Savari

STREETWAVE™ User Guide

Release 5.7
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Regulatory Compliance

IMPORTANT NOTE: FCC Compliance statement

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Any changes or modifications made to this device that are not expressly approved by Savari, Inc. may void the user's authority to operate the equipment.

IMPORTANT NOTE: FCC RF exposure statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must be at least 20 cm from the user and must not be co-located or operating in conjunction with any other antenna or transmitter.

The information in this guide may change without notice. The manufacturer assumes no responsibility for any errors that may appear in this guide.

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REVISION HISTORY

Sl No	Date	Chapter	Description	Version
1	30-05-2017	5.5, 5.6	Added supported services with screenshots	
2	30-06-2017	3.1, 3.4	Added FCC power limits and dimensions	1.5
3	17-10-2017	3.1	Updated section 3.1	1.6

1 Introduction

RSU2 is the next generation Road-side Unit (RSU) developed by Savari Inc. primarily for the USDOT (United States Department of Transportation) Connected Vehicles program. It is the latest addition to the StreetWAVE™ family of products. It is capable of transmitting signed or unsigned MAP Data message, Signal Phase and Immediate Forward message, Store and Repeat, and providing IPv6 connectivity to OBUs over a dedicated short-range communications (DSRC) 5.9 Gigahertz (GHz) wireless networks using the following protocol stack and other standards associated with DSRC for vehicular communications:

- IEEE 802.11p
- IEEE 1609-1 through 1609-4
- J2735 (2016 version)
- USDOT RSU 4.1 specification

StreetWAVE™ has a provisioning/test interface that can receive and load new versions of software, new configurations and credentials, and instructions to perform logging functions and download log messages to an external device. This device can be mounted on different roadside locations (E.g.: traffic pole)

2 Abbreviations

The following are the abbreviations used throughout this document:

Abbreviation	Expansion
ASN1	Abstract Syntax Notation 1
CA	Certificate Authority
CSV	Comma Separated Value
DHCP	Dynamic Host Control Protocol
DNS	Dynamic Naming Service
DSRC	Dedicated Short Range Communication
GID	Geometric Intersection Description
GPS	Global Positioning Satellite
HTTP	Hypertext Transfer Protocol
ITS	Intelligent Transportation Systems
ITIS	International Traveler Information Systems
IP	Internet Protocol
LED	Light Emitting Device
LTM	Left Turn Movement
MAP	Map Data
MIB	Management Information Base
NTCIP	National Transportation Communications for ITS Protocol
OBU/OBE	On-Board Equipment/On-Board Unit
PCAP	Packet Capture
PSID	Provider Service Identifier
RDNSS	Recursive DNS Server
RFC	Request for Comments
RSE/RSU	Roadside Equipment/Roadside Unit
RNDF	Route Network Definition File
RTM	Right Turn Movement
RX	Receive
SAE	Society for Automotive Engineers
SSH	Secure Shell
SPaT	Signal Phase and Timing
SNMP	Simple Network Management Protocol
TC	Traffic Controller
TCID	Traffic Controller Interface Device
TCP	Transmission Control Protocol
TM	Through Movement
TIM	Traveler Information Message
TX	Transmit
UDP	User Datagram Protocol
WAVE	Wireless Access in Vehicular Environments
WSA	WAVE Service Announcement

3 Setup Guide

Please refer to the ***StreetWAVE™ Installation Guide*** for more details on the StreetWAVE™ hardware components and installation procedures.

3.1 Hardware and Software Specifications

Item	Description
Mechanical	22 cm (L), 22 cm (W), 12 cm (H), 2 kg (weight)
Processor	1 GHz dual core i.MX6
Memory	Up to 4GB DDR3 DRAM
Storage	Up to 32GB µSD Flash 2-8GB eMMC
DSRC Radio	Two IEEE 802.11p 5GHz, 600mW, -94dB receiver sensitivity
GPS	U-blox. Tracking sensitivity -160 dBm
Secure Flash	Infineon HSM SLI97
Ethernet	10/100 RJ-45 ports with Auto Uplink.
Power Supply	5V-30V DC Input for RSU2
Temperature	-40C to +85C
Standards Compliance	IEEE 802.11p, IEEE 1609.2, IEEE 1609.3, IEEE 1609.4, SAE J2735 (2016)
Security	SSL, Firewall, 1609.2, HSM
RF Antenna Connectors	SMB Male FAKRA. Type C Blue GPS, Type Z Light Green DSRC0, Type Z Light Green DSRC1.
Power Consumption	• Nominal < 5W • Recommended Power supply 10W
LED	Indicators for power, status and diagnostics

3.2 Power

StreetWAVE™ can be powered by using 48V DC Power Over Ethernet (POE)
(**CAUTION:** Use POE injector/adapters supplied with StreetWAVE™ only**)**

3.3 GPS

StreetWAVE™ comes with an internal GPS that can provide the following:

- 1 Hz update rate
- Location accuracy of 2 m with WAAS (2.5 m without WAAS)

Note: WAAS is enabled by default.

3.4 DSRC Radios

DSRC radios support 802.11p in the hardware and transmit power capabilities of up to 19 dBm e.i.r.p. (up to 10 dBm conducted output power per DSRC Class B). The range of these radios is 450-500m and can be adjusted using TX power setting.

3.5 Antennas

StreetWAVE™ ships with the following antennas that directly mount to the main unit:

- Two 5 GHz DSRC Omni-directional
- One magnetic GPS

3.6 Storage

StreetWAVE™ has 4GB of integrated compact flash memory.

Note: StreetWAVE™ supports utilities like ssh and scp to make it easier for retrieving the log data to an external platform and perform post analysis.

3.7 LED

StreetWAVE™ unit is installed with three LEDs on the panel to indicate power and device operation state.

3.8 Ethernet

StreetWAVE™ consists of one Ethernet port (eth0) on the panel.

3.9 Enclosure

StreetWAVE™ enclosure is IP67 rated outdoor quality unit.

4 StreetWAVE™ Features

This chapter explains the salient features of the StreetWAVE™ roadside equipment.

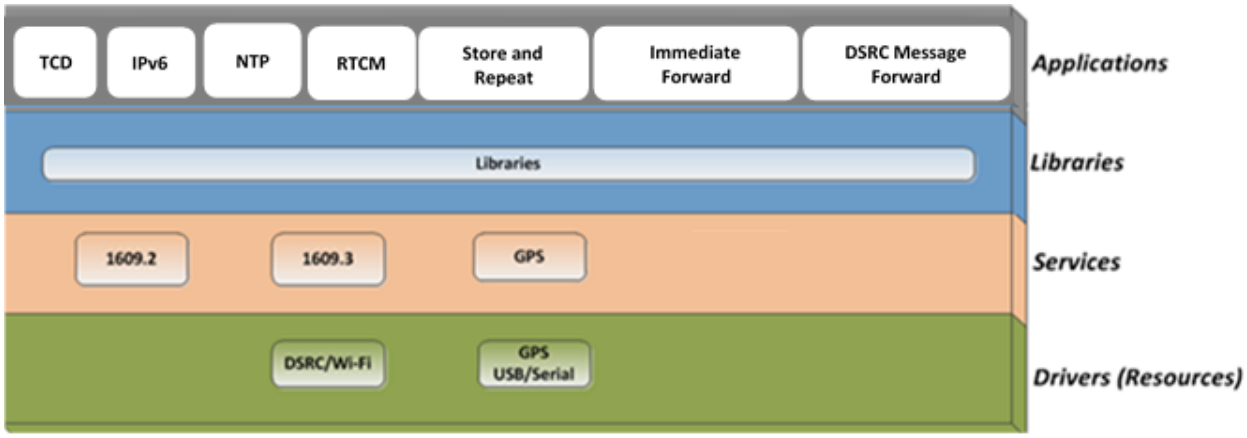

Figure 1: StreetWAVE Software Architecture Diagram

StreetWAVE™ features are explained briefly in the following sub-sections:

4.1 DSRC Radio Pair

Each StreetWAVE™ unit consists of two (2) integrated high power DSRC radios, which are exposed as the following two interfaces:

- **Radio 1**
- **Radio 2**

StreetWAVE™ radio configuration is very flexible. Any or both radios can be configured on any of the following channel modes:

- Alternating Channel Access
- Continuous Channel Access

The following applications can be configured to use any of the two interfaces (Radio1 or Radio2):

- Immediate Forward
- Store and Repeat
- IPv6-provider
- DSRC Message Forward
- TCD

- RTCM
- NTP

However, radio configuration between the above-mentioned applications should be consistent. You can operate multiple StreetWAVE™ units in a hub-and-spoke configuration in which the hub unit originates a message. It broadcasts those messages on its configured DSRC interface to OBUs as well as on Ethernet interface to the spoke StreetWAVE™ units in Savari 's proprietary format. The spoke StreetWAVE™ units receive them and broadcast them on their DSRC interfaces, essentially working as DSRC repeaters. This configuration is useful at an intersection where no specific location has line of sight to all approaches to the intersection. The Hub unit does not have to be in the traffic controller cabinet. It can be one of the units on the pole if it has Ethernet connectivity to the cabinet.

4.2 IPv4 and IPv6 Networking

Each StreetWAVE™ unit consists of one Ethernet interface (eth0). StreetWAVE™ provides support for both IPv4 and IPv6 networking on all its interfaces (eth0, Radio 1, or Radio 2).

You can enable the following on all the three available interfaces:

- IPv4 and IPv6 addresses
- IPv6 Router Advertisements

StreetWAVE™ can forward both IPv4 and IPv6 packets between its interfaces (Ethernet and DSRC) acting as a router. It also supports both IPv4 and IPv6 firewalls allowing the following:

- Source and destination IPv4 or IPv6 addresses
- Port-based rules

4.3 Immediate Forward

StreetWAVE™ Immediate Forward application supports the forwarding feature in addition to the following features.

4.3.1 UDP Listener

StreetWAVE™ Immediate Forward application listens on configured UDP ports. If any message is received on these ports in the format specified in ***USDOT RSE requirements,*** it will sign the message using the 1609.2 protocol, if specified in the incoming message, and immediately transmits on the configured DSRC interface with the PSID and channel specified in the incoming message. Incoming messages could specify different priorities but it must specify the same transmit mode (TxMode) and transmit channel (TxChannel). This feature is used when an

intermediate device (TCID or a Battelle device) is sending periodic Immediate Forward messages to a StreetWAVE™.

4.3.2 UDP Streaming

The StreetWAVE™ can be configured to receive data from other StreetWAVE™ and stream it over DSRC. This allows the StreetWAVE™ to function as a repeater. In this setup, one StreetWAVE™ is configured as the Hub unit and all other StreetWAVE™ that are connected to it as Spoke units (that are not capable of independently transmitting Store and Repeat, Immediate Forward etc. and are depending on the Hub to provide this data). The Hub transmits the data over the air as well as to the Spoke unit typically over an Ethernet link. The Spoke unit, upon reception of the Hub's packet, decodes and applies rules that are present in the packet, signs (if it is present in the packet) and forwards the packet over DSRC. The ability of the StreetWAVE™ to function in this manner can be used for streaming the packet data (in Savari proprietary format) from TMCs or back-end servers over the air. This arrangement could be useful in scenarios where a single StreetWAVE™ may not provide ample coverage for the geographic area of interest.

4.4 Store and Repeat

StreetWAVE™ supports transmission of Store and Repeat. The Store and Repeat application, which runs on the StreetWAVE™ unit, transmits on the configured channel over the Radio 1 (default configuration) interface.

Store and Repeat are configured in a data store inside the StreetWAVE™. The data store supports up to 100 Store and Repeat. The Store and Repeat are stored in the form of Active message files. Each file contains the transmissions parameters and the actual data of the Store and Repeat message. Each Store and Repeat message can be scheduled differently. The active message files follow the USDOT RSE 4.1 Specification.

4.4.1 Active Store and Repeat Message Configuration

StreetWAVE™ supports the USDOT Active Message Configuration file format for configuring active Store and Repeat messages.

US DOT Active Message Configuration file format

This format is defined in section ***US DOT RSU 4.1 requirements***. Each Store and Repeat active message should be defined in a separate file.

4.5 1609.3 IPv6 Provider

StreetWAVE™ supports WSAs as per the 1609.3 protocol. If enabled, StreetWAVE™ switches channels on the configured interface between the following:

- 178 (control channel)
- Configured service channel.

StreetWAVE™ runs IPv6 traffic on a service channel in the configured service channel interval. Such IPv6 traffic is transparent to StreetWAVE™. It merely routes IPv6 traffic from/to DSRC interface from the Ethernet interface.

StreetWAVE™ announces this service availability using WSAs including Service Info and WRA elements. The Service Info element consists of PSID, channel information, and the service channel. WRAs consist of router IPv6 prefix, gateway address, and DNS addresses so that OBEs can configure their IPv6 addresses, default gateway, and DNS servers.

4.6 1609.2 Security

StreetWAVE™ supports 1609.2 Draft 9.3 security protocol. It supports signed Immediate Forward, and Store and Repeat messages and signed WSAs to announce IPv6 services. The security feature can be individually enabled or disabled on Immediate Forward, Store and Repeat, and IPv6 applications.

StreetWAVE™ ships with the following pre-generated certificates supplied by US DOT:

- One root certificate
- Five different message signing certificates
- One WSA signing certificate

The following security profile is used for signing Immediate Forward, and Store and Repeat messages:

Field	Value	Notes
include_generation_time	True	SPAT profile requires true
include_expiration_time	false	SPAT profile requires false
message_life_time	0	not used in SPAT
include_generation_location	True	SPAT profile requires false

MAP (Immediate Forward)

Field	Value	Notes
include_generation_time	True	MAP profile requires true
include_expiration_time	false	MAP profile requires false
message_life_time	0	not used in MAP
include_generation_location	false	MAP profile requires false

Store and Repeat

Field	Value	Notes
include_generation_time	true	TIM profile requires true
include_expiration_time	false	TIM profile requires false
message_life_time	0	not used in TIM
include_generation_location	false	MAP profile requires false

WSA

Field	Value	Notes
certificate_interval	1000	
include_generation_time	true	
include_generation_location	true	
include_expiration_time	true	
check_replays	true	
check_relevance_generation_time	true	
check_relevance_generation_location	true	
check_relevance_expiry_time	true	

4.7 Interface Logging

StreetWAVE™ supports logging all DSRC and IP messages transmitted and received in the PCAP format to the persistent memory. All packet activity on all interfaces are captured and logged in the PCAP format. The PCAP files can then be seen in Wireshark after file offload has transferred the PCAP files to a back-office server. In addition, the system-status log messages are logged to separate files. There is ~3GB of space set aside for this total logging.

A packet from an OBE can be received and logged potentially by all StreetWAVE™ units at an intersection. This independent logging feature provides the ability to analyze which unit is capable of hearing from which approach and from how far. However, it may require analysis of logs from multiple StreetWAVE™ units to track a single vehicle. Such an analysis can be performed using post-processing tools and is not the main function of StreetWAVE™. Hence, this independent logging trade-off is chosen over the complexity of integrated logging.

4.8 DSRC Message Forward

StreetWAVE™ supports the DSRC Message Forward feature as outlined in USDOT RSU 4.1 specification. This application provides the capability to forward any DSRC message received over the air to an external server over an ethernet link. The specification USDOT RSU 4.1 lists certain filter criteria that must be met for the messages to be forwarded. The DSRC Message Forward feature transparently forwards all messages if the filter criterion is successful. The application does not terminate the packet with regards to security or content.

5 StreetWAVE™ Getting Started Using the CLI

This section describes the procedures to get the StreetWAVE™ started after installation and power up.

5.1 Accessing Methods

The StreetWAVE™ can be accessed from any PC or laptop using any of the following modes:

- SSH

Note: Serial port access is not available in StreetWAVE™.

1. **To Access using SSH**

   ssh root@ <Default IP Address> -p<port number>
   port number is 51012

Password: As given in the ***Default Configuration (CLI)*** section.

5.2 Default Configuration (CLI)

The StreetWAVE™ has the following default configuration:

Username: root

Password: 1[8V:2<J5*W;2I16H1nu

Ethernet (eth0)

Default IPv4 Address: 192.168.100.1

DSRC radio 1 (Radio 1**)**: This radio is configured in channel switching mode with IPv6 support on service channel 174 and WSAs (with WRAs) on control channel 178. WSAs announce the same IPv6 which is configurable through CLI

DSRC radio 2 (Radio 2**)**: This radio is configured in the continuous channel mode for channel 172.

Immediate Forward: This application is configured to listen on UDP port *1516 for incoming Immediate Forward text format messages from TCID over eth0 and broadcast them over DSRC channel 172.

Firewall:

By default, only the following traffic is allowed. Rest of the traffic is blocked.

- Incoming UDP over IPv6 traffic on eth0 from *FD01:1234:0186:8000::/64* destined to StreetWAVE™ port 1516: Incoming IPv6 traffic from TCID to StreetWAVE™.
- Incoming UDP over IPv4 traffic on eth0 destined to StreetWAVE™ port 51013: Incoming

IPv4 traffic from TCID to StreetWAVE™.

- Incoming IPv4 and IPv6 inter StreetWAVE™ UDP streaming traffic on port 51015: Inter StreetWAVE™ UDP streaming traffic.
- Incoming TCP over IPv6 or IPv4 traffic on eth0 to ports 51012 (ssh, scp) and 8080(web) of StreetWAVE™: Management access.
- Incoming UDP over IPv6 or IPv4 traffic on eth0 to port 3334 of StreetWAVE:
- All ICMPv6 and ICMP (v4) packets: StreetWAVE™ learning neighbors and vice versa.
- All StreetWAVE™ originated outgoing traffic.

5.3 System State

StreetWAVE™ is in following two different states when powered on:

- Run: All applications (Store and Repeat, DSRC Message Forward, Immediate Forward, and IPv6) have started up.

  Note: The *run* command takes the system to run state.

- Standby: All applications (Store and Repeat, DSRC Message Forward, Immediate Forward, and IPv6) are shut down.

  Note: The *Standby command* takes the system to standby state.

StreetWAVE™ automatically enters to run state after it is powered on. To cycle system state, please use the *standby* command followed by the *run* command.

Caution: The system should be halted (“halt”) before turning off power. Else, the TX/RX packet logs and system log files in the “/nojournal/” directory might get corrupted.

5.4 Applications

This section explains the parameters/counters of individual applications. These counters get reset when the user places the StreetWAVE™ into a 'run' state from a corresponding standby.

```
StreetWAVE>> show app
store-repeat
immediate-forward
gpsoutput
radio
ipv6-provider
dsrc-message-forward
tcd
bsmforwd
wsmpforwd
ntpclient
rtcm
```

Figure 2: Supported Applications

5.4.1 Store and Repeat

```
StreetWAVE>> show app store-repeat all

 status                    = store-repeat is enabled
 streaming-mode            = Inter RSU UDP streaming is disabled
 streaming-port            = 51015
 streaming-ip              = FF02::1
 certificate-attachrate    = 500
 ssp-list                  =
```

Figure 3: Store and Repeat

5.4.2 Immediate Forward

```
StreetWAVE>> show app immediate-forward all

 status                    = immediate-forward app is enabled
 listenerport              = 1516
 streaming-mode            = Inter RSU UDP streaming is disabled
 streaming-port            = 51015
 streaming-ip              = FF02::1
 tcdlisten                 = TCD Socket is listening
 certificate-attachrate    = 500
```

Figure 4: Immediate Forward

5.4.3 GPS Output

The StreetWAVE™ unit shall send the GPGGA NMEA string to a specific UDP port at a specified rate, upon acquisition of 3 or more satellites.

The following parameters are displayed in the Gpsoutput app status command:

show app gpsoutput all

```
StreetWAVE>> show app gpsoutput all

 status                    = gpsoutput app is disabled
 port                      = 5115
 streaming-ip              = FF02::1
 output-interface          = eth0
 sample-rate               = 1
 gpsoutput-string          =
 gps-ref-latitude          = 129454010
 gps-ref-longitude         = -775859310
 gps-ref-elevation         = 30407
 maximum-deviation         = 8
```

Figure 5: GPS Output

5.4.4 Radio

We can configure both the radios (Radio 1 and Radio 2) service channel and channel mode either alternative or continuous.

The following parameters are displayed in the Radio config app status command:

```
StreetWAVE>> show app radio all

 radio0 name                  = ath0
 radio1 name                  = ath1
 radio1 chan_mode             = 1
 radio2 chan_mode             = 0
 radio1 cch                   = 178
 radio2 cch                   = 255
 radio1 svc                   = 174
 radio2 svc                   = 172
```

Figure 6: Radio

5.4.5 Ipv6 Provider

The following parameters and counters are displayed in the IPv6 Provider application

Parameter	Description
IpService Enabled	Displays if an IP service is enabled (1) or disabled (0).
Signing Enabled	Displays if WSA packet signing is enabled (1) or disabled (0).
Current Service Channel	The current service channel.
Wsa Tx Packet	Number of WSA packets transmitted to the DSRC radio.

- The following is an example of IPv6 Provider application in the “Running” state:

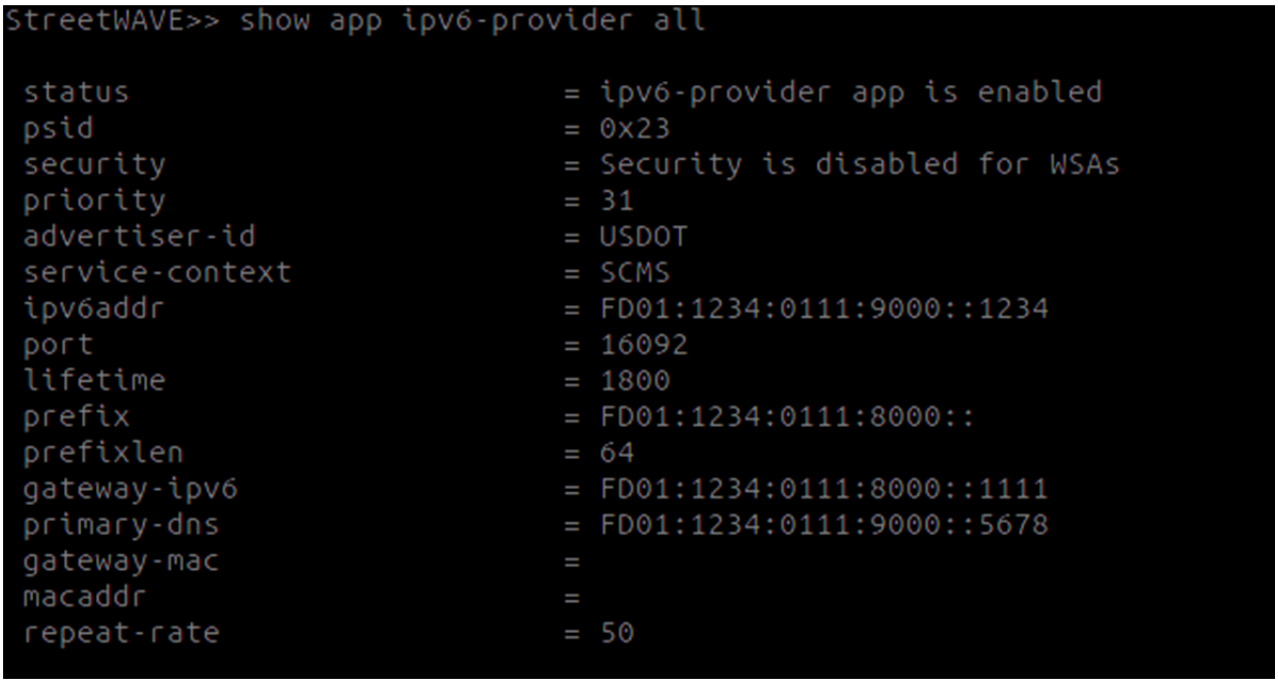

Figure 7: IPv6-provider

- >> show app ipv6-provider all

5.4.6 DSRC Message Forward

The following parameters and counters (per Radio 1 and Radio 2 interface) are displayed in the DSRC Message Forward application status:

Parameter	Description
PSID	psid of the incoming DSRC message
Rx	Number of packets received over the air
Tx	Number of packets forwarded
Drop	Number of packets dropped within the StreetWAVE™

The following is an example of Message Forward application in the “Running” state: The statistics are reported per “Radio 1” and “Radio 2” wireless interface.

```
StreetWAVE>> show app dsrc-message-forward all

 status                    = dsrc-messsage-forward app is disabled

 psid                      = 0xBFE0
 rssi                      = -75
 message-interval          = 1
 start-time                =
 stop-time                 =
 infusion-header           = prepending of infusion-header to the packet is disabled
 infusion-msgtype          = 0
 destination-protocol      = UDP
 destination-ip            = 2001:1890:110e:1111::a246
 destination-port          = 5567
 enabled                   = 1
```

Figure 8: DSRC Message Forward

5.4.7 TCD

```
StreetWAVE>> show app tcd all

 status                          = Tcd app is enabled
 mode                            = ntcip
 tc-ipaddr                       = 10.0.0.170
 tc-port                         = 501
 tc-type                         = econolite
 spat-tx-intvl                   = 100
 map-tx-intvl                    = 1000
 send-red-states                 = disabled
 mapfile                         = Sample_Map_Haggerty_12mile.xml
 broadcast-port                  = 6053
 spat-psid                       = 0xefffffff3
 spat-priority                   = 7
 spat-signature                  = False
 spat-encryption                 = False
 map-psid                        = 0xefffffff4
 map-priority                    = 7
 map-signature                   = False
 map-encryption                  = False
 transmit-enabled-lanes          = disabled
 certificate-optimisation        = enabled
 spat-certificate-attachrate     = 500
 map-certificate-attachrate      = 1000
```

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5.4.8 NTCP client

Here we configure the host name to get the time synchronization when the GPS fix is absent.

The following parameters are displayed in the NTP app status command:

```
StreetWAVE>> show app ntpclient hostname

hostname = 2401:4800:0:21::2
```

Figure 9: Ntpclient

5.4.9 RTCM

RTCM message used to get from the NOVATEL receiver on configured incoming IFM port.

The following parameters are displayed in the RTCM app status command:

```
StreetWAVE>> show app rtcm all

 status                    = rtcm app is disabled
 LocalPort                 = 1520
 PSID                      = 0x8000
 IfmPort                   = 1516
 preambleCRC               = remove preamble and CRC
 security                  = security is enabled
```

Figure 10: RTCM

5.5 System Status

The operating mode of the StreetWAVE™ is also displayed. The operating mode could be any of the following:

- Hub: Store and Repeat and Immediate Forward applications can be enabled in Hub mode. Any of the applications Store and Repeat, Immediate Forward, can also be individually configured in Hub mode.
- Spoke: In spoke mode, Spoke StreetWAVE™ will receive Store and Repeat and Immediate Forward messages from Hub StreetWAVE™.

Note: To revive Store and Repeat and Immediate Forward messages in Spoke StreetWAVE™ from the Hub StreetWAVE™, the applications have to be activated.

If configured in Hub or Spoke, the appropriate mode will be displayed as ‘enabled’. Both modes are mutually exclusive in that an StreetWAVE™ can either be Hub, Spoke, or in a streaming disabled mode (where neither Hub nor Spoke mode is enabled.).

5.5.1 Disk Usage

```
StreetWAVE>> show system disk-usage

Filesystem                Size      Used Available Use% Mounted on
rootfs                  189.5M     99.6M     86.0M  54% /
/dev/root               189.5M     99.6M     86.0M  54% /
tmpfs                   881.3M     60.0K    881.2M   0% /tmp
/dev/mmcblk0p3            3.3G      7.5M      3.1G   0% /nojournal
tmpfs                   512.0K         0    512.0K   0% /dev
```

The following command can be used to display the current disk usage

5.5.2 Memory Usage

```
StreetWAVE>> show system memory-usage

             total         used         free       shared      buffers
Mem:       1804856        67916      1736940           80          524
-/+ buffers:              67392      1737464
Swap:            0            0            0
```

The following command can be used to display the current memory usage.

5.5.3 CPU Usage

The following command can be used to display the current CPU usage for each process

```
StreetWAVE>> show system cpu-usage
08:12:48     CPU    %usr   %nice    %sys %iowait    %irq   %soft  %steal  %guest   %idle
08:12:49       0    3.26    0.00   21.74    0.00    0.00    6.52    0.00    0.00   68.48
```

5.5.4 Network

The following command can be used to display the ethernet configuration of the board

```
StreetWAVE>> show system network eth0 all

 proto          = static
 ipaddr         = 10.0.0.186
 macaddr        = 70:B3:D5:04:0F:A9
 netmask        = 255.255.255.0
 gateway        = 10.0.0.1
 ip6addr        =
 ip6gw          =
```

5.5.5 Firewall

StreetWAVE™ will be protected by the configured incoming firewall port.

The following parameters are displayed in the Firewall app status command for IPv4:

```
StreetWAVE>> show system firewall list ipv4

config rule 'udp_0_1516'
        option src 'lan'
        option proto 'udp'
        option dest_port '1516'
        option target 'ACCEPT'

config rule 'udp_0_6053'
        option src 'lan'
        option proto 'udp'
        option dest_port '6053'
        option target 'ACCEPT'

config rule 'udp_0_3334'
        option src 'lan'
        option proto 'udp'
        option dest_port '3334'
        option target 'ACCEPT'

config rule 'udp_0_16092'
        option src 'lan'
        option proto 'udp'
        option dest_port '16092'
        option target 'ACCEPT'

config rule 'udp_0_51015'
        option src 'lan'
        option proto 'udp'
        option dest_port '51015'
        option target 'ACCEPT'
```

The following parameters are displayed in the Firewall app status command for IPv6:

```
StreetWAVE>> show system firewall list ipv6

config rule 'udp_1_1516'
        option src 'lan'
        option proto 'udp'
        option dest_port '1516'
        option target 'ACCEPT'

config rule 'udp_1_6053'
        option src 'lan'
        option proto 'udp'
        option dest_port '6053'
        option target 'ACCEPT'

config rule 'udp_1_3334'
        option src 'lan'
        option proto 'udp'
        option dest_port '3334'
        option target 'ACCEPT'

config rule 'udp_1_16092'
        option src 'lan'
        option proto 'udp'
        option dest_port '16092'
        option target 'ACCEPT'

config rule 'udp_1_51015'
        option src 'lan'
        option proto 'udp'
        option dest_port '51015'
        option target 'ACCEPT'
```

5.5.6 Access Control List (ACL)

This Remote ACL configuration will allow the remote access based on the given IP addresses.

Allowed ACL can be displayed using the following command

```
StreetWAVE>> show system acl list all
IPv4  = 202.123.3.4

IPv6  = 2001::1
```

5.5.7 GPS Status

The GPS Fix status of the board can be displayed using the following show command:

```
StreetWAVE>> show system gpsstatus
3D fix (Lat: 12.945320, Lon: 77.586340, Elev: 915.70)
```

5.5.8 RSU Uptime

This section explains the system uptime of individual applications.

This shows the uptime of a specific application and the number of it gets restarted

(i) GPS

```
StreetWAVE>> show system rsu-uptime gpsd
up 2 days 19:10:09
restarted: 0 times
```

(ii) Service Manager

```
StreetWAVE>> show system rsu-uptime smgrd
up 2 days 19:10:25
restarted: 0 times
```

(iii) DSRC Message Forward

```
StreetWAVE>> show system rsu-uptime dsrc-message-forward
up 0 days 03:02:52
restarted: 0 times
```

(iv) Store-Repeat Applications

```
StreetWAVE>> show system rsu-uptime store-repeat
up 2 days 19:07:26
restarted: 0 times
```

(v) Immediate Forward Application

```
StreetWAVE>> show system rsu-uptime immediate-forward
up 2 days 19:07:38
restarted: 0 times
```

(vi) TCD applications

```
StreetWAVE>> show system rsu-uptime  tcd
up 2 days 19:08:26
restarted: 0 times
```

5.5.9 RSU Stats

The following parameters are displayed in the Store and Repeat app status command:

Parameter	Description
Tx Packet	Number of Store and Repeat Packets transmitted to the DSRC radio.
Udp Tx Packet	Number of Store - Repeat Packets transmitted over UDP streaming(Hub Spoke)
Signing Failures	Store and Repeat signing failure count.
Active List Files	Number of Store and Repeat active list files.
Transmit Channel	The DSRC channel on which Store and Repeat packets are transmitted.

```
StreetWAVE>> show system rsu-stats store-repeat
Status:
        Idle (Active StoreRepeatDB files are not present)
Stats:
        STORE-REPEAT:
                Tx Packet                : 0
                Udp Tx Packet            : 0
                Signing Failures         : 0
                Num Active List Files    : 0
                Transmit Channel         : 0
```

The above example displays the Store and Repeat application in ‘Idle’ state with no active list files present on the StreetWAVE™.

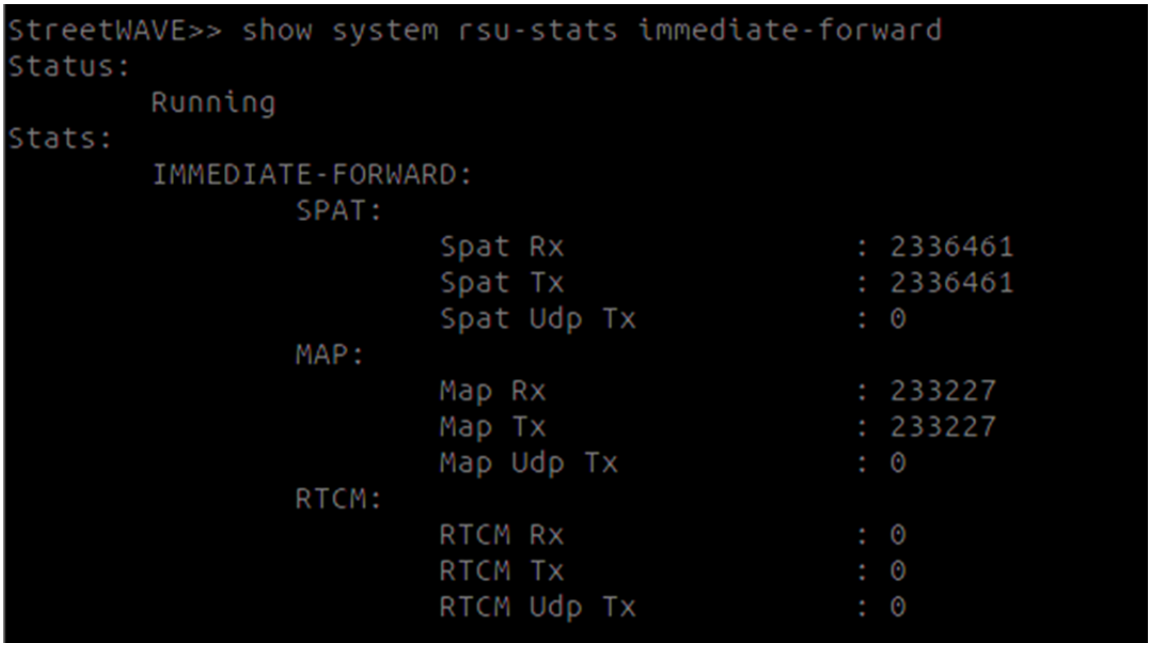
```
StreetWAVE>> show system rsu-stats store-repeat
Status:
        Running
Stats:
        STORE-REPEAT:
                Tx Packet                : 23350023
                Udp Tx Packet            : 0
                Signing Failures         : 0
                Num Active List Files    : 100
                Transmit Channel         : 174
```

The above example displays the Store and Repeat application in ‘Running’ state.

The following parameters and counters are displayed in the Immediate Forward status using the ***show rsu_stats immediate_forward*** command.

Immediate Forward:

Parameter	Description
Immediate Forward **Rx**	Number of Immediate Forward messages received from server.
Immediate Forward **Tx**	Number of Immediate Forward messages transmitted to the DSRC radio.
Immediate Forward **Udp Tx**	Number of Immediate Forward packets transmitted over UDP streaming.



Note: “Immediate Forward UDP Tx” is applicable when the StreetWAVE™ is configured as a “Hub” StreetWAVE™. It represents the Immediate Forward messages forwarded to the “Spoke” StreetWAVE™.

5.5.10 APP Stats

To know the status of the applications in RSU2

```
StreetWAVE>> show system app-status

             Enabled       Idle      Running          Not-Running
Service:
--------
SPAT           Y             _         Y                   _

MAP            Y             _         Y                   _

STORE-REPEAT   Y             _         Y                   _

WSA/IPV6       Y             Y         _                   _

DSRC-MSG-FORWD Y             Y         _                   _

RTCM           _             _         _                   Y

Oper Mode:
----------
IFM(MASTER)    N             _         _                   _

SRM(MASTER)    N             _         _                   _

IFM(SLAVE)     N             _         _                   _

SRM(SLAVE)     N             _         _                   _


-------------------------------------------------------------

Halt Last Executed On:   _

Run Last Executed On:    _
-------------------------------------------------------------
```

5.6 Visual Status Indicators

The following table displays the details about the LED status indicators:

LED Name	Indication	Description
“STS”	Off	The system is in “Standby” state or all applications (Store and Repeat, DSRC Message Forward Immediate Forward, and IPv6) are disabled.
	Green On	The system is in “run” state and at least one application (Store and Repeat, DSRC Message Forward, Immediate Forward, and IPv6) is enabled and functioning properly.
	Green Blinking	The system is in “run” state and at least one application is enabled and malfunctioning. Please check the system logs for details.
	Amber Blinking	System upgrade is initiated
“PWR”	On	The device is powered on.
	Off	The device is powered off.

6 Using the Command Line Interface (CLI)

6.1 Log File Handling

The following are the log file handling functions of StreetWAVE™:

6.1.1 Interface Logs

This is a repository for all the packets received and transmitted from all interface radio 1, radio 2 and Ethernet.

The StreetWAVE™ starts deleting the oldest log files (Interface log and Systemlogs) once the directory occupancy is 80% of the disk capacity.

6.1.2 Tx/Rx Packet Log File Name Format

TX/RX Packet log file names are in the following format:

<fileprefix>_<interface>_<out/in>_YYYY_MM_DD_HH_MM_SS.pcap, where

<fileprefix> is configured prefix

<interface> is eth/dsrc0/dsrc1

<out/in> is out for outgoing packets and in for incoming packets

YYYY_MM_DD_HH_MM_SS is the timestamp in UTC when the file was opened.

For example:

```
root@StreetWAVE:/nojournal/pcaplogs# pwd
/nojournal/pcaplogs
root@StreetWAVE:/nojournal/pcaplogs# ls -l
-rw-r--r--    1 root     root         42808 Jul 20 00:47
StreetWAVE_eth_out_2011_07_20_00_47_26.pcap
-rw-r--r--    1 root     root       1594308 Jul 20 01:01
StreetWAVE_dsrc0_in_2011_07_20_00_47_55.pcap
root@StreetWAVE:/nojournal/pcaplogs#
```

6.1.3 Retrieving the PCAP Files

The .pcap files can be retrieved only from StreetWAVE™ to any external device through SCP.

NOTE: Please use manual log file transfer when the system is in “standby” mode.

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6.1.4 Deleting the PCAP Files

Once pcap files are copied out of StreetWAVE™, it is advisable to delete them from StreetWAVE™. This helps to conserve disk space on the StreetWAVE™ for further TX Packet logging.

```
>> utils remove interface-log
<STRING:enter a file name to delete <maxlen:200>>

>> utils remove interface-log file_name
```

6.2 Network configuration

This is used to configure the IP addresses subnet and gateway for Ethernet and Radio1 and Radio2

6.2.1 IP Address configuration

When a IP address (ipv4/ipv6) is configured / reconfigured for an interface, corresponding gateway or gateway length should also be updated before committing the change.

```
>> config system network eth0 ip address
<STRING:Enter a Valid IPv4addr>

>> config system network eth0 ip address <Valid IPv4addr>
```

6.3 Firewall configuration

Firewall configuration requires separate rules for IPv4 and IPv6. Configuration files are separate for IPv4 and IPv6, but the format is same.

6.4 Immediate Forward

StreetWAVE™ Immediate Forward application requires the following two configurations:

- The main configuration file containing the UDP configuration.
- Incoming stream of messages as specified in ***US DOT RSE requirements***

UDP streaming configuration is not needed if only one StreetWAVE™ unit is used at a given intersection.

6.5 Store and Repeat

StreetWAVE™ Store and Repeat application requires the following two configurations:

- The main Configuration file contains ActiveDB path and UDP configuration.

- Store and Repeat active message configuration contains message scheduling parameters and message contents. (As per USDOT Req 4.1)

6.6 Sample Safety Pilot Deployment configuration

StreetWAVE™ radio configuration is very flexible. Any or both radios can be configured on any channel in channel switching or continuous mode. Any sub-system (Store and Repeat, Immediate Forward, and IPv6 provider) can be configured to use any of the two interfaces. However, channel mode, channel numbers, and DSRC radios between all sub-systems should be consistent on a given StreetWAVE™ unit.

The following is the recommended configuration:

- Store and Repeat and IPv6 run on Radio 1**,** channel-switching mode between control channel 178 and any service channel (except 172/178). Store and Repeat transmits on configured channel (182 default) in ActiveDB files and IPv6 runs on control channel.
- Immediate Forward, Immediate Forward, applications run on service channel 182 on Radio 2, which is in continuous channel mode.

One of the StreetWAVE™ units can be configured as a UDP streaming unit. This is called Hub StreetWAVE™. Other StreetWAVE™ units can be configured as stream receivers and are called spoke StreetWAVE™. However, if antennas are disconnected, these messages will not reach OBEs. The Hub unit can also be one of the units on the pole. In either case, it requires Ethernet connectivity to the cabinet. All spoke units also should have Ethernet connectivity to the cabinet.

A sample safety pilot multi-unit deployment configuration is illustrated in **Error! Reference source not found.** with salient configuration parameters. Only important parameters are shown below for illustration. Those parameters that are not shown here should be left at defaults for this configuration.

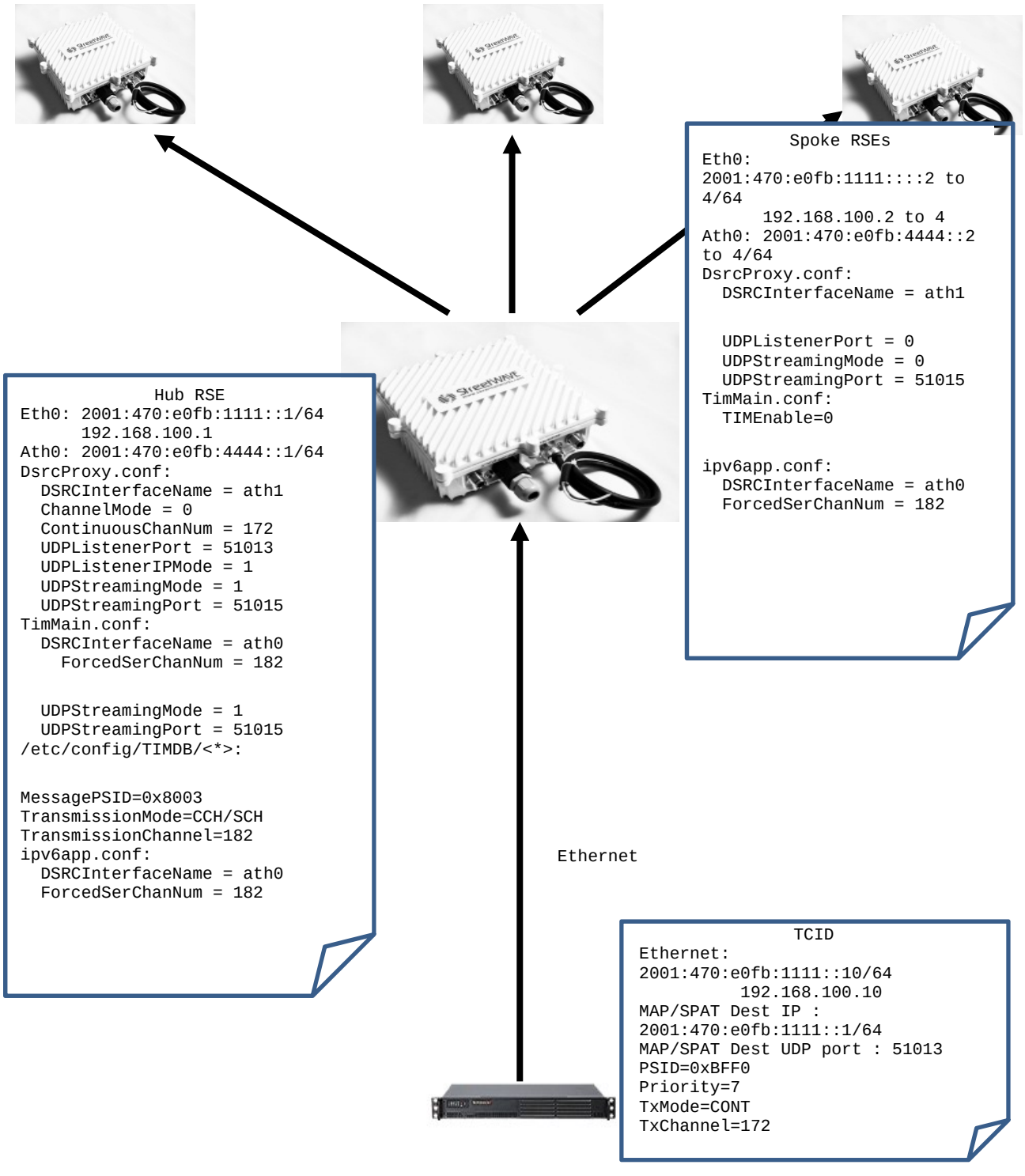

Figure 11: Safety Pilot Deployment

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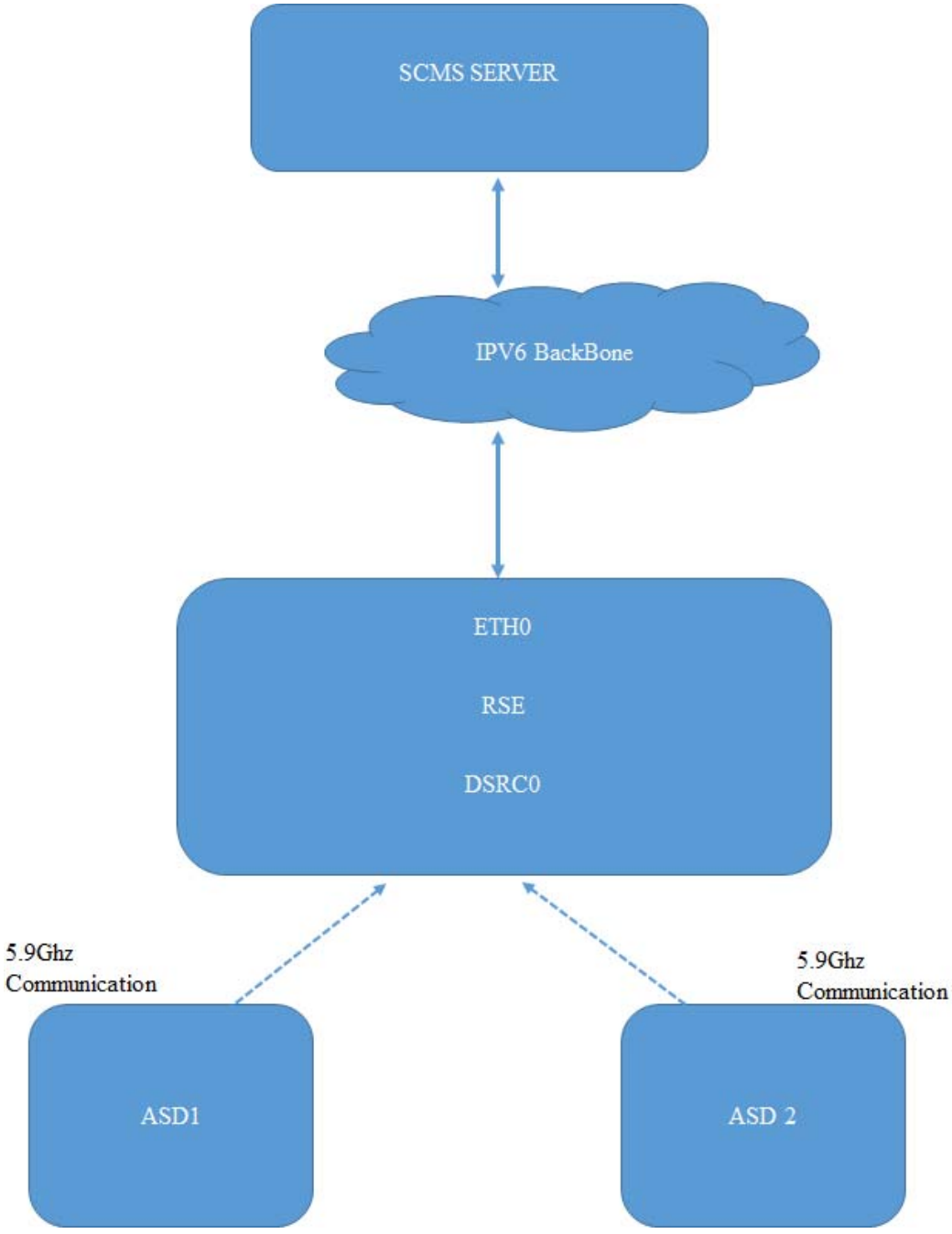
6.7 SCMS Server connection

This section explains connection between ASD to SCMS server through StreetWAVE™

6.7.1 High Level Architecture



ASD-SCMS Communication Establishment

The following paragraph explains the connection between ASD to StreetWAVE™ and StreetWAVE™ to SCMS server

a. StreetWAVE™ Broadcasts WSA with
    a. SCMS IPV6 Address
    b. SCMS Port
    c. Default Gateway which is DSRC IP of StreetWAVE™
    d. Prefix and Prefix Length which is in the same network as DSRC Interface Prefix
    e. Configured DNS IPV6 address
b. ASD receives these WSA. Generates IPV6 Address as per the prefix/prefix length announced.
c. Configures Default Gateway as per WSA. This is typically StreetWAVE™ DSRC IP address
d. Configures DNS received over WSA
e. ASD Tries to establish a communication with the Service IP and Service Port via StreetWAVE™. Service IP and Service Port are announced in the WSA and they are SCMS Server IP and Port
f. StreetWAVE™ will act as router for the traffic coming from ASD on DSRC Interface and Route all the traffic to the Ethernet Interface

6.7.2 StreetWAVE™ Configuration

For example

SCMS IP is 'fdca:39c0:a830::12' and SCMS Port is 8894
StreetWAVE™ Ethernet IP is 'fdca:39c0:a830::e6'

6.7.3 Configure LAN and DSRC IP addresses on StreetWAVE™

CLI command : config system network eth0 <parameter> < value>

Configure the parameters in the table for the above-mentioned file

Parameter	Value
config interface lan	
option ifname	'eth0'
option proto	'static
option ipaddr	'192.168.48.230'
option netmask	'255.255.248.0
option ip6addr1	'2001:100::1/64'
option ip6addr1	'fdca:39c0:a830::e6/48'
option ip6gw	'fdca:39c0:a830::6'
option ip6addr2	'2001:200::1/64'

option dns	'192.168.48.6'
option gateway	'192.168.48.1'

#DO NOT CHANGE THESE PARAMETERS FOR DSRCNET0

config system network radio1

config system network radio2

Parameter	Value
config interface dsrcnet0	
option ifname	'ath0
option proto	static
option ip6addr1	''fdca:39c0:a830:4444::1/64'
option ipaddr	'192.168.101.251'
option netmask	'255.255.255.0'

6.7.4 Configure Firewall Rules to Forward Packets from DSRC Interface to Ethernet Interface of StreetWAVE™

Configure the parameters mentioned in the following table for the above-mentioned file
this rule is to forward all traffic from OBUs on ath0 to CA on eth0

Parameter	Value	Description
config rule		
option src	dsrcnet0	ingress network dsrcnet0(ath0)
option src_ip	'fdca:39c0:a830:4444::/64	source IP6 address
option dest	lan	egress network lan(eth0)
option dest_ip	fdca:39c0:a830::/64	destination IP6 address
option proto		all
option dest_port	8894	If proto is set to tcp or udp, you can use dest_port.
option target	ACCEPT	

6.7.5 Configure IPV6App

>> config app ipv6-provider <parameter> <Value>

Parameter	Value	Range	Description
IPV6Enabled	1	0, 1	Enable/ Disable IPv6 sub-system
IPV6Priority	31	0, 63	IPv6 WSA priority
AdvertiserID			"CAMP"
ProviderServiceContext			"MBR"
IPV6Address	fdca:39c0:a830::12		SCMS IP
ServicePort	8894; 1024,65535		Service Port of SCMS
RouterLifeTime_s	1800	1,65535	
IPV6Prefix	'"fdca:39c0:a830:4444::";		PREFIX ANNOUNCED IN WSA

PrefixLen	48;	1,128	IPv6 prefix length to announce in WRA of WSA
DefaultGateway	'fdca:39c0:a830:4444::1		StreetWAVE™ DSRC IP
PrimaryDNS	fdca:39c0:a830::6		Primary DNS
GatewayMac			Gateway MAC address to announce in WRA
ProviderMacAddress			
WSARepeatRate	50	0, 255	Number of WSA to be transmitted per 5 secs

Consider the following to make sure the connections are secure

- Ping SCMS Server from StreetWAVE™ to ensure SCMS Server is accessible.
- Reboot the StreetWAVE™
- On Reboot, ASD Should be able to connect to StreetWAVE™.
- ASD Should get IP address in the domain 'fdca:39c0:a830:4444::
- ASD should also set its default Gateway as 'fdca:39c0:a830:4444::1.
- ASD should be able to ping StreetWAVE™ and SCMS.

6.7.6 Packet Logging Configuration

StreetWAVE™ generates per interface per direction packet log files as per configuration below. Log file names are in the following format:

- Ethernet interface outgoing : **<fileprefix>_eth_out_YYYY_MM_DD_HH_MM_SS.pcap**
- Ethernet interface incoming : **<fileprefix>_eth_in_YYYY_MM_DD_HH_MM_SS.pcap**
- DSRC0 interface outgoing : **<fileprefix>_dsrc0_out_YYYY_MM_DD_HH_MM_SS.pcap**
- DSRC0 interface incoming : **<fileprefix>_dsrc0_in_YYYY_MM_DD_HH_MM_SS.pcap**
- DSRC1 interface outgoing : **<fileprefix>_dsrc1_out_YYYY_MM_DD_HH_MM_SS.pcap**
- DSRC1 interface incoming : **<fileprefix>_dsrc1_in_YYYY_MM_DD_HH_MM_SS.pcap**

6.7.7 Copying the System Message Logs

You can also copy system message logs from "**/nojournal/Systemlogs**" to an external laptop in the same way as above. The system message log files are in text format and it can be opened in any normal text editor.

They have the following naming convention:

syslog_2017_05_25_12_17_51.txt

Procedure to copy the syslog from RSU to external laptop":

At CLI :

Utils copy src system-log:filename remote_username:scp://ipaddr:path/to/file

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7 Firmware Upgrade Procedure Using the CLI

This chapter contains procedure to upgrade firmware.

Use the following procedure to upgrade **(5.x to 5.x)** the STREETWAVE™ firmware using the CLI:

1. Connect a local PC to the STREETWAVE™ via Ethernet.
2. After connecting the Ethernet to STREETWAVE™, assign the IP address to the PC, in the same subnet of the STREETWAVE™.
3. Download the image to be upgraded from the Savari FTP site to the PC.
4. Login to the STREETWAVE™ from the PC using SSH with the following credentials:

   Login: root

   Password: 1[8V:2<J5*W;2I16H1nu
5. Copy the firmware image using the CLI command

   utils copy remote_username:scp://ipaddr:path/to/file.image image:file.image
6. After copying the file using the above command, verify the same using the below command.

   utils list rsu-image
7. Execute one of the following commands:

   utils rsu-upgrade -c < Firmware image name >

   Also, all configurations (including, network, and wireless) will be lost, and they may need to be configured again.

   utils rsu-upgrade -n < Firmware image name >

   (Where <Firmware image name> is the name of the firmware image that was copied in the **/tmp** folder.)

   When the **sysupgrade** *command is used with the* **-n** option, the STREETWAVE™ retains network (network, and wireless) configurations only.