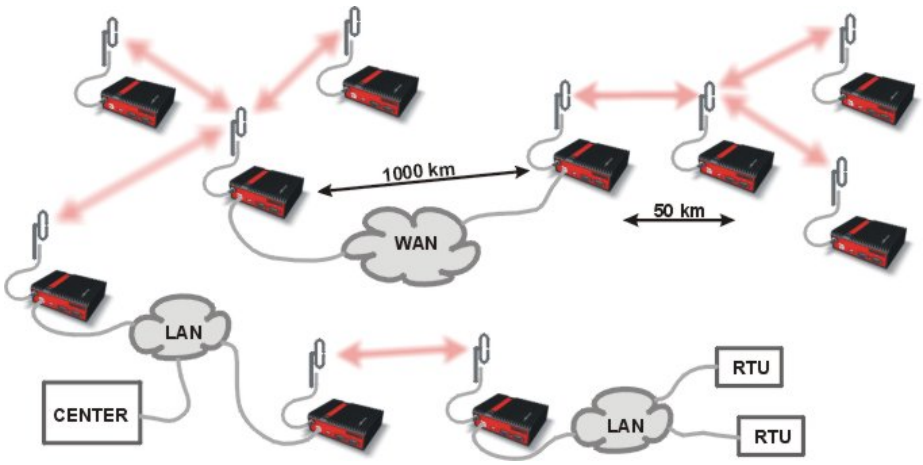
RACOM
RADIO DATA NETWORKS

Application notes



RipEX
Quality of Service

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Introduction

Quality of Service (QoS) is an advanced feature that allows the user to prioritize certain types of traffic stream over the radio interface. Used to manage transmission of different traffic streams.

The QoS function is only available in Router mode.

Please see more details in *RipEX Manual*[1].

[1] http://www.racom.eu/eng/products/m/ripex/h-menu.html#qos

1. Configuration Examples

This application note describes three typical Use Cases of QoS implemented in RipEX.

- Prioritization of Serial (COM) SCADA traffic
- Prioritization of TCP application
- Prioritization of Fast Remote Access

1.1. Serial (COM) SCADA Traffic Prioritization

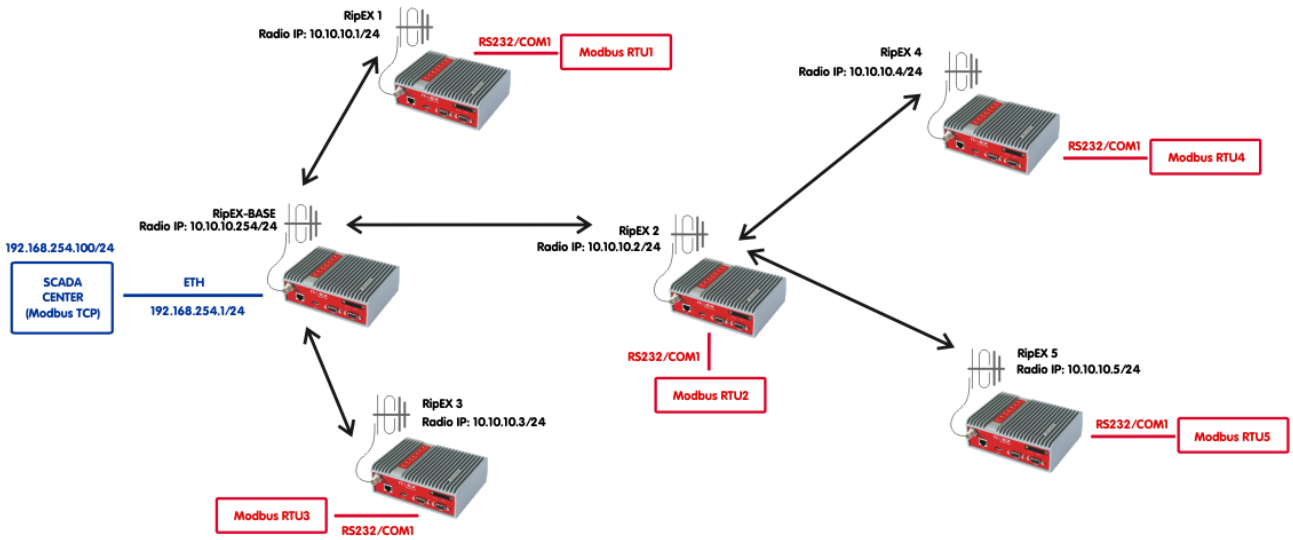

Fig. 1.1: Serial (COM) SCADA traffic prioritization diagram

Typical serial SCADA application is Master-Slave communication, i.e. there is only ever one application related packet on the Radio channel at a time. For such an application, no QoS is required. But collisions and lost packets might appear once we utilize other traffic simultaneously with this SCADA traffic, such as SNMP monitoring, frequent watched values, NTP data or remote radio re-configuration. Because this other traffic is not crucial (mission-critical) compared to serial communication and must not influence/limit serial traffic. QoS can be configured to prioritize (for example) serial traffic over other traffic so that this mission-critical application can run smoothly all the time.

In the first example, the central SCADA is connected via Ethernet to RipEX-Base unit. The SCADA Center utilizes Modbus TCP, but the remote RTUs are connected via RS232 (COM1) port and are configured as Modbus RTU slaves. RipEX itself enables free Modbus TCP to/from Modbus RTU conversion.

The routing is not required, Base driven protocol (BDP) is configured and all communication is configured in the Settings menu. Remote units can have default Ethernet IP address/mask.

Modbus TCP is handled in RipEX-Base and transferred as UDP to remote units. The source port on the Radio channel is UDP/8902 and the destination is UDP port 8881. The direction from remotes to RipEX-Base just switches the ports. QoS is configured accordingly. See the details in the following configuration steps.

1.1.1. RipEX-Base Configuration

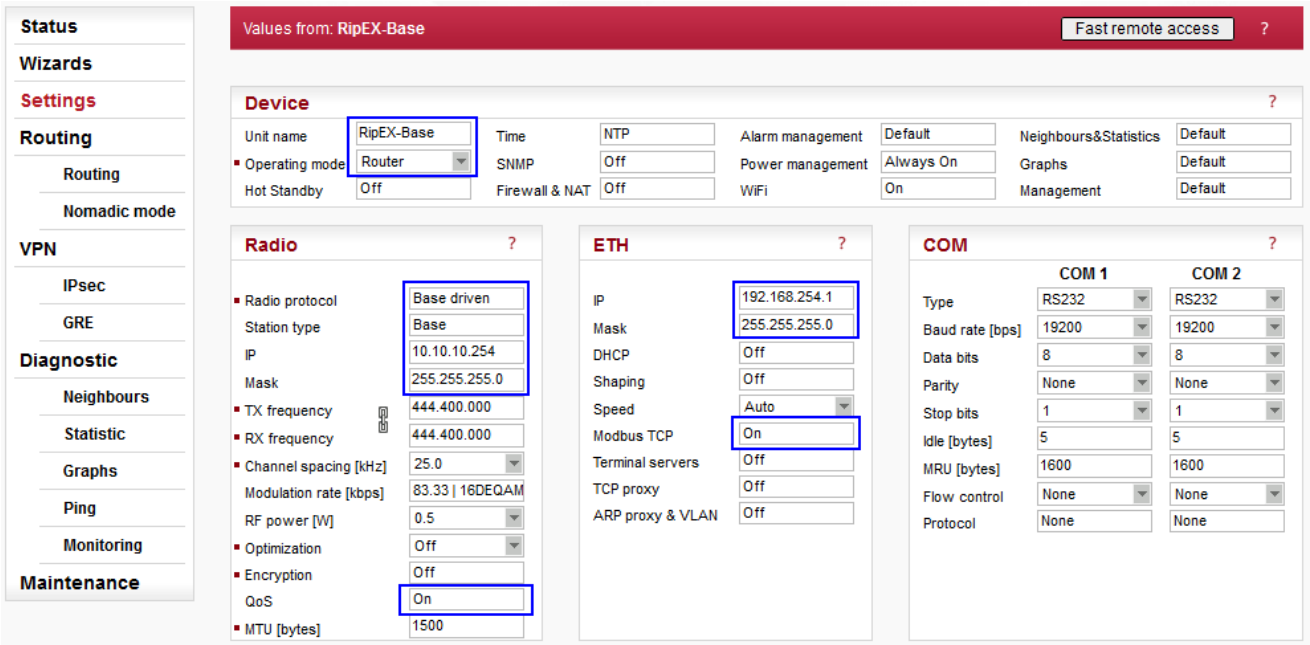

Fig. 1.2: RipEX-Base Settings

Parameters:

Unit name	RipEX-Base
Operating mode	Router
Radio protocol	Base driven
Station type	Base
Radio IP/Mask	10.10.10.254/255.255.255.0
QoS	On
ETH IP/Mask	192.168.254.1/255.255.255.0
Modbus TCP	On

The network is configured using Base driven Radio protocol. Set the Unit name, select the Router mode and configure correct IP addresses.

Open the Radio protocol menu and configure the protocol details.

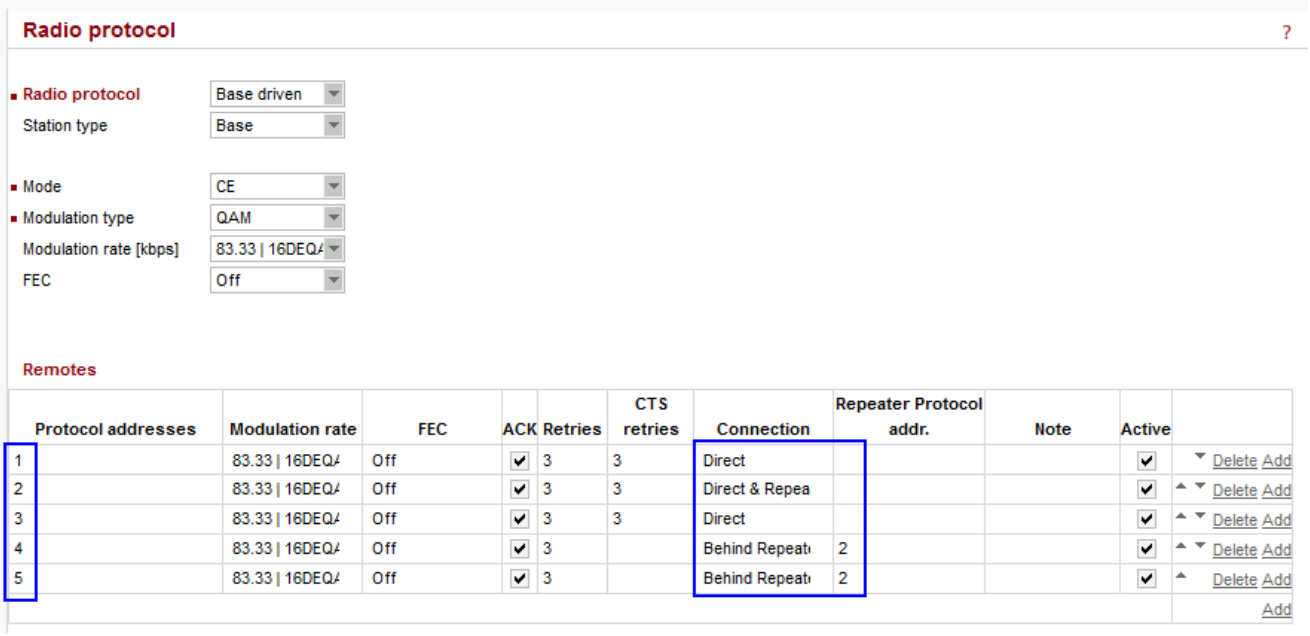

Fig. 1.3: RipEX-Base Radio protocol details

Configure any Mode, Modulation type and rate, but keep the Mode and type the same within the whole network.

NOTE:
The Modulation rates and other parameters can be different for remote units. Please see more details in the *Autospeed application note.*[1]

Configure all 5 remote RipEX units and focus on the “Connection” and “Repeater Protocol addr.” columns.

- Protocol address 1 – Direct connection
- Protocol address 2 – Direct connection and configured as Repeater
- Protocol address 3 – Direct connection
- Protocol address 4 – Behind the Repeater #2
- Protocol address 5 – Behind the Repeater #2

There is no need for any Routing rules. As stated earlier everything is controlled by the Base station by this Remotes’ table and BDP functionality. The Routing menu is empty.

NOTE:
Please see more details in the *BDP application note.*[2]

Open the Ethernet option “Modbus TCP”.

[1] http://www.racom.eu/eng/products/m/ripex/app/aspeed/index.html
[2] http://www.racom.eu/eng/products/m/ripex/app/bdp/index.html

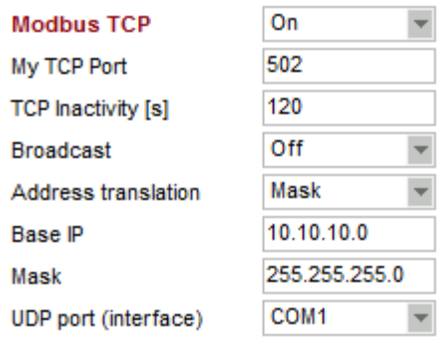

Fig. 1.4: RipEX-Base Modbus TCP configuration

Turn on the Modbus TCP functionality. Keep the default TCP port 502 for local Ethernet connection over Ethernet. Based upon your configuration, turn on or off the Broadcast option.

The address translation can be “Mask” because all the remote RTU’s are connected over COM1 and the Modbus RTU address equals to last Radio IP digit, e.g. RTU address 4 is connected to RipEX4 (Radio IP 10.10.10.4) via COM1 port.

Modbus TCP accepts the TCP connection from Modbus TCP SCADA Center (192.168.254.100) on port 502. The TCP connection is established only locally via Ethernet. Modbus TCP functionality in RipEX sends the Modbus TCP frames to remote units as UDP over the Radio channel. The Source port is internally set to UDP port 8902 and the destination port is the COM1’s port, i.e. 8881. QoS will be configured appropriately.

Please see more details in the *Modbus TCP/RTU application note*.[3]

Open the Radio QoS Settings.

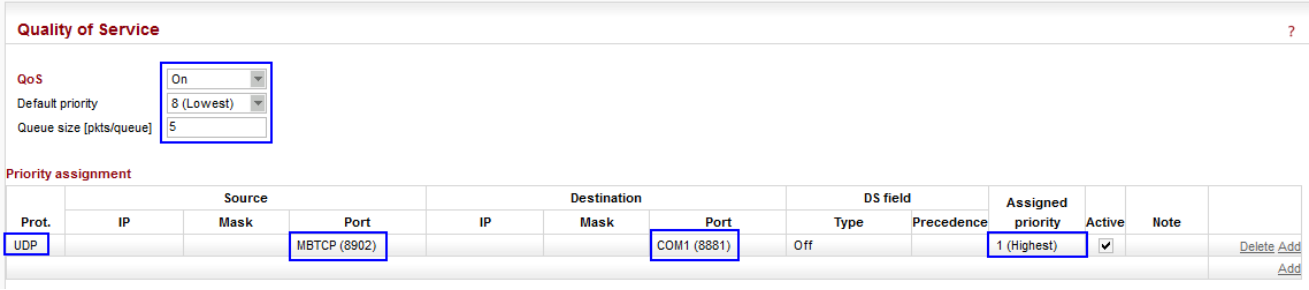

Fig. 1.5: RipEX-Base QoS

Turn on the QoS. Keep the Default priority to 8 (Lowest) and Queue size to 5 packets.

Add one QoS rule:

Protocol	UDP
Source port	MBTCP (8902)
Destination port	COM1 (8881)

[3] http://www.racom.eu/eng/products/m/ripex/app/modbus/index.html

Assigned priority 1 (Highest)

As described above, the Protocol must be set to “UDP”, the Source port to 8902 and the Destination port to 8881. Assign the highest priority (1) for this traffic.

The current configuration ensures all the packets matching the defined filters are inserted to the highest priority queue and dispatched first.

1.1.2. Remote RipEX Units Configurations

All remote RipEX units have the same configuration except:

- Unit name
- Radio IP address

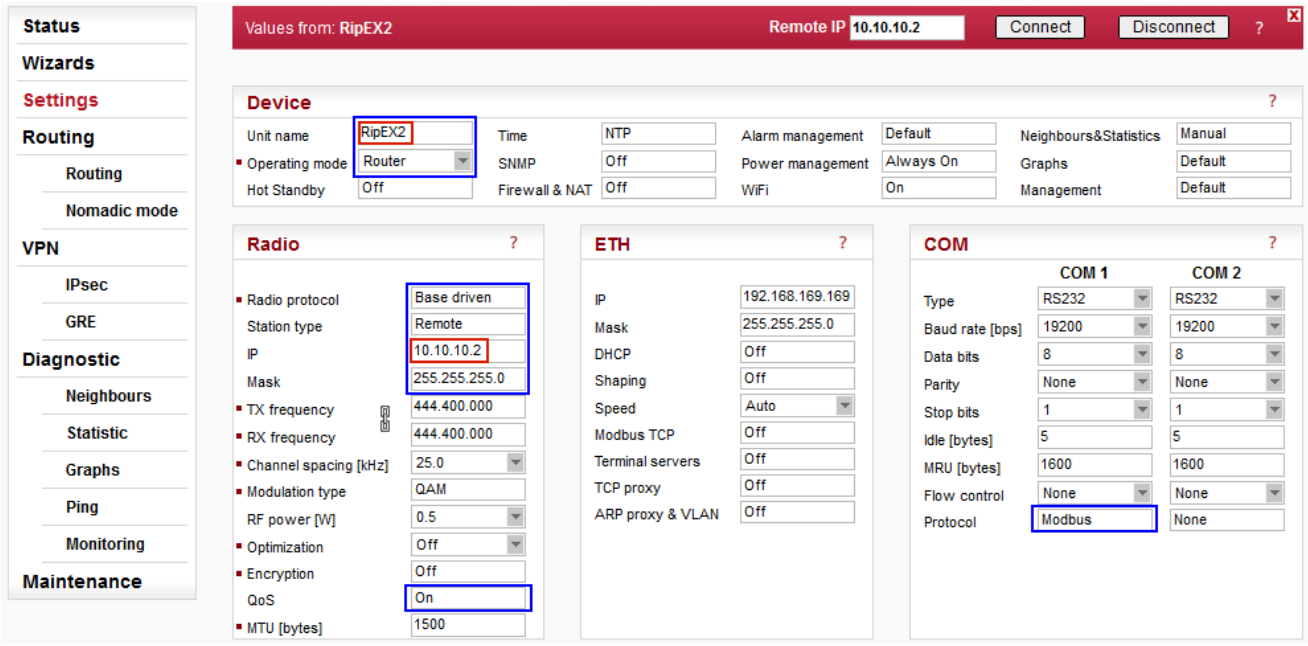

Fig. 1.6: Remote RipEX Settings

Common parameters for all remote units (blue):

Operating mode Router

Radio protocol Base driven

Station type Remote

Radio Mask 255.255.255.0 (default)

ETH IP/Mask 192.168.169.169 / 255.255.255.0 (default)

COM Protocol Modbus

Unique parameters for particular RipEX unit (red):

Unit name RipEX2

Radio IP 10.10.10.2

The network is configured using Base driven Radio protocol. Set the Unit name, select the Router mode and configure correct IP addresses.

Open the Radio protocol menu and configure the protocol details.

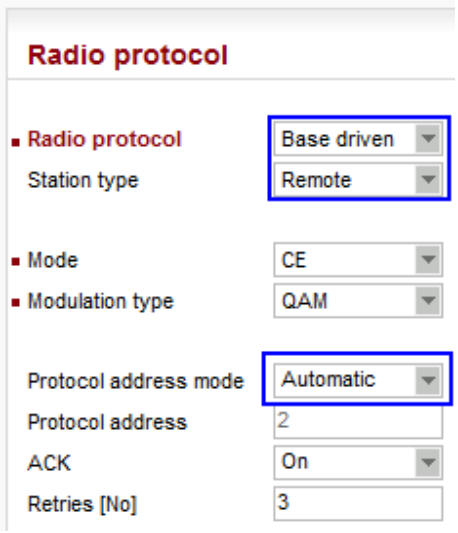

Fig. 1.7: Remote RipEX BDP Details

All remote units share completely the same BDP configuration.

Parameters:

Radio protocol Base driven

Station type Remote

Protocol address mode: Automatic

The Protocol address is automatically set based on the last Radio IP digit.

Open the COM1 Protocol menu.

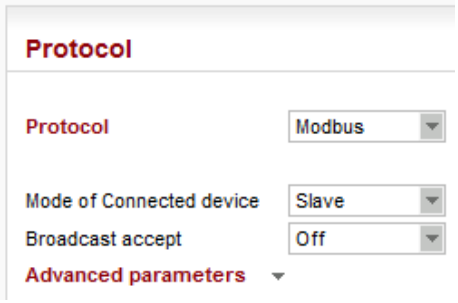

Fig. 1.8: Remote RipEX COM1 settings

Configure all remote RipEX units – select the Modbus protocol and the “Slave” mode.

Open the Radio QoS configuration.

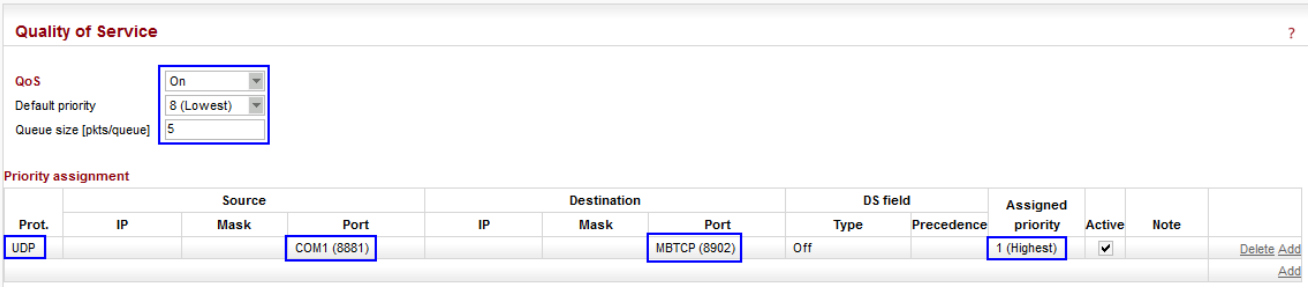

Fig. 1.9: Remote RipEX QoS

Turn on the QoS. Keep the Default priority to 8 (Lowest) and Queue size to 5 packets.

Add one QoS rule:

Protocol	UDP
Source port	COM1 (8881)
Destination port	MBTCP (8902)
Assigned priority	1 (Highest)

As described above, the Protocol must be set to “UDP”, the Source port to 8881 and the Destination port to 8902. Assign the highest priority for this traffic.

The current configuration assures all the packets matching the defined filters are inserted to the highest priority queue and dispatched first.

No routing rules are required in this example.

1.2. TCP application Prioritization

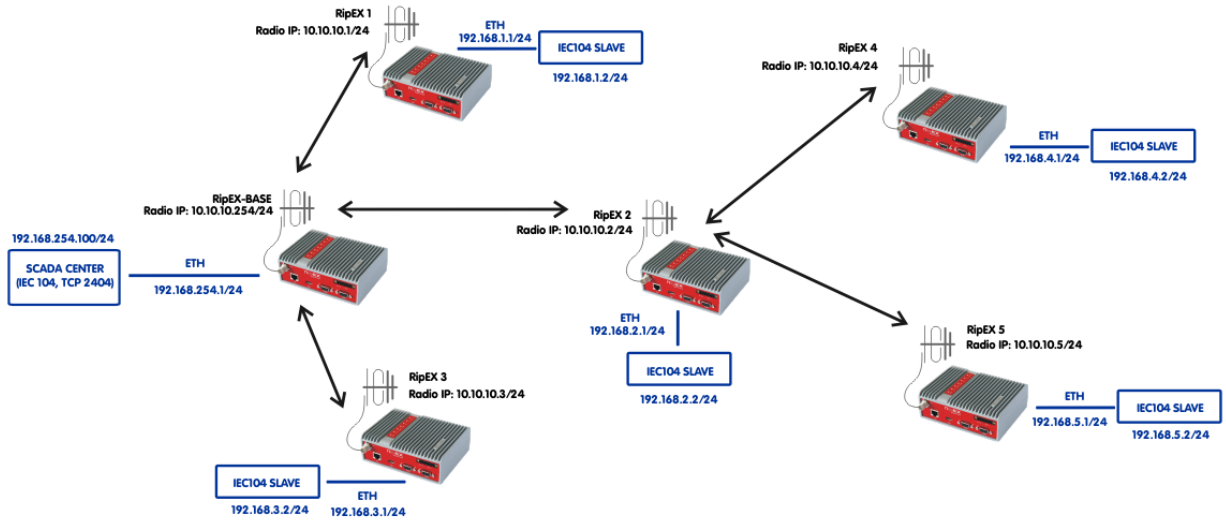

Fig. 1.10: IEC104 TCP traffic prioritization diagram

TCP's typical behaviour is, simply stated, to use as much of the link capacity as possible. To control TCP's behaviour, RipEX can be configured in Base driven Protocol to handleTCP efficiently and control channel utilization. QoS can improve the behaviour in the case of more than one TCP application being used in a network (or any other such as SNMP, NTP, remote configuration, …).

QoS can prioritize one or more traffic types over others. In our example, it is IEC104 traffic prioritization over other traffic. BDP controls TCP flows in a general way and QoS goes "deeper" and filters traffic according to given rules (particular ports, protocols, TOS fields, …) so that a primary IEC104 application runs smoothly.

This example requires modification of configuration settings in RipEX units. We need to change the remote Ethernet subnets – the IEC104 remote devices are connected via Ethernet and the SCADA Center needs to reach a remote device IP address. Default Ethernet IP address cannot be used (see Note below). Various options are possible; this method requires "only" IP address changes and Routing configuration.

NOTE:
Remote IEC104 slave devices could be configured with the same (default) IP address, but NAT functionality would be required. Please see the *NAT application notes*[4] for more details to find out whether it suits your requirements, or not.

[4] http://www.racom.eu/eng/products/m/ripex/app/nat/index.html

1.2.1. RipEX-Base Configuration

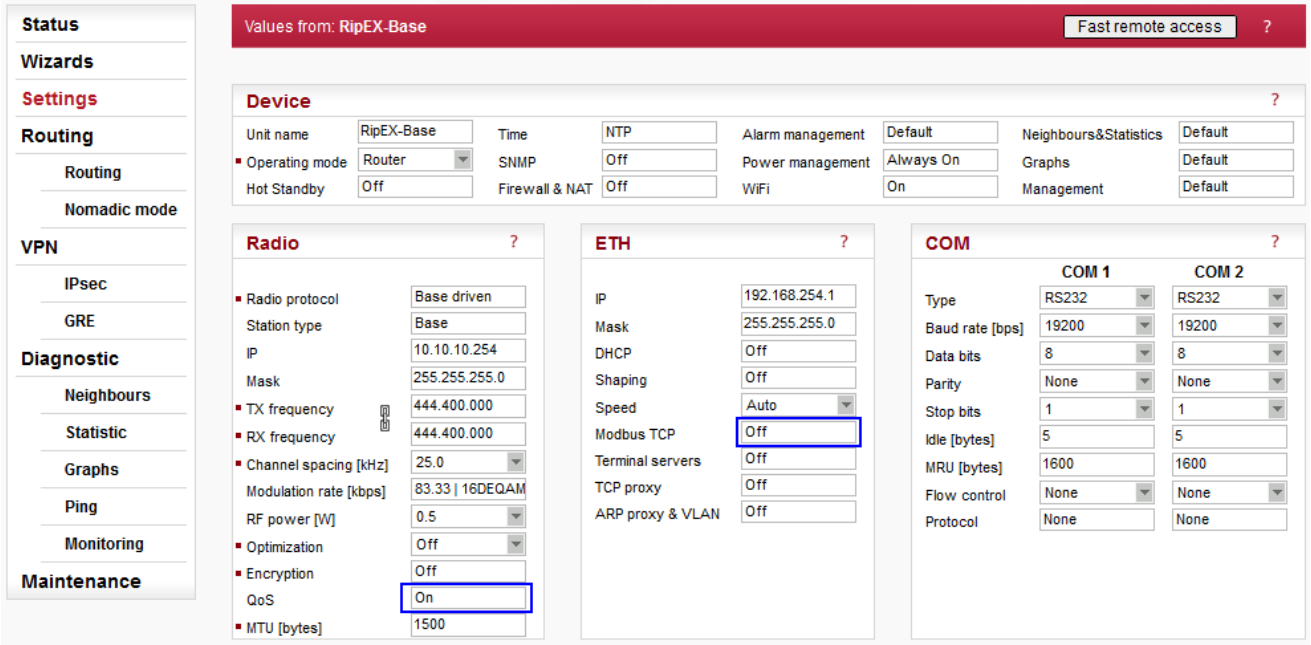

Fig. 1.11: RipEX-Base Settings

RipEX-Base configuration is almost the same as described in the previous Chapter 2.1 Serial (COM) SCADA Traffic Prioritization. The only difference is the QoS configuration.

NOTE:
You could, but do not have to turn off the Modbus TCP functionality.

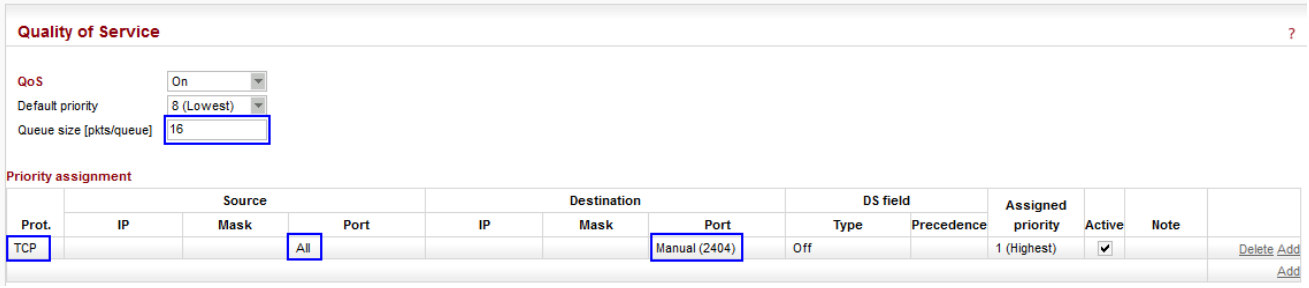

Fig. 1.12: RipEX-Base QoS settings

IEC104 uses the TCP port 2404 by default:

Protocol TCP

Source port All

Destination port Manual (2404)

Note that the Source port should be “All”, because the IEC104 centre uses TCP port 2404 only as a Destination port, but the Source port is usually dynamically chosen.

The Queue size is increased to 16. A TCP mechanism usually requires higher queue size than UDP. Optimize the value for your particular application in an interval 2-31 - Values higher than 12 are recommended.

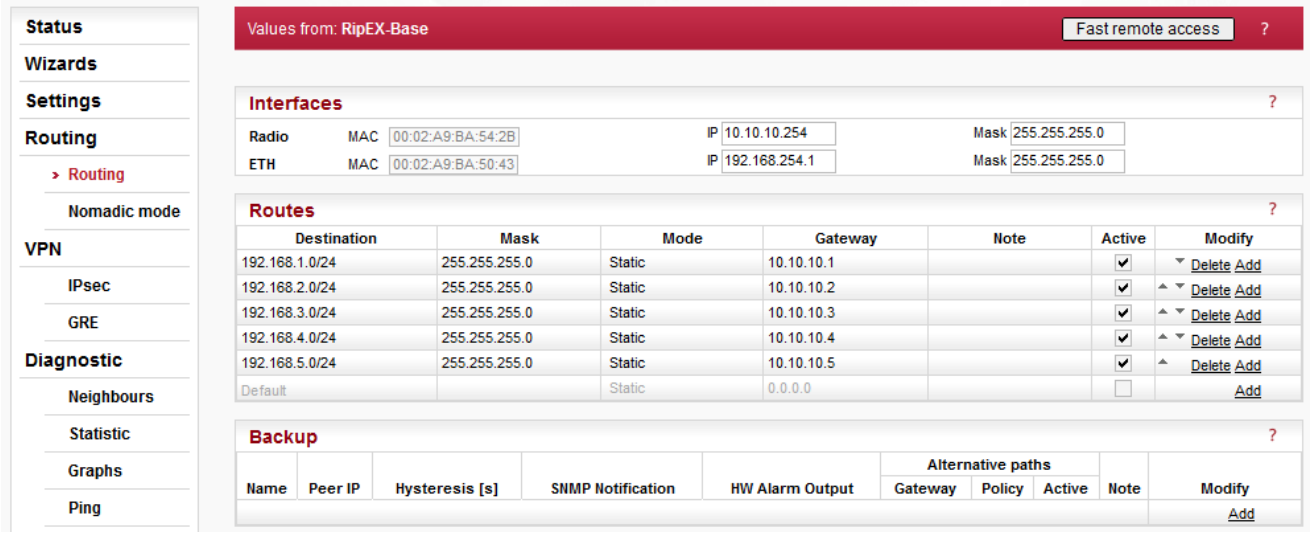

Fig. 1.13: RipEX-Base Routing

Add 5 routing rules, one rule for each remote RipEX.

- 192.168.1.0/24 via 10.10.10.1
- 192.168.2.0/24 via 10.10.10.2
- 192.168.3.0/24 via 10.10.10.3
- 192.168.4.0/24 via 10.10.10.4
- 192.168.5.0/24 via 10.10.10.5

NOTE:
The network utilizes BDP and thus, gateways are set to particular remote RipEX and not repeater IP (if it is behind that repeater). This knowledge/control is set in the BDP details (Settings menu).

1.2.2. Remote RipEX Units Configurations

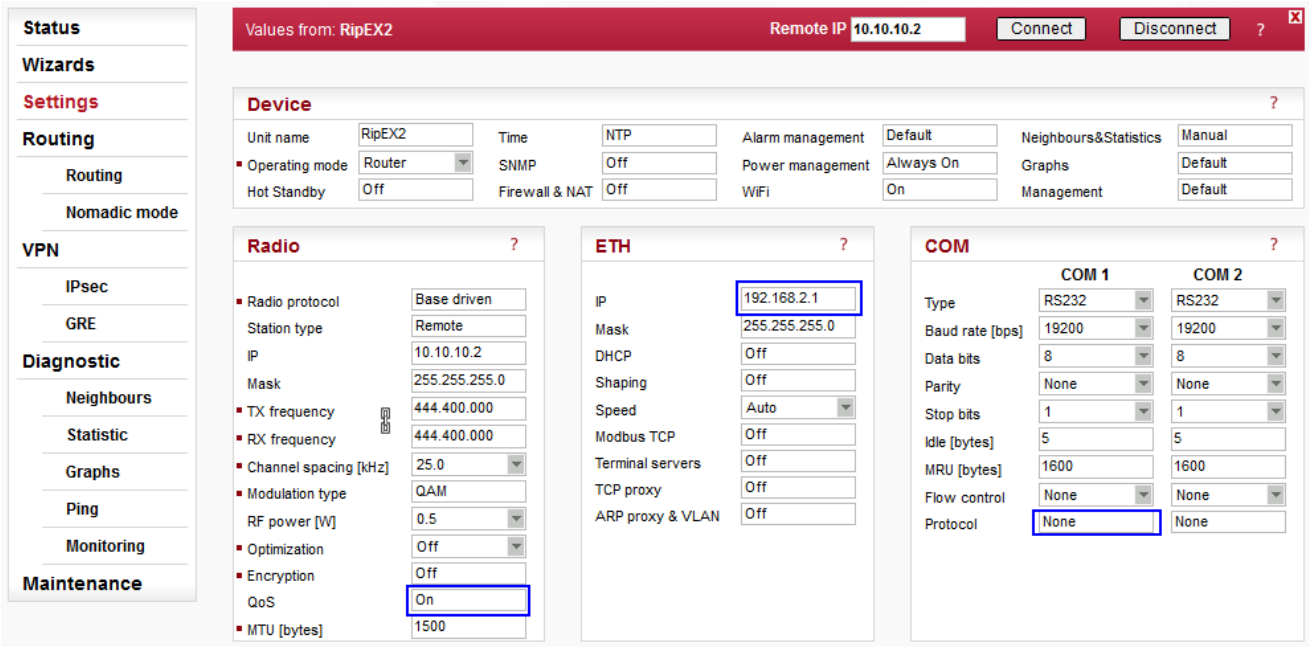

Fig. 1.14: Remote RipEX Configuration

In each remote, change the IP address following the rule:

- Radio IP address: 10.10.10.X –> Ethernet IP 192.168.X.1

For RipEX2, Ethernet IP address is 192.168.2.1.

NOTE:
You can disable the Modbus protocol on COM1.

Change the QoS configuration.

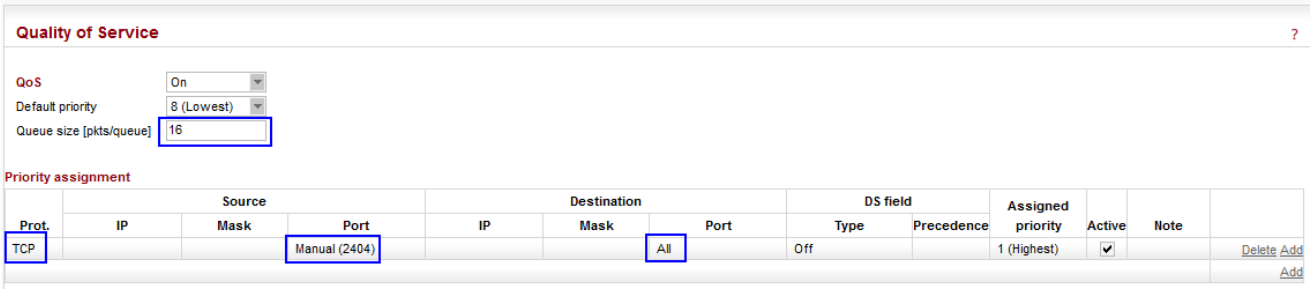

Fig. 1.15: Remote RipEX QoS settings

Increase the Queue size to 16 (the same value as in the Base unit).

Configure one QoS rule:

Protocol	TCP
Source port	Manual (2404)
Destination port	All

The ports are just swapped compared to Base unit.

1.3. Fast Remote Access (remote unit management) Prioritization

Fast Remote Access is a very helpful feature allowing remote units to be managed with minimum data being transmitted over the Radio channel. Only the effective data are transferred from remote RipEX over the Radio channel. The large amount of data needed to display full web interface is downloaded from the local unit which is usually connected via fast Ethernet interface.

A customer can have two different scenarios when controlling the unit management priority might be beneficial.

- 1.3.1. - Ordinary network traffic must not be affected by unit management (i.e. Fast Remote Access). QoS protects user application traffic against unwanted effects of management traffic.
- 1.3.2. - Remote unit management is important to work fluently under all circumstances. QoS is used to prioritize the management traffic, although it might even limit/disable running user application for a short period of time.

Applying QoS on management traffic might be useful especially in situations when a technical support package from a remote RipEX unit needs to be downloaded or a new firmware to a remote RipEX unit needs to be uploaded.

1.3.1. Fast Remote Access – The Lowest Priority

One approach is to change the default QoS priority and then configure a new QoS rule for Fast Remote Access traffic to lower its priority compared to other traffic.

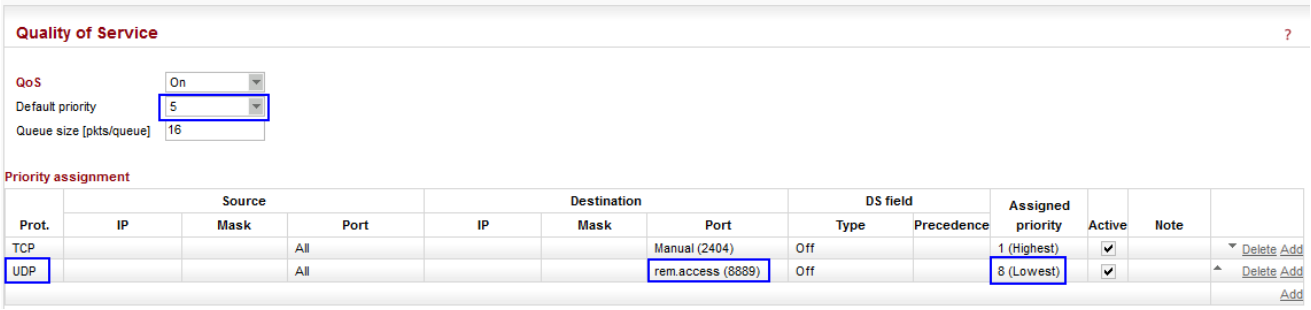

Fig. 1.16: RipEX-Base Fast Remote Access prioritization (Lowest)

Set the Default priority to 5. Any traffic going to the Radio channel which does not meet the QoS rules' filters, is handled with priority 5.

Create a new QoS rule:

Protocol	TCP
Source port	All
Destination port	rem.access (8889)
Assigned Priority	8 (Lowest)

Swap the Source and Destination ports in all remote RipEX units so that the opposite traffic is prioritized in remote RipEX as well. I.e. Source port = rem.access (8889), Destination port (All).

1.3.2. Fast Remote Access – The Highest Priority

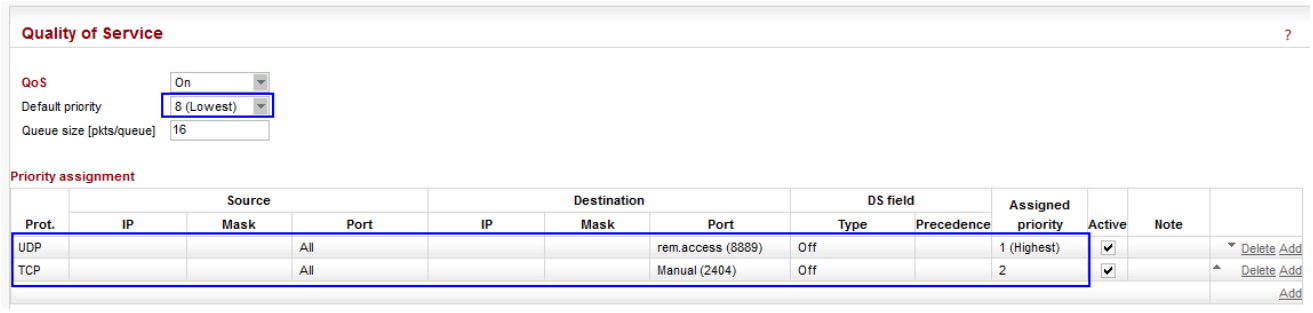

Fig. 1.17: RipEX-Base Fast Remote access prioritization (Highest)

The default priority can remain as the default value (8).

Add a new rule

and put it on the first line (to be evaluated first).

Protocol	TCP
Source port	All
Destination port	rem.access (8889)
Assigned Priority	1 (Highest)

Swap the Source and Destination ports in all remote RipEX units so that the opposite traffic is prioritized in remote RipEX as well. I.e. Source port = rem.access (8889), Destination port (All).

2. Functionality Verification and Troubleshooting

Monitoring does not display the QoS queues usage in its output. Neither does the Statistics menu show any information regarding any particular priority queue.

The only way to check the actual QoS functionality is via CLI.

NOTE:
CLI interface (Command Line Interface) is an alternative to web access. You can work with the CLI interface in text mode using an appropriate client, either SSH (putty) or Telnet.

Once logged in to the CLI environment, “cli_tcpdump“ with “-v” parameter can be used to see the DS (TOS) field. Each QoS rule in RipEX can also be configured to filter based on this field in IP packet.

In this example, only two commands are helpful for troubleshooting.

- tc -s qdisc show dev radio

This command displays the QoS queues with statistics. Example:

```
CLI(admin):~$ tc -s qdisc show dev radio
qdisc prio 1: bands 9 priomap  1 2 2 2 1 2 0 0 1 1 1 1 1 1 1 1
 Sent 2714 bytes 57 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 10: parent 1:1 limit 3p quantum 1514b perturb 10sec
 Sent 1344 bytes 32 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 20: parent 1:2 limit 5p quantum 1514b perturb 10sec
 Sent 1296 bytes 24 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 30: parent 1:3 limit 5p quantum 1514b perturb 10sec
 Sent 0 bytes 0 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 40: parent 1:4 limit 5p quantum 1514b perturb 10sec
 Sent 0 bytes 0 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 50: parent 1:5 limit 5p quantum 1514b perturb 10sec
 Sent 0 bytes 0 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 60: parent 1:6 limit 5p quantum 1514b perturb 10sec
 Sent 0 bytes 0 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 70: parent 1:7 limit 5p quantum 1514b perturb 10sec
 Sent 0 bytes 0 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 80: parent 1:8 limit 5p quantum 1514b perturb 10sec
 Sent 0 bytes 0 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
qdisc sfq 90: parent 1:9 limit 5p quantum 1514b perturb 10sec
 Sent 74 bytes 1 pkt (dropped 0, overlimits 0 requeues 0)
 rate 0bit 0pps backlog 0b 0p requeues 0
```

```
CLI(admin):~$ tc -s qdisc show dev radio | grep -A1 "sfq 20"
qdisc sfq 20: parent 1:2 limit 5p quantum 1514b perturb 10sec
 Sent 1296 bytes 24 pkt (dropped 0, overlimits 0 requeues 0)
```

The first paragraph starting with “qdisc prio” represents these queues as a whole. Its statistics output displays the total packets sent and dropped in QoS system.

Paragraphs starting by “qdisc sfq” represent particular priority queues (each priority level is assigned to separate queue) and their statistics output.

The queue for ARP packets is “qdisc sfq 10” and has the highest possible priority (this level is not configurable, neither is it displayed in the web interface, for simplicity). The other queues representing priorities 1-8 are listed in paragraphs labeled from “qdisc sfq 20” to “qdisc sfq 90”.

The priority for our Modbus data example (UDP, 8881/8902) are displayed in “qdisc sfq 20” paragraph. Other traffic has the default (lowest) priority 8 and is displayed in paragraph “qdisc sfq 90”.

- tc -s filter show dev radio

The second command displays the rules for placing packets to priority queues and their statistics. Example:

```
CLI(admin):~tc -s filter show dev radio
filter parent 1: protocol arp pref 1 u32
filter parent 1: protocol arp pref 1 u32 fh 800: ht divisor 1
filter parent 1: protocol arp pref 1 u32 fh 800::800 order 2048 key ht 800 bkt 0 flowid ▶
1:1  (rule hit 33 success 33)
  match 00000000/00000000 at 0 (success 33 )
filter parent 1: protocol ip pref 2 u32
filter parent 1: protocol ip pref 2 u32 fh 1: ht divisor 1
filter parent 1: protocol ip pref 2 u32 fh 1::800 order 2048 key ht 1 bkt 0 flowid 1:2  ▶
(rule hit 24 success 24)
  match 22c622b1/ffffffff at nexthdr+0 (success 24 )
filter parent 1: protocol ip pref 2 u32 fh 801: ht divisor 1
filter parent 1: protocol ip pref 2 u32 fh 801::800 order 2048 key ht 801 bkt 0 link 1:  ▶
(rule hit 25 success 0)
  match 00110000/00ff0000 at 8 (success 24 )
  match 00000000/00001fff at 4 (success 24 )
    offset 0f00>>6 at 0  eat
filter parent 1: protocol all pref 3 u32
filter parent 1: protocol all pref 3 u32 fh 802: ht divisor 1
filter parent 1: protocol all pref 3 u32 fh 802::800 order 2048 key ht 802 bkt 0 flowid ▶
1:9  (rule hit 1 success 1)
  match 00000000/00000000 at 0 (success 1 )
```

Output code starting with “**filter parent 1: protocol arp**” is the internal priority 0 (flowid 1:1 – corresponds to “sfq 10” in previous command) – used only for ARP, having the highest priority.

Output code starting with “**filter parent 1: protocol all**” is the table with the lowest priority 8 (flowid 1:9 – corresponds to “sfq 90” in previous command). In this example, this is the default priority.

Output code starting with “**filter parent 1: protocol ip**” are the user rules. In our example, the flowid is 1:2 (i.e. the highest user priority possible, corresponding to “sfq 20” in previous command).

If you need any further explanation and debugging help, contact our Technical support group at <support@racom.eu>.

NOTE:
The QoS state is stored in Technical support package.

Appendix A. Revision History

Revision 1.0 2018-04-03

First issue