

C-V2X IPv6 Transaction Support via Global IP Address

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1 Introduction

Qualcomm C-V2X chips support wireless sidelink global IPv6 (IP version 6) traffic concurrent with other non-IP V2V safety messages. In region where IEEE 1609.3 is used, sidelink Transmission Control Protocol (TCP) IPv6 connections can be useful for brief data transfer sessions between vehicles and networked application servers that are connected via roadside units (RSUs).

Example use cases include:

- The use cases defined by the following SAE application standards:
 - J2945/3: Requirements for Road Weather Applications
 - J2945/C: Traffic Probe Use and Operations
- Security Credential Management System (SCMS) exchanges

Global IPv6 addressing is fully supported by C-V2X IEEE1609.3 radio profile. Newer Qualcomm modem software and Telematics SDK features provide all the API's needed for both OBU and RSU implementations of such IPV6 Global Sessions.

A "Reference ITS Stack" as part of the Telematics SDK demonstrates how to build the WRA on the RSU, and how the OBU needs to enable generic IPV6 internet access through the RSU. Device developers can find detailed technical documentation and open-source samples for how to implement it on Qualcomm Developer Network website. These techniques allow ITS OBU TCP applications to connect through a RSU to application servers. Refer to Appendix A for the reference code and Section 1.2 for feature support on Qualcomm products.

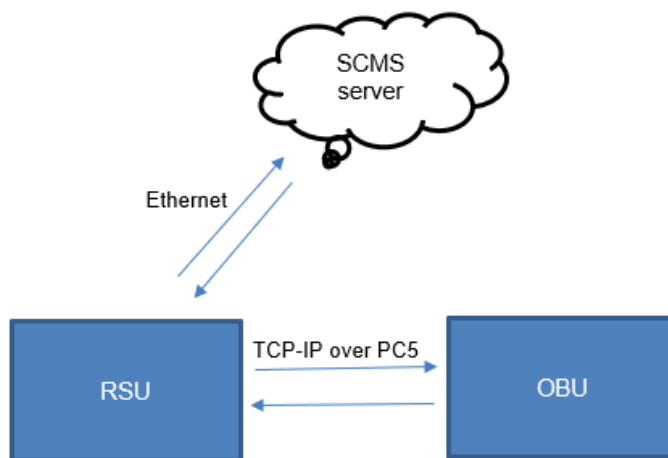


Figure 1-1 TCP over C-V2X transmission between OBU, RSU and SCMS server

TCP sessions are first considered by OBU's ITS stack upon reception of IEEE1609.3 WAVE Service Advertisements, which include a WAVE Router Advertisement (WRA). The WRA allows OBUs to discover RSU's IP configurations as they come into wireless range. When supported by OBU and RSU, global addressing allows OBUs to receive a single WRA, then configure their own IPv6 address and reach the application server. It is like Wi-Fi access point's SSID beacon, but combined with DHCP server, secured with a strong IEEE1609.2 signature, and only require a single broadcast message.

1.1 Conventions

Function declarations, function names, type declarations, attributes, and code samples appear in a different font, for example, `cp armcc armcpp`.

Code variables appear in angle brackets, for example, <number>. Commands to be entered appear in a different font, for example, `copy a:*. * b:`.

Button and key names appear in bold font, for example, click **Save** or press **Enter**.

1.2 Technical assistance

For assistance or clarification on information in this document, open a technical support case at <https://support.qualcomm.com>.

You will need to register for a Qualcomm ID account and your company must have support enabled to access our Case system.

Other systems and support resources are listed on <https://qualcomm.com/support>.

If you need further assistance, you can send an email to qualcomm.support@qti.qualcomm.com.

2 Adding Global IP support ITS products for internet application

IPv6 sessions between OBU/RSU are discovered as possible via RSU's periodic WRA (WAVE Router Advertisement) broadcasts. The WRA includes global IPv6 address prefix, DNS (Domain Name System) server, and everything an OBU needs to immediately reach internet or application servers beyond the Roadside unit, over V2X radio.

The OBU receives the WRA message, configure its IPv6 address based on the prefix specified in WRA.

the IEEE 1609.3 WRA, is just a special WAVE Service Announcement (WSA), which also includes PSID and the internet IPv6 address/port number to of each application available through a particular RSU. OBU can use this information, to decide whether, when and with what IPv6 server to initiate TCP session.

2.1 Detailed steps for OBU and RSU product ITS stacks

The following section summarizes the detail steps for configuring global IPv6 address for OBU/RSU products and ITS stacks.

2.1.1 ITS application implementation in the onboard unit

The table below captures the steps to implement IP connection on an OBU using Global IPv6.

Table 2-1 OBU Global IP address configuration steps

Typical IEEE 1609.3 Global IPV6 OBU Steps
1. Disable TimerT5000 L2 SRC randomizing or set to 65535 (see Section 2.3.1)
2. Set-up a receiving subscription for any non-IP IEEE1609.3 WSA+WRA broadcasts, with a PSID that is expected for your application's TCP connection.
3. Use IEEE 1609.2 security services (Aerolink) verify the signature of the WSA is authentic and properly signed with a certificate chain that is trusted.
4. Select the appropriate RSU, based on WSA parameters such as distance and signal quality.
5. Set-up a transmit one-shot flow with the traffic class and priority specified in SAE J3161/0 Deployment Profiles (For Qualcomm Telematics SDK solutions, this means linking to a specific Source port #). In Qualcomm Global IPV6 system software, this has a special catch-all Source port, #0, that will be used for all TCP transmissions.
6. As the application/security services determine the need an Internet connection
a. If WSA included limitations on the distance, speed, congestion at which to attempt the specific application, wait for those conditions to be met.
b. Suspend any BSM (Basic Safety Message) periodic BSM pseudonym randomization, during session.

Typical IEEE 1609.3 Global IPv6 OBU Steps
c. Set up the IPv6 networking for use with a specific RSU, based on WRA parameters: <ul style="list-style-type: none"> – the IPV6 Global address prefix via TelSDK – the DNS servers that may be used – optionally the RSU IP as the default Gateway/router
d. Initiate TCP connection to the server. Ensure the traffic-class is set per SAE J3161, for all packets to ensure selection of Per-packet Pro-se Priority (PPPP) 8
e. Set-up TLS (Transport Layer Security) session between OBU and SCMS server.
f. Exchange TCP data (upload or download),
g. Close socket, resuming pseudonym change logic

2.1.2 ITS application implementation in the roadside unit

The table below captures the steps to implement IP connection on an RSU using Global IP.

Table 2-2 RSU Global IPv6 address configuration steps

RSU Typical IEEE 1609.3 Global IPv6 Steps
1. Ensure that the RSU TimerT5000 is disabled or set to large timeout to prevent extraneous L2 randomizations.
2. Make sure Firewalls are enabled to allow OBU's to accept expected incoming ports/source addresses on the C-V2X interface, and that RSU can reach expected internet application servers.
3. Use the Qualcomm Telematics SDK library to set the IPV6 global prefix to be used for the RSU's C-V2X Links
4. Pre-configure C-V2X one-shot/ad-hoc event flow for the RSU to OBU transmissions, per SAE J3161 parameters, using the special port #0 (Qualcomm implementation specific) to catch all IP6 c-v2x transmissions. Per-Packet Pro-se Priority (PPPP) must be set to 8, per standard.
5. Ensure IP6 route from C-V2X radio to internet is configured in the operating system.
6. Build/Update the RSU's WSA with its WRA containing C-V2X interfaces IP address and port number for each PSID/internet server supported. Include in the WSA the Location2D and parameters about when IP traffic is allowed.
7. Use Aerolink and required certificates on a certified HSM to sign the WSA.
8. Begin broadcasting of the WSA periodically.
9. Monitor L2 SRC address for any changes, which will trigger rebuilding of WRA. (even though disabled, collisions can trigger)

2.2 Telematics SDK APIs that are related to Global IP over C-V2X

The following table summarizes the telematics SDK APIs that are related to configure the Global IP over C-V2X for both RSU and OBU.

Table 2-3 Telematics SDK APIs for Global IPv6 address configuration on C-V2X

API name	Purpose
<pre>virtual telux::common::Status telux::cv2x::ICv2xRadio::setGlobalIPInfo (const IPv6AddrType & ipv6Addr, common::ResponseCallback cb)</pre>	<p>RSU: This function needs to be called before WSA message is going to be broadcasted.</p> <p>OBU: This function needs to be called after received WSA message from RSU that contains the IP prefix</p>

API name	Purpose
virtual telux::common::Status telux::cv2x::ICv2xRadio::setGlobalIPUnicastRoutingInfo(const GlobalIPUnicastRoutingInfo & destL2Addr, common::ResponseCallback cb)	This function is used by OBU only . After receiving WSA from RSU, and after IP address has been set by setGlobalIPInfo() API. OBU needs to obtain RSU's L2 address and call this API to setup the routing information on OBU.
virtual telux::common::Status telux::cv2x::ICv2xRadio::createCv2xTcpSocket(const EventFlowInfo &eventInfo, const SocketInfo &sockInfo, CreateTcpSocketCallback cb)	This is for both RSU and OBU, before initiating any TCP connection, this function needs to be called to create a special "catch-all" flow for TCP traffic. The parameter "sockinfo" should have following values: Sockinfo.serviceId: any service ID that is not currently being used. Sockinfo.localPort = 0 Sockinfo.isUnicast = true

2.3 Additional notes for Global IP for internet application

Qualcomm's specific instructions for how implementor of OBU or RSU can deploy C-V2X IP solutions. These IP connections could be to internet servers beyond the RSU, private servers in the RSU's private WAN, or the RSU itself.

2.3.1 Connection management due to IP address change

As per IEEE1609.3, IPv6 addresses are derived from the random 3-byte L2 SRC address. Because of this, for TCP it is important to suppress unnecessary L2 changes, such as those might originate in the radio, unrelated to pseudonym changes. It is suggested to disable any periodic L2 SRC address changes during OBU/RSU TCP sessions. This applies to both OBU and RSU, supporting Global IPV6 addressing as well as those supporting link-local addressing.

The periodic V2X source L2 address update breaks the TCP connection between the OBU and RSU via PC5 with the 3GPP TimerT5000 parameter number of seconds after which a OBU needs to pick a new random L2 SRC Address, if it has not already been randomized via other mechanisms (such as the SAE J2945/1 or ETSI-ITS policy for pseudonym changes).

For testing purposes, to extend the L2 address update interval for a longer duration, the parameter TimerT5000 can be set to maximum of 65535 seconds.

In v2x.xml, modify the <TimerT5000> parameter value to the intended timer value.

```
<PrivacyConfig>
<TimerT5000>65535</TimerT5000>
</PrivacyConfig>
```

On Qualcomm implementations, Application Programmable Interfaces (APIs) and command tools are available to update this 3GPP "manage object" XML configuration. For example, the C-V2X config command to reload the updated v2x.xml file is.

```
cv2x-config --update-config-file <file_path>
```

2.3.2 Ensure the TCP traffic has PPPP value of 8

When running TCP over C-V2X, the TCP traffic and other critical V2X traffics (BSM and so on) share the same radio resource, therefore, it's important to assign the TCP traffic with lowest priority, this is achieved by setting the flow associated with the TCP traffic to have pppp value of 8. Setting the pppp level is done by setting the `TC` field of the IPv6 header to 8, however, the modem automatically assigns the PPPP level if the flow is associated with TCP, so user does not need to do anything special.

2.3.3 Improve the TCP throughput performance

Cv2x is designed largely to handle the periodic transmission of V2X/V2I messages, However, the TCP traffic could be very irregular and bursty, this could lead to some amount of transmit packet drop due to the radio resource starvation when handling the irregular and bursting TCP packets, which could lead to lowered TCP throughput performance. One way to optimize the performance is to use Linux traffic control utility(tc) to limit the bandwidth and burst, such that the packets will be delivered to modem in more controlled fashion, reduce the packet drop and increase the performance. Another way is to use Larger MTU size. Developer needs to performance experiments to identify what's the best approach to obtain the best performance, what would be the ideal MTU size, and what `tc` parameters give the best throughput. The following is an example `tc` command that could be used to achieve optimization:

```
tc qdisc add dev rmnet_data15 root tbf rate 310kbit burst 3k latency 500ms  
peakrate 320kbit mtu 1500
```

In above command, `tc` is used to enforce that average rate for the TCP is 310K bit/sec, and maximum burst is 3K with latency 500ms and peakrate is very close to average rate, to reduce the burstness. Developer needs to:

1. Analyze theoretical maximum throughput the modem can achieve, by looking at the MCS scheme, MTU size
2. Experiment with different parameter values (rate, burst, latency, peakrate) to find out the best performance.

3 Test configuration

The following figure shows a test configuration/topology that can be used to verify this feature.

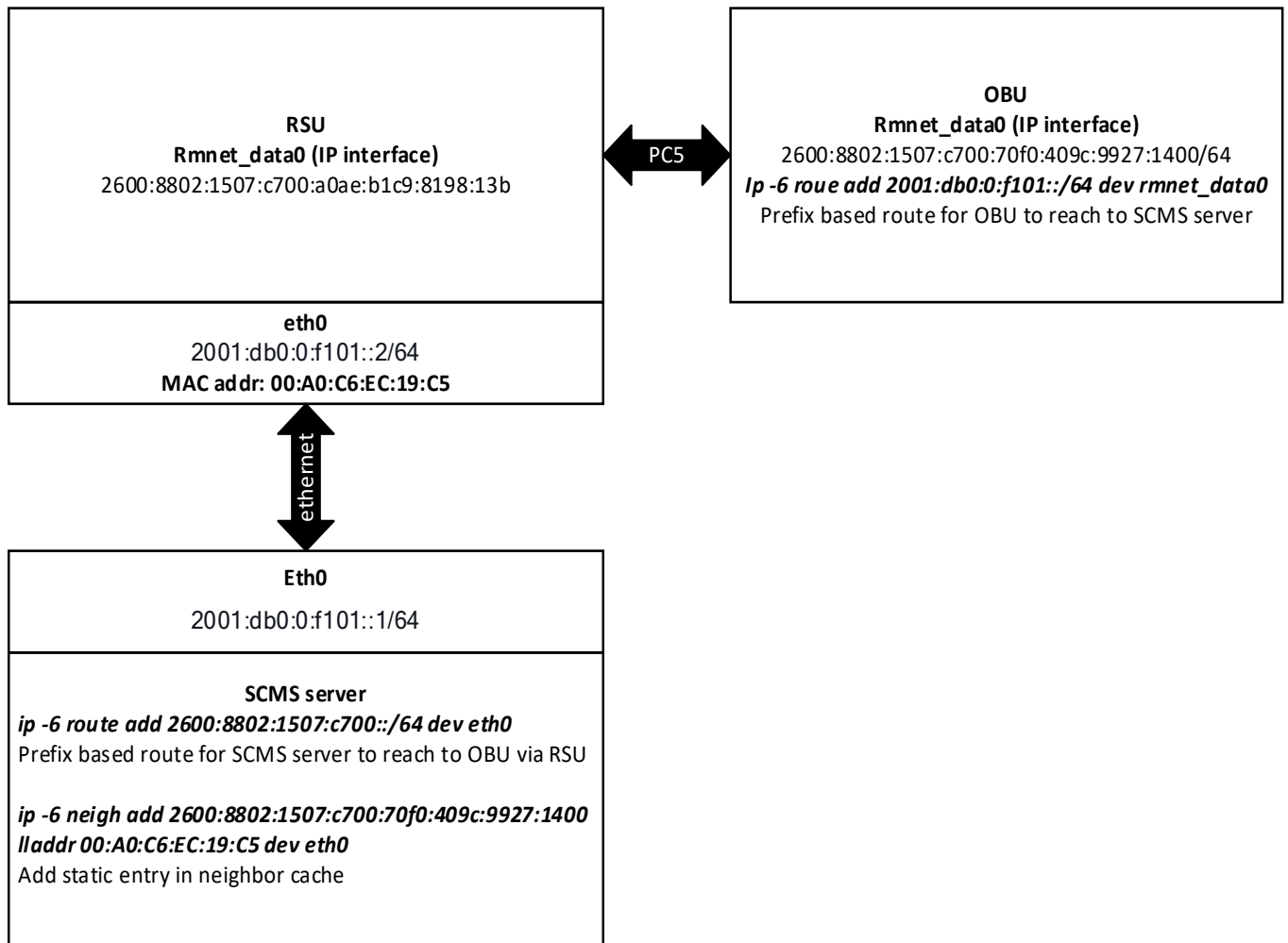


Figure 3-1 Test configuration

In [Figure 3-1](#), it's assumed that the OBU will be trying to communicate with a "SCMS" server that is connected to RSU via ethernet, The "SCMS" server is assumed to be Linux-based. All IPv6 address and routing configuration(including command line) are shown in the picture as example. To test/simulate TCP transaction, the standard "iperf3" tool can be used as follows:

- On SCMS server side, start iperf3 server with the following command.

```
iperf3 -s -B 2001:db0:f101::1
```

- After iperf server started, start the iperf client on OBU with the following command.

```
iperf3 -c 2001:db0:f101::1 -S 0x8 -t 30
```

You should see the iperf client connected to the server, and reporting bandwidth periodically, after the test finish (30 seconds), iperf print out the total data transferred and average bandwidth for this test.

A References

A.1 Reference documents and websites

Table A-1 Reference documents and websites

External websites
Reference code https://source.codeaurora.org/quic/le/platform/vendor/qcom-opensource/snaptel-sdk/tree/apps/reference/rits?h=telsdk.lnx.2.0.c18

A.2 Acronyms and terms

Table A-2 Acronyms and terms

Acronym or term	Definition
OBU	On Board Unit
SCMS	Security Credential Management System
RSU	Roadside Unit
WSA	WAVE Service Advertisement
WRA	WAVE Routing Advertisement
WAVE	Wireless Access in Vehicular Environments