:
		• If a reading operation of a packet is not finished it will provide the remaining data of the specific packet

Command	Response	Description
		• Otherwise it will provide the number of data bytes of packets stored in the socket buffer

5.8 Socket state

For a detailed description of TCP socket states, see the +USOCTL AT command description in AT commands manual [3], [7].

Command	Response	Description

`AT+USOCTL=0,0`	`+USOCTL: 0,0,6`
	`OK`
		Query the socket type of the socket #0. The socket type information is provided by the third parameter (in this case 6 – TCP).

`AT+USOCTL=0,10`	`+USOCTL: 0,10,4`
	`OK`
		It is possible to query the state of TCP connection associated with the socket; in this example the socket #0 (this command is valid only for TCP socket).
		The third parameter of information text response provides the socket status (in this case 4 - the socket is in ESTABLISHED status).

`AT+USOCTL=0,10`	`+USOCTL: 0,10,7`
	`OK`
		The third parameter of the information text response provides the socket status (in this case 7 - a TCP connection termination procedure is being performed).

`AT+USOCTL=0,11`	`+USOCTL: 0,11,0`
	`OK`
		Query for TCP outgoing unacknowledged data of the socket #0 (this command is valid only for TCP socket). In this case 0 bytes of data are unacknowledged.
		☞ For SARA-R5 series the <param_id>=11 is not supported.

`AT+USOCTL=0,1`	`+USOCTL: 0,1,0`
	`OK`
		Query for the last socket error for socket #0. If there are no errors the value is 0.

5.9 Socket close

By remote server

Command	Response	Description
	`+UUSOCL: 1`	The URC indicates the connection associated to socket 1 is closed. The socket #1 is cleared. ⚠ After this indication has been received the socket buffer is cleared.

By the module

Command	Response	Description
`AT+USOCL=0`	`OK`	The socket is closed by the module (socket #0). ⚠ No +UUSOCL URC returned.

5.10 Testing sockets

A simple way to test TCP/UDP sockets over the network is to send data to an echo server.

☞ u-blox provides an echo server for testing purposes: echo.u-blox.com.

Here below an example using IPv4 UDP socket:

Command	Response	Description
		The module is already registered on the network, and a data connection is active.

`AT+USOCR=17`	`+USOCR: 0`
	`OK`
		Create a UDP socket.

`AT+UDNSRN=0,"echo.u-blox.com"`	`+UDNSRN: "195.34.89.241"`
	`OK`
		DNS resolution of the URL.

`AT+USOST=0,"195.34.89.241",7,5,"Hello"`	`+USOST: 0,5`
	`OK`
		Write 5 characters to server.

	`+UUSORD: 0,5`	

`AT+USORF=0,5`	`+USORF: 0,"195.34.89.241",7,5,"Hello"`
	`OK`
		Read 5 echoed characters.

For additional details and examples on the use of the u-blox echo server, see the dedicated application note [23] .

5.11 Secure socket

☞ The section does not apply to SARA-R422 modules.

Use the +USOSEC AT command to enable or disable the use of SSL/TLS/DTLS connection on a TCP or UDP socket.

A secure manager profile must be configured before starting a secure socket session. See section 3 for more details on this aspect.

☞ On SARA-R5 and SARA-R422S / SARA-R422M8S / SARA-R422M10S modules the command is applicable on TCP and UDP sockets.

☞ The enable or disable operation can be performed only after the socket has been created with +USOCR AT command.

6 MQTT

u-blox cellular modules implement MQTT protocol revision 3.1.

☞ Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using MQTT AT commands.

☞ The section does not apply to SARA-R422 modules.

6.1 Basic setup

6.1.1 Default and minimal configuration

The configuration required to start a MQTT session depends on the broker (server) configuration, the most important is the MQTT remote server information. Get the broker configuration in order to correctly set up the module, before starting a session.

Command	Response	Description
`AT+CMEE=2`	`OK`	Set verbose error result codes.

`AT+UMQTT?`	`+UMQTT: 0,"357862090033897"`
	`+UMQTT: 2,"",1883`
	`+UMQTT: 3,"",1883`
	`+UMQTT: 4,""`
	`+UMQTT: 6,0`
	`+UMQTT: 7,0`
	`+UMQTT: 8,""`
	`+UMQTT: 9,0,""`
	`+UMQTT: 10,0`
	`+UMQTT: 11,0`
	`OK`
		Read the current profile configuration.
		All the reported values can be modified, see the AT commands manual [3], [7] for a detailed description.
		☞ The default client id value is the IMEI of the module because it guarantees the uniqueness of the client to the server.

`AT+UMQTT=2,"192.168.105.30",1883`	`OK`	Set the remote MQTT server's IP address and port. Alternatively, the server name can be set with the AT+UMQTT=3 command.

6.1.2 Last will configuration

The "last will" parameters configure the message that the MQTT clients connected to the broker will receive in case of the module disconnection due to an error. Following is an example of setup.

Command	Response	Description
`AT+UMQTT=6,1`	`OK`	Set the last will quality of service (QoS) level to 1
`AT+UMQTT=8,"u-blox/publish"`	`OK`	Set the last will topic.
`AT+UMQTT=9,"Unrequested disconnect."`	`OK`	Set the last will message.

6.1.3 Profile management

Command	Response	Description
`AT+UMQTTNV=2`	`OK`	Store the current MQTT client profile parameters to the NVM.
`AT+UMQTTNV=0`	`OK`	Restore MQTT client profile parameters to the factory-programmed setting.

`AT+UMQTT?`	`+UMQTT: 0,"357862090033897"`
	`+UMQTT: 2,"",1883`
	`+UMQTT: 3,"",1883`
	`+UMQTT: 4,""`
	`+UMQTT: 6,0`
		Read the current profile configuration.

Command	Response	Description
	+UMQTT: 7,0 +UMQTT: 8,"" +UMQTT: 9,0,"" +UMQTT: 10,0 +UMQTT: 11,0 OK	
AT+UMQTTNV=1	OK	Set MQTT client profile parameters to values previously stored in the NVM.
AT+UMQTT?	+UMQTT: 0,"357862090033897" +UMQTT: 2,"185.215.193.15",1883 +UMQTT: 3,"",1883 +UMQTT: 4,"" +UMQTT: 6,0 +UMQTT: 7,0 +UMQTT: 8,"" +UMQTT: 9,0,"" +UMQTT: 10,0 +UMQTT: 11,0 OK	Read the current profile configuration.

6.2 Start and end a MQTT session

See the section 6.1 to configure the MQTT profile before starting a connection.

Command	Response	Description
AT+UMQTTC=1	OK	Connect to the broker.
	+UUMQTTC: 1,1	The MQTT session request is successfully performed. The MQTT session can start. The +UUMQTTC URC provides the result of the requested action from the MQTT broker
AT+UMQTTC=0	OK	Disconnect from the broker, end of the MQTT session.
	+UUMQTTC: 0,1	The disconnection is successfully performed.

6.3 Subscribe to a topic and publish a message to the same topic

The following example is a demonstration of the main functionalities that can be performed with the AT commands. In this MQTT session the module subscribes to a topic, publishes a message to the topic and receives the published message (since it is subscribed to topic of the published message).

Command	Response	Description
AT+UMQTTC=4,0,"module/lights"	OK	Subscribe to a topic. The broker granted QoS level is 0.
	+UUMQTTC: 4,1,0,"module/light"	
AT+UMQTTC=2,0,0,0,"module/lights","light_1 is red"	OK	Publish "light_1 is red " message to the “module/lights” topic with requested QoS level and retain value set to 0.
	+UUMQTTC: 2,1	
	+UUMQTTC: 6,1	Notification of the received publish message.
AT+UMQTTC=6,1	+UMQTTC: 6,0,27,13,"module/lights",14,"light_1 is red" OK	Read the received publish message.
AT+UMQTTC=5,"module/lights"	OK	Unsubscribe from the previously subscribed topic.
	+UUMQTTC: 5,1	

6.4 Publish a message with hexadecimal mode set

The following example shows how to publish a message whose payload is composed of hexadecimal bytes instead of ASCII characters. Two possibilities can be adopted, the first one is the publishing in "ASCII mode" of the "ABCD3031" string while the second is the publishing of the same string in “HEX mode”.

Command	Response	Description

`AT+UMQTTC=4,0,"module/ascii"`	`OK`
	`+UUMQTTC: 4,1,0,"module/ascii"`
		Subscribe to the "module/ascii" topic.

`AT+UMQTTC=2,0,0,0,"module/ascii","ABCD3031"`	`OK`
	`+UUMQTTC: 2,1`
		Send a Publish message, the “`ABCD3031`" payload is encoded with ASCII characters (the 4th parameter value (<hex_mode>) is 0).

	`+UUMQTTC: 6,1`	Notification of the received publish message.

`AT+UMQTTC=6,1`	`+UMQTTC: 6,0,20,12,"module/ascii",`
	`8,"ABCD3031"`
	`OK`
		Read the received publish message, the payload is displayed in ASCII, so the received string is same as the one sent: 8 characters.
		The payload bytes in the MQTT packet are:
		`41 42 43 44 33 30 33 31`

`AT+UMQTTC=4,0,"module/hex"`	`OK`
	`+UUMQTTC: 4,1,0,"module/hex"`
		Subscribe to the "module/hex" topic.

`AT+UMQTTC=2,0,0,1,"module/hex","ABCD3031"`	`OK`
	`+UUMQTTC: 2,1`
		Send a Publish message with the same payload encoded as hexadecimal (the 4th parameter value (<hex_mode>) is 1).

	`+UUMQTTC: 6,1`	Notification of the received publish message.

`AT+UMQTTC=6,1`	`+UMQTTC: 6,0,14,10,"module/hex",`
	`4,"«Í01"`
	`OK`
		Read the received publish message, the payload length is 4 because each pair of characters is considered as one byte.
		The payload bytes in the MQTT packet are:
		`AB CD 30 31`
		
		Since "AB" and "CD" are not strict ASCII characters their output depends on the interface of the terminal application used to communicate with the module. In this example, the m-center is used: the "AB" and "CD" bytes are respectively displayed as "«” and “Í" characters.
		The other 2 bytes "30" and "31" are respectively the standard ASCII characters "0" and "1".

6.5 Publish a binary message to a topic

If the message payload contains special characters like quotation marks (“”), carriage return (<CR>), etc., the AT+UMQTTC=9 command should be used.

Command	Response	Description
`AT+UMQTTC=4,0,"module/special"`	`OK`	Subscribe to the "module/special" topic.
	`+UUMQTTC: 4,1,0,"u-blox/special"`	
`AT+UMQTTC=9,1,0,"module/special",21`	`>`	Send a Publish message with special characters in the payload.
`"this is an example"<CR>`	`OK`	
	`+UUMQTTC: 2,1`	
	`+UUMQTTC: 6,1`	Notification of the received publish message.

`AT+UMQTTC=6,1`	`+UMQTTC: 6,0,35, 14,"module/special",21,""this is an example""`
	`OK`
		Read the received publish message, the quotation marks and the carriage return are displayed.

6.6 Ping the MQTT broker

The ping command starts a session of ping requests to the broker server. The ping requests are sent at intervals, the length of the interval depends on the inactivity timeout (keep-alive time) set when configuring the MQTT profile.

Command	Response	Description
`AT+UMQTT=10,30`	`OK`	Configure the inactivity timeout as 30 s.
`AT+UMQTTC=1`	`OK`	Connect to the broker and start a MQTT session.
	`+UUMQTTC: 1,1`	
`AT+UMQTTC=8,1`	`OK`	Start a “ping loop”. A PINGREQ packet is sent to the broker when there is no activity with the broker, in this example after 24 s of inactivity a PINGREQ packet is sent and PINGRESP is received. The ping request is approximately triggered after 80% of the keep alive time.
	`+UUMQTTC: 8,0`	Notification of a ping failure, the broker is not responding.

6.7 Last will packet

To see the last will publish message, two modules shall start a MQTT session with the same gateway. For the first module, before starting a MQTT session, the last will parameter shall be configured, see section 6.1.2. The second module shall subscribe to the last will topic of the first module.

Command	Response	Description
Module #1		
`AT+UMQTTC=1`	`OK`	Connect to the broker and start a MQTT session.
	`+UUMQTTC: 1,1`	
Module #2		
`AT+UMQTTC=1`	`OK`	Connect to the same broker and start a MQTT session.
	`+UUMQTTC: 1,1`	

Command	Response	Description

`AT+UMQTTC=4,0,"u-blox/publish"`	`OK`
	`+UUMQTTC: 4,1,0,"u-blox/publish"`
		Subscribe to the last will topic "u-blox/publish".

Module #1		

`AT+UPSDA=0,4`	`OK`
	`+UUMQTTC: 0,101`
		Simulate a network error.
		The URC notifies that the network connection is lost.

Module #2		
	`+UUMQTTC: 6,1`	Notification of the received publish message.

`AT+UMQTTC=6,1`	`+UMQTTC: 6,0,37,14,"u-blox/publish",23,"Unrequested disconnect."`
	`OK`
		Read the received last will publish message.

6.8 Debug

In case of errors returned by the broker with the +UUMQTTC: x,0 URC, it is possible to investigate the type of error using the +UMQTTER AT command.

Command	Response	Description

`AT+UMQTTC=1`	`OK`
	`+UUMQTTC: 1,0`
		Unsuccessful session start.

`AT+UMQTTER`	`+UMQTTER: 13,50`
	`OK`
		Error code 50 is “PSD or CSD connection not established”, that means the context is not active.

6.9 Secure MQTT

Configure a secure manager profile before starting a secure MQTT session (using the TLS encryption protocol). For more details, see section 3.

The following example show to configure the MQTT profile before starting a secure session with the broker. Only the secure manager profile and the remote port must be configured, the other MQTT commands will behave as in the case of unencrypted session.

Command	Response	Description
`AT+UMQTT=11,1,2`	`OK`	Enable the secure MQTT option using the USECMNG profile 2.
`AT+UMQTT=2,"192.168.105.30",8883`	`OK`	Set the remote MQTT broker IP address and port. The default port for secure MQTT is 8883.

`AT+UMQTTC=1`	`OK`
	`+UUMQTTC: 1,1`
		Connect to the broker and start a secure MQTT session.

7 MQTT-SN

u-blox cellular modules implement MQTT-SN protocol revision 1.2.

☞ Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using MQTT-SN AT commands.

☞ The section does not apply to SARA-R422 modules.

7.1 Basic setup

7.1.1 Default and minimal configuration

The configuration required to start a MQTT-SN session depends on the gateway configuration, most importantly, the MQTT-SN remote server information. Before starting a session, be sure to correctly set up the module with the gateway configuration.

Command	Response	Description
AT+CMEE=2	OK	Set verbose error result codes.
AT+UMQTTSN?	+UMQTTSN: 0,"357862090033897" +UMQTTSN: 1,"",1883 +UMQTTSN: 2,"",1883 +UMQTTSN: 4,0 +UMQTTSN: 5,0 +UMQTTSN: 6,"" +UMQTTSN: 7,0,"" +UMQTTSN: 8,0 +UMQTTSN: 9,0 OK	Read the current profile configuration. All the reported values can be modified, see the AT commands manual [3], [7] for a detailed description. ☞ The default client id value is the IMEI of the module because it guarantees the uniqueness of the client to the server.
AT+UMQTTSN=2,"192.168.105.30",10000	OK	Set the IP address and port of the remote MQTTSN gateway. Alternatively, the gateway's server name can be set with the AT+UMQTTSN=1 command.

7.1.2 Last will configuration

The "last will" parameters configure the message that the MQTT-SN clients connected to the gateway will receive in case of a module disconnection due to an error. Following is a set up example.

Command	Response	Description
AT+UMQTTSN=4,1	OK	Set the last will QoS level to 1.
AT+UMQTTSN=6,"u-blox/publish"	OK	Set the last will topic.
AT+UMQTTSN=7,"Unrequested disconnect."	OK	Set the last will message.

7.1.3 Profile management

Command	Response	Description
AT+UMQTTSNNV=2	OK	Store the current MQTT-SN client profile parameters to the NVM.
AT+UMQTTSNNV=0	OK	Restore MQTT-SN client profile parameters to the factory-programmed setting.
AT+UMQTTSN?	+UMQTTSN: 0,"357862090033897" +UMQTTSN: 1,"",1883 +UMQTTSN: 2,"",1883 +UMQTTSN: 4,0	

Command	Response	Description
	+UMQTTSN: 5,0 +UMQTTSN: 6,"" +UMQTTSN: 7,0,"" +UMQTTSN: 8,0 +UMQTTSN: 9,0 OK	
AT+UMQTTSNNV=1	OK	Set MQTT-SN client profile parameters to values previously stored in the NVM.
AT+UMQTTSN?	+UMQTTSN: 0,"357862090033897" +UMQTTSN: 1,"",1883 +UMQTTSN: 2,"192.168.105.30",1883 +UMQTTSN: 4,0 +UMQTTSN: 5,0 +UMQTTSN: 6,"" +UMQTTSN: 7,0,"" +UMQTTSN: 8,0 +UMQTTSN: 9,0 OK	

7.2 Start and end a MQTT-SN session

See the default and minimal configuration described in section 7.1.1, to configure the MQTT-SN profile before starting a connection.

Command	Response	Description
AT+UMQTTSNC=1	OK +UUMQTTSNC: 1,1	Connect to the gateway and start a MQTT-SN session.
AT+UMQTTSNC=0	OK +UUMQTTSNC: 0,1	Disconnect from the gateway, end of the MQTT-SN session.

7.3 Subscribe to a normal topic

Example of MQTT-SN session subscription to a topic.

Command	Response	Description
AT+UMQTTSNC=5,0,0,"room/temperature"	OK	Subscribe to a normal topic (0) with requested QoS level set to 0.
	+UUMQTTSNC: 5,1,0,1	The gateway granted QoS level is 0 and the topic ID for "room/temperature" is 1.

7.4 Publish and read a message to a topic

In this MQTT-SN session the module publishes a message to the topic and receives the published message (assuming it is subscribed to topic of the published message).

Command	Response	Description
AT+UMQTTSNC=4,0,0,0,0,"1","20 degrees Celsius"	OK +UUMQTTSNC: 4,1	Publish the "20 degrees Celsius" message to the topic ID 1 with requested QoS level and retain value set to 0.
	+UUMQTTSNC: 9,1	Notification of the received publish message.
AT+UMQTTSNC=9,1	+UMQTTSNC: 9,1,0,19,1,"1",18,"20 degrees Celsius" OK	Read the received publish message.

7.5 Unsubscribe from a normal topic

Command	Response	Description

`AT+UMQTTSNC=6,0,"1"`	`OK`
	`+UUMQTTSNC: 6,1`
		Unsubscribe from the subscribed topic ID ‘1’.

7.6 Register to a topic and publish a message to the same topic

The following example differs from the previous one only for the non-receipt of publish message since the module is not subscribed to the topic.

Command	Response	Description

`AT+UMQTTSNC=2,"kitchen/temperature"`	`OK`
	`+UUMQTTSNC: 2,1,2`
		Register to a normal topic.
		The returned topic ID for "room/temperature" is 2.

`AT+UMQTTSNC=4,1,0,0,0,"2","25 degrees Celsius"`	`OK`
	`+UUMQTTSNC: 4,1`
		Publish the "25 degrees Celsius" message to the "kitchen/temperature" topic using the above topic ID.

7.7 Subscribe to a short topic name and publish a message to the same topic

The short topic is composed of only 2 characters.

Command	Response	Description

`AT+UMQTTSNC=5,0,2,"aa"`	`OK`
	`+UUMQTTSNC: 5,1,2,0`
		Subscribe to a short topic (2) with requested QoS level set to 0.
		The gateway granted QoS level is 0

`AT+UMQTTSNC=4,1,0,0,2,"aa","test"`	`OK`
	`+UUMQTTSNC: 4,1`
		Publish the "test" message to the "aa" topic with requested QoS level and retain value set to 0.

	`+UUMQTTSNC: 9,1`	Notification of the received publish message.

`AT+UMQTTSNC=9,1`	`+UMQTTSNC: 9,0,2,6,2,"aa",4,"test"`
	`OK`
		Read the received publish message.

`AT+UMQTTSNC=6,2,"aa"`	`OK`
	`+UUMQTTSNC: 6,1`
		Unsubscribe from the previously subscribed topic.

7.8 Last will

To see the last will publish message, two modules shall start a MQTT-SN session with the same gateway. For the first module, before starting a MQTT-SN session, the last will parameter shall be configured; see last will configuration in section 7.1.2. The second module shall subscribe to the last will topic of the first module.

Command	Response	Description
Module #1		

`AT+UMQTTSNC=1`	`OK`
	`+UUMQTTSNC: 1,1`
		Connect to the gateway and start a MQTT-SN session.

Module #2		

Command	Response	Description

`AT+UMQTTSNC=1`	`OK`
	`+UUMQTTSNC: 1,1`
		Connect to the same gateway and start a MQTT-SN session.

`AT+UMQTTSNC=5,0,0,"u-blox/publish"`	`OK`
	`+UUMQTTSNC: 5,1,0,1`
		Subscribe to the last will topic "u-blox/publish".

Module #1		
`AT+UPSDA=0,4`	`OK`	Simulate a network error.
	`+UUMQTTSNC: 0,101`	The URC notifies that the network connection is lost.
Module #2		
	`+UUMQTTSNC: 9,1`	Notification of the received publish message.

`AT+UMQTTSNC=9,1`	`UMQTTSNC: 9,0,0,24,1,"1",23,"Unrequested disconnect."`
	`OK`
		Read the received last will publish message.

7.9 Error handling

In case of errors returned by the gateway with the +UUMQTTSNC: x,0 URC, it is possible to investigate the type of error using the +UMQTTSNER AT command.

Command	Response	Description

`AT+UMQTTSNC=5,1,0,"kitchen/temperature"`	`OK`
	`+UUMQTTSNC: 5,0`
		Unsuccessful subscribe.

`AT+UMQTTSNER`	`+UMQTTSNER: 14,21`
	`OK`
		Error code 21 is "Timeout error" that means the gateway did not replay to the subscribe request.

7.10 Secure MQTT-SN

Configure a secure manager profile before starting a secure MQTT-SN session (using the DTLS encryption protocol). For further details, see the section 3.

The following example shows how to configure the MQTT-SN profile before starting a secure session with the gateway. Only the secure manager profile and the remote port must be configured; the other MQTT-SN commands will behave as in the case of an unencrypted session.

Command	Response	Description
`AT+UMQTTSN=9,1,2`	`OK`	Enable the secure MQTT-SN option using the USECMNG profile 2.
`AT+UMQTTSN=2,"192.168.105.30",10001`	`OK`	Set the remote MQTT-SN gateway IP address and port.

`AT+UMQTTSNC=1`	`OK`
	`+UMQTTSNC: 1,1`
		Connect to the gateway and start a secure MQTT-SN session.

7.11 MQTT Anywhere

MQTT Anywhere is a u-blox IoT communication SIM-based LPWA service that can operate around the world without the need for specific cellular agreements with multiple MNOs.

This service uses the MQTT-SN protocol, and it is directly integrated into u-blox products. Additionally, devices are authenticated via the hardware IoT SIM card, ensuring that the user traffic is never exposed to the public internet. Device payloads can be enriched and transformed using the Data Flow Manager within u-blox Thingstream, which also provides integration with virtually any 3rd party enterprise system or IoT platform.

☞ MQTT Anywhere is not supported by SARA-R5 "00B" product versions and by SARA-R422 product.

☞ Be aware in case of using a Thingstream SIM card (IoT SIM card) that there are available two different APNs:

- APN 'tsudp' allows only connectivity to Thingstream MQTT Anywhere server and it is mandatory to access this service;
- APN 'tsiot' allows generic data traffic:
- For more information on Thingstream and u-blox services offering please visit this webpage.

☞ Be aware that security services can be used with the 'tsudp' APN and the Thingstream SIM card only if the AT+USECOPCMD="cfgipv4",4 command is issued. With this additional configuration, the security functionalities are enabled via a u-blox proxy enclose in the Thingstream portal.

Additional details on this topic are available on the product webpage.

In addition to the MQTT-SN basic settings, the MQTT Anywhere service required the configuration of a unique client ID and the clean session. See an example of these configurations in the table below.

Command	Response	Description
`AT+UMQTTSN=0,"identity:xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx"`	`OK`	To ensure a unique value, the identity value of the SN thing needs to be used as the client ID. ☞ The identity value can be found on the management console page of u-blox Thingstream platform.
`AT+UMQTTSN=8,600`	`OK`	Set the connection duration (in seconds).
`AT+UMQTTSN=10,1`	`OK`	Set the MQTT-SN clean session.

A complete example of the 'MQTT Anywhere' configuration can be seen on the IoT Communication-as-a-Service guide webpage.

7.12 MQTT Flex

MQTT Flex is a u-blox IoT communication BYO-SIM LPWA service that provides the flexibility to choose your own cellular connectivity, combined with the advantages of IoT Communication-as-a-Service.

This service uses the MQTT-SN protocol, and it is directly integrated into u-blox products. Additionally, devices are securely authenticated via the client key and certificate generated by the Thingstream platform, ensuring that the user traffic is never exposed to the public internet. Device payloads can be enriched and transformed using the Data Flow Manager within u-blox Thingstream, which also provides integration with virtually any 3rd party enterprise system or IoT platform.

☞ MQTT Flex is not supported by SARA-R5 "00B" product versions and by SARA-R422 product.

Additional details on this topic are available on the product webpage.

Differently from the MQTT Anywhere configuration, the MQTT Flex service required the configuration of the security profile together with the configuration of the MQTT-SN internal application. All the relevant steps are reported in the following sections.

7.12.1 Specify the client key and certificate to be used

This example assumes the client key and certificate generated by the Thingstream platform associated with the Flex Thing are correctly stored in the file system of the module using the +UDWNFILE AT command and using the file names device.pem for the certificate and device.key for the key.

Command	Response	Description

`AT+USECMNG=1,1,"MQTTFlex_cert","device.pem"`	`+USECMNG: 1,1,"MQTTFlex_cert ","73A0...8D"`
	`OK`
		Import the client certificate from the file "device.pem" stored on the file system.

`AT+USECMNG=1,2,"MQTTFlex_key","device.key"`	`+USECMNG: 1,2,"MQTTFlex_key ","73A0...8D"`
	`OK`
		Import the client key from the file "device.key" stored on the file system.

7.12.2 Configure the DTLS security profile

The following commands set up the DTLS security profile which the MQTT-SN client will make use of.

Command	Response	Description
`AT+USECPRF=0`	`OK`	Reset (set to factory-programmed value) all the parameters of security profile #0.
`AT+USECPRF=0,0,0`	`OK`	Disable the certificate validation; the server certificate will not be checked or verified.
`AT+USECPRF=0,1,3`	`OK`	Select TLSv1.2 as SSL/TLS to use.
`AT+USECPRF=0,2,99,"C0","30"`	`OK`	Select a specific cipher suite for profile #0.
`AT+USECPRF=0,5,"MQTTFlex_cert"`	`OK`	Select trusted client certificate internal name for profile #0.
`AT+USECPRF=0,6,"MQTTFlex_key"`	`OK`	Select trusted client key internal name for profile #0.

7.12.3 Configure the MQTT-SN client

Command	Response	Description
`AT+UMQTTSN=0,"device:xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx"`	`OK`	To ensure a unique value, the device value of the SN thing needs to be used as the client ID. ☞ The device value can be found on the management console page of u-blox Thingstream platform.
`AT+UMQTTSN=1,"mqtt-flex.thingstream.io",2443`	`OK`	Configure the MQTT-SN gateway endpoint.
`AT+UMQTTSN=9,1,0`	`OK`	Set the MQTT-SN internal client to use the required DTLS profile.

Once the MQTT-SN client configuration is completed, it is possible to use the feature and perform the connection like a generic MQTT-SN application (e.g., with the AT+UMQTTSNC=1 command).

A complete example of the ‘MQTT Flex’ configuration can be seen on the IoT Communication-as-a-Service guide webpage.

8 CoAP

☞ The section does not apply to SARA-R422 modules.

CoAP is an application layer protocol based on UDP for resource-constrained internet devices described into RFC 7252 [18].

Main CoAP features are:

- Web protocol fulfilling M2M requirements in constrained environments.
- UDP (RFC 768 [17]) binding with optional reliability supporting unicast and multicast requests.
- Asynchronous message exchanges.
- Low header overhead and parsing complexity.
- URI and Content-type support.
- Simple proxy and caching capabilities.
- A stateless HTTP mapping, allowing proxies to be built providing access to CoAP resources via HTTP in a uniform way or for HTTP simple interfaces to be realized alternatively over CoAP.
- Security binding to Datagram Transport Layer Security (DTLS) [19].
- Transfer block-wise as described into RFC 7959 [20].
- Transmission over TCP and TLS: described into RFC 8323 [21].

Implementation details:

- Maximum URI length is 783 characters. URI_HOST, URI_PATH and URI_QUERY are limited to 255 characters as per RFC 7252 [18].
- Maximum supported payload in uplink is 512 bytes. Use block transfer for data block greater than 512 bytes.
- In DTLS and TLS connection, the OK final result code will be returned only after the security connection handshake is completed successfully.
- It is allowed only one CoAP transmission until it is completed.
- Only 4 profiles can be stored.

8.1 Good practices on writing CoAP application

To create a good CoAP application keep the following in mind:

- **Register the module to the network and establish a data connection**: the module should be connected to the network and have a data connection to send CoAP commands. This is a mandatory step.
- **Configure a profile and store it**: create a basic configuration that can be stored for further restart.
- **Restore the profile**: this can be used to avoid to trigger always the same commands at the module boot and it can be used to verify if the current configuration is aligned with one expected.
- **Configure and send CoAP commands**: change the configuration parameter in order to send CoAP commands.
- **Wait and parse URCs**: wait until final +UCOAPCR is received and store then parse +UCOAPCD to be parsed to have a complete reply from the server.
- **Error handling**: procedure that can be used to debug errors from the server or from configuration.

This flow is described in the Figure 10.

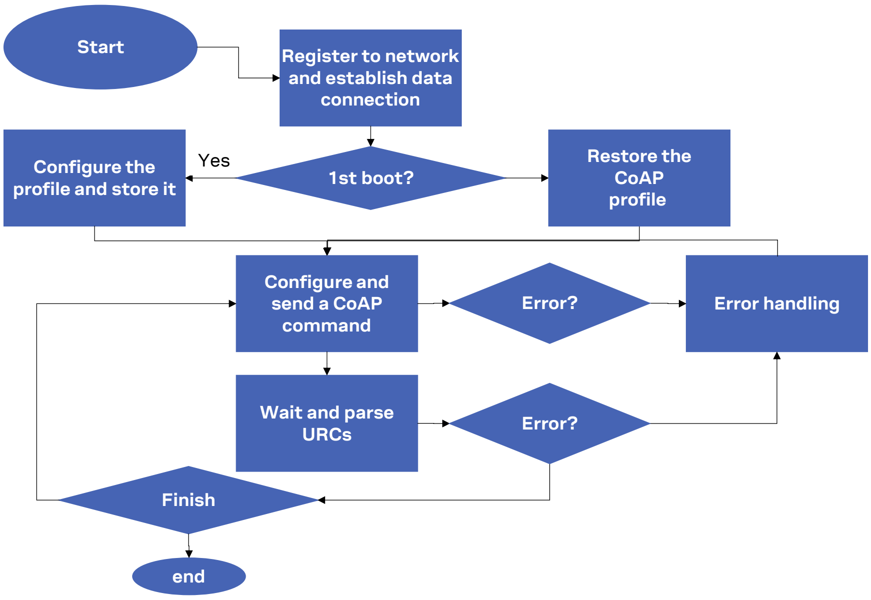

Start
Register to network and establish data connection
1st boot?
Yes
Configure the profile and store it
Restore the CoAP profile
Configure and send a CoAP command
Error?
Error handling
Wait and parse URCs
Error?
Finish
end

Figure 10: CoAP workflow

8.2 Basic setup

☞ Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using CoAP AT commands.

8.2.1 Current configuration

Command	Response	Description
`AT+CMEE=2`	`OK`	Set verbose error result codes.
`AT+UCOAP=4,1`	`OK`	Set current profile as valid.

`AT+UCOAP=2,0,1`
`AT+UCOAP=2,1,1`
`AT+UCOAP=2,2,1`
`AT+UCOAP=2,3,1`
	`OK`
	`OK`
	`OK`
	`OK`
		Enable automatic recognition of URI_HOST, URI_PORT, URI_PATH and URI_QUERY directly from URI.

`AT+UCOAP=2,4,1`	`OK`	Set content format for PUT/POST as "Plain/Text".

8.2.2 Profile management

Command	Response	Description
`AT+UCOAP=6,0`	`OK`	Store current profile to be stored as profile number 0.

`AT+UCOAP=7`	`+UCOAP: "URI_STR","<server_uri>"`
	`+UCOAP: "OPT_MASK",7`
	`+UCOAP: "PROFILE_NUM",0`
	`+UCOAP: "STATUS_FLAG",1`
	`+UCOAP: "USECMNG_PROFILE",0`
	`+UCOAP: "RAI_FLAG",0`
	`+UCOAP: INVALID PROFILE NUMBER 1`
	`+UCOAP: INVALID PROFILE NUMBER 2`
	`+UCOAP: INVALID PROFILE NUMBER 3`
		Check all stored profile configuration. In this configuration only profile 0 is a valid profile that can be used.

Command	Response	Description
	OK	
AT+UCOAP=5,0	OK	Restore profile number 0 as current profile.
AT+UCOAP?	+UCOAP: "URI_STR","<server_uri>" +UCOAP: "OPT_MASK",7 +UCOAP: "PROFILE_NUM",0 +UCOAP: "STATUS_FLAG",1 +UCOAP: "USECMNG_PROFILE",0 +UCOAP: "RAI_FLAG",0 OK	Verify that current profile is configured as expected.

8.3 Basic operation

8.3.1 GET

Command	Response	Description
AT+UCOAP=1,"<server_uri>"	OK	Set URI to be used in GET request. In this example we use coap.me server. Reply can be different in the future.
AT+UCOAP=2,5,1	OK	Set message to be NON confirmable
AT+UCOAPC=1	OK +UCOAPCD: 2,0,"776F726C64",0 +UCOAPCR: 1,1	Command trigger reply from the server in hexadecimal format that corresponds to “world”.

8.3.2 PUT/POST

Command	Response	Description
AT+UCOAP=1,"<server_uri>"	OK	Set URI to be used in PUT/POST request. In this example we use coap.me server. Reply can be different in the future.
AT+UCOAP=2,5,0	OK	Set message to be CONfirmable, so server should reply with an ACK
AT+UCOAPC=3,"736f6d655f74657874",0	OK +UCOAPCD: 2,0,"505554204F4B",0 +UCOAPCR: 3,1	Server replied in hex that correspond to “PUT OK” when PUT command is triggered.
AT+UCOAPC=4,"736f6d655f74657874",0	OK +UCOAPCD: 2,0,"504F5354204F4B",0 +UCOAPCR: 4,1	Server replied in hex that correspond to “POST OK” when POST command is triggered.

8.3.3 Block transfer

Command	Response	Description
`AT+UCOAP=1,"<server_uri>"`	`OK`	Set URI to be used in PUT request. In this example we use coap.me server. Reply can be different in the future.

`AT+UCOAPC=3,"4d657373616765206e756d6265722030206669727374206d657373616765206f66207365726965207375626469766964656420696e746f203634206279746573",0,0,1`	`OK`
	`+UCOAPCD: 2,0,"",0`
	`+UCOAPCR: 3,1`
		Send data separated into two messages.
		First message is 64 bytes and is set that more block will be transmitted, so the server can be prepared for adding other data.

`AT+UCOAPC=3,"4d657373616765206e756d6265722031206669727374206d657373616765206f66207365726965207375626469766964656420696e746f203634206279746573",0,1,0`	`OK`
	`+UCOAPCD: 2,0,"",0,1,64`
	`+UCOAPCR: 3,1`
		Second message (about 64 bytes) and the message number is different. No more block will be transmitted after.

8.3.4 TCP connection

Command	Response	Description
`AT+UCOAP=1,"<server_uri>"`	`OK`	Set URI to be used in GET request. In this example we use a local server that supports CoAP over TCP.

`AT+UCOAPC=1`	`OK`
	`+UCOAPCD: 2,0,"546869732069732061207465737420736572766572206D6164652077697468206C6962636F617020287365652068747470733A2F2F6C6962636F61702E6E6574290A436F707972696768742028432920323031302D2D32303230204F6C616620426572676D616E6E203C626572676D616E6E40747A692E6F72673E20616E64206F74686572730A0A",0`
	`+UCOAPCR: 1,1`
		Command trigger reply from server in hex that corresponds to "This is a test server made with libcoap (see https://libcoap.net)
		Copyright (C) 2010--2020 Olaf Bergmann <bergmann@tzi.org> and others".

8.4 Error handling

8.4.1 Configuration error

Command	Response	Description
`AT+UCOAPC=1`	`+CME ERROR: operation not allowed`	The connection is started but some configuration parameters are not configured properly.

`AT+UCOAPER`	`+UCOAPER: 15,17`
	`OK`
		Using this command and checking the AT commands manual [3], [7] it is possible to retrieve the error result code (in this case "Current profile invalid").
		It means that the profile is not configured properly.

8.4.2 Error on server reply

Command	Response	Description

`AT+UCOAPC=3,"736f6d655f74657874",0`	`OK`
	`+UCOAPCD: 4,0,"4572726F7220342E30353A204D6574686F64206E6F7420737570706F727465642068657265",0`
	`+UCOAPCR: 3,1`
		Command is executed successfully.
		The server replies with <error_code> and <error_description> that is reported here as "Error 4.05: Method not supported here".

8.5 Secure connection

8.5.1 Basic configuration

Configure a secure manager profile before trigger a CoAP command with secure connection. For further details, see section 3.

Command	Response	Description
`AT+UCOAP=8,0`	`OK`	Profile 0 will be used in a secure connection.

8.5.2 DTLS connection

Command	Response	Description
`AT+UCOAP=1,"<server_uri>"`	`OK`	Set the URI to be used in GET request. In this example it is used a server configured with proper security setup.

`AT+UCOAPC=1`	`OK`
	`+UCOAPCD: 2,0,"546869732069732061207465737420736572766572206D6164652077697468206C6962636F6170202873656520687474707733A2F2F6C6962636F61702E6E6574290A436F7079726967687420284329203230301302D2D32303230204F6C616620426572676D616E6E203C626572676D616E6E40747A692E6F72673E20616E64206F74686572730A0A",0`
	`+UCOAPCR: 1,1`
		Command trigger reply from server in hex that corresponds to “This is a test server made with libcoap (see https://libcoap.net)
		Copyright (C) 2010--2020 Olaf Bergmann <bergmann@tzi.org> and others”.

8.5.3 TLS connection

Even if AT commands are the same, unlike the DTLS connection reported in the previous example, the TLS connection uses TCP protocol and therefore, a dedicated URI must be used for security using TCP (TLS).

☞ Ensure the CoAP server is supporting the TCP extension. This is not guaranteed because the native protocol is UDP. Fort this reason, a dedicated URI should be used, and the user must verify also that the server supports TLS connections.

Command	Response	Description
`AT+UCOAP=1,"<server_uri>"`	`OK`	Set the URI to be used in GET request. In this example we use a server that is configured with proper security setup.

`AT+UCOAPC=1`	`OK`
	`+UCOAPCD: 2,0,"546869732069732061207465737420736572766572206D6164652077697468206C6962636F6170202873656520687474707733A2F2F6C6962636F61702E6E6574290A436F7079726967687420284329203230301302D2D32303230204F6C616620426572676D616E6E203C626572676D616E6E40747A692E6F72673E20616E64206F74686572730A0A",0`
	`+UCOAPCR: 1,1`
		Command trigger reply from server in hexadecimal format that corresponds to “This is a test server made with libcoap (see https://libcoap.net)
		Copyright (C) 2010--2020 Olaf Bergmann <bergmann@tzi.org> and others”.

9 FTP

☞ Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using FTP AT commands.

☞ The section does not apply to SARA-R422 modules.

Command	Response	Description
		Parameter configuration for FTP server connection. These parameters will be set:
AT+UFTP=1,"ftp.u-blox.com"	OK	• FTP server hostname
AT+UFTP=2,"anonymous"	OK	• FTP username
AT+UFTP=3,"password"	OK	• FTP password
AT+UFTP=6,1	OK	• FTP connection mode (PASSIVE connection). Most FTP servers prefer the PASSIVE mode due to security issues.
AT+UDNSRN=0,"ftp.u-blox.com"	+UDNSRN: "195.34.89.241" OK	Hostname resolution.
		Connect to the server and manage the FTP connection using the +UFTPC AT command. Let's start connecting to the server.
AT+UFTPC=1	OK	The +UUFTPCR URC provides the FTP command result (the last parameter provides the result, 1 if is successfully performed).
	+UUFTPCR: 1,1	
AT+UFTPC=13	OK	Request the file list on the server.
	+UUFTPCD: 13,194,"-rw-r--r-- 1 ftp ftp 1037 Aug 5 09:45 dat_000 -rw-r--r-- 1 ftp ftp 21041 Aug 5 09:12 data.zip -rw-r--r-- 1 ftp ftp 12 Aug 5 09:42 xlog.zip "	The +UUFTPCD URC provides the FTP data.
	+UUFTPCR: 13,1	
AT+UFTPC=10,"uploads"	OK	Directory creation on the FTP server.
	+UUFTPCR: 10,1	
AT+UFTPC=13	OK	Request again the file list.
	+UUFTPCD: 13,258,"-rw-r--r-- 1 ftp ftp 1037 Aug 5 09:45 dat_000 -rw-r--r-- 1 ftp ftp 21041 Aug 5 09:12 data.zip drwxr-xr-x 2 ftp ftp 4096 Aug 5 09:48 uploads -rw-r--r-- 1 ftp ftp 12 Aug 5 09:42 xlog.zip "	
	+UUFTPCR: 13,1	
		Change directory to directory name "uploads".
AT+UFTPC=8,"uploads"	OK	☞ Use AT+UFTPC=8,".." to return back in the parent directory.
	+UUFTPCR: 8,1	
AT+UFTPC=5,"gps_positions","gps_positions"	OK	Upload a file from the module to the FTP server from the local file system of the module (in this example filename "gps_positions").
	+UUFTPCR: 5,1	

Command	Response	Description

`AT+UFTPC=5,"gps_positions","gps_positions",250`	`OK`
	`+UUFTPCR: 5,1`
		Restart the upload file from the module to FTP server from the local module file system (in this example filename "gps_positions"), starting from byte 250.
		☞ The FTP server should support the REST command to support these functionalities. The server should write the file starting from byte indicated.

`AT+UFTPC=13`	`OK`
	`+UUFTPCD: 13,70,"-rw-r--r-- 1 ftp ftp 176673 Aug 5 10:03 gps_positions"`
	`+UUFTPCR: 13,1`
		File list request.

`AT+UFTPC=8,".."`	`OK`
	`+UUFTPCR: 8,1`
		Return to the parent directory.

`AT+UFTPC=4,"data.zip","data.zip"`	`OK`
	`+UUFTPCR: 4,1`
		Download a file from the FTP server to the local file system of the module.

`AT+UFTPC=4,"data.zip","data.zip",1`	`OK`
	`+UUFTPCR: 4,1`
		Restart the file download from the FTP server to the local module file system from the latest byte saved on the file system (this is automatically calculated). The data received is written after the latest byte available on the file system.

`AT+UFTPC=0`	`OK`
	`+UUFTPCR: 0,1`
		FTP server disconnection.

`AT+UPSDA=0,4`	`OK`	PS data connection detachment with the +UPSDA AT command. ☞ Only the specified profile will be deactivated.

9.1 Direct link

9.1.1 Retrieve a file from FTP server

Command	Response	Description
		Parameter configuration for FTP server connection. These parameters will be set:
`AT+UFTP=1,"ftp.u-blox.com"`	`OK`	• FTP server hostname
`AT+UFTP=2,"anonymous"`	`OK`	• FTP username
`AT+UFTP=3,"password"`	`OK`	• FTP password
`AT+UFTP=6,1`	`OK`	• FTP connection mode (PASSIVE connection)

`AT+UDNSRN=0,"ftp.u-blox.com"`	`+UDNSRN: "195.34.89.241"`
	`OK`
		Hostname resolution.

		Connect to the server and manage the FTP connection using the +UFTPC AT command.

`AT+UFTPC=1`	`OK`
	`+UUFTPCR: 1,1`
		The +UUFTPCR URC is returned when the connection is established.

`AT+UFTPC=6,"file_to_retrieve"`	`CONNECT`	Send to the FTP server a RETRIEVE file request for `file_to_retrieve`. The CONNECT intermediate result code means the direct link mode is activated: the data received from FTP connection will be redirected to the serial port.

Command	Response	Description
`AT+UFTPC=6,"file_to_retrieve",250`	`CONNECT`	Restart a RETRIEVE file request for `file_to_retrieve` file from byte 250. The CONNECT intermediate result code means the direct link mode activation: the data received from FTP connection is redirected to the serial port. The data reception begins with the byte indicated.
`+++`	`DISCONNECT` `OK`	⚠ When the file has entirely been retrieved the module does not exit from the direct link mode. It is necessary to manually exit using the "+++" escape sequence.
	`+UUFTPCR: 6,1`	The +UUFTPCR URC notifies how the retrieve operation has been concluded (1 means success).

9.1.2 Aborting retrieve file request

Command	Response	Description
`+++`	`DISCONNECT` `OK`	If entering "+++" escape sequence before the requested file has been entirely retrieved from FTP server, the module exits from the direct link.
	`+UUFTPCR: 6,0`	The +UUFTPCR URC notifies that the retrieve operation has not been concluded successfully (0 means fail).

9.1.3 Store a file on FTP server

Command	Response	Description
		Parameter configuration for FTP server connection. These parameters will be set:
`AT+UFTP=1,"ftp.u-blox.com"`	`OK`	• FTP server hostname;
`AT+UFTP=2,"anonymous"`	`OK`	• FTP username;
`AT+UFTP=3,"password"`	`OK`	• FTP password;
`AT+UFTP=6,1`	`OK`	• FTP connection mode (PASSIVE connection).

`AT+UDNSRN=0,"ftp.u-blox.com"`	`+UDNSRN: "195.34.89.241"`
	`OK`
		Hostname resolution.

		Connect to the server and manage the FTP. Connection using the +UFTPC command. Let's start connecting to the server.

`AT+UFTPC=1`	`OK`
	`+UUFTPCR: 1,1`
		The +UUFTPCR URC is returned when the connection is established.

`AT+UFTPC=7,"file_to_store"`	`CONNECT`	Send to FTP server a STORE file request for `file_to_store`. The CONNECT intermediate result code means the direct link mode is activated: the data sent through the serial port will be redirected to the FTP server through the FTP connection.
`AT+UFTPC=7,"file_to_store",250`	`CONNECT`	Restart the STORE file request for `file_to_store` from byte 250. The CONNECT intermediate result code means the direct link mode activation: the data sent through the serial port is redirected to the FTP server through the FTP connection.

Command	Response	Description
		The data is written on the FTP server starting from byte indicated. ☞ The FTP server should support REST command to support this functionality.
`+++`	`DISCONNECT` `OK`	When the data upload is completed use the "+++" escape sequence for exiting from the direct link mode.
	`+UUFTPCR: 7,1`	The +UUFTPCR URC notifies if the STORE operation has been concluded successfully.

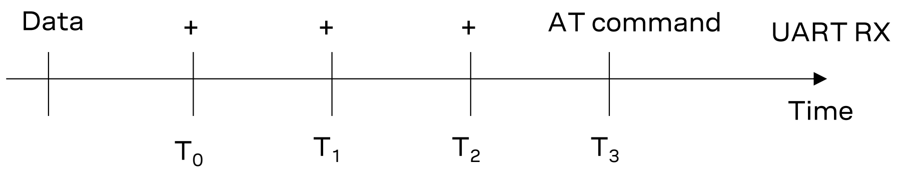
9.1.4 About "+++" escape sequence usage

To switch from the data mode to the command mode, the application shall send a proper escape sequence to the module. The application can configure the escape sequence by means of the following commands:

- ATS2: this command sets the character used as the escape character (by default it is "+")
- ATS12: this command sets the escape prompt delay (TEPD) timer (by default it is 1 s)

For more details on the AT commands, see the AT commands manual [3], [7].

The escape sequence must follow certain timing constraints to be distinguished from generic data.



- T0 > TEPD: there must be at least TEPD seconds after the last data byte and the first escape character
- T1 < TEPD: the second escape character must be sent within TEPD seconds after the first escape character
- T2 < TEPD: the third escape character must be sent within TEPD seconds after the second escape character
- T3 > TEPD: There must be at least TEPD seconds after the last escape character and the first AT command

9.2 Using secure option

Command	Response	Description
		Parameters configuration for the FTP server connection in secure mode. These parameters are set:
`AT+UFTP=0,"123.213.132.231"`	`OK`	• FTP server address
`AT+UFTP=2,"myname"`	`OK`	• FTP username
`AT+UFTP=3,"mypwd"`	`OK`	• FTP password

`AT+UFTP=8,1`
`AT+UFTP=12,1`
	`OK`
	`OK`
		• FTP SSL encryption control channel enabled
		• FTP SSL encryption data channel enabled

`AT+UFTPC=1`		FTP login.
		Connect to the server and manage the FTP connection using the +UFTPC AT command. Let's start connecting to the server.
	`OK`	
	`+UUFTPCR: 1,1`	The +UUFTPCR URC provides the FTP command result (the second parameter

Command	Response	Description
		provides the result, 1 if is successfully performed).
		Some operators may not accept a secure FTP connection:
AT+UFTPC=1	OK +UUFTPCR: 1,0	The URC provides the FTP command result: the second parameter is 0, an error has occurred.
AT+UFTPER	+UFTPER: 8,63 OK	Retrieving of error class and code: • Error class 8: "Wrong FTP API usage" • Error code 63: "Cannot set secure socket"

☞ When the FTP client is using a secure connection, only the explicit mode is supported (ftpes://). Moreover, in the explicit mode, the secure connection will be established after the FTP connection (before login) on the same port of the control channel.

☞ When the FTP client is using a secure connection, the FTPS server may request that the session data of the control channel connection should be reused to establish secure connection on the data channel. In this case, the session resumption feature for the FTPS client shall be configured via <op_code>=13 of the +USECPRF AT command.

9.3 Error handling

In case of errors returned in the last FTP operation, it is possible to investigate the type of error using the +UFTPER AT command.

Command	Response	Description
AT+UFTPC=1	OK +UUFTPCR: 1,0	Unsuccessful login.
AT+UFTPER	+UFTPER: 1,1 OK	Error code 1 is “User missing”.

10 HTTP

☞ Make sure to follow the steps in section 2 before using the AT commands in this section. This is necessary because a PS data connection must be activated before using HTTP AT commands.

☞ The section does not apply to SARA-R422 modules.

10.1 Basic setup

This section shows an example use of the u-blox proprietary +UHTTP and +UHTTPC AT commands. These commands are used for sending requests to a remote HTTP server, receiving the server responses, and transparently storing them in the file system. The supported methods are: HEAD, GET, DELETE, PUT, POST file, and POST data. For detailed AT command descriptions, see the AT commands manual [3], [7].

Command	Response	Description
AT+CMEE=2	OK	Set verbose error result codes.
AT+UHTTP=0	OK	Reset the HTTP profile #0.
AT+UHTTP=0,1,"httpbin.org"	OK	Set the server domain name and port. ☞ HTTP server name (e.g., " httpbin.org "). The factory-programmed value is an empty text string.
AT+UHTTP=0,5,80	OK	
AT+UDNSRN=0,"httpbin.org"	+UDNSRN: "54.72.52.58" OK	DNS resolution of httpbin.org.
AT+UHTTPC=0,0,"/","head.ffs"	OK +UUHTTPCR: 0,0,1	HEAD request of the default page and store the result into the "head.ffs" file on the local file system of the module. The +UUHTTPCR URC notifies the success/failure of the operation (in this example: success).
AT+UHTTPC=0,1,"/","get.ffs"	OK +UUHTTPCR: 0,1,1	GET request of the default page and store the result into the "get.ffs" file on the local file system of the module. The +UUHTTPCR URC notifies the success/failure of the operation (in this example: success).
AT+UHTTPC=0,5,"/post","post.ffs","name_post=MyName&age_post=30",0	OK +UUHTTPCR: 0,5,1	POST request sending data using content-type application/x-www-form-urlencoded. The result is saved in the "post.ffs" file on the local file system of the module. The +UUHTTPCR notifies the success/failure of the operation (in this example: success).
		Set the authentication for the HTTP server:
AT+UHTTP=0,2,"test_user"	OK	HTTP server username.
AT+UHTTP=0,3,"P455w0rd"	OK	HTTP server password.
AT+UHTTP=0,4,1	OK	HTTP server authentication method (basic authentication).
AT+UHTTPC=0,1," /basic-auth/test_user/P455w0rd","get_auth.ffs"	OK +UUHTTPCR: 0,1,1	GET request returning information on authenticated user. The page requires basic authentication. The result is saved in "get_auth.ffs" file on the local file system of the module. The +UUHTTPCR URC notifies the success/failure of the operation (in this example: success).

10.2 HTTP POST

Command	Response	Description
`AT+CMEE=2`	`OK`	Set the verbose error result codes.
`AT+UPSD=0,1,"click"`	`OK`	Set the APN.
`AT+UPSDA=0,3`	`OK`	PS data attach.

`AT+UPSND=0,0`	`+UPSND: 0,0,"10.130.31.65"`
	`OK`
		Check whether the IP address is assigned.

`AT+UDWNFILE="postdata.txt",11`	`>hello world`
	`OK`
		Write some data in the file to send.

`AT+URDFILE="postdata.txt"`	`+URDFILE: postdata.txt,11,"hello world"`
	`OK`
		Optionally check whether the data is present.

`AT+UHTTP=0`	`OK`	Reset the HTTP profile #0.
`AT+UHTTP=0,1,"httpbin.org"`	`OK`	Set up a connection to an echo server (httbin.org) that checks and echoes post commands.
`AT+UHTTP=0,5,80`	`OK`	Set the port of the HTTP request to 80

`AT+UHTTPC=0,4,"/post","result.txt","postdata.txt",1`	`OK`
	`+UUHTTPCR: 0,4,1`
		Submit a post command in text format and store the answer in result.txt.

`AT+URDFILE="result.txt"`	`+URDFILE: result.txt,498,`
	`"HTTP/1.1 200 OK`
	`Content-Type: application/json`
	`Date: Tue, 15 Jan 2013 16:06:11 GMT`
	`Server: gunicorn/0.16.1`
	`Content-Length: 345`
	`Connection: Close`
	
	`{`
	`"headers": {`
	`"Content-Length": "11",`
	`"Host": "httpbin.org",`
	`"Content-Type": "text/plain",`
	`"User-Agent": "UBlox Leon G200/1.0 (N7/HTTP 1.0)",`
	`"Connection": "keep-alive"`
	`},`
	`"args": {},`
	`"data": "hello world",`
	`"url":`
	`"http://httpbin.org/post",`
	`"files": {},`
	`"json": null,`
	`"form": {},`
	`"origin": "10.82.21.198"`
	`}"`
	`OK"`
		Check the server's reply.

10.3 Error handling

In case of errors returned in the last HTTP operation of a specified HTTP profile, it is possible to investigate the type of error using the +UHTTPER AT command.

Command	Response	Description
`AT+UHTTPC=0,4,"/post","result.txt","postdata.txt",1`	`OK`	Successfully submit a post command in text format and store the answer in result.txt.
	`+UUHTTPCR: 0,4,1`	

`AT+UHTTPER=1`	`+UFTPER: 1,0,0`
	`OK`
		In HTTP profile 1 the error code 0 is “No error”.

10.4 Secure HTTP

Configure a secure manager profile before starting a secure HTTP. See section 3 for further details on this.

The following example reports how to configure the secure HTTP. Only the secure manager profile must be configured, the other HTTP commands will behave as in the case of unencrypted session.

Command	Response	Description
`AT+UHTTP=0,6,1`	`OK`	Enable secure HTTP. HTTPS (SSL encryption) and set the HTTP server port to 443. ☞ The port number is set automatically to 443 (standard value for HTTPS). If the application is turning back to HTTP (using AT+UHTTP=0,6,0 command), the port number is changed automatically to 80. Differently, if the port number is changed manually (e.g., using AT+UHTTP=0,5,9000 command), a change in the security option (e.g., with +UHTTP=0,6,1) will not modify the port manually selected.

11 LwM2M

LwM2M application examples are available in the LwM2M objects and commands application note [10].

Appendix

A Design for low-power scenarios

A.1 Linger time

The linger time is the interval between the first FIN message sent by the initiator in a closing sequence and the moment when the socket is closed.

Considering that the time required to close the socket depends on several aspects, such as the communication link and the data queued on the receiver side, it may be useful for the application to set a linger time. A set linger time defines a bounded maximum time to linger independently to the closing sequence.

If a proper sequence of messages is not received and linger time is expired, a reset (RST) packet is sent by the module and the connection is closed.

☞ Setting a short linger time may result in a loss of data that is queued at the receiver side.

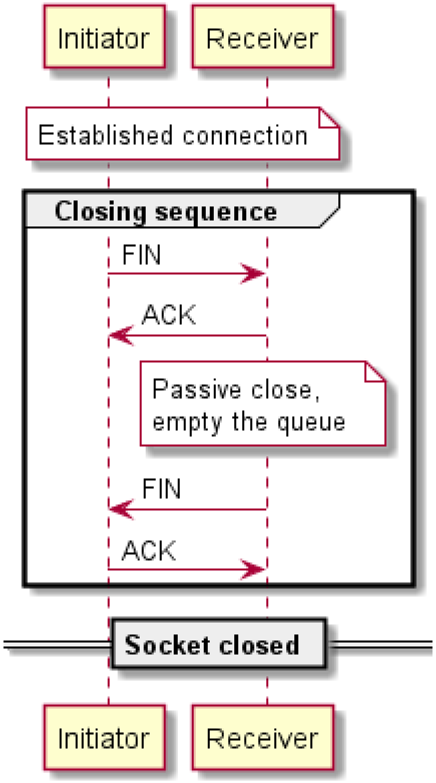


Figure 11: Socket closing sequence

For applications that require low power consumption, it is recommended to reduce the linger time and close the socket sooner, even before terminating the closing sequence.

A.1.1 Linger time configuration

The linger time can be set in the socket creation using the +USOSO AT command. The linger time value can be retrieved by using the +USOGO AT command.

The linger time can also be configured in the socket of the internal applications that use the TCP protocol. Particularly, it can be configured in the FTP, HTTP and MQTT. The table below lists the AT commands for its configuration and the default values, for each application.

Application	Command	Description	Default value
Generic socket	`AT+USOSO=0,65535,128,1,<opt_val2>`	Enabling linger time with <opt_val2> signed 16 bit numeric parameter, it sets the linger time, the range goes from 0 to 32767 ms.	0 s
FTP	`AT+UFTP=5,<timeout>[,[<linger_cmd>],[<linger_data>]]`	<linger_cmd>, <linger_data>: linger time for command/data socket in seconds. The range goes from 0 to 120 s; 0 means linger time is not set.	60 s
HTTP	`AT+UHTTP=<profile_id>,7,<HTTP_timeout>[,<linger_timer>]`	<linger_timer>: Linger timer for socket close expressed in seconds. The range goes from 0 to 120 s; 0 means linger time is not set.	30 s
MQTT	`AT+UMQTT=10,<timeout>,<linger_time>`	<linger_time>: Linger time expressed in seconds. The range goes from 0 to 120 s; 0 means linger time is not set.	10 s

☞ The linger time configuration in FTP, HTTP and MQTT is not supported by SARA-R5 "00B" product versions and by SARA-R422 modules.

☞ In SARA-R422S, SARA-R422M8S and SARA-R422M10S products, the use of the linger time may increase the time required to close the sockets which will be at a maximum equal to the linger time set.

A.2 Release Assistance Indication (RAI)

In case the device has no more data to transmit, the network waits for an inactivity period between the module and network before releasing the module from connected mode into idle mode. This period is configured for each network and can be different between networks. Some networks could have an inactivity period of just 2 s, and others up to 60 s. Nominally 5 s is used for LPWA IoT networks.

When the application has completed sending and receiving its data, it must wait for the network to release the connection to enter idle mode. To reduce this wait time, Release Assistance Indication (RAI) feature can be used to remove this wasted time and save power. This feature was introduced in 3GPP Release 13 for the Control Plane EPS optimization and Release 14 for the User Plane.

To use RAI the application must indicate no further uplink or downlink data transmission is expected via a flag in a supporting AT command.

☞ The RAI configuration is not supported by SARA-R5 "00B" product versions.

☞ The RAI feature can be used if the UDP protocol is adopted for communication. Currently, in u-blox modules it is supported for UDP internal socket and CoAP protocols. It can be configured with the following AT commands: +CSODCP, +USOSTF (where supported), and +UCOAP. For additional details on these AT commands and all the related configurations, see the AT commands manual [3], [7].

More details on the RAI feature are available in the low-power chapter of the application development guide [9].

B Glossary

Abbreviation	Definition
AEAD	Authenticated Encryption with Associated Data
AEC	Automotive Electronics Council
AES	Advanced Encryption Standard
APN	Access Point Name
ARIA	a block cipher technique
ARM	Arm (Advanced RISC Machines) Holdings
ASCII	American Standard Code for Information Interchange
BBR	Battery Backed RAM
BER	Bit Error Rate
CA	certification authority
CBC	Block ciphers
CHACHA20	A high-speed stream cipher
CID	Context Identifier
CoAP	Constrained Application Protocol
CPU	Central Processing Unit
CSD	Circuit-Switched Data
CUT	Coordinated Universal Time
DC	Direct Current
DCE	Data Circuit-terminating Equipment* / Data Communication Equipment*
DDC	Display Data Channel
DER	Distinguished Encoding Rules
DH or DHE	Diffie–Hellman
DL	Down Link (Reception)
DNS	Domain Name System
DRX	Discontinuous Reception
DSA	Digital Signature Algorithm
DTE	Data Terminal Equipment
DTLS	Datagram Transport Layer Security
ECDH	Elliptic-Curve Diffie–Hellman
ECDHE	Elliptic-Curve Diffie–Hellman
ECDSA	Elliptic-Curve Digital Signature Algorithm
ePCO	Extended Protocol Configuration Options
EPS	Evolved Packet System
FOTA	Firmware updates Over-The-Air
HKDF	HMAC-based Key Derivation Functions
HMAC	Hash-Based Message Authentication
ICMP	Internet Control Message Protocol
IoT	Internet of Things
LPWA	Low-Power Wide-Area
LPWAN	Low-Power Wide-Area Network
M2M	Machine to Machine
MAC	Message Authentication Code
MCU	MicroController Unit

Abbreviation	Definition
MNO	Mobile Network Operator
MTU	Maximum transmission unit
NAT	Network Address Translation
NVM	Non-Volatile Memory
PEM	Privacy-Enhanced Mail
PS	Packet switched
PSD	Packet-Switched Data
PSK	Pre-Shared Key
PSM	Power Saving Mode
RA	Router Advertisement
RAI	Release Assistance Indication
RAT	Radio Access Technologies
RFC	Request for Comments
RoT	Root of Trust
RS	Router Solicitation
RST	Reset (referred to a TCP reset packet)
RSA	Rivest-Shamir-Adleman
SAO	Socket Always On
SHA	Secure Hash Algorithm
SLAAC	StateLess Address AutoConfiguration
SNI	Server name indication
SSL	Secure Sockets Layer
TLS	Transport Layer Security
TTL	Time To Live
WAN	Wide Area Network

Table 2: Abbreviations and terms

Related documentation

[1] u-blox SARA-R5 series data sheet, UBX-19016638
[2] u-blox SARA-R5 series system integration manual, UBX-19041356
[3] u-blox SARA-R5 AT commands manual, UBX-19047455
[4] u-blox EVK-R5 user guide, UBX-19042592
[5] u-blox SARA-R4 series data sheet, UBX-16024152
[6] u-blox SARA-R4 series system integration manual, UBX-16029218
[7] u-blox SARA-R4 AT commands manual, UBX-17003787
[8] u-blox EVK-R4 user guide, UBX-16029216
[9] u-blox SARA-R5 application development guide, UBX-20009652
[10] u-blox LwM2M objects and commands application note, UBX-18068860
[11] u-blox SARA-R4 application development guide, UBX-20050829
[12] u-blox Multiplexer implementation application note, UBX-13001887
[13] u-blox services webpage, https://developer.thingstream.io/guides/security-services
[14] SARA-R5 FW update application note, UBX-20033314
[15] SARA-R4 FW update application note, UBX-17049154
[16] u-blox SARA-R4 / SARA-R5 series GNSS implementation application note, UBX-20012413
[17] RFC 768 - User Datagram Protocol (UDP)
[18] RFC 7252 - Constrained Application Protocol (CoAP)
[19] RFC 6347 - Datagram Transport Layer Security Version 1.2
[20] RFC 7959 - Block-Wise Transfers in the Constrained Application Protocol (CoAP)
[21] RFC 8323 - Constrained Application Protocol (CoAP) over TCP, TLS, and WebSockets
[22] RFC 5077 - Transport Layer Security (TLS) Session Resumption without Server-Side State
[23] u-blox test server configuration, UBX-14005690

☞ For product change notifications and regular updates of u-blox documentation, register on our website, www.u-blox.com.

Revision history

Revision	Date	Name	Comments
R01	26-Oct-2020	mreb	Initial release
R02	07-Apr-2021	mreb	Extended document applicability to SARA-R4 series modules
R03	16-Jul-2021	mreb	Bridge mode, port filtering feature and Release Assistance Indication description added
R04	04-Mar-2022	mreb	Updated document and added MQTT Flex description
R05	28-Sep-2022	mreb	Extended document applicability to SARA-R42 ”01B” product versions

Contact

For further support and contact information, visit us at www.u-blox.com/support.