ACKSYS
COMMUNICATIONS & SYSTEMS

WAVEOS
USER GUIDE

ACKSYS COMMUNICATIONS & SYSTEMS

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I INTRODUCTION

This reference guide applies to the following devices:

- ❖ RAILBOX, RAILTRACK family, all models
- ❖ Airlink & Airbox series, all models
- ❖ AirWan, all models
- ❖ AirXroad, all models
- ❖ EmbedAir series, all models
- ❖ RuggedAir series, all models
- ❖ WaveNet-Ex series, all models

Wherever this document refers to “the product” without further precision, it means one of the products in the above list.

Together with the quick start guide included in the product package, it covers product installation, configuration and usage, and general information about Wi-Fi protocols.

This reference guide describes the WaveOS version 4.18.0.1

- If your product contains an earlier version, you can download a firmware update from our Internet web site.
- If your product contains a more recent version, you can check our web site to download a documentation update.

The firmware change log (which you can download from the ACKSYS web site) explains which features are available depending on the firmware version.

All recommendations for equipment installation, such as power supplies, antennas and connection cables are documented in the quick installation guide specific to each product.

Regulatory information / Disclaimers

Installation and use of this Wireless LAN device must be in strict accordance with the instructions included in the user documentation provided with the product. Any changes or modifications (including the antennas) made to this device that are not expressly approved by the manufacturer may void the user's authority to operate the equipment. The manufacturer is not responsible for any radio or television interference caused by unauthorized modification of this device, or the substitution of the connecting cables and equipment other than manufacturer specified. It is the responsibility of the user to correct any interference caused by such unauthorized modification, substitution or attachment. Manufacturer and any authorized resellers or distributors will assume no liability for any damage or violation of government regulations arising from failing to comply with these guidelines.

Information in this document is subject to change without notice and does not represent a commitment on the part of ACKSYS.

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ACKSYS reserves the right to make improvements and/or changes to this manual, or to the products and/or the programs described in this manual, at any time.

Information provided in this manual is intended to be accurate and reliable.

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This product might include unintentional technical or typographical errors. Changes are periodically made to the information herein to correct such errors and these changes are incorporated in new editions of the publication.

II PRODUCTS LINE OVERVIEW

II.1 Products goals

These products provide Wi-Fi connectivity for Ethernet devices. Thanks to their configuration capabilities, they can create various topologies; see section *Wireless topologies examples* for details.

II.2 Features common to all products

Many features are common to all products in this product line.

Networking:

Layer 2 software bridging, VLAN, Tunneling, STP/RSTP, 802.1p and 802.11e QOS.
Layer 3 routing with DSCP retagging, NAT, firewall, Diffserv QOS, Multicast routing
DHCP server or client, DNS relay

Configuration and maintenance:

HTTP and HTTPS Web browser configuration
Acksys WaveManager compatibility
SNMP agent for status and configuration
Events handler, alarms
Browser-based firmware upgrades
Emergency upgrade mode
Performance graph trace

Wi-Fi capabilities:

Radio:

- Dual band (2.4 GHz and 5 GHz)
- Support either 802.11n, 20 or 40 MHz channel width or 802.11ac, 20, 40 or 80 MHz channel width
- Backward compatible with 802.11a, b, g, n

Wireless Roles:

- Access point, bridging client, 802.11s Mesh, ad-hoc, RogueAP
- Access point: Client isolation, 802.11x authenticator, slow bit rates lockout, clients MAC filtering
- Client modes: 4 addresses, MAC translation, cloning

Security (depending on the mode):

- WPA2, 802.1x (RADIUS)
- A/B/G compatible security: WPA, WEP

Long-distance Wi-Fi
WME/WMM configuration support
Miscellaneous: 802.11h, 802.11d, client 802.11r support.

II.3 Extra features per product model

This section focuses on the features that involve specific software configuration. Other distinctive characteristics are covered in the quick installation guide of each product.

Configuration and maintenance:

C-Key configuration backup
LED status
Hardware alarm contactor, digital output and digital input

Wide area radio networks:

2G/3G/4G data communications, 2 SIM slots
Multi-constellation satellite positioning (GNSS)

Ethernet capabilities:

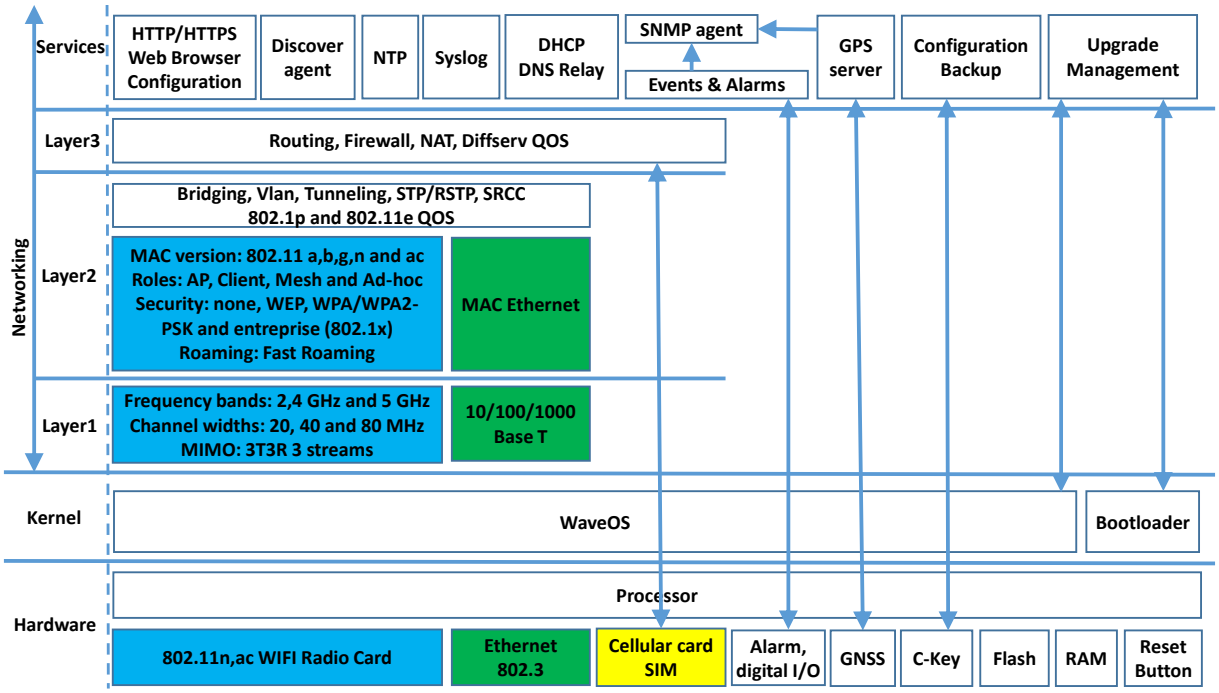
10/100/1000 base T
Auto-crossing (MDX)
Automatic speed and duplex selection

Some features depend on Radio Card type (802.11n or 802.11ac, 802.11ax):

Feature \ Radio card type	802.11n	802.11ac	802.11ac Wave 2	802.11ax
802.11 max modulation rate	450 Mbps	1300 Mbps	1730 Mbps	4083 Mbps
Max remote clients per access point	124	128	128	512
Fast Roaming	✓			
Connect Before Break Roaming	✓	✓	✓	
Scanning/roaming cluster	✓	As scanner	As scanner	
Mesh	✓			
Line Topology Repeater	✓			
Max roles per radio (AP, client, repeater, portal)	8	8	8	16
Dual radio repeater	✓	✓	✓	✓
VLAN-tagged frames forwarding	✓	✓	✓	✓
SRCC support[1]		✓	✓	✓

1. SRCC only works with 802.11ac on the first radio card: **RuggedAir/1000** and **Railbox/2x**

II.4 System design



II.5 Products settings compatibility

The product settings can be backed up in a file through the web interface or in the C-KEY. This backup is not compatible with all products range.

This section shows the backup compatibility between the products.

Backup from	Backup can be loaded in
RailBox/10*	RailBox/10*
RailBox/11*	RailBox/11*
RailBox/22*	RailBox/22*
RailBox/20*	RailBox/20*
RailBox/24*	RailBox/27*
RailBox/27*	RailBox/24*

III DEVICE INSTALLATION

The **quick start guide** shipped with your product includes specific startup instructions and recommendations. Please read it first.

III.1 Power supply

The quick start guide gives the maximum power consumption for your product. You should consider this value as the minimum that your power supply must provide. Furthermore, there is an additional point to consider: these products include Wi-Fi radio cards that can cause quick power surges during wireless communication. These surges are included into power consumption given by the quick start but, if your power supply is too slow to deliver power, it can cause product reboots or unpredictable behavior.

III.2 Antenna types

The following sections describe the most commonly used antenna type and the way to install them.

These explanations rely on good understanding of what a radiation pattern represents. If you are not familiar with it, please read this page first: *http://www.antenna-theory.com/basics/radPattern.html*. This represents a good starting point.

The radiation patterns shown in the next sections are only provided as examples to give a better understanding of the distinctive characteristics of each antenna type.

III.2.1 Omnidirectional antenna

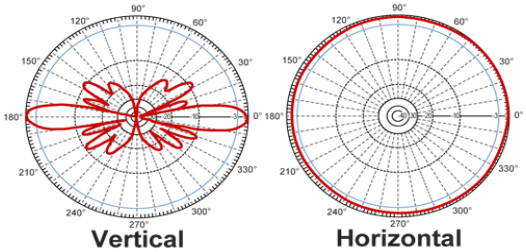
The radiated power is uniform in all the horizontal directions. Power drops progressively while approaching the direction of the antenna axis (vertical). The corresponding radiation pattern is given below.

This type of antenna is used to cover a wide area all around the antenna.

When using them, make sure that they are placed in the same plane.

Antenna

Radiation pattern

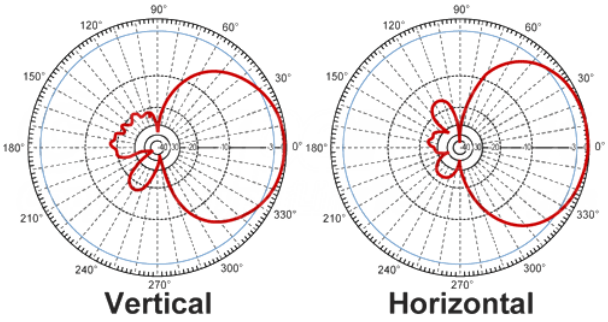


III.2.2 Patch antenna

This kind of antenna focuses radiations on one side (see radiation pattern below). This allows wall mounting without wasting radiations in the wall. The gain is generally comprised between 7dBi and 9dBi.

Antenna

Radiation pattern

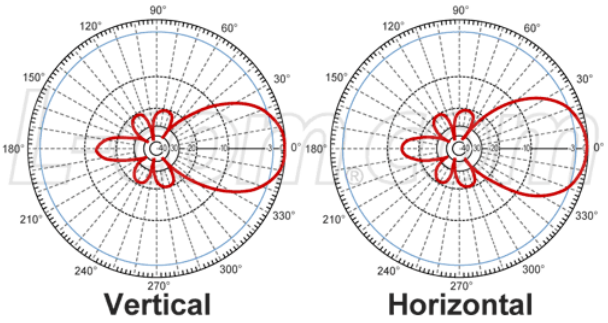


III.2.3 Yagi antenna

This kind of antenna also focuses radiations on one side (see radiation pattern below). But its gain is usually higher than patch antenna (11dBi to 15dBi).

Antenna

Radiation pattern

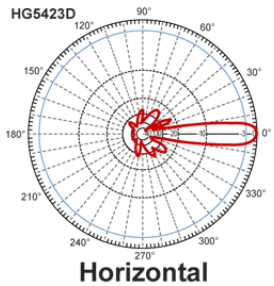


III.2.4 Dish antenna

This antenna focus the radiations in one point and then can achieve very high gain (>20dBi).

Antenna

Radiation pattern



III.2.5 MIMO antenna

Antenna manufacturers provide MIMO version of each antenna type described previously. MIMO antennas are basically a set of several (usually 2 or 3) standard antennas put together in a single enclosure.

In any case, refer to the antenna datasheet to get information about the Radiation pattern and internal layout.

III.3 Antenna installation

Radio connectors come in several flavors: SMA, RPSMA, QMA, N-Type and so on. Please do not mistake SMA for RPSMA. They look alike, but the central pin or hole is inverted. RPSMA is reserved for Wi-Fi only operation. Other uses, like GPS or Cellular radio, use SMA connectors.

There are two major cases when considering Wi-Fi antenna installation.

III.3.1 Legacy 802.11a/b/g case

You can establish Wi-Fi links from a few feet to several miles but it requires some cautions:

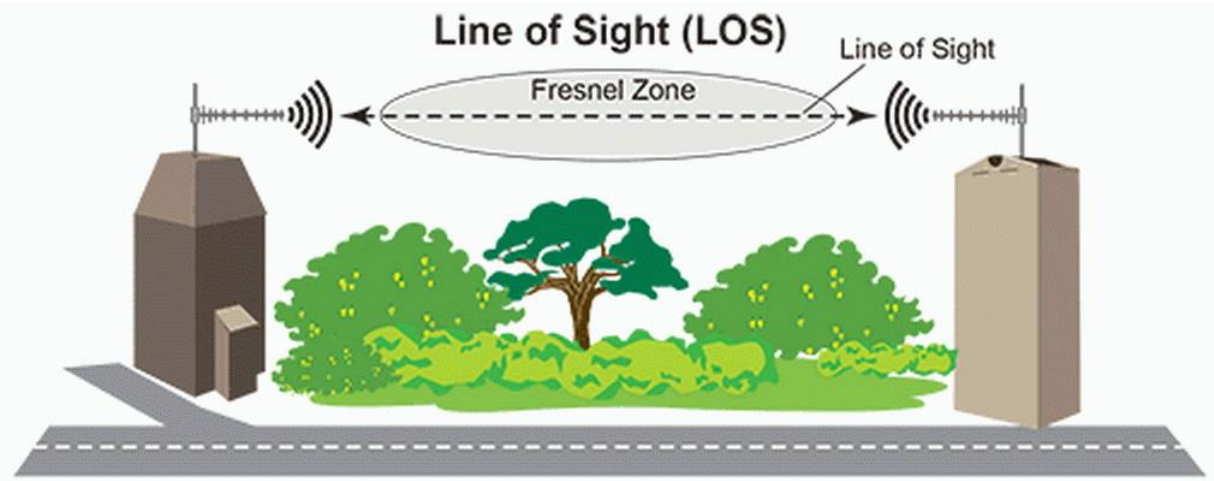
You must adapt the EIRP of the products (but you must keep it in the local regulations range) according to the distance and obstacles between devices.

The link RSSI must be high enough, else when environment changes (climatic conditions change or space reorganization) the link might break.

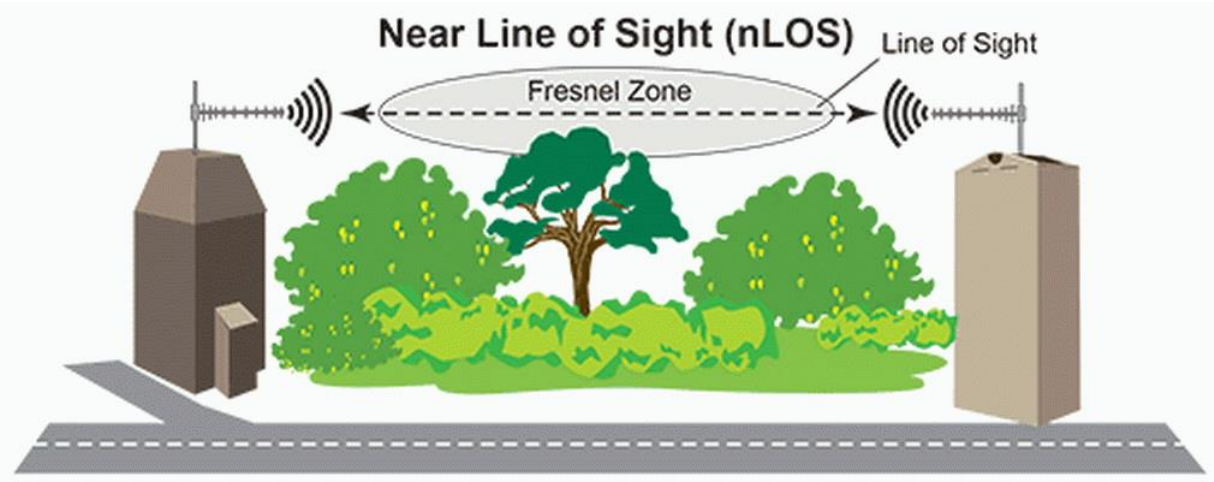
To increase the EIRP you can either:

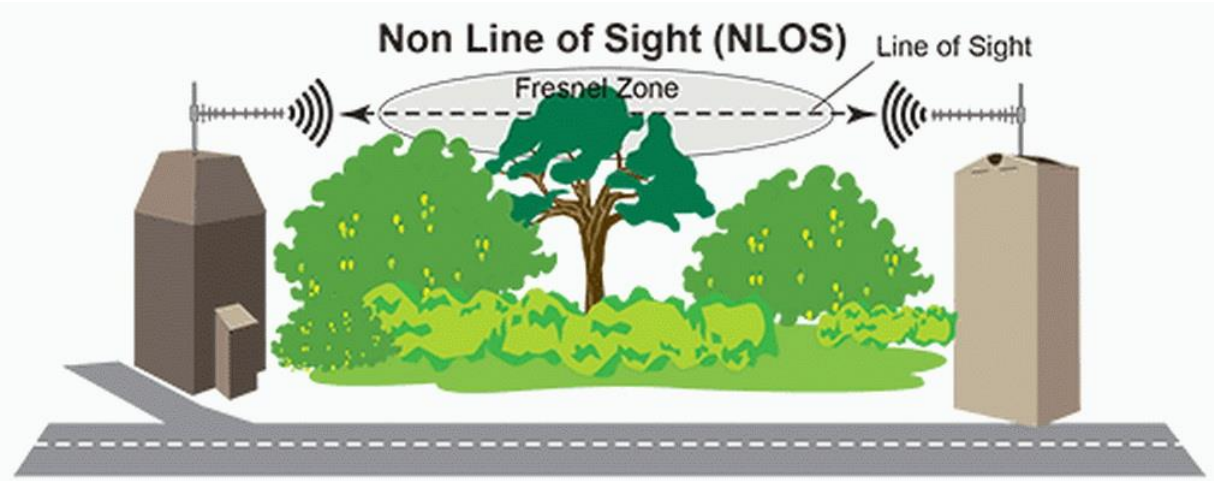
- use an antenna with a larger gain,
- use a product with a larger radio output power
- marginally, use better quality connectors and radio cables.

For outdoor link, products must be “line of sight” from the other one. This is a **mandatory condition** and should be considered with attention. The schematic below explains what we mean by “line of sight”.



Non-line-of-sight (NLOS) and near-line-of-sight are radio transmissions across a path that is partially obstructed, usually by a physical object in the innermost Fresnel zone.





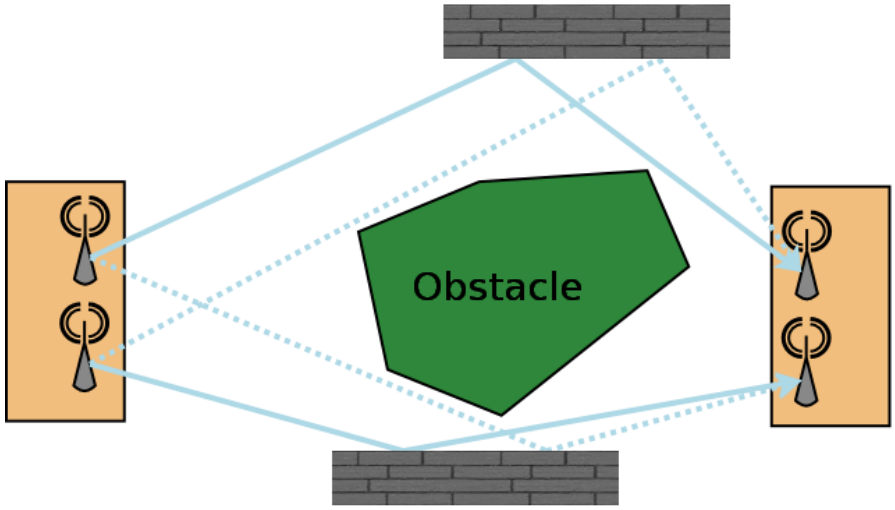
Near Line Of Sight can usually be dealt with using better antennas, but Non Line Of Sight usually requires alternative paths or multipath propagation methods.

Obstacles that commonly cause NLOS conditions include buildings, trees, hills, mountains …

III.3.2 802.11n/ac/ax

With these norms, considerations about EIRP and RSSI are still relevant. But the 802.11n/ac/ax takes advantage of MIMO (Multiple Input Multiple Output) technology and introduces new ways to use multiple antennas.

802.11a/b/g products already use more than one antenna but they were limited to the diversity mode (only one antenna transmits at a time). Moreover, bounces on walls or other obstacles cause multiple paths that confuse the receiver (see figure below).



802.11n/ac uses these bounces to allow several independent streams (2 to 4) to be sent and identified simultaneously. At the beginning of the transmission, a well-known pattern is sent. The receiver uses that pattern to calibrate itself and characterize the transmission channel for each antenna.

Using that information, the receiver is able to calculate which stream belongs to what antenna.

In this case there must be at least one antenna per stream to be sent. Supernumerary antennas are used to transmit additional spatial information.

Since 802.11n/ac/ax use bounces to increase bandwidth, a line of sight outdoor application will have less performance compared to an indoor one, because there are potentially no bounces at all. This problem can be solved by sending polarized radio waves orthogonal to each other. Such so-called “Slant Antennas” are actually made of 2 specifically polarized antennas put together in a single case.

III.3.3 Cellular antennas

If you use only one antenna, make sure it is plugged in the “main” antenna connector. The “diversity” connector is used only to enhance reception.

If you use the diversity antenna, make sure it is placed at least 30 cm away from the main antenna, and that the coaxial cables are well separated from each other.

Some hints for best performance:

- Keep the antennas perpendicular to the ground,
- Avoid being surrounded by metal objects,
- Place the diversity antenna so that its polarization and the main’s polarization do not line up.

III.3.4 GNSS antennas

GNSS is a generic acronym for GPS, GALILEO and similar satellite positioning systems. GNSS antennas come in two flavors: active or passive. Active antennas hold a built-in preamplifier which is powered through the antenna cable.

Plugging a passive antenna on an active input connector can shortcut the power supply. Plugging an active antenna on a passive input connector leads to feeble reception. Always use the correct type of antenna suitable for the input connector.

GNSS signals are feeble. Keep cables as short as possible. Beware of glass windows that may be opaque to the GNSS radio frequency.

III.4 802.11 radio channel choice

Wi-Fi standard compliant products can use two RF bands:

- The 2.4 GHz band covers the channels compatible with 802.11b/g/n standards,
- The 5 GHz band covers the channels compatible with 802.11a/n/ac/ax standards.

Several points must be considered when selecting a radio channel for optimal performance:

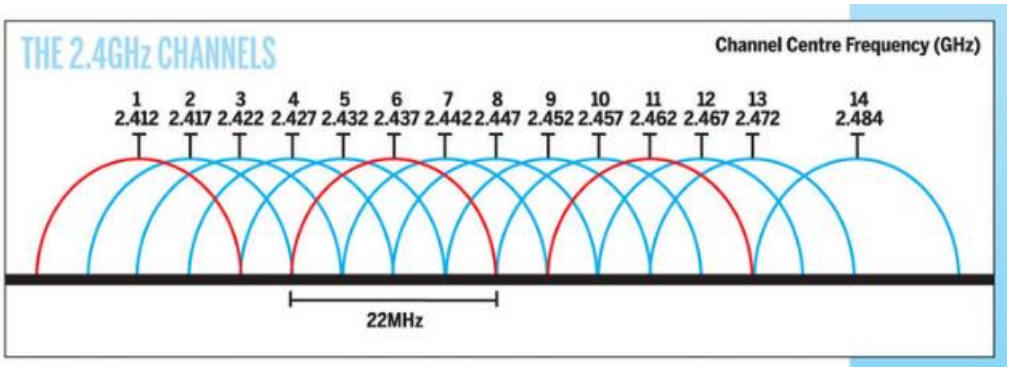
- First of all, local regulation rules that may forbid or limit using some channels;
- Transmit power on each channel, that may be limited by the legislation and by the hardware;
- Radio noise and interferences originating from other Wi-Fi devices operating on the same channel or non-Wi-Fi devices like microwaves oven, cordless telephones, Bluetooth devices, others wireless devices;
- Collisions due to the “hidden station” effect when all access points in your system use the same channel.

A preliminary site survey is strongly recommended to detect overloaded radio channels BEFORE buying band specific antenna. An overloaded channel may strongly affect performances. It is recommended to use a free channel.

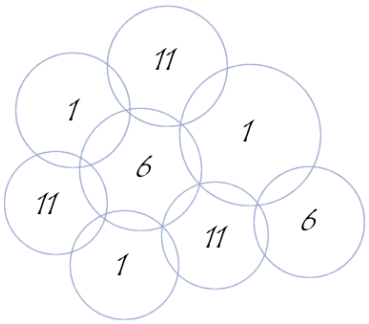
Wi-Fi performance also depends greatly on the radio link quality (a.k.a. RSSI). The better the RSSI is, the better the throughput and error rate can be. Signal quality is a function of distance, obstacles, narrow pathways, hygrometry, and antennas orientation.

III.4.1 2.4GHz overlapping radio channels

The radio channel is only an indication of the central frequency in use. Modulation enlarges the channel to a 20-22 MHz band. This must be taken into account when several Wi-Fi cells are near to each other in 2.4GHz (5GHz channels do not overlap), otherwise the effective performance will decrease due to interferences. This point is especially important when you try to cover a geographic area with several access points.



Although the use of “non-overlapping” channels 1, 6, and 11 has limits when products are too close, the 1–6–11 guideline has merit. If transmitter channels are chosen closer than channels 1, 6 and 11 (for example, 1, 4, 7 and 10), overlap between the channels may cause unacceptable degradation of signal quality and throughput.



Picture III-1: Example of geographical implantation of non-overlapping channels

III.5 802.11 regulatory domain rules

To control the use of Wi-Fi radio channels, there are 3 major regulatory rules sets in wide use all around the world:

- ETSI: for European countries
- FCC: for American countries
- MKK/TELEC: for Asian countries

Specific regulatory domains (France, Brazil, Korean, Australia …) derive from the major regulatory rules with several modifications.

The regulatory domain gives the rules to use each RF band.

To abide by your local laws, you must select the country where the product will be installed before activating the Wi-Fi card.

III.5.1 Antenna gain and RF output power

If you plan to use a high gain antenna, you might exceed the EIRP allowed in your country. In this case you must reduce manually the radio transmit power of your product (see *Advanced Settings tab* in section *VI.1.1.1 Wireless/Radio*).

In the following sections you will find the FCC and ETSI rules to adapt the product transmit power to the antenna used.

Definition of terms:

RF Output power: RF power radiated by the ACKSYS wireless device without the antenna

EIRP: RF power radiated by the ACKSYS wireless device with the antenna.

EIRP = RF OUTPUT POWER + ANTENNA GAIN (dBi)

III.5.2 FCC rules for 2.4 GHz band

2.4 GHz point to multipoint: MAX EIRP = +36 dBm (4 Watts)				
MAX RF Output POWER dBm	(mW)	MAX Gain dBi	MAX EIRP dBm	(W)
30	(1000)	6	36	(4)
27	(500)	9		
24	(250	12		
21	(125)	15		
18	(62.5)	18		
15	(32)	21		
12	(16)	24		

In other words, when using antennas with a gain higher than 6dBi, for every 1 dBi gain over 6 dBi, the MAX RF output power must be reduced by 1 dB.

2.4 GHz point to point: MAX EIRP = special rules				
MAX RF Output POWER dBm	(mW)	MAX Gain (dBi)	MAX EIRP dBm	(W)
30	(1000)	6	36	(4)
29	(800)	9	38	(6.3)
28	(630)	12	40	(10)
27	(500)	15	42	(16)
26	(400)	18	44	(25)
25	(316)	21	46	(39.8)
24	(250)	24	48	(63)
23	(200)	27	50	(100)
22	(160)	30	52	(158)

When using antennas with a gain higher than 6dBi, for every 3 dBi gain over 6 dBi, the MAX RF output power must be reduced by 1 dB.

III.5.3 FCC rules for 5 GHz band

5 GHz point to multipoint: MAX EIRP = special rules						
BAND	Freq. (GHz)	Channels	Location	MAX RF output POWER (dBm/mW)	MAX Gain (dBi)	MAX EIRP (dBm/mW)
UNII	5.15-5.25	36, 40, 44, 48	Indoor & outdoor	16 / 40	6(1)	22 / 160
UNII-2	5.25-5.35	52, 56, 60, 64	Indoor & outdoor	23 / 200	6(1)	29 / 800
UNII-2 ext.	5.470-5.725	100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	Indoor & outdoor	23 / 200	6(1)	29 / 800
UNII-3	5.725-5.825	149 to 165	outdoor	29 / 800	6(1)	35 / 3.2 W

(1) If antennas higher than 6dBi gain are utilized, a reduction of 1 dB of the MAX RF output POWER is required for every 1 dBi increase in the antenna gain above 6dBi.

5 GHz point to point: MAX EIRP = special rules						
BAND	Freq. (GHz)	Channels	Location	MAX RF output POWER (dBm/mW)	MAX Gain (dBi)	MAX EIRP (dBm/mW)
UNII	5.15-5.25	36, 40, 44, 48	Indoor	16 / 40	6	22 / 160
UNII-2	5.25-5.35	52, 56, 60, 64	Indoor & outdoor	23 / 200	6	29 / 800
UNII-2 ext.	5.470-5.725	100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	Indoor & outdoor	23 / 200	6	29 / 800
UNII-3	5.725-5.825	149 to 165	outdoor	30 / 1 W	23(2)	53 / 200 W

(2) If antennas higher than 23 dBi gain are utilized, a reduction of 1 dB of the MAX RF output POWER is required for every 1 dBi increase in the antenna gain above 23 dBi.

Some channels require DFS support; please, see section "*Radars detection overview (DFS)*".

III.5.4 ETSI rules for 2.4 GHz band

2.4 GHz point to multipoint: MAX EIRP = +20 dBm (100 mWatts)						
BAND	Freq. (GHz)	Channels	Location	MAX RF output POWER (dBm/mW)	MAX Gain (dBi)	MAX EIRP (dBm/mW)
ISM	2.4-2.483	1 to 13	Indoor/ outdoor	NA	NA	20 / 100

III.5.5 ETSI rules for 5GHz band

5 GHz point to multipoint: MAX EIRP = special rules						
BAND	Freq. (GHz)	Channels	Location	MAX RF output POWER dBm (mW)	MAX Gain (dBi)	MAX EIRP (dBm/mW)
UNII	5.15-5.25	36, 40, 44, 48	Indoor	NA	NA	23 / 200
UNII-2	5.25-5.35	52, 56, 60, 64	Indoor	NA	NA	If TPC 23 / 200 Else 20 / 100
UNII-2 ext.	5.470-5.725	100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	Indoor & outdoor	NA	NA	If TPC 30 / 1000 Else 27 / 500
UNII-3	5.725-5.825	149 to 165	Forbidden	NA	NA	NA

TPC means Transmit Power Control. It's a mechanism by which 2 devices initiating a communication will negotiate so that their respective power level is as low as possible, just loud enough to hear each other.

Some channels require DFS support; see section "*Radars detection overview (DFS)*".

III.5.6 Radars detection overview (DFS)

In some regions, it is important to ensure that wireless equipment does not interfere with certain radar systems in the 5 GHz band. If radar is detected, the wireless network automatically switches to a channel that does not interfere with the radar system. Freeing the channel when a radar is detected is called DFS (Dynamic Frequency Selection).

The radar detection is only required for a master device (AP, mesh node, ad-hoc). For a slave device (client), the radar detection is not required but the device must use a passive scan (listen only to join a network). Please notice that passive scan does not allows connection to hidden SSIDs (active scan is required). Actually, a client needs to send probes (active scan) in order to identify a hidden SSID AP.

Radar detection is a probabilistic activity, because radio signals can be distorted by distance, echoes and other hazards. The radio hardware compares the radio signal with known radar patterns. This mechanism can inherently fail in two ways:

- Not detecting a real radar pattern because it is distorted;
- Detecting a not-existent radar pattern because another radio signal is distorted resulting in something similar to a radar signal. This is called false detection.

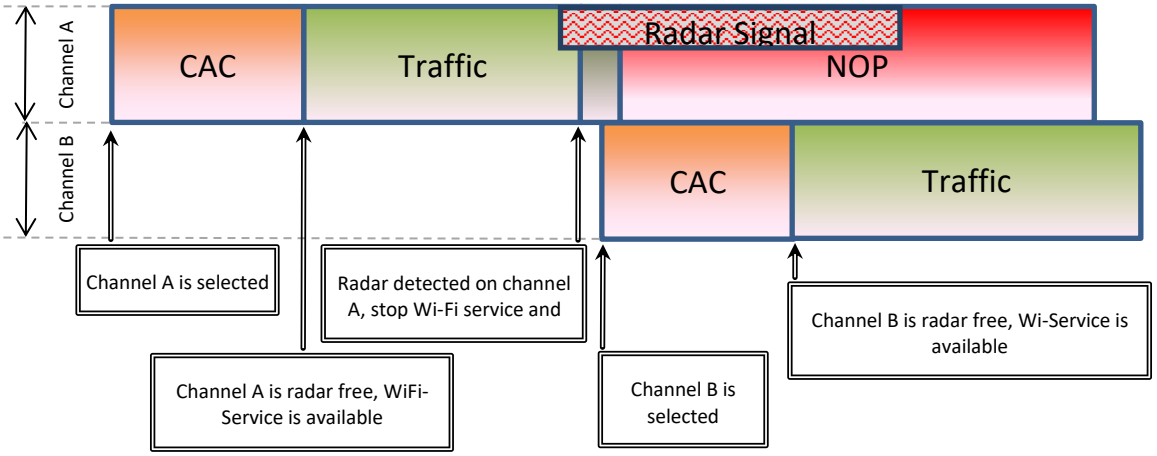
The detector makes its best to avoid these pitfalls but obviously cannot guarantee a 100% exact detection. And indeed, the standards do **not** require 100% detection success. This may result in false detections, and unexpected channel switching in some cases.

The ACKSYS product maintains a database of all applicable channels, where each channel is marked as “Radar Free”, “Radar detected”, “No radar detection”. The product can only select a channel marked as “Radar free” or “No radar detection”.

When the selected channel requires the DFS mechanism, the product starts the Channel Availability Check (CAC) period. During this period, the Wi-Fi service is not available because the product is checking if no radar is present on the channel. If a radar is detected during the CAC period, the channel is marked as “Radar detected”, and the product will select another channel.

If the selected channel is “radar free”, the product can operate it. During operation, the product continuously monitors the spectrum to search for radar patterns. If radar is detected, the product stops the Wi-Fi service, and will select another channel.

After radar detection, the channel is marked as “Radar detected” for a Channel Avoidance Period (NOP). During this period the product cannot select this channel.



Two lists of typical radar waveforms must be detected according to ETSI or FCC standards. Basically, a typical radar waveform is defined by different parameters like:

- Pulse Width
- Number of pulses per radar burst
- Time between pulses (Pulse Repetition Frequency or Pulse Repetition Interval)
- Number of bursts

The list of channels that require DFS are the following:

DFS in FCC			
Channels	BAND	CAC period	NOP period
36, 40, 44, 48	UNII	DFS is not required	
52, 56, 60, 64	UNII-2	1 min	30 min
100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140	UNII-2 ext.	1 min	30 min
149 to 165	UNII-3	DFS is not required	

DFS in ETSI			
Channels	BAND	CAC period	NOP period
36, 40, 44, 48	UNII	DFS is not required	
52, 56, 60, 64	UNII-2	1 min	30 min
100, 104, 108, 112	UNII-2 ext.	1 min	30 min
116,120, 124, 128		10 min	30 min
132, 136, 140		1 min	30 min

CAC and NOP periods are minimal values.

NOTE: If the slave device (client) does not support the radar detection, the EIRP is limited to 23 dBm.

III.5.7 Specific DFS features for ACKSYS products range

The ACKSYS products support three master roles: AP, mesh node and ADHOC. Only the AP role supports DFS. Therefore, the two other master roles (mesh node, ad-hoc) can only use non-DFS channels.

In slave mode, ACKSYS products do not support radar detection but satisfy DFS requirements, because they use the passive scan mode. Be aware the EIRP must always be lower than 23 dBm.

The CAC period in ETSI mode for channel 116 is forced to 10 min whereas the minimum recommended value is 1mn. That enables to supporting HT40 with channels 116/120 and HT80 with channels 116/120/124/128.

The list of radar waveforms detected by ACKSYS products are listed in:

- *ETSI EN 301 893 standard*. The supported release is mentioned in the DFS test report/CE declaration of the product. New radar pulses are added with every version.
- *FCC part 15 sub part E*. The supported release is mentioned in the DFS test report.

IV ADMINISTRATION OVERVIEW

IV.1 Web interface

The primary means to fully configure the product is the web browser interface. It is described in more details in the *Web Interface reference* chapter.

To get access to the product you may have to set its IP address first, this is done using either the *Acksys WaveManager* software.

You can use any recent browser except Microsoft Internet Explorer 11.

IV.2 Reset pushbutton

The RESET pushbutton has three uses:

- a short press (< 2 seconds) will reboot the product. The DIAG led will turn red steadily when the reboot takes place, until the product is operational.
- a long press while the product is running will reset it to factory settings. Press and hold the reset button until the DIAG led turns RED.
- a long press at startup time (either at power-up or very shortly after a reboot) will activate the “Emergency upgrade” mode. When the mode is activated the DIAG LED will blink quickly. This mode allows either to reload the firmware from *Acksys WaveManager* or to reset to factory settings with another press on the pushbutton (see above).

IV.3 Acksys WaveManager

Acksys WaveManager can detect these products, display their configuration and set their IP address, even when they are incorrectly configured, or an incorrect subnet.

Acksys WaveManager can also be used to set the SSID and WiFi operating frequency (radio channel)

Acksys WaveManager can also be used to reload the firmware when the product is in “Emergency upgrade” mode.

IV.4 Emergency upgrade

The “Emergency upgrade” mode is entered via the pushbutton. It allows recovery when a product was powered down during a regular firmware upgrade, or if the product experienced such conditions that it is completely non-operational.

The “Emergency upgrade” mode is described in more details in chapter *VIII Firmware Upgrade*

IV.5 SNMP agent

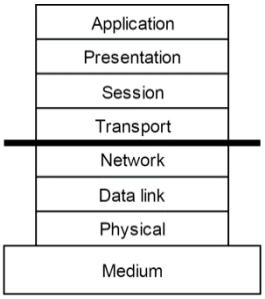
The product embeds a SNMP agent allowing configuration and monitoring from a SNMP manager like Acksys WaveManager, HP OpenView™ or net-snmp commands.
The SNMP agent is described in more details in its own chapter.

V TECHNICAL REFERENCE

V.1 Networking components

V.1.1 OSI model

The discussion of the networking features will often refer to the Open Systems Interconnection (OSI) model. It is a conceptual view of communications systems standardized by the ISO. Please refer to *http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html* or other resources for further explanations.



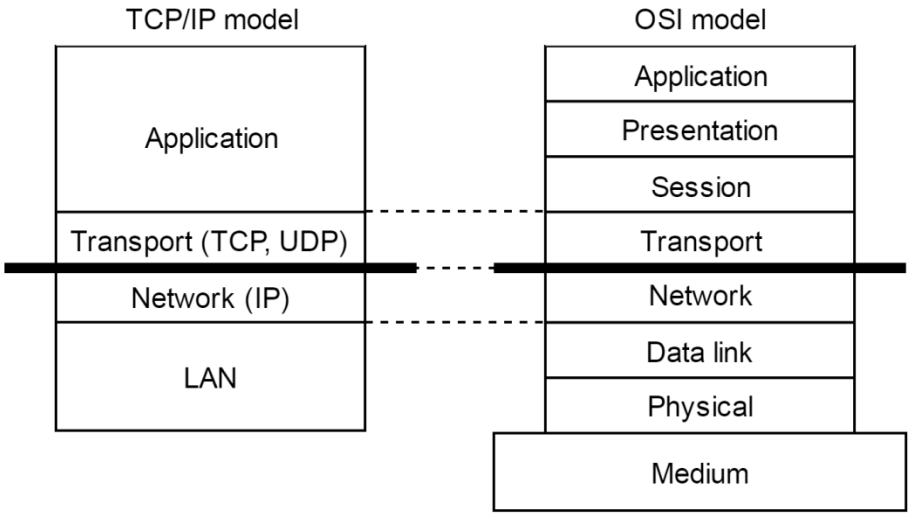
Picture V-1: The OSI layers

This user guide focuses on the three lower layers of the model: physical, data link and network.

V.1.2 TCP/IP model

TCP/IP is the protocols stack used by Internet and most Intranets.

In a device participating in a TCP/IP network, there are four software layers: the **application layer**, the **transport layer** (TCP or UDP), the **network layer** (IP), the **LAN layer** (Ethernet, Wi-Fi, point-to-point modems, etc.). Though the TCP/IP model is older than OSI, it is somewhat correlated since it is one of the origins of OSI.



Picture V-2: Comparison of TCP/IP and OSI models

Each layer has its own purpose and addressing scheme.

The **LAN layer address** allows a device to send data to another device connected to the same LAN. But there is not enough information in a LAN address to send to a device connected on another LAN through a router.

The **Network (IP) address** solves this problem by defining addresses which can be subject to routing. When the source and destination devices are not on the same LAN, the source device can send data to an intermediate router (also called gateway). The router has routing tables which allows it to forward data to the destination device, maybe through other gateways.

The **transport layer address,** called a “port”, is used inside a destination device to deliver data to the correct application process.

You can move packets between two physical links depending on their MAC addresses, without changing the packets: this is called bridging or switching. You can move packets between LANs by selecting their destination depending on the IP addresses: this is called routing. Routing offers additional features, like the possibility to masquerade IP addresses, or to selectively disable routing: this is firewalling.

V.1.3 LAN layer: network interfaces

In the context of TCP/IP networks, a network interface is a way to communicate with other computers. This way could be a piece of hardware and its software drivers, like an Ethernet LAN, or a pair of modems linking COM ports of two peer computers; it could also be a whole subsystem like a PABX, a Wi-Fi infrastructure, or a couple of Ethernet paired for redundancy.

In WaveOS, the network interface is implemented as a software object that conceptualizes a communication port. It provides communication between

- an upper software layer such as the IP networking layer or a bridge,
- and lower communication interfaces, such as physical media, tunnels, Wi-Fi “roles” or bridges.

You can group compatible network interfaces inside bridges. Access points are commonly bridged with an Ethernet LAN to provide Ethernet access to its Wi-Fi clients. The IP protocol views the bridge as a single interface with a single IP address, just like if the bridge was an external hardware switch.

Giving an IP address to a network interface attaches it to the IP layer.

V.1.4 Physical interface

A physical interface is a software object that relies on a hardware device like an Ethernet card or a WiFi radio card.

The *VI.1.1 Physical interfaces* submenu configures the physical interfaces.

V.1.5 Network segment

A network segment is a hardware assembly that interconnects two or more computers, and allows them to exchange physical “signals” without processing them. For example: a RJ45 cable, a coaxial Ethernet, or a handful of RJ45 cables linked by an Ethernet Hub.

The concept of network segment in Ethernet compatible networks is similar to the “collision domain”. It indicates which devices will always receive a frame sent and which devices must synchronize to access the media.

Note that a network switch splits the network into several segments, because it filters frames between its ports; conversely a legacy network hub maintains the view of several ports sharing a single segment because collisions can occur between ports.

V.1.6 Virtual interface

A virtual interface is a software object that implements special-purpose processing on data frames and that can be associated with a physical interface, or another virtual interface, or stand alone.

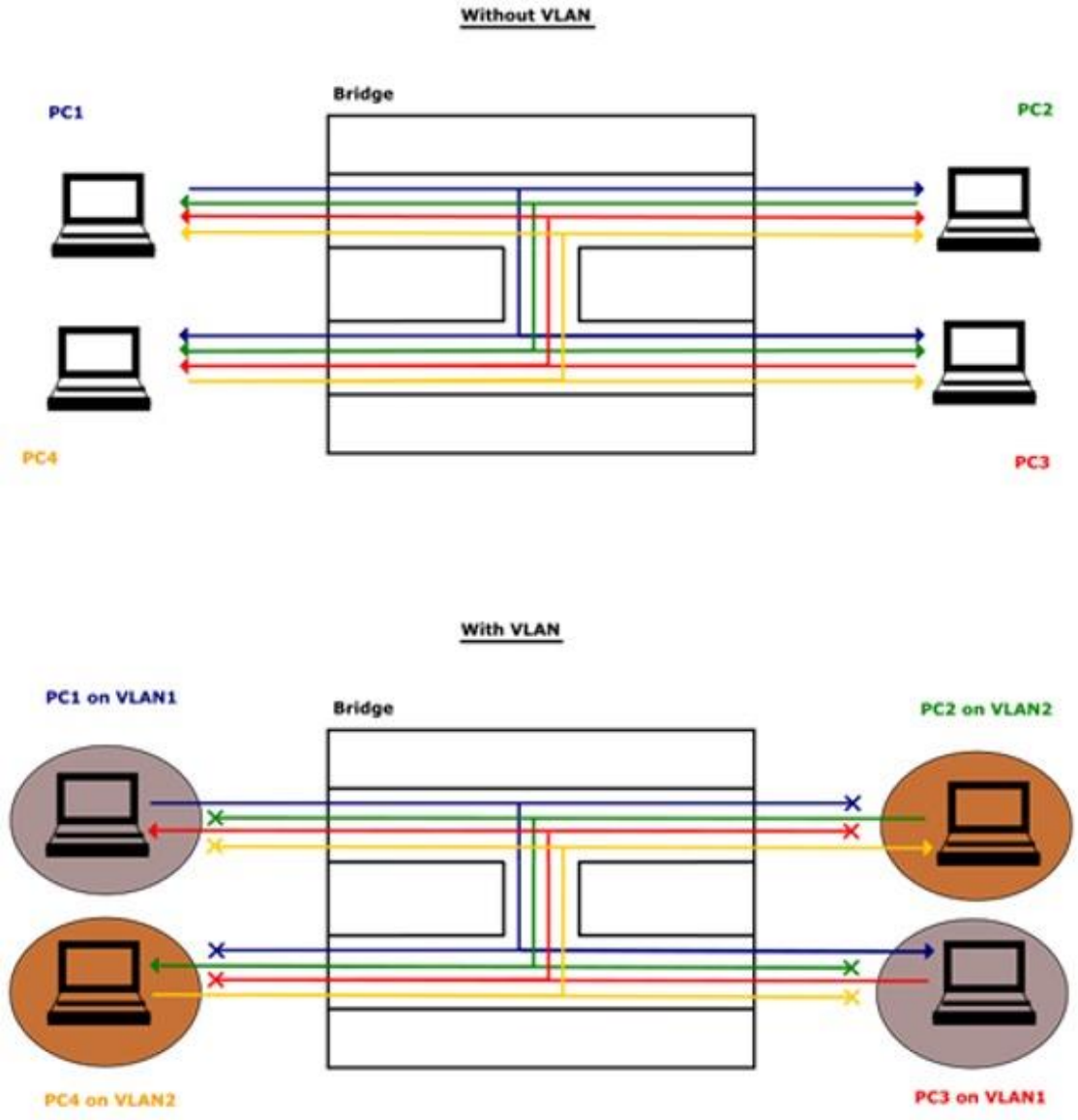
Virtual devices are commonly used to create tunnels or to multiplex several unrelated flows through one medium using VLANs.

The *Cellular* submenu configures the virtual interfaces.

V.1.7 VLAN

The VLAN (Virtual LAN) concept allows splitting up a broadcasting domain at the data link layer into several sub-domains, by assigning to each sub-domain a VLAN identifying number, the **VLAN_ID**.

VLANs have a number of advantages. They help reduce to a sub-domain the target of broadcast frames, isolate unrelated hosts which share the same physical network, and allow bridges to make different forwarding decisions based on VLAN IDs.



Picture V-3: Computers receive only from computers on the same VLAN

V.1.7.1 Frame tagging

When a network segment must convey frames for several VLANs, the frames are tagged with the corresponding VLAN_ID.

V.1.7.2 Vlan interface

A VLAN interface is a Virtual interface that filters a VLAN_ID of ingress traffic on a physical interface, then untags it by removing the VLAN_ID. Conversely, all egressing traffic of the VLAN interface will be tagged with the VLAN_ID.

The VLAN interfaces are achieved with the VIRTUAL INTERFACES/802.1Q TAGS in submenu.

Please see: *VI.1.2.1 802.1q Tagging*

V.1.8 Bridge

A bridge is a device that connects two or more 802.1 compatible network segments and forwards frames selectively. Bridging is done at layer 2 (data link layer) of the OSI model: frames are forwarded based on their Ethernet address, rather than their IP address (unlike a router). Since forwarding is done at Layer 2, all layer 3 protocols can go transparently through a bridge.

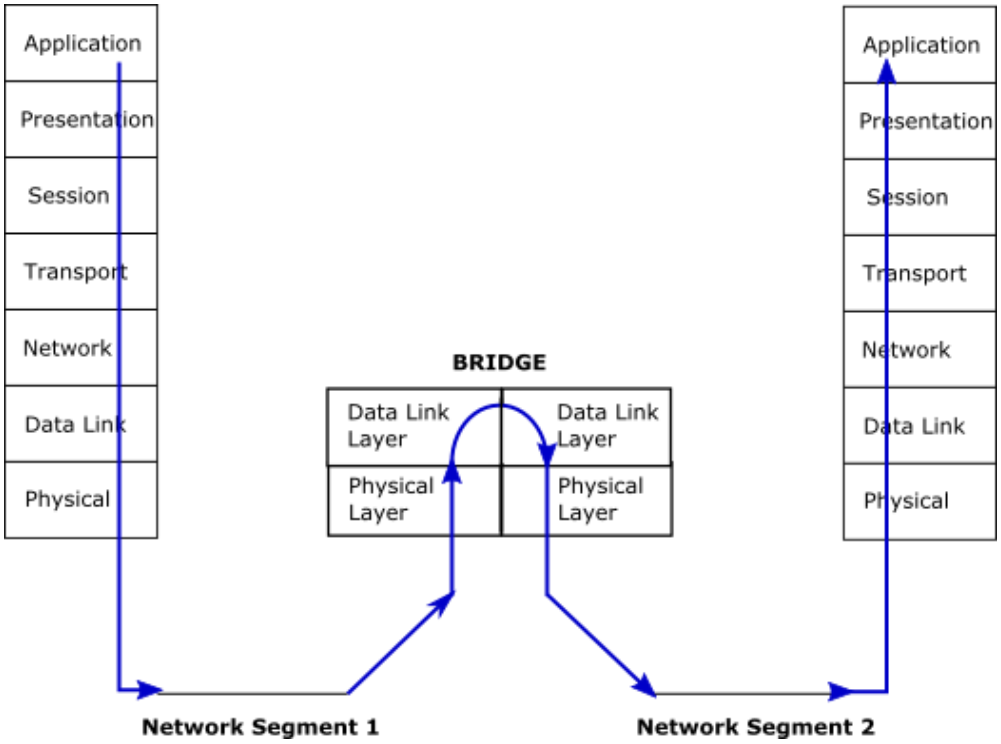
Each network segment is connected to the bridge via a **port**. A port can be a physical or virtual interface.

The bridge builds an internal list of MAC addresses in use on each attached network segment. When forwarding a frame, the bridge looks up the destination in its table and forwards only to the port bearing the address. If the destination address is not found in a table, the frame is duplicated and forwarded on every port but the originating one.

A bridge can appear as a distinct hardware called a “switch”. Alternately, a router can embed a “software bridge” which groups several ports in a single layer 2 interface to be configured at layer 3.

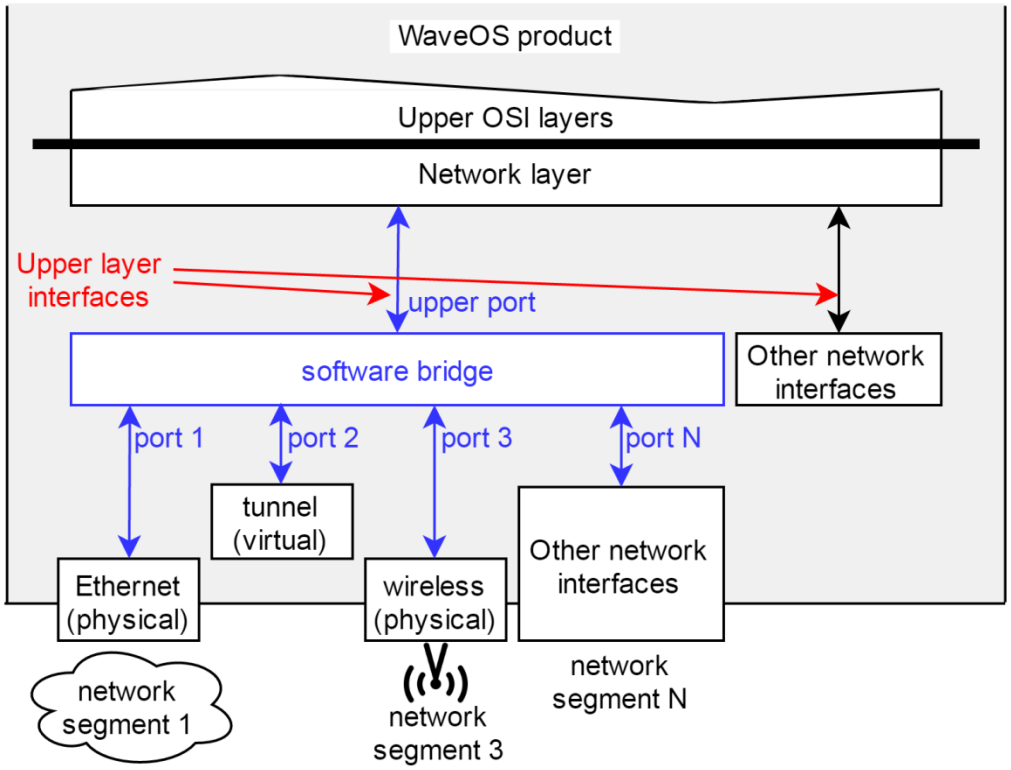
Picture V-4: An 8-ports switch

In order to bridge interfaces together, refer to *VI.1.4.1 Network configuration* and the **Interfaces Settings** submenu.



V.1.8.1 Bridge upper layer interface

The software bridges integrated in a router have one dedicated port through which the network upper layer services can route data to the underlying network segments or configure the bridge itself. This special port is called the upper layer interface.



Picture V-5: Upper layer interface in software bridges

V.1.8.2 Vlan bridging

There are 2 types of bridges in WaveOS:

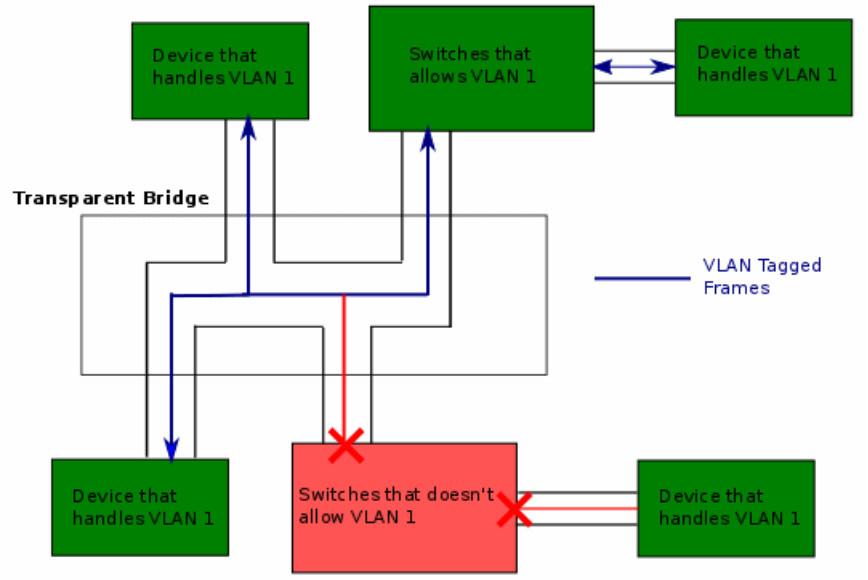
- Transparent Bridge: Bridge that does not handle VLANs.
- Bridge-VLAN: Bridge that handles VLANs.

Transparent bridges are less powerful but easier to set up. They can be tweaked to use a limited form of VLAN filtering.

a. Transparent Bridge

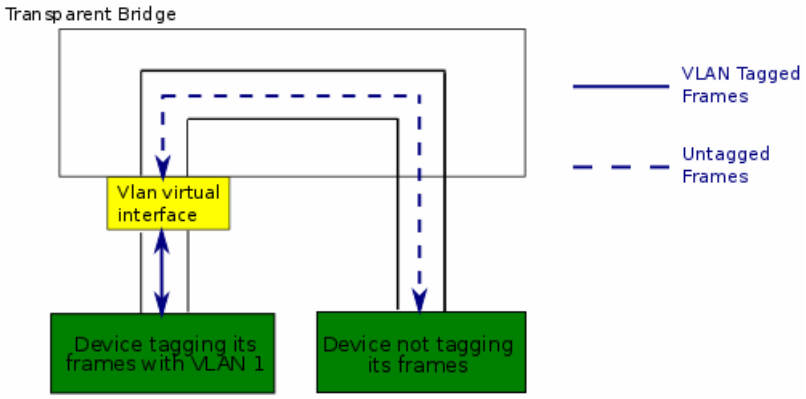
A transparent bridge does not consider VLANs or VLAN tags in frames. Frames are forwarded to any bridge port, only depending on their destination address. If an ingress frame contains a VLAN tag, it will egress unchanged.

So, a bridge port can potentially output both tagged and untagged frames. Manageable external switches connected to this bridge must be carefully set to filter or pass through the planned VLAN tags or untagged frames. See next picture.



Picture V-6: Transparent bridge forwards tagged frames unmodified

However, you can create VLAN interfaces (see above) and plug them on the bridge ports. This enforces the use of tags, and allows converting from one VLAN to another:



Picture V-7: VLAN tag conversion using a virtual interface

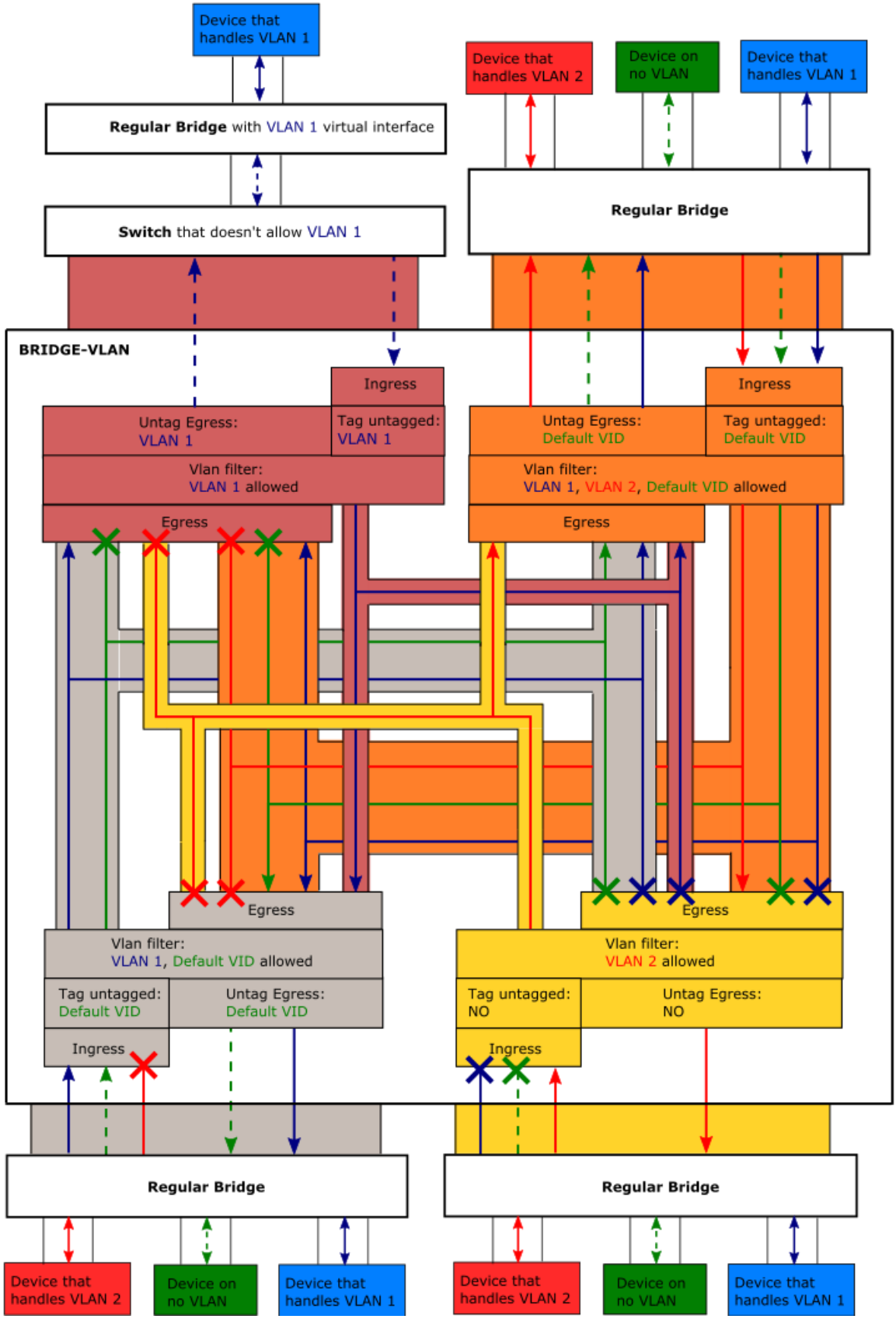
The VLAN interface drops untagged and wrongly tagged ingress frames. It untags properly tagged ingress frames before forwarding them to the bridge. In the other direction it tags egress traffic.

b. Bridge-VLAN

In a **Bridge-VLAN**, each interface has a list of authorized VLANs. VLANs that are not in this list cannot be forwarded via this interface.

Ingress untagged traffic is dropped and not forwarded by the bridge. Instead it can be tagged with a configurable Default VLAN_ID, so it can then be forwarded by the bridge.

Egress traffic can be tagged or untagged.



The bridges-vlans are achieved with the BRIDGING / VLAN MANAGEMENT submenu.

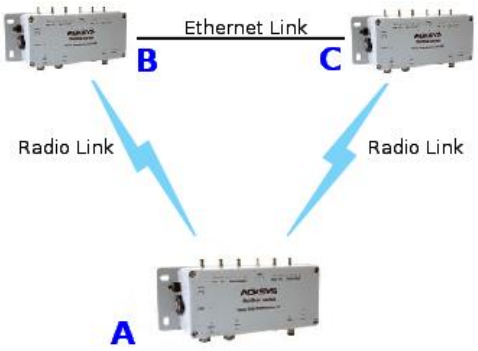
Please see: Vlan Management

V.1.8.3 Spanning Tree Protocols (STP, RSTP)

a. Spanning Tree overview

Incentive

Interconnecting various switch devices and MAC bridges in a LAN may lead to network loops. For example (see picture below), say you have 3 bridges A, B and C, and there is a direct (Ethernet or Wi-Fi) connection between A and B, another between B and C, another between C and A; then when a device connected to A sends a broadcast, it will be resent by A to B and C, B will resend it to C and C will resend it to A. The broadcast frame is caught in a loop which will soon take a lot of the available bandwidth resulting in a so-called “broadcast storm”.



However, loops may be useful to create backup routes when a link fails.

See Point-to-point redundancy with dual band section for an example.

Topology model and related terms

The STP/RSTP topology is built on physical network links interconnected by **bridges**. The whole structure is called a **Bridged LAN**. Examples of bridges are: Ethernet switches, manageable switches and the software bridge included in the product.

One physical network link may connect together several **end stations** and several bridges. Examples of such links are: the legacy Coaxial Ethernet, the Twisted Pair Ethernet hub, or a wireless Access Point. When there are exactly two bridges connected by the link, it is called a “point-to-point link” from the STP/RSTP point of view. A point-to-point link may connect end stations in addition to the two bridges.

The interface between the bridge and the physical network link is called a **port**. A bridge has several ports and its main function is to forward frames from one port to the others.

There are two ways to provide redundancy in a bridged LAN. First, a bridge may have several ports connected to the same physical network link, to guard against a port failure. Second, a group of bridges may form a loop (a mesh) to guard against a bridge failure.

Operation

When the STP protocol is activated on several interconnected bridges, they will exchange information to agree upon a unique path to transmit frames from one point to another.

The bridges will coordinate to set up a tree structure, thus avoiding loops, and this tree is capable of rearranging automatically when links are broken.

STP should be activated on all bridges participating in a LAN loop. The alternate protocol RSTP is an evolution of STP that reacts more rapidly to broken links in some cases, thus accelerating broken links recovery.

Warning: If the bridge contains **wireless** interfaces, some caution must be taken to ensure proper functioning of **STP/RSTP** on these interfaces:

- If the **wireless** interface is an **Access Point**: The number of clients connected to this Access Point must be limited to 1.
- If the **wireless** interface is a **Client**: The Bridging mode must be "**4 addresses format (WDS)**" (since ARPNAT cannot handle non-IP STP frames). Please note that this implies that the roaming functionality is compatible with ST/RSTP only if set to the Connect before break mode.

b. RSTP overview

RSTP is a network protocol defined in the standard 802.1d that ensures a loop-free topology in a bridged LAN (With WDS for wireless interface).

It also allows including alternate paths and backup ports in the network topology.

RSTP provides quick recovery of connectivity to minimize frame loss.

Packets named **BPDU** are used for RSTP negotiation between bridges, and for topology changes.

Protocol outlines

Root election

RSTP defines the network topology as a Spanning Tree (an inverted tree). It first selects a **Root bridge**, from which Ethernet/Wireless connections branch out to connect other switches.

After the root bridge is chosen, each other bridge in the network will have 2 types of links:

- **Upper links**: Links leading to the root bridge
- **Lower links**: Link not leading to the root bridge.

Then, each bridge will negotiate with its neighbors to state on which ports are attached to lower links: the **Designated ports**, and which ports are attached to upper links. From these, a single one will be selected as the **Root port**.

Port roles

If several ports in the bridge have an upper link, to avoid loops, RSTP will define these ports either as **backup** if they share the same medium as the root port, or **alternate** if they are on a different medium. It does so according to ports performance parameters.

Only Root and Designated ports are allowed to forward packets, Alternate and backup ports are not allowed to forward.

In case of failure on Root port, RSTP will change an Alternate or Backup port to Root port.

So RSTP defines 5 port roles for a bridge:

- **Root**
- **Designated**
- **Alternate**
- **Backup**
- **Disabled (**no link).

Port states

To avoid loops during RSTP port role definition, ports are allowed neither to forward traffic, nor to learn MAC addresses. After assigning roles, ports are allowed to learn MAC addresses but not yet to forward traffic. Eventually the ports transit to the forwarding state.

In RSTP, a port has 3 states:

- **Discarding**: It is not allowed to forward traffic.
- **Learning**: It is not allowed to forward traffic, but it is learning MAC addresses.
- **Forwarding**: It is allowed to forward traffic, and it is learning MAC addresses.

Topology change propagation

In RSTP, a topology change is generated if a root or designated port moves to forwarding state. All bridges (root and non-root bridges) can generate and forward topology change information through BPDU to upper and lower links in the network, which allows RSTP to achieve shorter convergence time than STP.

Performance Improvements

Convergence speed

To speed up the transition to forwarding state, and so have a functional network, RSTP defines some performance parameters:

The Edge port type: a port attached to LAN with no other bridge attached. RSTP will make the edge ports transition directly to forwarding state.

The Point-to-Point link type: a direct link between two bridges (without any intermediate equipment like a hub between the two bridges). This will help designated port to transition faster to forwarding state.

The forward delay: The delay to transition Root and Designated Ports to Forwarding state.

Failure recovery speed

Some parameters act on the connectivity recovery speed in case of a bridge failure:

Hello period: Each bridge broadcasts on its designated ports a BPDU every "**Hello_time**" (by default = 2s), to notify its bridge neighbors of the RSTP statement and actual root. A lower-link bridge considers that it has lost connectivity with its upper-link neighbor if it did not receive 3 consecutive BPDUs (by default 3x2s = 6s).

Reducing the Hello time speeds up recovery in case of bridge failure, at the expense of greater bandwidth used for the BPDUs.

Best path enforcement

Automatic selection of the root bridge may lead to suboptimal routes for the traffic flows. So, priorities can be set to make RTSP use known best paths:

Bridge priority: The Root bridge is selected by first comparing bridges priorities, and secondly bridges MAC addresses. The user can enforce a known best path by setting the bridges priorities to enforce election of the desired Root bridge.

Port path cost and Port priority: When a bridge has several upper links, these parameters will permit to select which will the root port on the bridge, and which will be the alternate or backup port.

Backward compatibility with STP:

RSTP will revert to legacy STP on an interface if a legacy version of an STP BPDU is detected on that port. This may lead to degraded performance. So, all bridges in a LAN should use RSTP, although the LAN will still recover (less quickly) with STP.

V.1.9 Tunneling

Tunneling is a way to encapsulate data frames to allow them to pass networks with incompatible address spaces or even incompatible protocols.

Generic Routing Encapsulation (GRE) tunnels are tunnels that can encapsulate unicast/multicast traffic.

GRE creates a bidirectional tunnel between a pair of endpoints (network devices). The source point encapsulates the packets and redirects them to the destination point that will de-encapsulate them, so the GRE tunnel will behave as a virtual point to point link.

The source and destination point are configured via a GRE virtual interface on each side of the GRE tunnel. Each GRE interface contains the IP address of the other side of the tunnel.

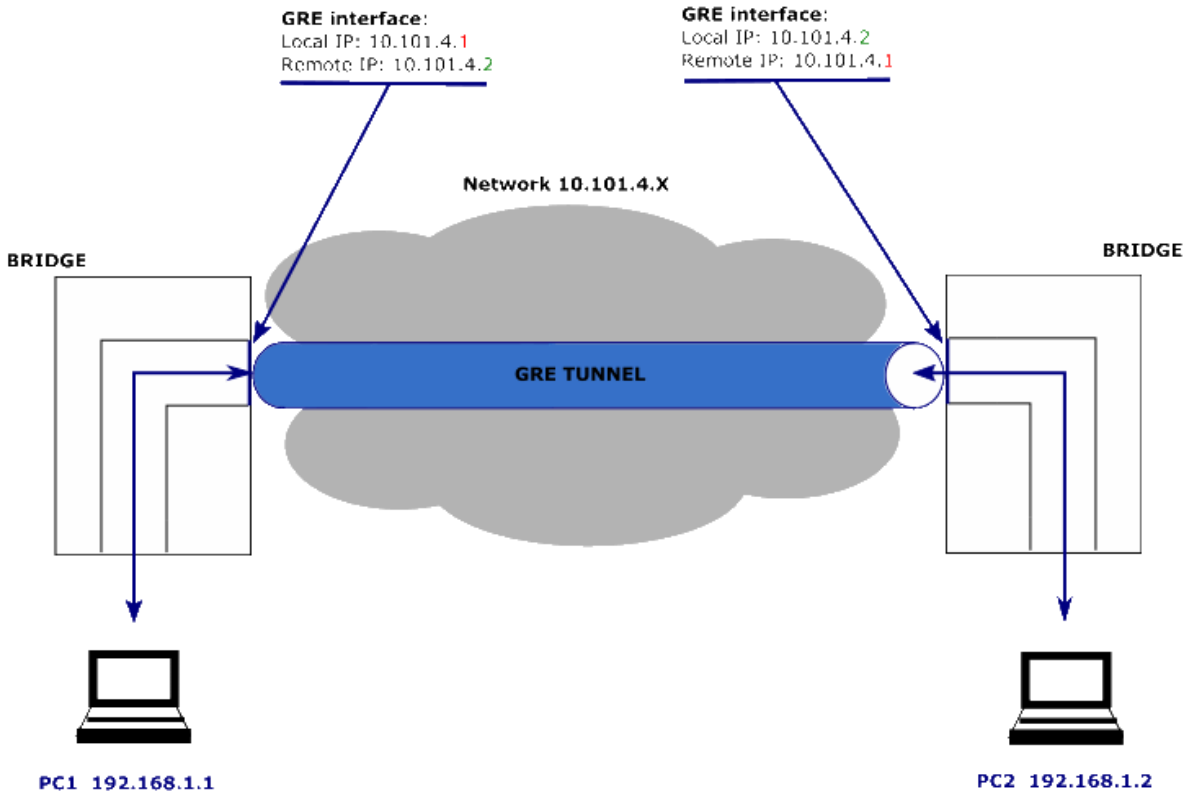
Packets that need to be encapsulated and delivered to some destination (**payload packets**) are encapsulated in GRE packets, then the GRE packet is encapsulated in some other protocol (the **delivery protocol**) and then forwarded.

The protocol type of the **payload packets** can be one of **ETHER TYPES** (see RFC1700).

WaveOS supports **IPV4** as **delivery protocol**.

GRE tunnels are stateless, they cannot change the source endpoint interface to down, if the destination endpoint is unreachable.

WaveOS supports layer 2 tunneling over GRE by bridging the physical interface with a GRE tunnel interface.



Layer 2 tunneling over GRE can be configured with the **VIRTUAL INTERFACES/L2 TUNNELS**.

Please see*: VI.1.3.3 L2 Tunnels*

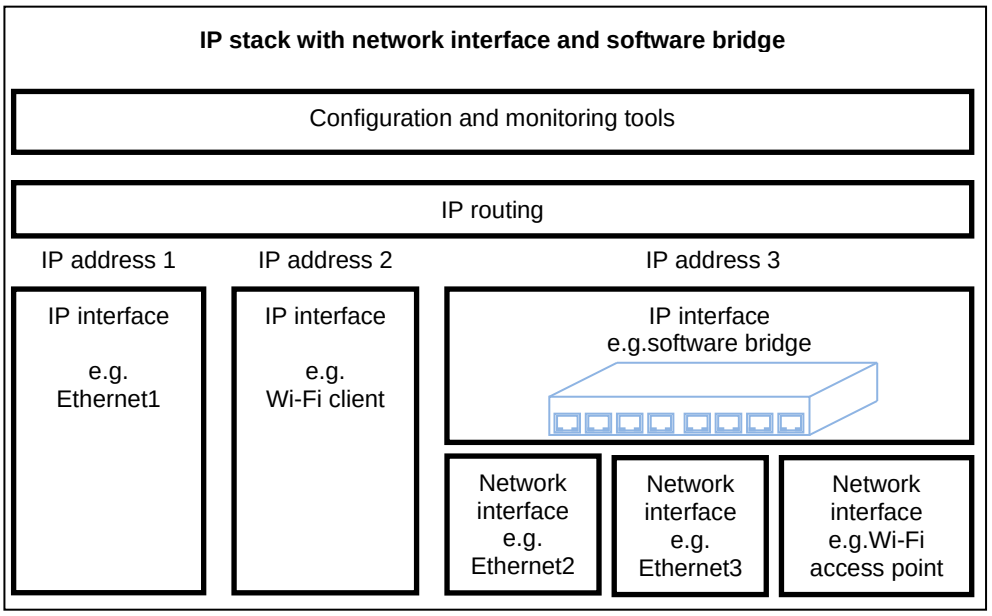
V.1.10 Unicast Routing in IP networks

Routing is the act of finding a path from one place to another, on which a packet can travel. It enables hosts that are not on the same local network to communicate with each other.

A router receives packets not aimed at itself, and selects a path for forwarding it packet, based on its address to the next intermediate router or final destination. To achieve the path selection, the router, uses a routing table built either automatically or by the user.

Routing is done at the layer 3 of the OSI model.

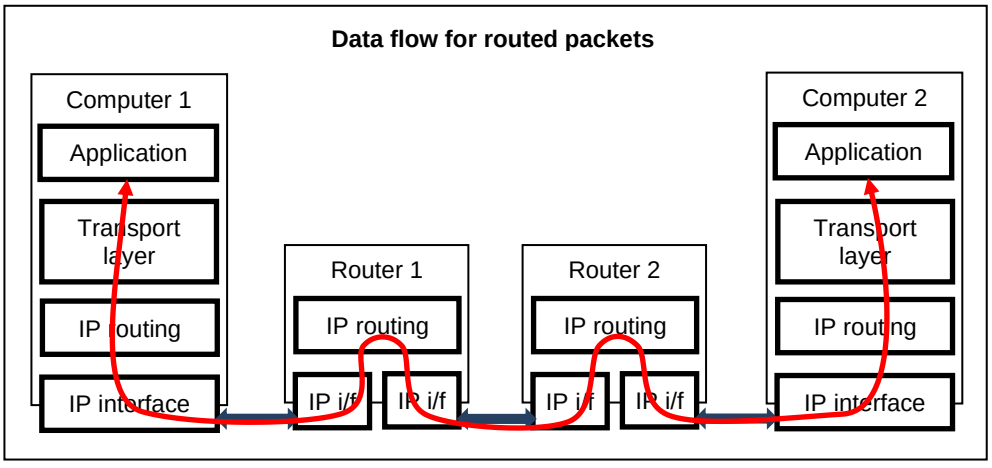
IP is the part of the TCP/IP stack that manages computer addresses and routing. Within one computer, the IP protocol sees each network interface as a separate LAN. Each LAN must have an IP address, something like “192.168.1.2”, to enable it to be used by IP. A network interface is thus the piece of software that drives one network hardware interface.



Picture V-8: Example of combined routing/bridging setup

The set of all the LANs that can communicate together by means of routers is an “internetwork”; the Internet itself is an example of such concept. Routers themselves are nothing more than a computer equipped with several network connections and used specifically to route packets.

Here is the path followed by a data packet traversing 2 routers. The source and destination IP address never change during the transit, contrary to the MAC addresses which change at each routing point.



On **WaveOS**, routing is implied when several network interfaces are configured. It can be tuned further in the **ROUTING/FIREWALL** submenu. Please see: *Routing / Firewall* chapter.

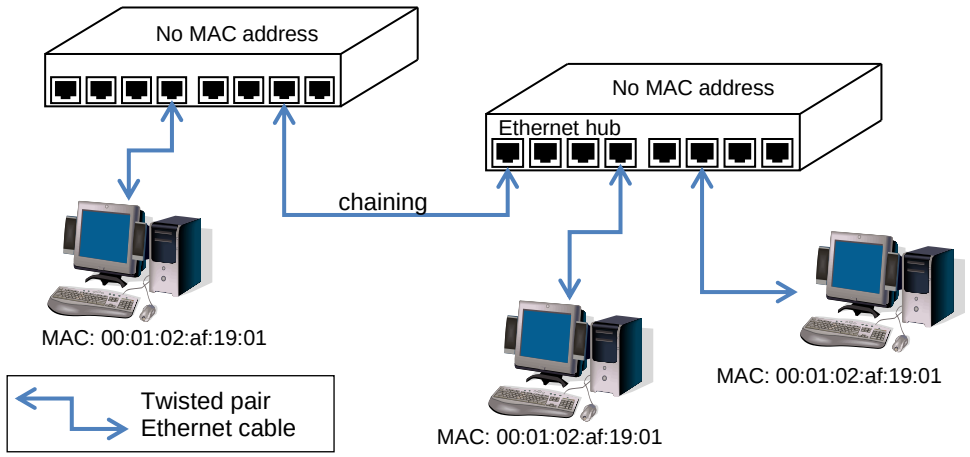
V.1.11 Addressing in the Data Link Layer (OSI layer 2)

V.1.11.1 Ethernet Address

The Ethernet address is also referred to as the hardware address or MAC address. The first three bytes identify the hardware manufacturer, e.g. Hex 00:09:90 for an ACKSYS product. The last three bytes change in each product. This address is assigned at the factory and should not be changed.

An Ethernet LAN can be made of hubs, switches, bridges. These retransmit data packet without changes. You can think of hubs as mere electrical amplifiers, and you can think of switches as filtering hubs. They must not be confused with IP routers (see below).

Ethernet LAN example



V.1.11.2 Wi-Fi MAC Address

The Wi-Fi protocols use the Ethernet addresses format to identify radio cards and to distinguish various functions on the same card. These addresses are either factory assigned by the radio card maker, or dynamically computed, e.g. when the same radio card advertises two access point functions (two wlans).

A Wi-Fi MAC address can also be used as the BSSID, an identifier which delimits which stations can talk together using only Wi-Fi techniques (e.g. using an Access Point but not TCP/IP or Ethernet)

V.1.12 Addressing in the IP layer (OSI layer 3)

V.1.12.1 IP addresses IPv4

The IP address is a 4 bytes (or 32 bits) number, unique to each device on the network, which hosts can use to communicate. The IP address is usually represented in the “decimal dotted notation” which consists of the decimal value of each of the four bytes, separated by dots.

The IP address is divided into two parts: network and host. The main purpose of this division is to ease the routing process. The set of bits constitutive of the network part is identified by a “network mask”. For example, the mask 255.255.255.0 selects the 24 upper bits of an address as the network address, and the lower 8 bits as the host address.

Another way to specify a netmask is to indicate the number of '1' bits, assuming they all are the most significant. For example, in **192.168.1.0/24** the **/24** part means **netmask 255.255.255.0**

Example: Class C network address and netmask

1	1	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0
193								168								1								200							
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
255								255								255								0							

Historical usage has named **Class A network** the networks 1.x.x.x/8 to 127.x.x.x/8; **Class B** the networks 128.0.x.x/16 to 191.255.x.x/16; **Class C** the networks 192.0.0.x/24 to 223.255.255.x/24.

A host part with all bits set to 1 is the broadcast address, meaning "for every device". A host part with all bits fixed to 0 addresses the network as a whole (for example, in routing entries). Addresses above 224.0.0.0 are used for multicast addressing.

V.1.12.2 IP addresses IPv6

WaveOs 4.18.0.1 Key new features of IPv6:

- Host autoconfiguration through "Stateless Address Autoconfiguration" (SLAAC)
- SLAAC allows devices to generate their own IP address without a DHCP server
- LOTS of addresses – so no **need** to use host-based NAT

Similarly to IPv4, some of IPv6 address pool is reserved for specific services and use-cases. The table below will be useful when working with IPv6 addresses and assigning or simply trying to understand how each IPv6 address has been allocated or used in comparison to IPv4.

IPv6 Address Types

Prefix	Address type	IPv4 equivalent	Designation and explanation
2000::/3	**Global Unicast**	No equivalent single block	Other than the exceptions documented in this table, the operators of networks using these addresses can be found using the Whois servers of the RIRs listed in the registry at: https://www.iana.org/assignments/ipv6-unicast-address-assignments/ipv6-unicast-address-assignments.xhtml

IPv6 Address Types			
Prefix	**Address type**	**IPv4 equivalent**	**Designation and explanation**
fe80::/10	**Link-Local Addresses**	169.254.0.0/16 (RFC3927)	These addresses are used on a single link or a non-routed common access network, such as an Ethernet LAN. They do not need to be unique outside of that link. Link-local addresses may appear as the source or destination of an IPv6 packet. Routers must not forward IPv6 packets if the source or destination contains a link-local address. Link-local addresses may appear as the source or destination of an IPv6 packet. Routers must not forward IPv6 packets if the source or destination contains a link-local address.
ff00::/8	**Multicast**	224.0.0.0/4	These addresses are used to identify multicast groups. They should only be used as destination addresses, never as source addresses.
fc00::/7	**Unique Local Addresses (ULAs)**	Private, or RFC1918 address space: 10.0.0.0/8 172.16.0.0/12 192.168.0.0/16	These addresses are reserved for local use in home and enterprise environments and are not public address space. These addresses might not be unique, and there is no formal address registration. Packets with these addresses in the source or destination fields are not intended to be routed on the public Internet but are intended to be routed within the enterprise or organization. See RFC4193 for more details.

V.1.12.1 IPv6 Autoconfiguration

IPv6 nodes can use SLAAC to determine their

- IP address
- Default gateway
- (Optionally) DNS resolver

SLAAC works by routers sending link-local multicast Router Advertisement (RAs)

An RA message contains information that may include:

- On-link prefix(es), with preferred/valid lifetimes

- The link Maximum Transmission Unit (MTU) ; typically 1500 for Ethernet
- An indication of the availability of DHCPv6; M = stateful DHCPv6 available, O = stateless DHCPv6 available
- A-flag; A = 1 means configure address with SLAAC; A = 0 means do not configure address with SLAAC

(Optional) DNS resolver information (RFC 8106)

V.1.12.2 Public and private addresses

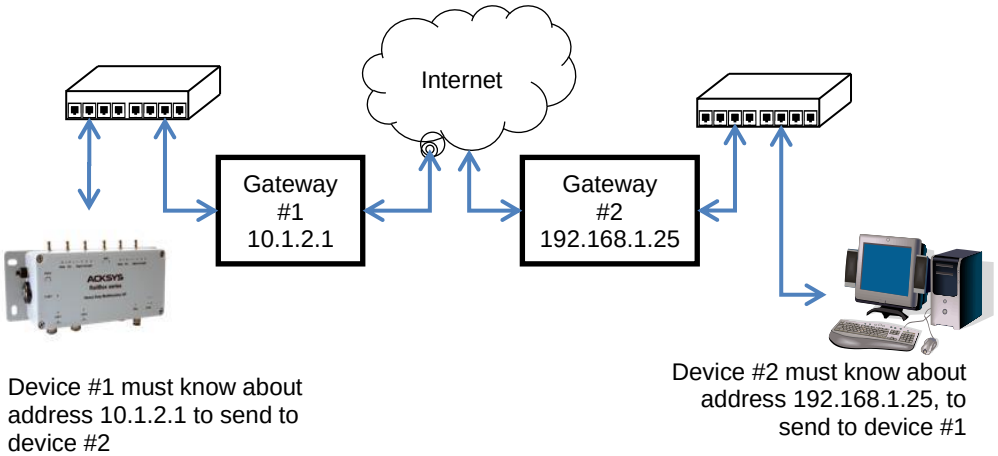
IP addresses can be private or public. Public ones are reserved to devices that require sending data over a public network, such as internet. They are usually purchased or leased from a local ISP.

Ideally each device in the world should have its own IP address so that they always can communicate together. In the real world, most organizations manage their own IP address space independently, so there are duplicates from one organization to another. Two rules help avoiding conflicts:

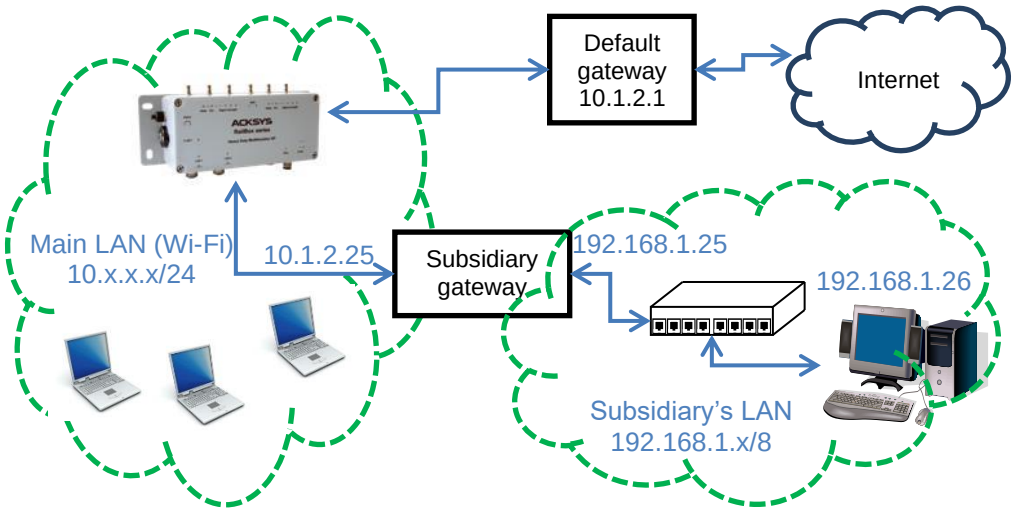
- Internally, organizations use only private addresses from a known set: 10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16
- Routers between private area and the Internet convert internal, private addresses to their own Internet public address, hence making the whole world believe that there is only one computer there, holding all the organization's computing resources. This conversion is called NAT (Network Addresses Translation).

V.1.12.3 Routers (a.k.a. gateways)

Each network device communicating through routers MUST know the IP address of the gateway nearest to it. It will use this gateway to forward data to farther LANs. If a device does not know its gateway, it may receive data but may not return an answer. For example, this can forbid answering a PING even if the PING request makes its way to the device.



When several routers are available on a single LAN to access various remote LANs, the network devices on the LAN should know about each router's own address and the remote network addresses they lead to. Usually, one of the routers is designated as "default", the other ones are treated as exceptions to this default route.



Network devices often use the DHCP protocol to get their IP address. The DHCP server may provide the address of the local router at the same time. To set your Acksys product as DHCP client, please refer to section VI.1.10.1 DHCP Server.

V.1.13 Multicast routing

Multicast traffic is used to distribute a single data packet to many receivers. Examples are video broadcasting (one sender, many receivers) or teleconferencing (many senders, many receivers). Multicast traffic normally uses the UDP transport protocol.

Multicast routing aims to broadcast at minimal cost a data flow to selected receivers. To achieve this goal:

- Bridges must forward multicast frames only to networks segments bearing local receivers or requiring IP routers;
- IP Routers must forward multicast packets only to network interfaces bearing either local receivers or requiring IP routers;
- IP routers must select the best path from the data sender to all receivers.
  When it is known that the number of willing receivers is large against the total number of hosts in the network, multicast traffic can be flooded throughout the network. This so-called "dense mode" is simple but it takes a lot of network resources and is not scalable. Usually, there are only a limited number of receivers, this is called "sparse mode". Two features are required to limit the traffic:
- The receivers must advertise their will to receive
- The intermediate routers must build an optimal distribution tree, e.g. only one copy of the data is sent to a router on the same LAN than two receivers, and only one router distributes a multicast flow on one given LAN.

V.1.13.1 Multicast addresses

A multicast address is usually called a "group" since it does not point to any specific location in the network.

a. Ethernet Data link layer

On Ethernet compatible networks (which includes Wi-Fi), group addresses have the least significant bit of the first byte set to 1 (this is the first bit to be transmitted in a frame). In this sense the broadcast address is also a multicast.

b. Network layer

IPv4 reserves all 32-bits addresses beginning with binary “1110” for multicast. This covers the group range 224.0.0.0 to 239.255.255.255.

Groups in the range 224.0.0.0 to 224.0.0.255 are reserved for LAN delivery, and cannot be routed outside a LAN.

c. Conversion between layers

When an IP multicast is sent out on an Ethernet network, in order for the Ethernet to multicast the frame, the IP group is converted to an Ethernet multicast address.

IPv4 groups are converted to “01:00:5E:” + 23 lower bits of the group.

IPv6 groups are converted to “33:33:” + 32 lower bits of the group.

Hence, two different groups may be received by a device expecting only one of them. The receiving network layer must filter out unexpected groups.

V.1.13.2 PIM-SM

WaveOS implements the Protocol Independent Multicast – Sparse Mode (PIM-SM) to establish the routing tables required for multicast traffic. PIM must run on all the intermediate routers between the data sources and their receivers. The main features of PIM-SM are:

- Manage “rendezvous points” (RP) routers, which are the central distribution points for any given multicast flow
- Identify and manage local multicast sources
- Identify local receivers
- Find routes for multicast flows
- Manage multicast routing tables
- Handle rendezvous points redundancy
- Handle routers redundancy

a. Routers redundancy

When several multicast routers are available on a local network, they automatically negotiate and elect the “Designated Router” (DR) that will process multicast for this network. Periodical messages ensure the detection of the DR failure to trigger a new election.

b. Local sources management

Multicast sources need no protocols to trigger multicast distribution. They just send out their data. Switches and bridges forward multicast traffic to both the local self-advertized receivers and local routers.

c. Local receivers management

Initially, routers do not deliver multicast traffic on local networks until a local receiver advertises itself by broadcasting an “IGMP join” message. This triggers routing of the requested multicast flow from the outside world to the local network.

To account for possible receiver failures and IGMP frames losses, the multicast router periodically sends an “IGMP global query” to refresh its knowledge of local multicast receivers.

Intermediate switches and bridges in the local network may optimize local multicast traffic by using “IGMP snooping”. For this purpose, they may issue “IGMP global query” themselves. These messages differ from the routers’ in two points:

- Their source IP address is 0.0.0.0
- Based on this address, receiving bridges do not account the originator as a multicast router, and so will not forward multicast data to it.

When all local receivers cease to respond to queries for a group, the router stops forwarding this group on the LAN.

d. Rendezvous points functions

To avoid configuring each router in the network with each possible source for a multicast flow, each multicast group is assigned one multicast router known as the “rendezvous point” for this group.

Data from a multicast source is encapsulated and sent (tunneled) by the local router (the sender’s DR) to the rendezvous point in unicast.

Requests from receivers are routed by the multicast routers to the rendezvous point.

After initial communication establishment, the rendezvous point may optimize the path, ensuring that the multicast traffic will flow directly from the source to the destinations.

e. Rendezvous points selection

Any multicast router can be designated by static configuration as a rendezvous point for a group. After that, other routers come to know its existence by either:

- Static configuration in the other routers
- Dynamic negotiation with the BSR (Bootstrap router).

For redundancy, several rendezvous points may serve the same group. Priorities can be enforced, and in the event of equal priorities, an algorithm ensures that the same rendezvous point is used by all routers.

f. BSR election

When rendezvous points are set up dynamically, a Bootstrap Router (BSR) is designated to broadcast periodically the table of currently active rendezvous points.

Any multicast router can be designated by static configuration as a BSR for the network. For redundancy, several BSR may be defined with various priorities. In this case they will elect a master BSR automatically.

g. Multicast route selection

When routing *unicast*, the router receives a packet, extracts its *destination address* and forward depending on the destination. On the contrary, when routing *multicast*, the router receives a request for a group which is converted to a *source address* (the one of the rendezvous point). The router must make the request travel in the reverse path toward the source. This is known as Reverse Path Forwarding (RPF). Routers which are

on the path of the request set their forwarding tables so that multicast data will travel in the opposite direction.

Several routers may exist on any given LAN; a Designated Router (DR) is elected so that the LAN will not receive duplicate packets for the same group. Also, PIM checks and prunes redundant routes between routers.

V.1.13.3 Multicast pitfalls and solutions

Many details can make a seemingly good configuration fail at forwarding multicast traffic. Here we describe the most common and give directions to solve the issues.

a. Router misconfiguration

A multicast router makes full use of its local unicast routing tables in order to compute RPF and SSM paths, and to join other routers. So the IP tables and routes must be correctly set up for unicast operation as well.

Solution: as a prerequisite, check that each router is correctly configured for unicast operation.

b. Sender misconfiguration

The sender must be correctly configured for unicast operation. First,

If the sender's source IP is wrong, the local DR will not accept its multicast traffic

But the sender will nevertheless emit its multicast traffic since it is unacknowledged UDP traffic. Second,

The sender must know the route to deliver multicasts

Usually, the sender's network configuration includes a default route and multicasts will egress through the network interface bearing the default route.

Solution: pay attention to set the sender IP address in the same subnet than the DR, and either to associate the group address with a local network interface, or to have a DR on the same LAN than the default unicast router.

c. Small TTL

Multicast traffic has the capability to flood the network. In order to limit the potential for mistake,

Most standard multicast senders use a default TTL of 1

This is specially the case with software commonly used for network tuning and testing, like Videolan VLC, IPERF and JPERF.

According to the IP protocol, the TTL parameter constrains the number of local networks that a packet can cross. Hence TTL= "1" means "only local delivery".

Solution: configure the sending software so that it uses a larger TTL.

The minimum value must take into account the shortest path between source and farthest destination, going either through the RP or directly.

Setting incorrect values will result in packets silently dropped by a certain router along the distribution path.

d. MTU and DON'T_FRAGMENT option

This one is not specific to multicast but is prominent is this case, because UDP is generally used. If a packet is larger than the MTU of any subnetwork in the distribution path, the relevant router must fragment it. However,

Most senders default to using the IP Don't Fragment flag

This is specially the case with the Linux kernel, and consequently all application software running under Linux, if they do not provide a means to reset this IP option.

Using large packet sizes will usually result in packets silently dropped by a certain router along the distribution path. Often it will be the sender's DR since it must encapsulate traffic to the RP, thus reducing the MTU.

Solution: configure applications to use the maximum frame size that do not need fragmentation; or configure the sender to clear the Don't Fragment flag.

e. Wireless slow multicast traffic

The 802.11 infrastructure mode is asymmetric by essence. When an Access Point sends data to a station, it uses a data rate appropriate for this station. When it sends to many stations as in multicast, 802.11 states that:

the AP must send multicast using the lowest rate available,

which is 1 or 6 Mbps depending on the radio band.

When a station sends multicast frames to the AP, it uses the best rate, but in order to make the frame available to other stations, the AP immediately re-broadcasts the frames at the lowest rate.

This results in

- very slow multicast traffic over Wireless,
- great waste of bandwidth for other traffic.

Solution: Make multicast traffic pass the wireless link while encapsulated in a tunnel. This can be for example a GRE tunnel configured for this purpose, or you can take advantage of the encapsulation between the sender's DR and the RP (in which case you must forbid the RP to switch to the shortest path, which would bypass the tunnel).

f. Wireless transmitting traffic permanently

The radio channel is a sparse resource. On another hand,

the multicast sender blindly sends to its DR,

and this DR quite blindly sends to the RP (except that the RP can request a temporary suspension when it has no receivers).

Solution: the path between the sender and its DR should not cross a wireless LAN. The path between the sender and its RP should not cross a wireless LAN, though this

requirement is less stringent. If you refer to the previous pitfall item, an optimal system has the sender and the RP on the same side of the wireless LAN, and use a GRE tunnel to transfer multicast data to the other side.

g. Wireless transmitting unwanted multicast traffic

An Access Point connected to an Ethernet segment conceptually extends the Ethernet to the associated stations.

Unwanted multicasts reaching the AP from the Ethernet will be forwarded to the stations at very low speed, wasting bandwidth.

In WaveOS this can occur if the AP is added to a bridge together with other interfaces.

Solution: if you know in advance that no wireless station is interested in some multicast group, you can set bridge filters to forbid outgoing multicast traffic. See *Bridge filter* in the web interface chapter.

h. Access points and multicast routers

When the multicast router starts it enumerates the available network interfaces.

If one of them is an access point, it may be that this AP is not yet started because it is configured to search for a channel (ACS function) or because the chosen channel is subject to DFS delays (CAC or NOP). In this case the multicast router cannot establish various negotiations, and this network interface will stay ignored forever.

Access point are delayed by ACS and DFS

Solution: Put the AP all alone in its own bridge. The multicast router will consider that the bridge itself is available, whatever the AP state.

i. Long delays at startup

While running, the multicast router reacts to various events in a timely manner. However, users will go through unexpectedly long delays when WaveOS starts up.

This normal behavior comes from:

- a number of protocols (IGMP, DR election, BSR election, RP election, RPF establishment),
- starting simultaneously,
- depending on each other,
- each having large retry timers.

The resolutions of the timers used in PIM (5 s) compound this effect.

Solution: Only broad indications can be given here. Keep in mind that the problem is only at startup though.

On one hand you must balance between a slightly faster startup by tweaking various timers (IGMP querier, HELLO and RD-Candidate messages), the extra load put on the network and compatibility with alien multicast routers; and on another hand, you must balance between static RP list configuration, and the extra administration burden.

j. Associating VRRP and PIM

When using a VRRP router as multicast router, VRRP will resume or suspend the PIM router depending on the VRRP state being master or backup. This behavior is

configurable by linking VRRP to multicast routing in the *VRRP configuration page*, in case you do not use PIM on the same interfaces as VRRP.

Several points must be kept in mind when dealing with complex configurations.

1) The multicast router is all-or-nothing: either it runs and manages all configured interfaces, or it stops and manages none. If a part of the network interfaces is not involved in VRRP, these interfaces will be unmanaged nevertheless when VRRP transitions to backup state.
2) When the VRRP backup transitions to master state, PIM restarts. This means that the takeover delay is the same as for a startup, which means, much longer for the multicast traffic than for the unicast traffic.

V.1.14 Firewall

Network interfaces can be conceptually grouped into “zones” in order to assign common administrative policies to them. *Firewall*

The firewall permits to set rules that are applied to each packet, and that decides if a packet must be forwarded or blocked.

In WaveOS, the firewall feature can be tuned in submenu: ROUTING/FIREWALL/NETWORK ZONES

Please see: *Firewall*

V.1.15 Zones and Network Address Translation (NAT)

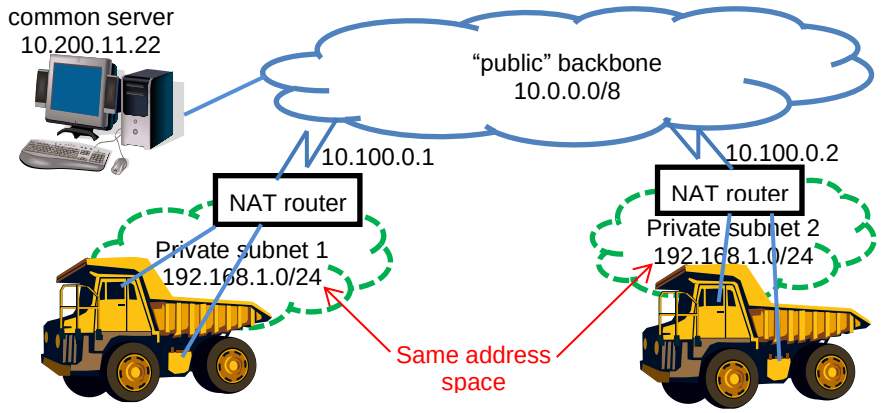
In a router, you may need to selectively block or allow traffic between network interfaces. A zone is an administrative concept which groups several IP interfaces in order to specify common extra processing:

- Firewall rules
- IP address conversion rules (to implement NATs).

V.1.15.1 NAT/PAT (Network/Port Addresses Translation) routers

When a global network is composed of several networks managed by independent administrators and connected together, the same IP addresses could potentially be assigned inside the subnetworks. This is customarily seen in the Internet which serves as a backbone to connect together the private networks of many companies. This could be used also when many identical subnetworks must be set up and connected to a root backbone.

In this kind of setup, each subnetwork has a router which is the gateway to and from the subnetwork. The routers are interconnected by the backbone. To avoid IP addresses duplicates, the routers convert the subnetwork IP addresses to backbone IP addresses, hence the name “NAT”.



In the case of a NAT/PAT router, the network is split in two “**zones**”: the **public zone** which is materialized by the backbone, and where a central administration gives out “public” IP addresses; and the **private zone** where the administrator can assign IP addresses without the knowledge of IP addresses outside.

Then the NAT/PAT router changes all outgoing (from private to public) IP datagrams to masquerade the source private IP address into its own unique, public IP address. It also changes the incoming (from public to private) IP datagrams replacing the destination address, which is the router’s public address, to the private IP address of some device in the private network. In order to keep offering a wide address space as seen from the public side, the NAT/PAT router uses port numbers as extensions to the IP addresses. Hence, the NAT/PAT mainly works with UDP and TCP; it cannot handle generic ICMP routing, but only towards one private device at most.

The NAT/PAT router must manage incoming connection calls as well as outgoing connection calls. It uses two main conversion tables:

- A configurable table which assigns a private destination IP to selected destination ports in the incoming calls

- An internal conversion table which tracks which ports are assigned to which (private IP, private port) couple for outgoing datagrams.

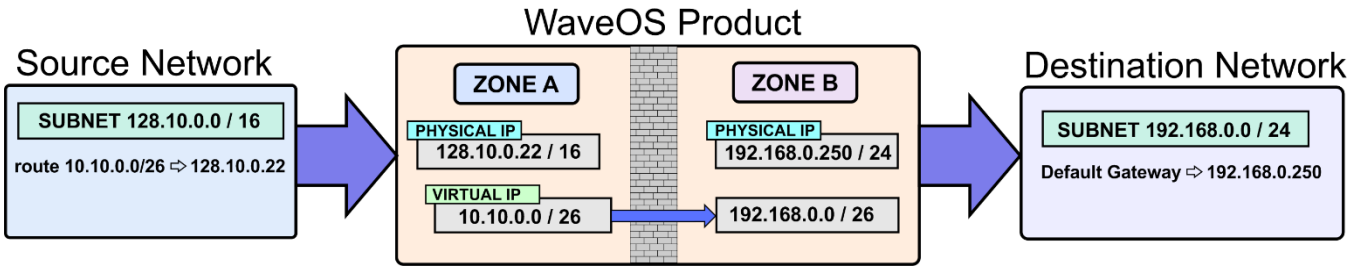
Due to the various processing involved, the performance of a NAT/PAT router is lower than the performance of a regular router, which is lower than the performance of a simple software bridge.

V.1.15.2 NAT 1:1

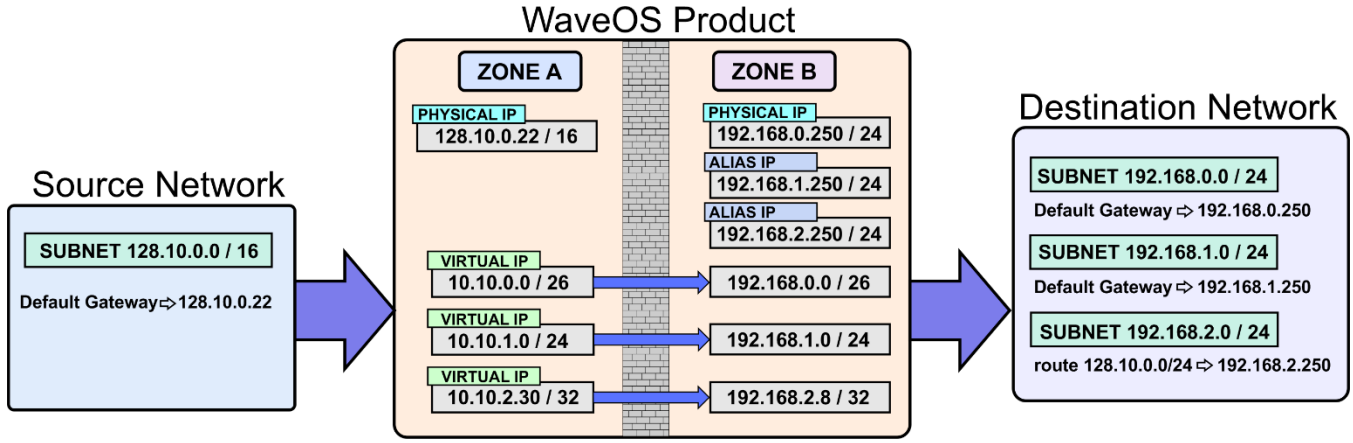
In the case of 1:1 NAT, the translations are still carried out by routing between different zones, but there is no longer any notion of private and public zones. The idea here is to create virtual subnets, associated with a given zone (Source zone), and to perform translations from these virtual subnets to the real subnets of another zone (Destination zone). We can thus translate either unique IP addresses or entire subnets.

In the following example, we have a source network on subnet 128.10.0.0/16, and a destination network on subnet 192.168.0.0/24.

From the source network, we want to access the 64 lower addresses of subnet 192.168.0.0 of the destination network (192.68.0.0 to 192.168.0.63).
To do this, we create a virtual subnet in Zone A (source zone), which will be defined in the source network by a static route. In the WaveOS product, we will then be able to define a rule for translating this virtual subnet to the physical addresses of the destination network. To restrict translation to the first 64 addresses of the subnet, the subnet mask on the virtual IP must be 255.255.255.192 (or /26 CIDR notation)



Now if we want to add access to the whole 192.168.1.0 subnet and reach a unique 192.168.2.0 subnet address, we just need to add the virtual addresses and define the proper translation rules. However, it will be necessary to create on the destination interface an alias of the IP address of the product for each of the subnets, in order to be able to define the return path, via static routes, or default gateways.



V.1.15.1 NAT 66

NAT66 feature is available in waveOs, an address translation technology based on IPv6 networks, used to convert an IPv6 address prefix in an IPv6 message into another IPv6 address prefix (Cellular Use case).

In its simplest form, a NAT66 device will be attached to two network links, one of which is an "internal" network link attached to a leaf network within a single administrative domain, and the other of which is an "external" network with connectivity to the global Internet. All of the hosts on the internal network will use addresses from a single, locally-routed prefix, and those addresses will be translated to/from addresses in a globally-routable prefix as IP packets transit the NAT66 device.More info here

V.2 Wireless concepts in 802.11

V.2.1 Wireless architectures

A wireless LAN (WLAN) is a group of Wi-Fi capable stations. They communicate with each other by following rules specified for a given architecture.

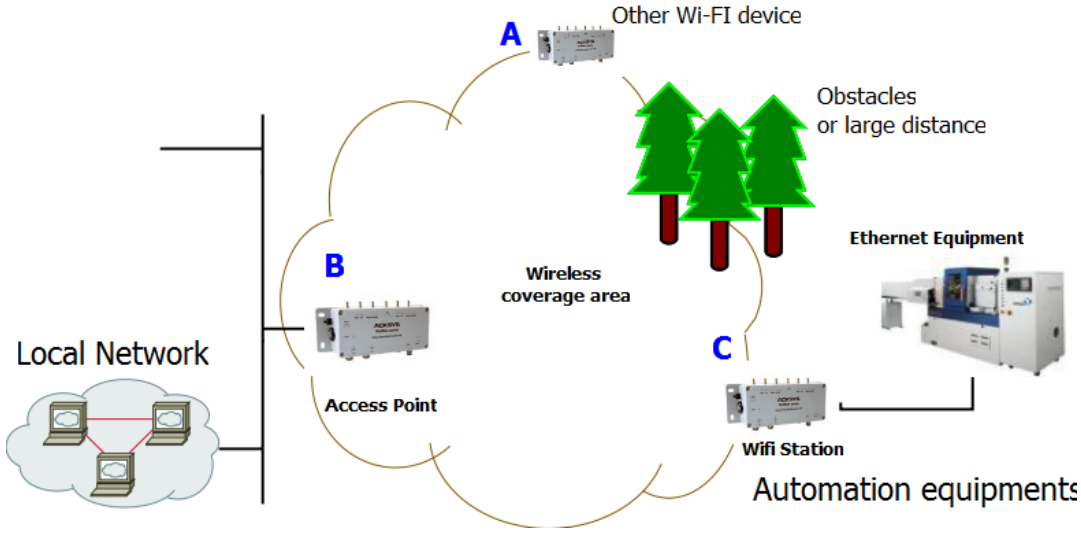
The stations in the group have in common a wireless network name which identifies the WLAN. The IEEE802.11 norm defines three architectures to communicate between Wi-Fi stations:

- Infrastructure (a client/server where the AP relays all traffic)
- Ad-hoc (peer to peer multipoint communication, no relaying)
- Mesh network (all stations are involved in relaying traffic)

V.2.1.1 Infrastructure Mode

In an infrastructure network there are 2 kinds of devices (called **stations**):

- The access points (APs)
- Client Wi-Fi devices (client stations) that connect to an access point to gain access to other Wi-Fi devices or LAN devices.



Products **A**, **B**, **C** can communicate with each other.
Product **B** relays data between products **A** and **C**.
Product **B** relays data between the LAN and products **A** and **C**.

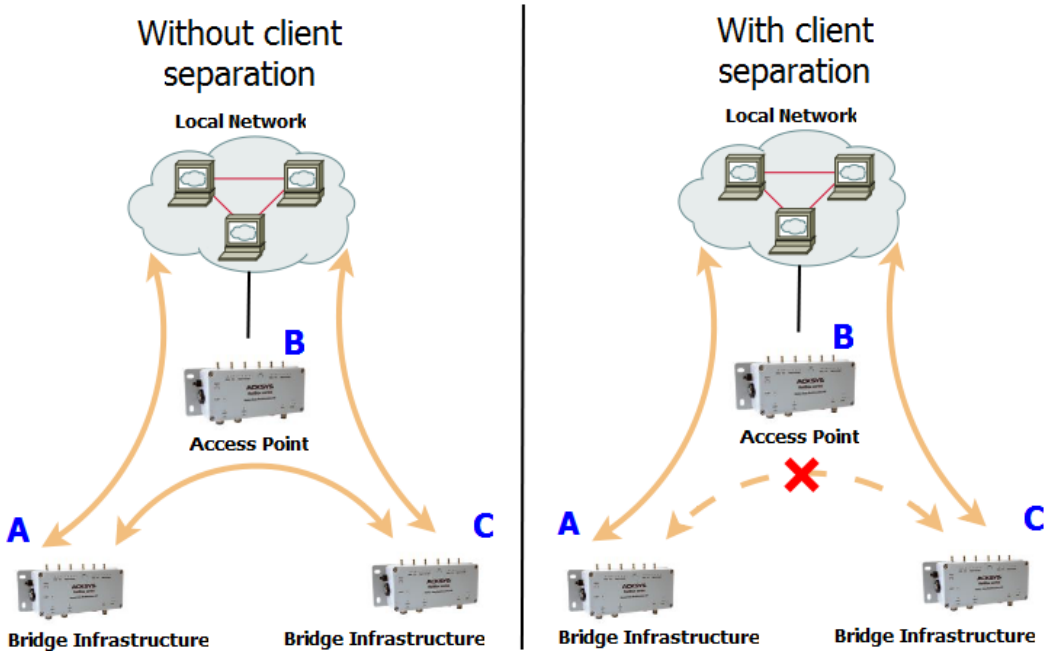
The infrastructure mode provides central connection points for WLAN clients and the AP may also bridge them to a wired network. Prior to any communication, the client must join the WLAN (wireless LAN) by selecting one access point, authenticating and possibly establishing encryption keys.

The AP and its associated clients form a Basic Service Set (BSS) identified by a BSSID, in the form of a MAC address automatically forged by the AP. More APs can be added to the WLAN to increase the reach of the infrastructure and support any number of wireless clients. The whole WLAN is identified by the SSID, a string of 1 to 32 bytes, usually a human-readable text. All wireless stations and APs in the same WLAN must be configured to use the same SSID.

The APs in the WLAN are then cabled to a common wired LAN to allow wireless clients access, for example, to Internet connections or printers.

Compared to the alternative ad-hoc wireless networks, infrastructure mode networks offer the advantage of scalability, centralized security management and improved reach.

Since the 1.4.2 revision, the firmware implements the “clients isolation” feature which allows the AP to block communication between clients. In this case product A will be able to communicate with product B and the “local network” but not with product C (according to the figure below). Product C will also be able to communicate with product B and the “local network” but not with product A. The picture shows the access point behavior with and without the Separation Client option.



In the infrastructure mode concept, a client is supposed to be a single unit. However the wireless client can bridge several Ethernet devices to a BSS towards the AP, and it still appears as only one device, by converting MAC addresses on the fly (see section *V.2.6 Wired to wireless bridging in infrastructure mode*).

V.2.1.2 Ad-hoc Mode

On wireless computer networks, ad-hoc mode is a way for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows all wireless devices, within range of each other, to see each other and communicate in peer-to-peer fashion without involving central access points (including those built into broadband wireless routers).

To set up an ad-hoc network, each wireless adapter must be configured for ad-hoc mode (as opposed to the alternative infrastructure mode).

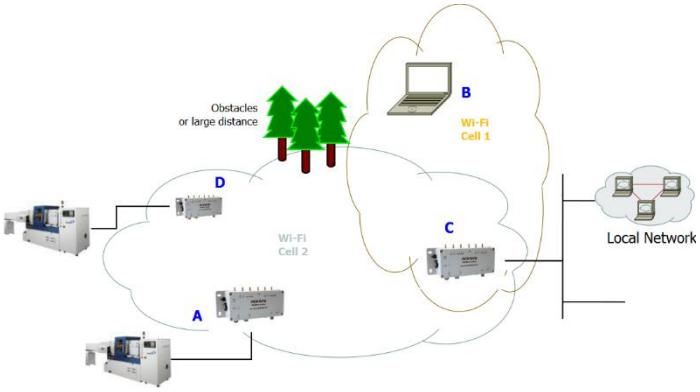
In addition, all wireless adapters on the ad-hoc network must use the same SSID and the same channel number.

An ad-hoc network tends to feature a small group of devices in very close environment. All communicating devices must share the same cell. There is no way to establish a route in order to link 2 remote products.

Without security, Ad-hoc mode works in 802.11abgn/ac mode.

With WEP security, Ad-Hoc mode works in 802.11abg mode

Ad-Hoc mode does not support WPA/WPA2 security.



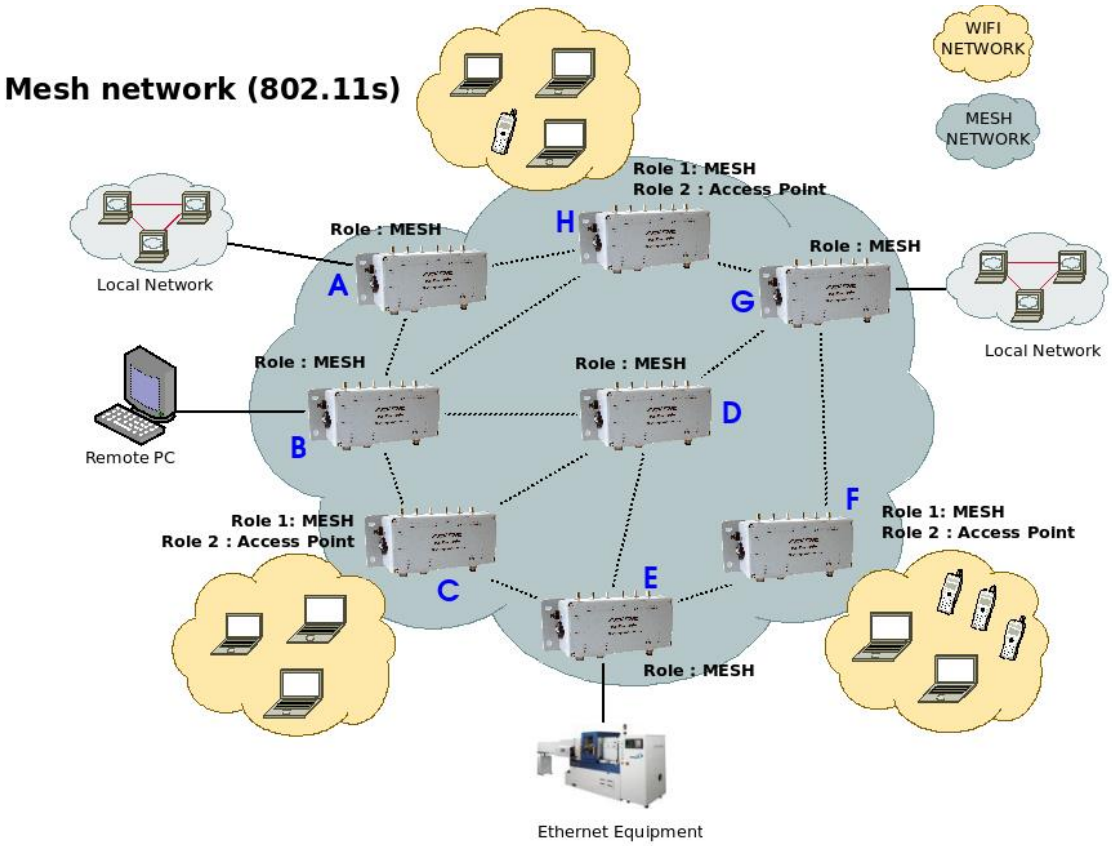
Products **A**, **C**, **D** can communicate with each other.
Products **B**, **C** can communicate with each other.
Products **B**, **D** cannot communicate, obstacle on the way.
Products **A**, **B** cannot communicate, they are too far away.
Product **C** cannot relay from **A, D** to **B**.

V.2.1.3 Mesh (802.11s) Mode

In a 802.11s mesh network there are 3 kinds of devices. They all participate in the process of packet relaying:

- A **mesh station** has a functionality of its own (i.e. a laptop computer).
- A **mesh access point** provides both “mesh” and “basic access point” facilities, bridging non-mesh Wi-Fi devices to the mesh network.
- A **mesh portal** allows other network types to be bridged to the mesh network. For example, a portal would bridge Ethernet to Wi-Fi mesh.

ACKSYS products currently implement “station” and “portal” functions. Products equipped with two radio cards can be used as mesh access points.



Products **A** to **H** can communicate with each other. Products **A, B, D, E, G** provide Mesh portal functionality. Products **C, F, H** provide Mesh AP functionality.

Routing protocols

To determine the transmission path between two mesh points, a routing protocol must analyze the network. 802.11s defines HWMP as a mandatory protocol, and it has provisions to plug in other third-party routing protocols. ACKSYS devices implement HWMP.

Security protocols

802.11s networks can use either no security, or the WPA3-PSK (SAE-Personnal) security described in section *V.2.5.7 Mesh Secure Authentication of Equals (SAE)*. This security is roughly similar to infrastructure WPA/PSK.

V.2.1.4 Wireless Network Name

This name is also referred to as the SSID and serves as a wireless network identifier.

A service set identifier, or SSID, is a name used to identify the specific 802.11 wireless LAN to which a user wishes to access. A client device will receive broadcast messages from all access points within range, advertising their SSIDs, and can choose one to connect to, based on pre-configuration, or by displaying a list of SSIDs in range and asking the user to select one.

Devices participating in a Wi-Fi communication must all use the same SSID. When you are browsing for available wireless networks, this name will appear in the list. For security purposes we highly recommend changing the pre-configured network name.

The SSID used in 802.11s Mesh mode is called “mesh ID”. It takes the same form as the infrastructure SSID, but is a separate parameter: if you use the same string for an infrastructure SSID and a mesh ID, they are considered as two distinct WLANs.

V.2.1.5 Virtual AP (multi-SSID) and multifunction cards

The products can handle several virtual functions (interfaces)) on a single radio card, within certain limits. For example, one radio device can be used to advertise several SSID, simulating several real APs at once, together with one mesh point.

When one radio card supports simultaneous virtual interfaces, **they must all be set to the same channel** (hence the client scanning must be restricted to the channel you selected, and multichannel roaming is impossible). The **channel bandwidth is therefore shared** between all interfaces.

The multifunction limits are indicated on the web interface, page “Setup / Physical interfaces Overview”.

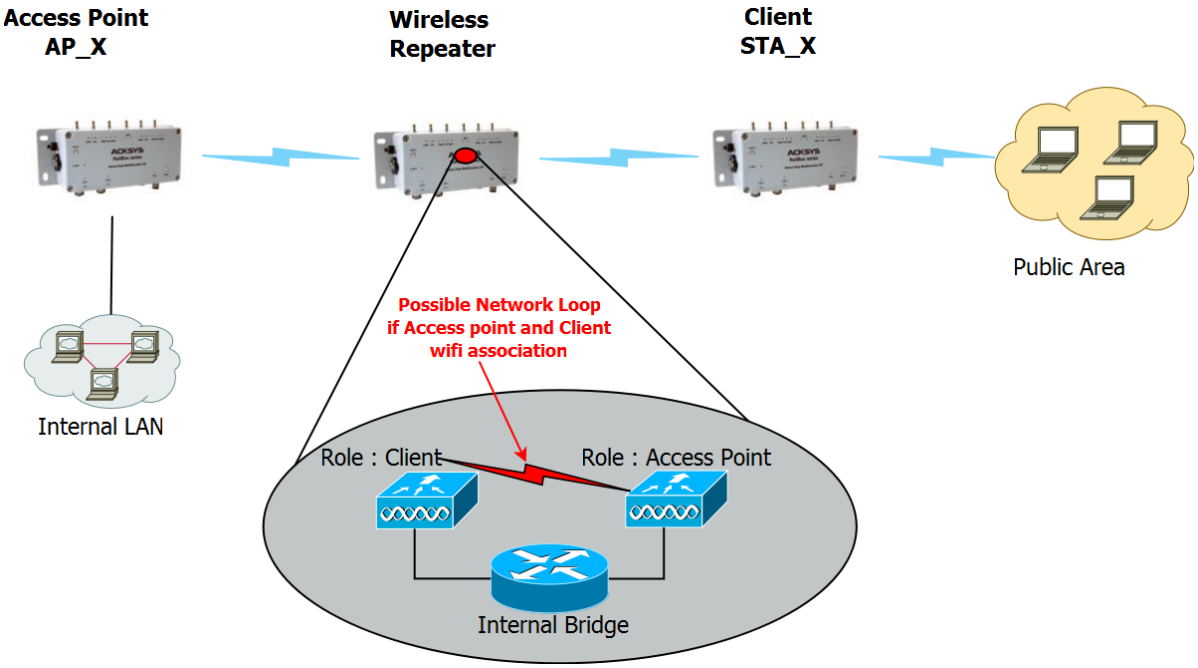
V.2.1.6 Wireless repeater

When the distance between an Access point **AP_X** and a Wireless Station **STA_X** is too long for a direct connection, a **wireless repeater** is used to bridge the gap.

The wireless repeater has 2 roles:

- ➔ Client Role to relay data from/to the Access point AP_X.
- ➔ Access point Role to relay data from/to the Wireless Station STA_X.

These 2 roles will be bridged together in the same switch. Thereby, several configurations are possible for a repeater.



Special caution should be taken when configuring the Repeater to avoid the client repeater association with the Access point repeater (when they have the same SSID), which will then generates a network loop.

There are two ways to avoid this network loop:

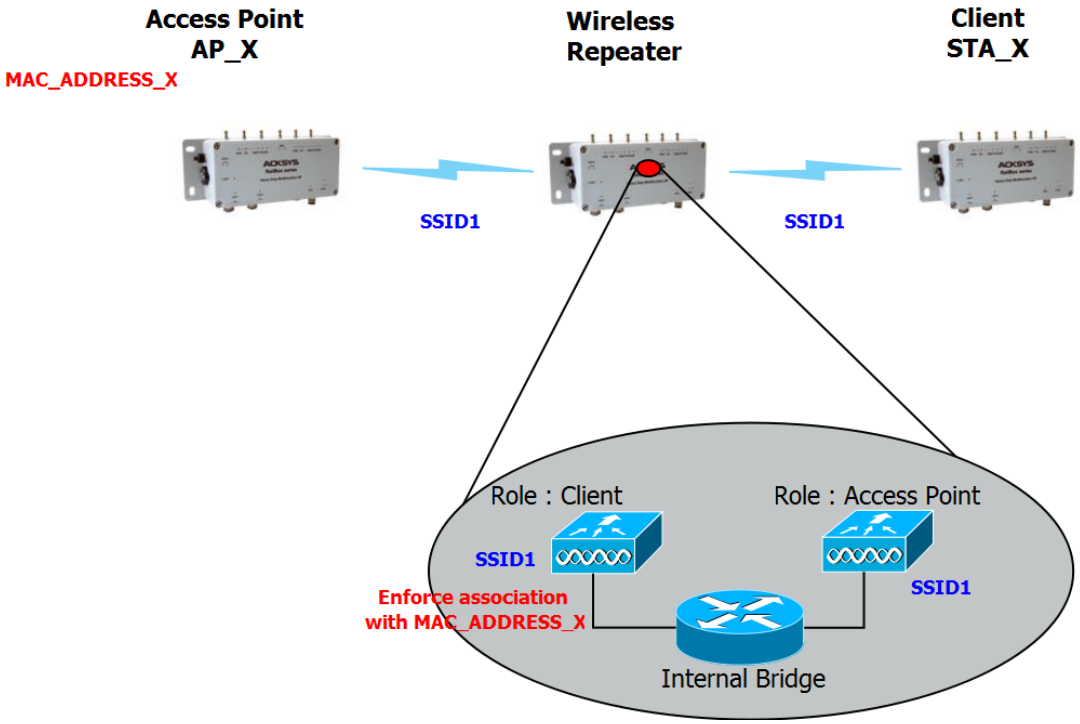
➔ Set the same SSID on client role and Access point role of the repeater, but enforce the client role to associate with the BSSID of the AP_X. Use the “multiple SSID” feature of the client role to unlock BSSID configuration.

Advantage:

Service continuity: the repeater will extend the current network with the same SSID. So, the end user can keep the same SSID in all the network locations

Drawback:

When AP_X is replaced, the client role of the repeater must be reconfigured, so that it only associates with the new BSSID.



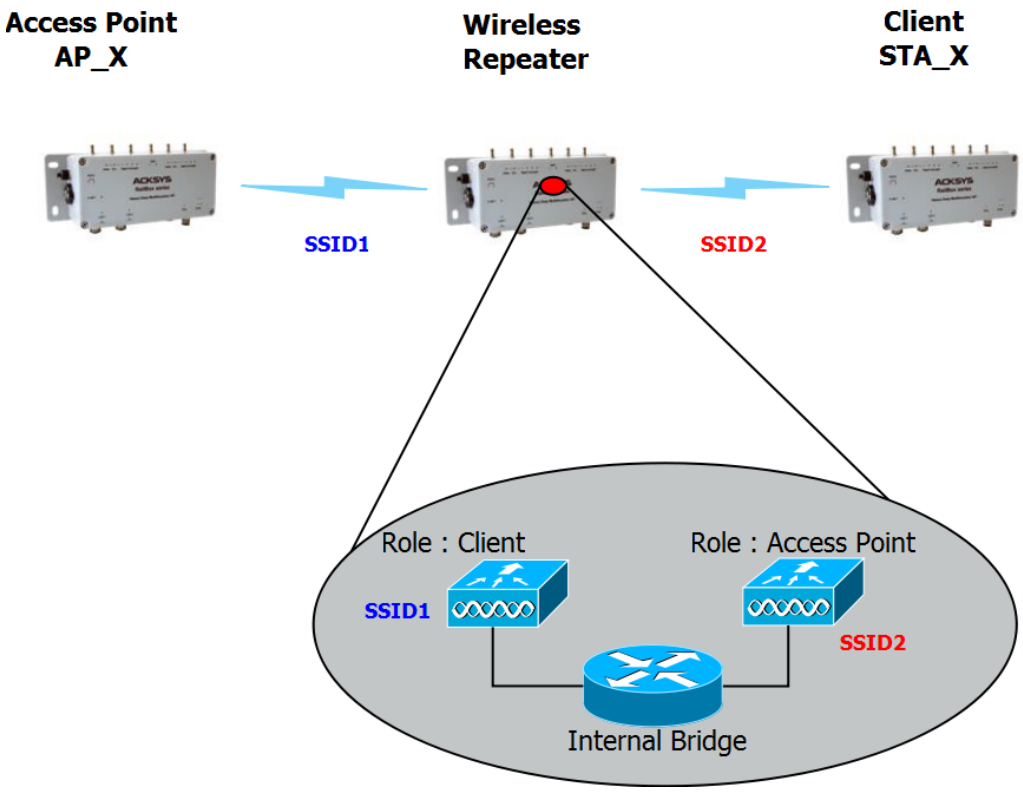
➔ Set a different SSID on client role and Access point role of the repeater.

Advantage:

No need to reconfigure the repeater if we change the AP_X.

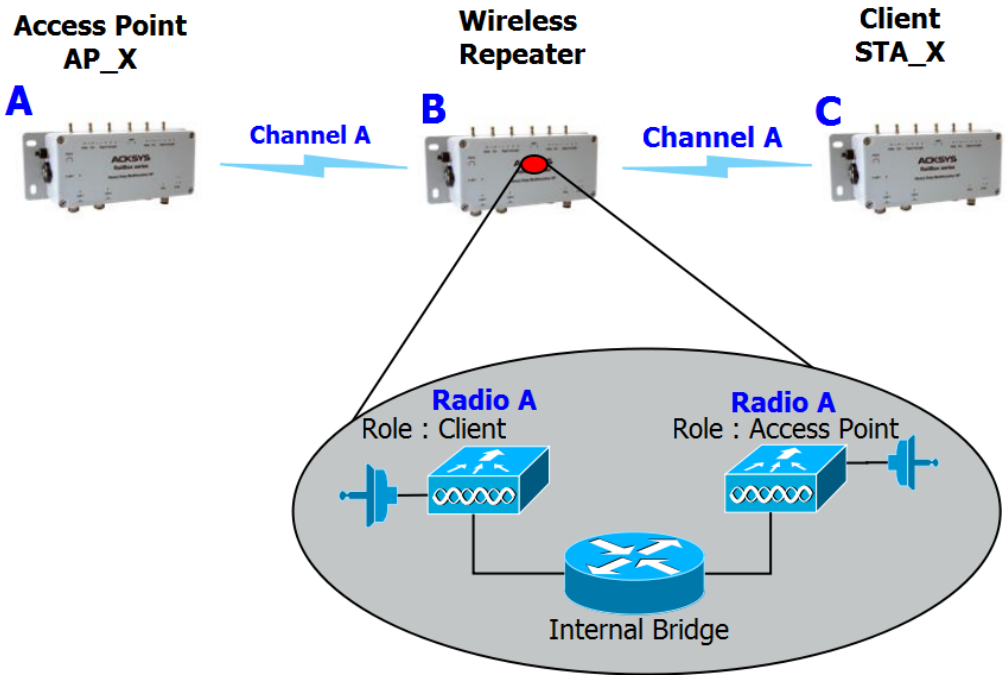
Drawback:

It requires the end users to use multiple SSIDs, as the network extension has now a different SSID.



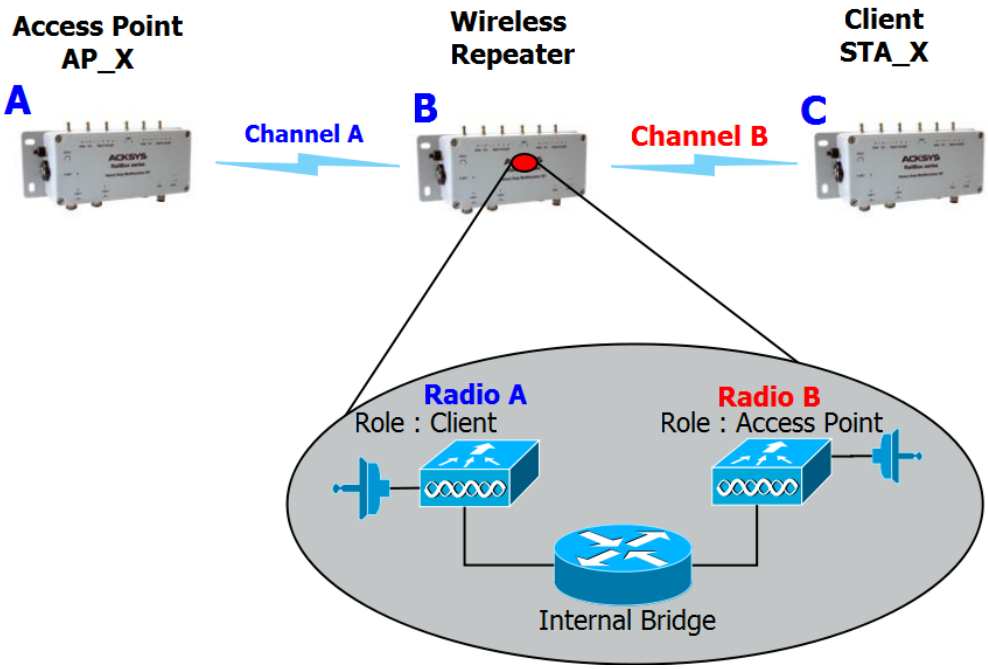
Impact on Throughput:

A repeater uses one radio card to perform the 2 roles, Client+Access point, and to perform the transmissions from AP_X to Repeater, and then Repeater to STA_X (and vice-versa). Since the repeater, having only one radio card, cannot receive and transmit at the same time, the throughput is reduced by at least 50%.



High performance Repeater:

To enhance throughput, a dual radio repeater can use one radio for the AP role and the other radio for the client role, using a different channel on each radio card, so it can transmit and receive at the same time.



Advantage:

Doubles the available bandwidth; also solves the loop problem.

Drawback:

The end users must search several channels for the SSID.

V.2.2 Hardware

The cellular interface is functionally equivalent to the data service in a mobile phone. It replaces the secondary Wi-Fi interface. It requires one or two antennas; using the second one improves the quality of communication.

When a third antenna connector is present, it is used for satellite positioning (see next section about GNSS).

The cellular interface connects to public mobile networks. Doing so requires an account with an appropriate public operator. The account takes the form of a SIM card installed in the product. You can install two SIM cards, so that you can choose one operator out of two.

V.2.3 Modulation and coding

There are 5 kinds of wireless transmission formats available: 802.11b, 802.11g, 802.11a, 802.11n and 802.11ac.

V.2.3.1 802.11b

802.11b is supported for compatibility with old devices. Using it will lower the throughput for all devices in the radio range, because 802.11b uses a lot of bandwidth for little throughput.

Op. Frequency	Typical throughput	Bit Rate (Max)
2.4 GHz	4.5 Mbit/s	11 Mbit/s

Note: actual throughput and bitrate depends on the distance between stations, antennas quality and radio conditions

802.11b has a maximum raw data rate of 11 Mbit/s and uses the same media access method defined in the original standard. 802.11b devices suffer interference from other products operating in the 2.4 GHz band. Devices operating in the 2.4 GHz range include: microwave ovens, Bluetooth devices, baby monitors and old cordless telephones.

V.2.3.2 802.11g

This transmission standard works in the 2.4 GHz band (like 802.11b) but operates at a maximum raw data rate of 54 Mbit/s, or about 20 Mbit/s mean throughput. 802.11g hardware is fully backward compatible with 802.11b hardware.

Op. Frequency	Typical throughput	Bit Rate (Max)
2.4 GHz	20 Mbit/s	54 Mbit/s

Note: actual throughput and bitrate depends on the distance between stations, antennas quality and radio conditions

Like 802.11b, 802.11g devices suffer interference from other products operating in the 2.4 GHz band. Devices operating in the 2.4 GHz range include: microwave ovens, Bluetooth devices, baby monitors and old cordless telephones.

V.2.3.3 802.11a

The 802.11na operates in 5 GHz band with a maximum raw data rate of 54 Mbit/s, which yields a realistic mean throughput in the mid-20 Mbit/s.

Op. Frequency	Typical throughput	Bit Rate (Max)
5 GHz	20Mbit/s	54Mbit/s

Note: actual throughput and bitrate depends on the distance between stations, antennas quality and radio conditions

Since the 2.4 GHz band is often saturated, using the relatively unused 5 GHz band gives 802.11a provides a significant advantage. However, this high carrier frequency also brings a slight disadvantage: The effective overall range of 802.11a is slightly less than that of 802.11b/g; 802.11a signals cannot penetrate as far as those for 802.11b because they are absorbed more easily by walls and other solid objects in their path.

V.2.3.4 802.11n

802.11n can operate on either the 2.4 GHz or 5 GHz band. According to the chosen one, the above notes about range and band saturation also apply.

802.11n also allows using a channel width of either 20 MHz or 40 MHz to double bandwidth. “HT20” refers to the standard single channel operation; “HT40” refers to the extended double channel operation.

802.11n hardware may allow transmission of more than one data stream (so-called “spatial streams”) simultaneously. In order for the streams not to interfere with each other, the radio signal must bounce on obstacles in various directions, or the antennas must be polarized. Both cases result in lower range due to power losses, but faster transmission.

The number of spatial streams must not be confused for the number of antennas. Furthermore, antennas can be dedicated to emission or reception only. Hence an 802.11n radio specification must include three numbers: number of transmitters, number of receivers, and number of spatial streams.

In order to automatically adapt to radio conditions, the 802.11n uses various transmission parameters: number of streams, modulation, channel width and so on. The resulting transmission format is named Modulation and Coding Scheme (MCS). ACKSYS products handle 1 to 3 streams depending on the model. Here are the physical bit rates achievable with one, two and three streams:

Maximum bit rate (Mbps)

Channel width	20 MHz	40 MHz
1 stream		
MCS 0	7.2	15
MCS 1	14.4	30
MCS 2	21.7	45
MCS 3	28.9	60
MCS 4	43.3	90
MCS 5	57.8	120
MCS 6	65.0	135
MCS 7	72.2	150
2 streams		
MCS 8 = 2xMSC0	14.4	30
MCS 9 = 2xMCS1	28.9	60
MCS 10 = 2xMCS2	43.3	90
MCS 11 = 2xMCS3	57.8	120
MCS 12 = 2xMCS4	86.7	180
MCS 13 = 2xMCS5	115.6	240
MCS 14 = 2xMCS6	130.0	270
MCS 15 = 2xMCS7	144.4	300
3 streams		
MCS 16 = 3xMCS0	21.7	45
MCS 17 = 3xMCS1	43.3	90
MCS 18 = 3xMCS2	65.00	135
MCS 19 = 3xMCS3	86.7	180
MCS 20 = 3xMCS4	130	270
MCS 21 = 3xMCS5	173.3	360
MCS 22 = 3xMCS6	195	405
MCS 23 = 3xMCS7	216.7	450

Note 1: When the peer station cannot handle short guard intervals, the bit rate is reduced by about 10%. Guard interval is an 802.11n feature allowing shortening some idle times during transmission.
Note 2: As can be inferred from the above table, the bit rate is proportional to the number of streams. A 3 streams radio can transfer up to 450 Mbps.
Note 3: Actual bitrate and throughput depend on the distance between stations, antennas quality and radio conditions

For detailed information and relationship about MCS, bit rates, maximum transmit power and receiver sensitivity, refer to the quick start guide appropriate for each product.

V.2.3.5 802.11ac

Compared to 802.11n, 802.11ac will add the 80 MHz channel size (wider channels increase speed), the 256-QAM modulation (and therefore 2 new MCS per stream), and will support 5GHz band only.

Here are the physical bit rates achievable with 1, 2 and 3 streams:

Maximum bit rate (Mbps)

Channel width	20 MHz	40 MHz	80 MHz
1 stream			
MCS 0	7.2	15	32.5
MCS 1	14.4	30	65
MCS 2	21.7	45	97.5
MCS 3	28.9	60	130
MCS 4	43.3	90	195
MCS 5	57.8	120	260
MCS 6	65	135	292.5
MCS 7	72.2	150	325
MCS 8	86.7	180	390
MCS 9	n/a	200	433.3
2 streams			
MCS 0	14.4	30	65
MCS 1	28.9	60	130
MCS 2	43.3	90	195
MCS 3	57.8	120	260
MCS 4	86.7	180	390
MCS 5	115.6	240	520
MCS 6	130.3	270	585
MCS 7	144.4	300	650
MCS 8	173.3	360	780
MCS 9	n/a	400	866.7
3 streams			
MCS 0	21.7	45	97.5
MCS 1	43.3	90	195
MCS 2	65	135	292.5
MCS 3	86.7	180	390
MCS 4	130	270	585
MCS 5	173.3	360	780
MCS 6	195	405	n/a
MCS 7	216.7	450	975
MCS 8	260	540	1170
MCS 9	288.9	600	1300

V.2.4 Radio channels and national regulation rules

A wireless network uses specific channels on the 2.4 GHz or 5 GHz radio spectrum to handle communication between stations. Some channels in your area may suffer from interference from other electronic devices. Choose the clearest channel to help optimize the performance and coverage of your wireless network.

Region/country

Every country control and limit available radio frequencies. The broadly named 802.11 2.4 GHz and 5 GHz bands are further limited to allow sharing with other radio devices (radars, weather devices). You must set the country where you will operate the product; then, the channels proposed in the menus will be limited to the ones available in the selected country.

In the “AP” role, the product will insert the country rules in its beacons as required by the 802.11d protocol. In the “client” role, the product uses the country rules provided by the AP using the 802.11d protocol.

For further details about radio regulation areas, refer to chapters *802.11 regulatory domain rules*, and *Appendix – 802.11 Radio channels*

Automatic channel selection

In Access Point mode, the product can select the best channel among a list, or among all channels available in the country. At startup (note that this occurs only once), the AP chooses the best channel depending on the measured noise and occupancy of each possible channel. This noise analysis postpones the end of the product startup for around 0.5 second per analyzed channel.

Roles other than AP do not recognize this option. For repeater, mesh and ad-hoc roles you must set one channel only. For the client role, all available channels are scanned except when proactive roaming mode is selected.

V.2.5 Wireless security

There are many technologies available to counteract wireless network intrusion, but currently no method is absolutely secure. The best strategy may be to combine a number of security measures.

Possible steps towards securing a wireless network include:

1. All wireless LAN devices need to be secured
2. All users of the wireless network need to be trained in wireless network security
3. All wireless networks need to be actively monitored for weaknesses and breaches

Available wireless security protections are:

Not broadcasting the SSID (access point only feature)
WEP encryption
Enhanced Open (WPA3-OWE)
WPA, WPA2 or WPA3 – PSK (*Pre-Shared Key*)
WPA, WPA2 or WPA3 – Enterprise, also known as 802.1x or RADIUS.
OSEN

WEP encryption vs. WPA and WPA2 encryption

The encryption depends on the wireless topology. In ad-hoc mode, only WEP encryption is available, because WPA requires a point-to-point link in order to establish the cryptographic keys. In infrastructure mode, there is a point-to-point link between each station and its associated Access Point, and you can use WEP or WPA/WPA2.

V.2.5.1 WEP encryption

WEP is a method of encrypting data for wireless communication and is intended to provide the same level of privacy as a wired network. However, due to progress in crypto science, **WEP is not considered secure anymore**, **and cannot be used altogether with 802.11N/AC modes.** To gain access to a WEP network you must know the key. The key is a string of characters that you create. When using WEP you will need to determine the level of encryption. The type of encryption determines the key length. 128-bit encryption requires a longer key than 64-bit encryption.

Keys are defined by entering a string in HEX (hexadecimal - using characters 0-9, A-F) or ASCII (American Standard Code for Information Interchange - alphanumeric characters) format.

ASCII format is provided so that you can enter a string that is easier to remember. The ASCII string is converted into HEX for use over the network. Four keys can be defined so that you can change keys easily. A default key is selected for use on the network.

V.2.5.2 WEP authentication

Two methods of authentication can be used with WEP: *Open System authentication* and *Shared Key authentication*.

In *Open System authentication*, the WLAN client need not provide its credentials to the Access Point during authentication. Thus, any client, regardless of its WEP keys, can authenticate itself with the Access Point and then attempt to associate. In effect, no authentication (in the true sense of the term) occurs. After the authentication and association, WEP can be used for encrypting the data frames. At this point, the client needs to have the right keys.

In *Shared Key authentication*, WEP is used for authentication. A four-way challenge-response handshake is used:

1) The client station sends an authentication request to the Access Point.
2) The Access Point sends back a clear-text challenge.
3) The client has to encrypt the challenge text using the configured WEP key and send it back in another authentication request.
4) The Access Point decrypts the information and compares it with the clear-text it had sent. Depending on the result of this comparison, the Access Point sends back a positive or negative response. After the authentication and association, WEP can be used for encrypting the data frames.

At first glance, it might seem as though Shared Key authentication is more secure than Open System authentication, since the latter offers no real authentication. However, it is quite the reverse. It is possible to derive the static WEP key by capturing the four handshake frames in Shared Key authentication. Hence, it is advisable to use Open System authentication for WEP authentication, rather than Shared Key authentication. **Please note that both authentication mechanisms are weak and are now deprecated.**

V.2.5.3 Enhanced Open (WPA3-OWE)

Wi-Fi Enhanced Open is a new security standard for public networks based on Opportunistic Wireless Encryption (OWE). It provides encryption and privacy over open, non-password protected networks in areas such as coffee shops, hotels, restaurants, and libraries. Enhanced Open does not provide authentication.

V.2.5.4 WPA/WPA2/WPA3 encryption

WPA/WPA2/WPA3 greatly increases the level of over-the-air data protection and access control on existing and future Wi-Fi networks. It addresses all known weaknesses of Wired Equivalent Privacy (WEP), the original native security mechanism in the 802.11 standard.

WPA/WPA2/WP3 not only provides strong data encryption to correct the weaknesses of WEP, it adds user authentication that was largely missing in WEP. WPA2 is designed to secure all versions of 802.11 devices, including 802.11b, 802.11a, and 802.11g, multi-band and multi-mode.

WPA is the older standard which, due to progress in crypto science, is not considered secure anymore.

WPA2 is a more recent and more robust implementation of the stronger IEEE 802.11i security standard.

WPA3 is the latest implementation which brings better protections to individual users by providing more robust password-based authentication. This capability is enabled through Simultaneous Authentication of Equals (SAE), which replaces Pre-shared Key (PSK) in WPA2-Personal.

Note that there are three versions of WPA3 which are incompatible with each other due to security vulnerabilities. WaveOS uses the most recent version after August 2019

The cipher type is the encryption algorithm used to secure the data communication.

TKIP (*Temporal Key Integrity Protocol*) provides per-packet key generation and is based on WEP.

AES (*Advanced Encryption Standard*) is a very secure block-based encryption.

You can choose from 3 security options (WPA not recommended):

WPA Mode	Cipher Type	Security solution
WPA	RC4	RC4-TKIP
WPA2	AES	AES-CCMP
WPA3	AES	AES-GCMP-256

a. <u>Pre-shared key mode (PSK)</u>

In Pre-Shared Key mode (PSK, also known as ***personal mode***), each Access Point client must provide a password to access the network. The password may be from 8 to 63 printable ASCII characters. Most operating systems allow the password to be stored to avoid re-typing. The password must also remain stored in the Wi-Fi access point.

All Wi-Fi devices on your Wi-Fi cell must have the same Pre-Shared Key.

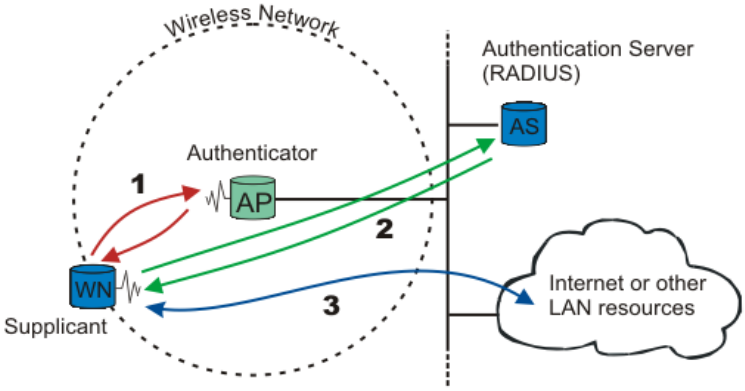
b. <u>Enterprise mode (802.1x, RADIUS)</u>

WPA/WPA2-Enterprise, or 802.1x, provides authentication to devices trying to attach to a private network through a boundary Access Point, establishing the access point as the gateway to LAN resources, or preventing access from that device if authentication fails.

NOTE: since in a chain of repeaters the farthest ones would depend on the nearest ones to access the 802.1X server, this security is not available in repeater mode. WPA/WPA2-PSK can still be used.

The authentication process is organized around several agents:

- User, also called supplicant or Wireless Node (WN),
- Wireless access point or authenticator,
- Authentication server, most often a RADIUS (Remote Authentication Dial-In User Service) server,
- Authentication modus operandi.



When a wireless node (WN) requests access to a LAN resource, the first step is the physical association between the client and the access point, defining a so-called “access port” (number 1 on the diagram).

The access point (AP) asks for the WN's identity. Then it establishes a point-to-point EAP tunnel between the WN and the authentication server (number 2 on the diagram). *No other traffic other than EAP is allowed until the WN is authenticated (the* “port” *is closed).* Until authenticated the client cannot access the LAN.

Once the authentication server informs the authenticator that the WN is authenticated, the traffic to the LAN is allowed (number 3 on the diagram): the “port” is open. Otherwise the “port” stays closed.

Note: 802.1x also offers a system to exchange keys which will be used to encrypt communications and to check integrity.

Authentication modus operandi

802.1x uses one of the EAP (Extensible Authentication Protocol) methods. The most commonly used ones are:

- EAP-PEAP
- EAP-TLS
- EAP-TTLS

The EAP method used is transparent to the access point. On another hand the access point clients, like bridges, must be aware of the authentication method. The choice of method must take into account the capabilities of the server/supplicant couple as well as the level of security needed.

For example, a Windows 10 supplicant allows:

- PEAP authentication with login and password (called MSCHAP V2)
- Use of certificates.

Preauthentication

A client is said to preauthenticate when it is authenticating with a new AP through the currently associated AP. This aims to speed up the association time when the client decides to roam to the preauthenticated AP, because it will remove the important overhead of the 802.1x protocol.

Preauthentication must be enabled in the AP to allow the client to use it. The Client role in these products always uses preauthentication when offered by the AP.

Pre-authentication makes the client store communication keys before it needs it. The client can keep many keys in advance, allowing roaming from one AP to another to another… and back to the first, without re-executing the 802.1 x protocol.

In the client, the keys are kept in a cache table whose lifetime is configurable.

V.2.5.5 Protected management frame (802.11w)

This feature protects your device from a hacker DoS (Deny of Service) attack.

By default, the management frames are not protected. Anyone can send a DEAUTH frame to a client or to the AP.

In this situation, a hacker can gather AP information using a Wi-Fi sniffer and then send to a legacy client a DEAUTH frame with the AP mac address. The client receives this frame, and then closes the connection with the AP.

The 802.11w adds a field in the frame to authenticate the frame sender.

If the Wi-Fi equipment receives a management frame from an incorrect sender, it will discard the frame.

Please note that with WPA3, protected management frame is always enabled and required.

If you choose a WPA2/WP3 mixed mode, WaveOS will automatically set Protected management to enabled/optional, to authorize the association with WPA2 peers which don’t support this option.

V.2.5.6 OSU Server-Only Authenticated L2 Encryption Network (OSEN)

This security mode is reserved for Hotspot 2.0 r2 passpoint.

V.2.5.7 Mesh Secure Authentication of Equals (SAE)

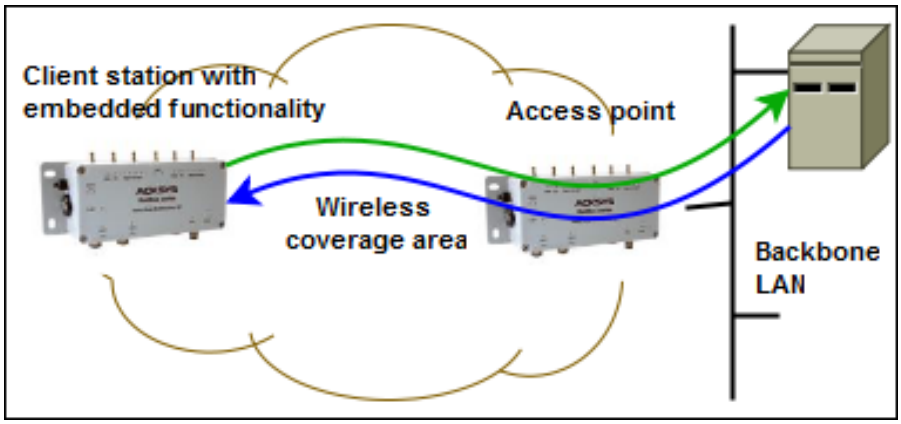
In 802.11s mesh mode, no mesh node has a special identification role, all nodes are considered equal in privileges. When SAE is used, all nodes must have a preset common key. Each time a node comes in reach of another node in the same mesh, it will verify that the peer node knows the key. The encryption uses the WPA2 protocols suite (AES/CCMP).

The password key can be from 8 to 63 printable ASCII characters. The same password must remain stored in all the mesh nodes.

V.2.6 Wired to wireless bridging in infrastructure mode

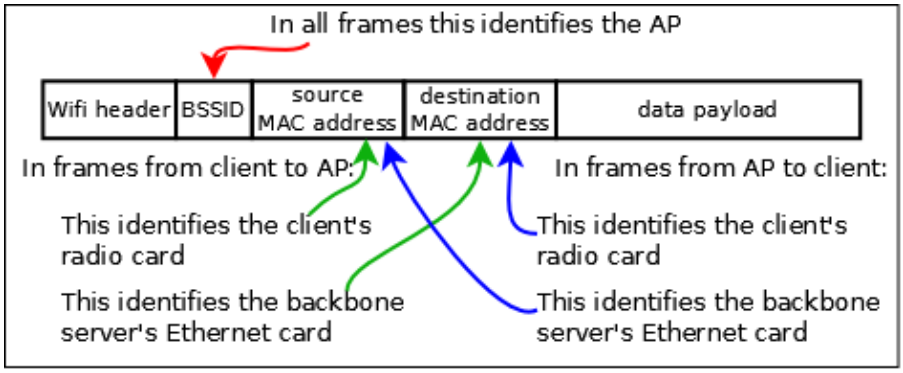
V.2.6.1 The problem

As outlined in section *V.2.1.1*, in the 802.11 standard **an infrastructure client is supposed to be a single unit with a single MAC address.** The AP forwards data to/from the client, from/to other clients or wired devices. In this respect the AP is similar to an Ethernet switch.



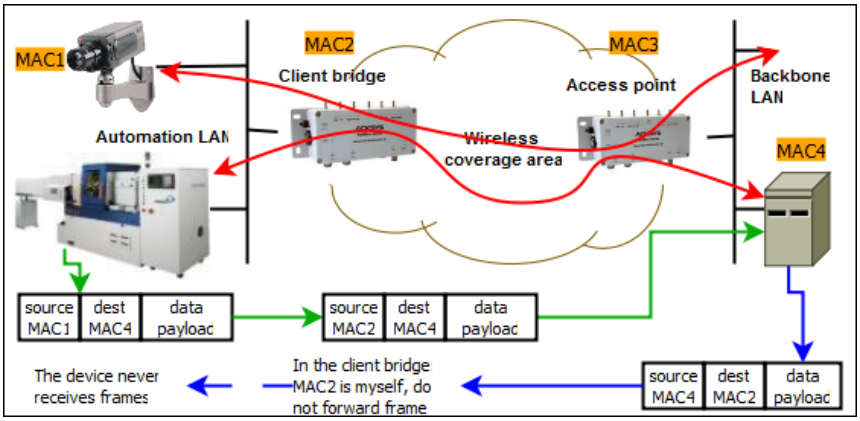
Bridging several devices with a single wireless client

To allow the AP to forward data, each frame includes a source MAC and a destination MAC.



Standard infrastructure data frames (3 addresses)

When using a client station to bridge a wired network to an AP, the situation is different. What appears to the AP as a single device with a single MAC address (that of the radio card), is hiding several wired devices, each of them having its own MAC address. Since they do not participate in the association process to the AP, they did not authenticate, hence the AP will not accept frames containing their MAC address as a source. If the client changes the source MAC address to its own, other problems appear, see picture below.



Sample problem bridging several devices with a single wireless client

V.2.6.2 The solutions

There are four ways to overcome this limitation and allow bridging the devices behind the client station:

- Routing. Let the wired LAN on the client side be an IP subnetwork, and let the client be a router or a NAT. This is a very clean solution but needs to manage the subnetwork. Strictly spoken, this is routing (layer 3 networking), not bridging (layer 2 networking).
- Masquerading. Let the client change the wired devices MAC address to its own and back, an approach also known as "Level 2.5 NAT" or "ARPNAT". This is the default operation in the "**client (infrastructure)**" mode. It is described in more details in section *Masquerading (ARPNAT)* below.
- Cloning. Let the client use the MAC address of the wired device. This is limited to one wired device.
- Using the "**client (infrastructure)**" and "**4 addresses format**" bridging mode, involving a more sophisticated frame format. The 802.11 standard provides a "4-addresses" frame format to solve this kind of issues but it does not fully specify it; hence this mode is not always compatible between clients and APs from different vendors. The ACKSYS products, as well as several Linux-based clients and APs, support this mode described in section b below.

Note that the mesh mode (not an infrastructure mode) also allows bridging.

a. Masquerading (ARPNAT)

In this solution to the bridging problem, the client bridge keeps a table to convert devices MAC addresses to and from their IP addresses.

In frames sent to the AP, the bridge replaces the devices source MAC address with its own and remembers the MAC/IP correspondence of the frame.

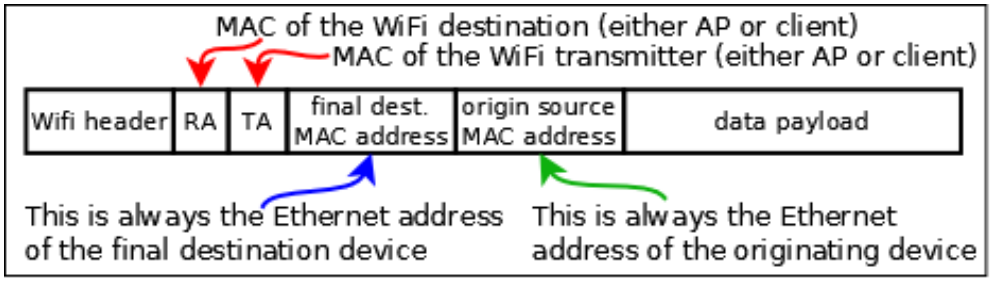
When a frame comes back from the AP its destination MAC address is the one of the bridge. The bridge finds the IP address in the frame, finds out the corresponding device MAC address, pokes it in the destination MAC of the frame, and sends it to the wired LAN side.

This solution is compatible with any third-party AP since all processing is done on the client side. However, there are special behaviors to keep in mind:

1) The conversion table handles MAC/IP conversions only. This means that **only the TCP/IP protocols suite** (TCP, UDP, IP, ICMP, ARP, DHCP and so on) can be bridged.
2) The conversion table is updated only by frames from the LAN to the Wi-Fi. This is usually not a problem because prior to any data transfer, a broadcast ARP request/reply exchange must take place. But if the client bridge is powered down, when it comes up again, the ARP exchange is not necessarily restarted by the devices on the backbone side. Then, when the bridge receives a data frame from the AP, its conversion table is empty and the frame is not forwarded. In this case, the bridge itself initiates an ARP for the destination IP address mentioned in the frame, triggering from the LAN device a response that will update the table, so that the next frame can be forwarded.
3) Equipment on **the backbone cannot use an IP gateway (a router or a NAT) located on the client LAN side, except if the product is the gateway and if the destination subnet is directly routable by the product**. The reason is that the destination IP address in the frames received from the AP are not the one of the gateway, but the address of an equipment farther beyond the gateway; but the MAC address needed is that of the gateway. So, the address conversion is not possible.
4) DHCP is a protocol used to set up IP addresses. The wired device MAC address is conveyed not only in the DHCP frame header, but also in the data payload. The address conversion causes an address mismatch at the DHCP server. To satisfy the DHCP server requirements, the bridge advertises itself as a DHCP relay agent, resolving the mismatch. For this to work, **a DHCP server located on the AP side must be able to send unicast IP packets to the bridge**. This means that the bridge must have an IP address reachable from the DHCP server prior to serving IP addresses to the devices behind the bridge.
5) ARP is a protocol used to discover MAC addresses. The ARP frames contain MAC addresses both in their headers and in their data. Special processing is done in the bridge to convert these frames.
   CISCO and others can set up a “proxy ARP server” in their APs. This means that the AP itself converts IP to MAC addresses on behalf of the backbone equipment. The proxy ARP server can get confused because all devices on the bridged LAN appear to have the same MAC address (the one of the bridge radio card) but different IP addresses. The solution is to **disable the proxy ARP server on the AP side**. In the CISCO product this is called “passive client mode”.
6) More generally, applications or protocols running on the backbone side and relying on MAC addresses to identify devices, will encounter problems in this mode. Fortunately, such software is hardly used.

b. <u>Infrastructure client using 4 addresses format (WDS)</u>

When the client is in 4 addresses format bridging mode, it uses a special frame header where both Wi-Fi and LAN MAC addresses are indicated. This is called the “4-addresses frame format”. By conveying both the client MAC and the wired device MAC in the wireless frame, the client can correctly route Wi-Fi frames to its LAN while the AP can know that it sends to an authenticated client.



4-addresses frame format

In this solution to the bridging problem, the client bridge and the AP encapsulate both data and Ethernet MAC addresses in the Wi-fi frame, adding both the AP and the client Wi-Fi MAC addresses. So, the frame can reach its Wi-Fi destination, which removes the Wi-Fi addresses and retrieves the original frame unchanged. The same process takes place both ways.

This solution is independent of the layer 3 IP addresses:

1) This mode can bridge protocols other that TCP/IP.
2) It transfers DHCP and ARP frames unchanged, avoiding most verification issues on the AP side, like proxy ARP or DHCP servers.
3) It allows using an IP gateway either on the AP side or on the bridge side, accessible from either side.

But since this solution relies on unspecified 802.11 features, is should be used only between products of the same brand or range, or when you know that the AP and client use compatible software.

Please note that 4-addresses frame format is not compatible with the roaming feature.

Final note: The 4-addresses frame format is sometimes called WDS (wireless distribution system). This acronym designates a frame format that can be used in a variety of ways. It does NOT designate a specific Wi-Fi architecture (like infrastructure or mesh).

Configuration

The access point role (AP) always supports both standard ARPNAT and 4-addresses clients simultaneously. The client bridges can be set up either in ARPNAT or 4-addresses format.

c. Cloning

The ARPNAT solution loses the MAC address information from the wired devices when bridging frames to the wireless interface. Most devices do not care about MAC address substitution because they use the IP protocol in Layer 3 and ARPNAT takes care of IP addresses.

But some devices do not use IP in layer 3 (PROFINET equipment, LAN video camera…) and the MAC address is the unique ID identifying the equipment correctly.

With the cloning feature, the product can use the MAC address of a wired equipment as the source MAC address on the wireless interface. The cloned address is used for all wireless transactions: association, authentication and data exchange. The original MAC address of the radio card is ignored.

To set up the wireless MAC address, the product clones the source MAC address from the first incoming frame after a reboot or the configured MAC address. So, there should be **only one** device connected to the LAN of the product.

If you mix the non-IP device with other IP devices, you must ensure that the non-IP device will send the first frame after the product is turned on, to be sure the product will clone the correct MAC address. To avoid this problem with a PROFINET equipment you should use the “PROFINET cloning”, in which case the first PROFINET frame source MAC address will be used for cloning.

V.2.7 Fast roaming features

In order to keep network connectivity when a client product is installed in a quickly moving vehicle, you can adjust some configuration parameters. Please note that the fast roaming feature is not compatible with 4-addresses format, and therefore not compatible with STP/RSTP.

V.2.7.1 Mono-channel vs. multichannel roaming

The client role can either look for APs on one channel only, or it can scan several channels. Each way has its pro’s and con’s.

Mono-channel

All the APs compete for the air media, so that the available bandwidth is reduced for all clients and APs. But the client is informed of the APs presence and condition at all times, and can communicate with its current AP at all times. Also, if one of the APs is near a source of interference on the selected channel, all APs must be switched to another channel.

Multi-channel

You can arrange for APs which are in radio range of each other to use different channels. In this way they will not compete for air bandwidth. You should not choose channels which are too close to each other, since they might interfere.
The client must scan each chosen channel in its turn. For this it must go “off-channel” for a small time, leaving the channel of its currently associated AP; during this time, it cannot exchange data. The data is then buffered under certain limits. This reduces data throughput for the client.

Configuration

After activating the proactive roaming feature, you must adjust the list of channels scanned by the client. You can select one or several channels.
If proactive roaming is not activated, all channels allowed in the country are scanned; this maximizes the chance of finding a matching AP, but slows down data transfers.

V.2.7.2 Proactive roaming vs. reactive roaming

Reactive

Reactive roaming takes place when the client can no longer communicate with its AP. When too many failures take place, the client disconnects from its current AP and begins to search a new one. Reactive roaming is the default mode, because there is nothing to configure in this case. In this mode, channel scanning; also called “foreground scan”, does never take place during data transfers, leaving all the bandwidth available for data transfers. But the roaming process is slow (it must wait for the end of the scan) and data

cannot be transmitted during this time. Whenever a client cannot associate to any AP, it enters reactive roaming.

Proactive

Proactive roaming means that the client will search, select and switch to another AP before signal level is so low that a lot of errors can happen. By selecting appropriate parameters, the change from one AP to another will take place before data throughput is affected, and the reassociation process will be quick if the new AP is in sufficient radio range. Hence few data (if any) will be lost.

To enable proactive roaming the client must search for APs while it is already associated and potentially exchanging data. This process is called “background scan” and somewhat reduces data throughput.

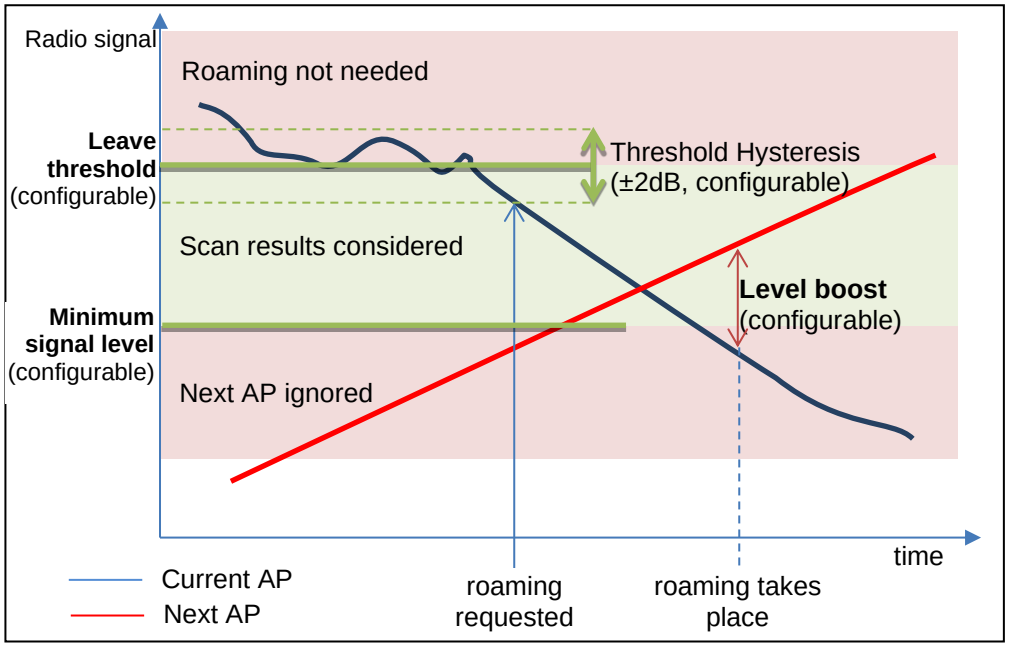
Configuration

You must configure the radio signal level threshold at which you consider that the link quality is insufficient for your throughput requirements.

But radio signal reception level is not a stable measurement; it varies under many unforeseen parameters (moving objects, humidity…). When the AP signal is near the threshold, it can go back and forth around the limit. You do not want to switch from AP to AP too often, since this means you cannot transfer data during these reassociation periods. To account for this, crossing the limit is subject to a hysteresis called “required level boost” (default: 6 dB).

Finally, even when the threshold is crossed, you do not want to reassociate with a worse AP, but you do not want to lose the current bad AP either. The “required level boost” configuration parameter specifies how much better you want the new AP to be in order to begin reassociation.

The effects of the various parameters are shown in this picture.



NOTE: the threshold hysteresis is configurable in versions 2.2.7 and later. The “leave threshold” is called “minimum level” in earlier firmwares.

V.2.7.3 What happens when the current AP fails

Contrary to wired LANs, the Wi-Fi medium is not limited in width, in sources of interferences or in obstacles. Hence the currently associated AP may abruptly disappear from the client's "sight" due to moving objects in the field, climatic changes, AP power down and so on.

The client has four ways to know its AP is available:

- Checking that beacons from the AP are regularly received,
- Receiving data,
- Receiving acknowledges for data sent,
- Receiving responses to probes sent.

If the failure is short-lived, data is retransmitted, and a few missing beacons is allowed. Conversely, long-lived absence of beacons or data acks triggers a disconnection. If another AP previously detected is still around, the client will switch to it; else the client will enter reactive roaming. To properly distinguish short-lived from long-lived failures, this process is reacting more slowly than proactive roaming, depending on your configuration.

Configuration

On the client side you can configure the number of missing beacons that will trigger the roaming process. The delay will depend on the beacon frequency that was configured in the AP. Please bear in mind that losing a frame or two is very common in Wi-Fi, and the missing beacons count should not be set below 3.

On the AP side you can set the beacon interval. The smaller the interval, the faster failures are detected; but beacons are transmitted at the lowest allowed bit rate, and consume more bandwidth than data frames.

V.2.7.4 Scanning

Scanning is the process used by the client station to find the APs around, in order to associate with one of them. Scanning takes place periodically. During each period, the client will successively switch to configured scan channels, send a broadcast "probe request" frame and wait for responses.

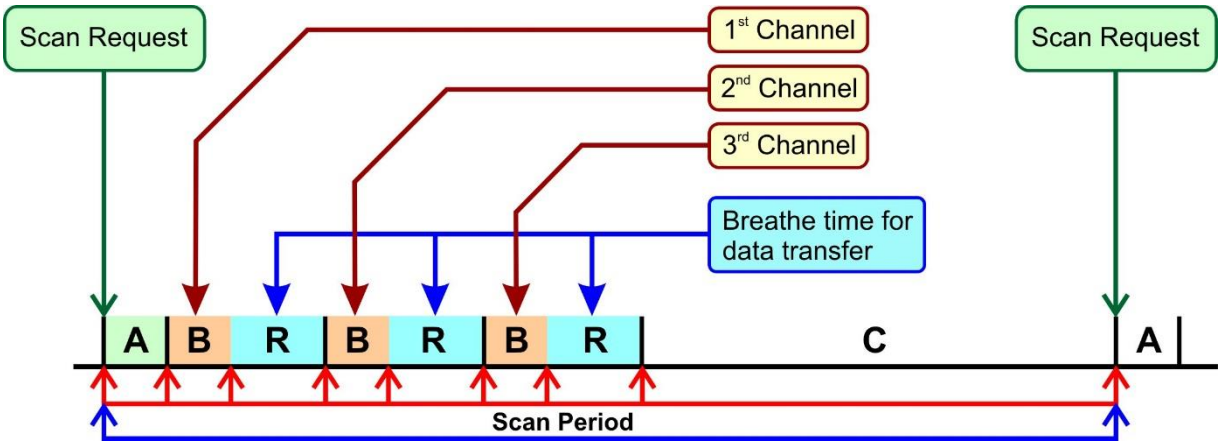
The probe request contains the SSID among other data. Any AP capable of serving this SSID will answer. The signal quality at which the response is received is used to select the best AP.

When the scanned channel is not the one of the current AP, the client is said "off-channel" and it cannot transmit nor receive data during this time; the data is buffered meanwhile. To inform the AP that it cannot receive, the client sends a "power save mode" indication to the AP before going off-channel, so that the AP can buffer frames in the meanwhile. Configuring too many scan channels will result in loss of throughput and/or loss of data. To allow sufficient time for buffered data to flow out, you can configure the delay between two scan periods.

Configuration

The two scan parameters are the list of scan channels and the delay between scans. Warning! This delay is not the scan period, but increases the scan period, as shown in the following diagram, showing the background scan (C parameter).

NOTE: when the client is not associated to any AP (after a client restart, or if the current AP suddenly disappears), there is no data to exchange, hence the breath time “R” in the diagram is shortened to 0, resulting in a slightly faster scan cycle.

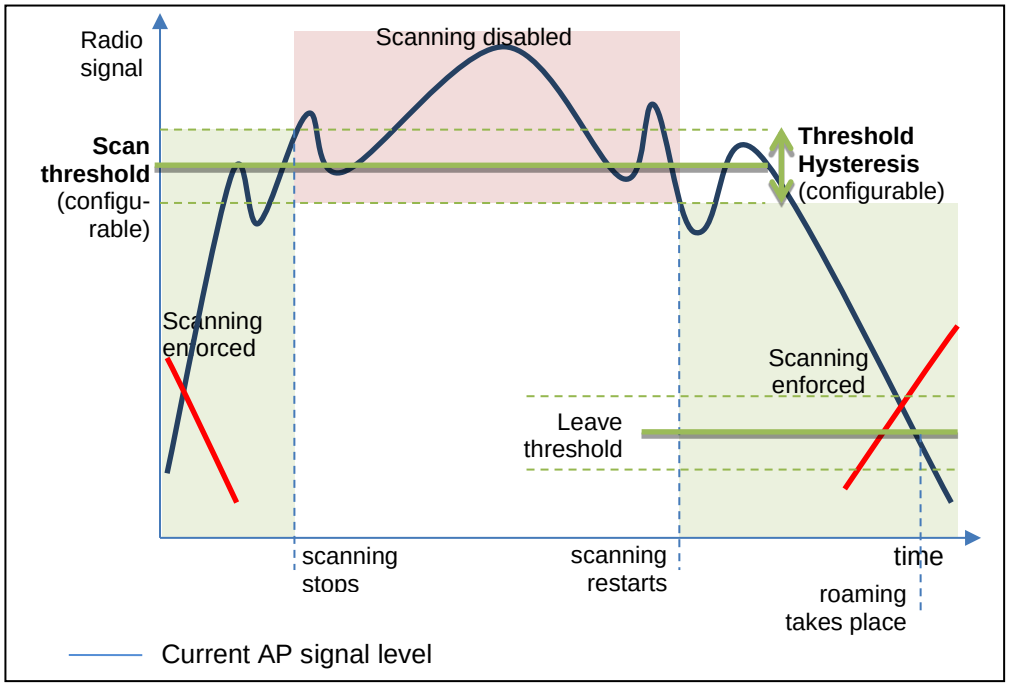


A: Initialization = a few ms
B: Channel scan = 56ms
C: Padding = configurable by steps of 4 ms
R: Breathe time = 200ms
(C is the “Delay between two successive scan cycles” in the web interface)
The ‘R’ delay is removed in reactive (foreground) scan cycles, thus shortening them while the client is not connected to an AP.
NOTE: the ‘B’ delay is configurable in versions 2.4.3 and later. See next section.

Scanning itself normally takes place unconditionally. To gain extra throughput when the signal level is good, you can configure a “scan threshold”. This parameter sets the signal level above which you estimate that no roaming is ever necessary. Setting the “scan threshold” to zero disables this feature (default).

When set, the scan threshold is compared to the power received from the current AP. When the power is greater than the threshold, the scan process is stopped at the next scan period. When the power received is lower than the threshold, the scan process is restarted.

To avoid oscillation effects due to a received power rapidly changing around the threshold, a hysteresis is implemented. Its value is the same as the hysteresis used for the “leave threshold”.



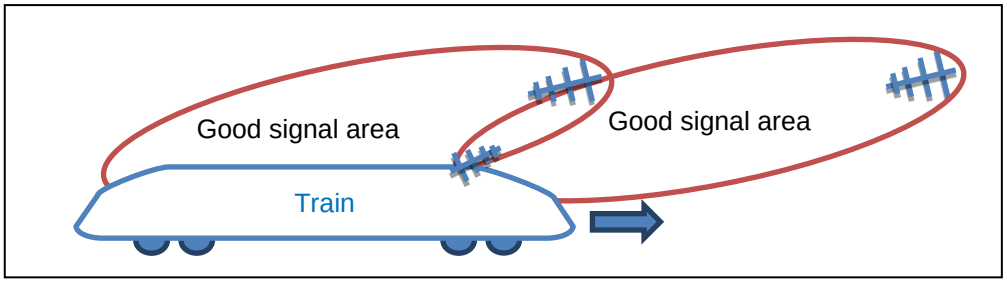
NOTE: the scan threshold is configurable in versions 2.2.7 and later.

V.2.7.5 Advanced Roaming settings

In several situations the basic roaming settings are not sufficient. This includes directional antennas handling, fine tuning of the mean signal decay rate and fine tuning of the bandwidth used for scanning.

a. <u>Directional AP handling</u>

If the Wi-Fi client is, say, embedded on a train, and a directional antenna is fixed on the roof (see picture), a high signal level means that the AP will soon be on the other (bad) side of the directional antenna soon, hence it is a good time to roam to another AP farther ahead, with a lower reception level.



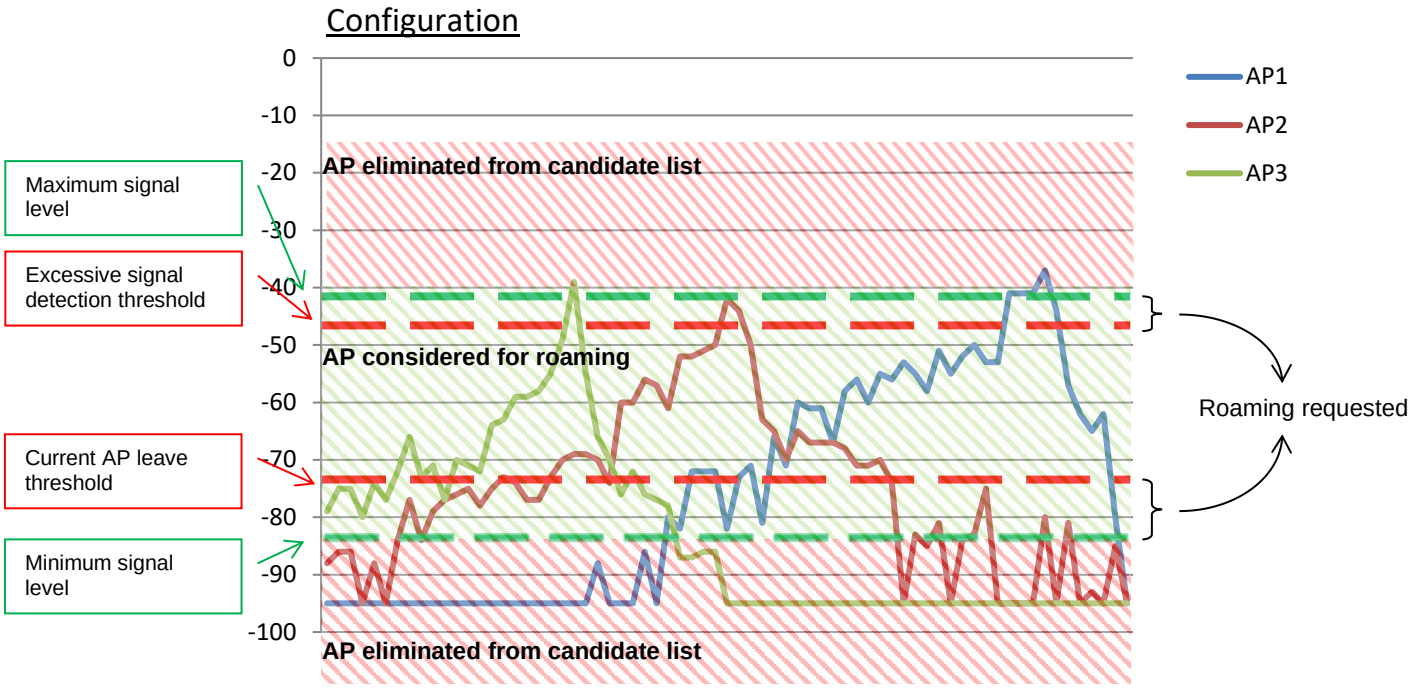
Train soon loosing current AP despite good signal

In this case when the AP is seen with a high signal level it is likely that the client will lose the association in the next few seconds.

The **Excessive signal detection threshold** parameter drives the decision of dynamically leaving the <u>current AP</u> when its level <u>becomes</u> too high. The **Maximum signal level** parameter drives the static elimination of APs with high signal level as candidates for the next association; the check is performed after each scan.

Good stability places some constraints on these parameters:

- When both parameters are used, you must set the threshold level lower (less powerful) than the max level.
- These parameters are incompatible with the **Current AP scan threshold**, which is another way of managing high signal level APs.
- The **excessive** threshold also uses the **Threshold hysteresis** parameter
- The max level is not checked during the first scan after association, to avoid leaving an AP which just became current.



At the end of scan process, the product chooses a candidate AP. The candidate AP is the AP where you will roam if the roaming is requested.

Roaming won't occur before the **Minimum roaming interval** has elapsed since the last association. In areas where several APs are received with about the same signal quality, this parameter helps avoid frequent roaming due to slight signal variations.

Roaming won't occur to an AP that was left recently before the **No-return delay** has elapsed. This parameter helps enforce roaming to a sequential succession of APs, even if signal bounces make a previous AP appear temporarily as more desirable.

b. Smoothing factor (RSSI decay rate)

Various parameters are meant to trigger events:

- scan threshold
- leave threshold
- excessive signal detection threshold

For the purpose of threshold crossing detection, all these parameters are compared to the RSSI of the current AP.

The RSSI of the current AP is defined as an exponential moving average computed over the most recent beacons received from the current AP. So, the comparison is done, not against the current signal level, but against an average. Note that only the beacons signal levels are used, since they are transmitted at a stable bit rate and power level and they are received with homogenous receiver sensitivity.

In order to favor more or less the recent beacons against the older ones in the computed RSSI average, you can set the exponential factor of the moving average. This factor is called the "RSSI smoothing factor". It represents the percentage attached to the most recent beacon in the computation.

The smoothing factor is a value between 0 and 1 in steps of 1/16th. For example, a value of 3/16 means that the signal power levels of the previous beacons are used like this:

- for the most recent beacon, $\frac{3}{16} = 18.75\%$ of the signal value,
- for the penultimate beacon, $\frac{3}{16} \times \frac{13}{16} = 15\%$,
- for the antepenultimate beacon, $\frac{3}{16} \times \frac{13}{16} \times \frac{13}{16} = 12\%$,
- and so on.

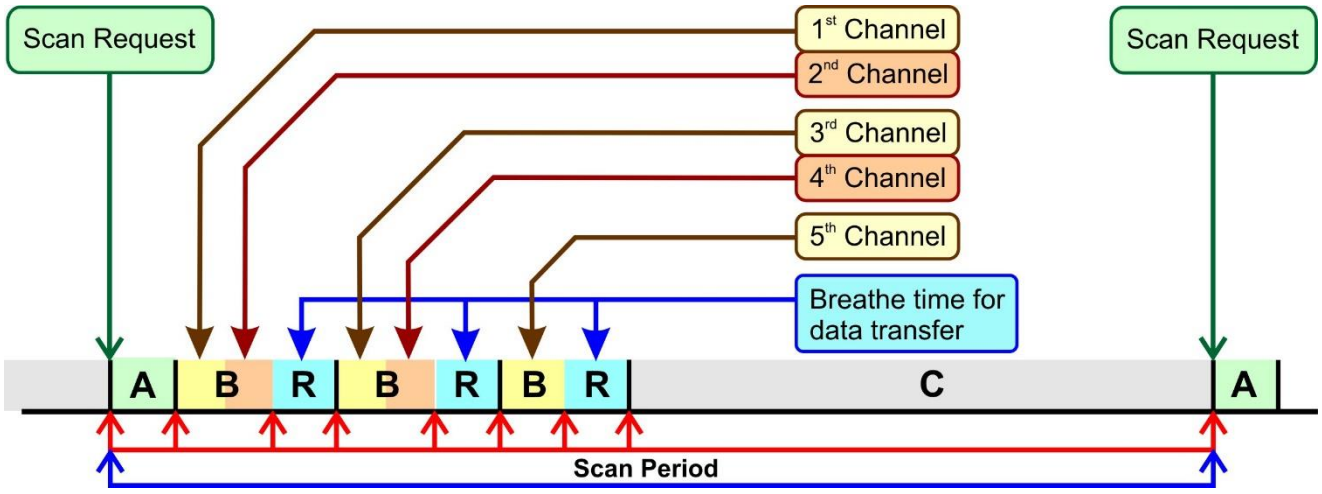
Configuration

In the browser interface the factors are expressed as the percentage attached to the last beacon. As an extreme case, using 100% (or 16/16th) means that only the most recent beacon is used in the comparisons.

c. Off-channel configuration

You can shorten the duration of the off-channel probe request/response sequences (the 'B' parameter in the "scan period" picture). This solves the situation where a large data flow is entering the AP which cannot forward it to the client because it is scanning another channel, and the AP has insufficient buffers. The 'B' delay is the sum of (B1) a switching delay (very quick), (B2) a synchronization delay (ensuring that our probe will not collide with another transmitter on the channel), (B3) probe request transmission (at the lowest rate available), (B4) response waiting delay.

Also, the scanner can switch from channel to channel, without returning to the current channel. In the next picture, 5 channels must be scanned. During one scan sequence 'B', the delays (B2)-(B3)-(B4) are repeated without returning to the data channel, until either the parameter "Maximum time off-channel" or the current AP beacon interval is exhausted. This behavior saves some of the switching delays (B1) and improves mean throughput at the expense of the instant throughput.



Configuration

You can configure items (B2) with the “Offchannel adaptation delay” and (B4) with “Per channel probe response delay”, and you can define the overall off-channel duration of one ‘B’ scan sequence with the “Maximum time off-channel” parameter. All these parameters are defined ±4 ms.

Default values

The default parameters allow probing 2 channels per scan sequence, as displayed in the picture. The default “maximum time off-channel” is 125 ms, but since most AP have a beacon period of 100 ms, this parameter is usually automatically reduced to 100 ms. The two other default parameters are set to 30 ms, but are actually rounded down to 28 ms.

If the channel list includes DFS channels, the delay indicated in "Maximum time off-channel" must take into account the minimum value of "Per channel probe response delay" in the DFS case.

For example, if we scan channel 36 (not DFS) and 52 (DFS):

The "Maximum time off-channel" must be at least "Offchannel adaptation delay" +108. Note that when we leave this parameter empty, it displays 125 in the background but it is automatically adjusted to: 125 + "Offchannel adaptation delay"

With "Offchannel adaptation delay" = 30 (rounded to 28); "Per channel probe response delay" = 30 (rounded to 28); "Maximum time off-channel" = 150, the scan cycle is: channel 36 (approx 56 ms) then return to the operating channel (200 ms) then channel 52 (approx 138 ms) then "Delay between two successive scan cycles" and we start again. We see that the maximum delay of 150ms is never used to the maximum, the maximum interruption of service is 138 ms.

Setting a value a little greater than 138 makes it possible to absorb the peaks of CPU usage of the router. For example if, at the same time, it does multicast routing, encrypted VPN, etc. In fact, in this example, up to 138 + 56 + (56-4) = 246 ms, the scan cycle will be identical.

To scan the 2 channels consecutively, you can set "Offchannel adaptation delay" = 30 (rounded to 28); "Per channel probe response delay" = 30 (rounded to 28); "Maximum time off-channel" = 200 (i.e. 138 + 56 + 6 ms of margin), the scan cycle will then be: channel 36 (approx 56 ms) then directly channel 52 (approx 138 ms) then "Delay between two successive scan cycles" and we start again.

V.2.7.6 Authentication speed up

In the association task, the AP and the client must exchange several frames. The number of frames increases with the security level.

In the WPA protocol, the PMK (Pairwise Master Key) is used to generate the temporally keys which will be used to encrypt the data.

- WPA/WPA2-PSK: The PMK is derived from the Pre-Shared Key.
- WPA/WPA2-EAP: The PMK is distributed by the radius server.

The table below gives the number of frames vs the security level

Security policy	Number of frame
Open (without security)	4 frames - 4 Authentication frames
WEP	4 frames - 4 Authentication frames
WPA/WPA2-PSK	8 frames - 4 Authentication frames - 4 Key exchange frames
WPA/WPA2-EAP (with radius server)	> 8 frames - 4 Authentication frames - Several radius authentication frames - 4 key exchange frames

The “4 Authentication frames” are mandatory by the 802.11 protocol.

The “4 Key exchange frames” are necessary to exchange the temporally key.

The “several radius authentication frames” are necessary to authenticate the Wi-Fi client with the radius server. The numbers of frame are depending of the authentication method.

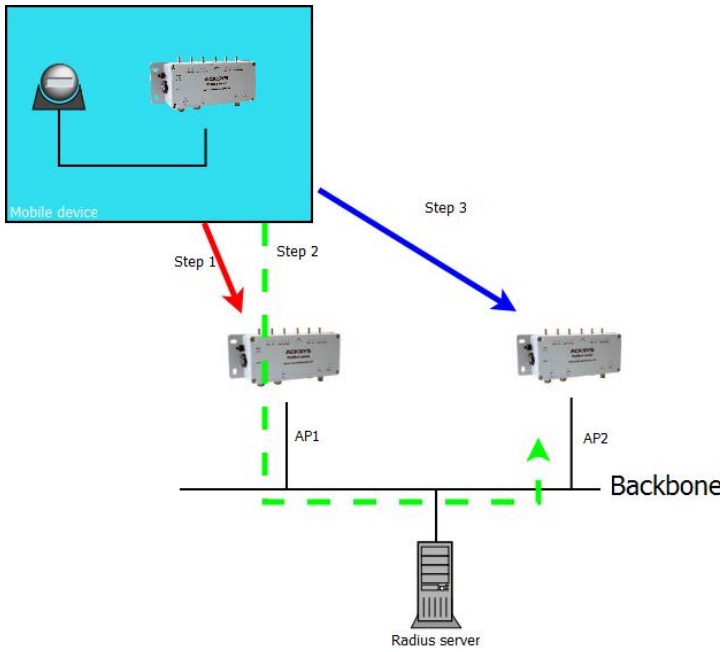
a. Pre-authentication / PMK caching

With this feature, the authentication with WPA/WPA2-EAP policy is reduced to 8 frames (as in PSK mode).

The AP beacons convey its pre-authentication / PMK caching capabilities. A client can choose between them the capabilities it supports and use them.

The products support both features and automatically use them if the roaming is enabled.

The picture below shows the 3 steps of the pre-authentication process:



Step 1: The Wi-Fi client associates with AP1 for the first time. In this step the client does a full authentication. The radius server sends the PMK to both AP1 and the Wi-Fi client. AP1 and the Wi-Fi client store the PMK in their local cache.

At the end of this step, the Wi-Fi client is connected to AP1

Step 2: The Wi-Fi client discovers AP2 by scan process. It uses the secured link with AP1 to process a pre-authentication with AP2. During this step, the radius server sends the PMK to AP2 and the Wi-Fi client. They both store the PMK in their local cache.

At the end of this step, the Wi-Fi client is still connected with AP1.

Step 3: The Wi-Fi client roams to AP2. Both AP2 and the Wi-Fi client check if the PMK in their local cache is correct.

If the PMK is correct, AP2 starts the WPA handshake with the Wi-Fi client.

If the PMK is not correct, the AP starts a radius authentication.

At the end of this step, the Wi-Fi client is connected with AP2.

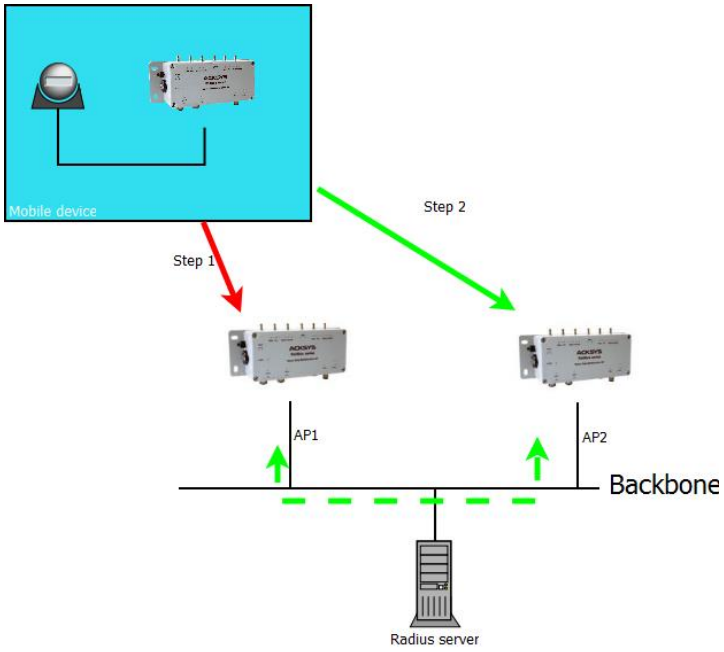
b. Fast Transition Support (802.11r)

With this feature, the authentication with all WPA/WPA2 policies is reduced to 4 frames (as in open mode).

With the 802.11r, the temporal key is distributed through the back bone between the different APs.

The products support the 802.11r only in client mode.

The picture below shows the steps of an 802.11r authentication:



Step 1: The Wi-Fi client does a full authentication with AP1. AP1 stores the PMK and temporally keys. This full authentication process produces data that will be stored by the Wi-Fi client for the next step.

Step 2: The Wi-Fi client roams on AP2 and uses data stored in the previous step in its authentication request. With these data, AP2 knows that this Wi-Fi client is successfully authenticated with AP1. AP2 directly requests the temporally keys from AP1 (using the back bone). If AP1 gives all the needed keys to AP2, the Wi-Fi client is allowed to finish the association process with AP2. In the other case, the Wi-Fi client starts a full authentication with AP2.

V.2.7.7 Connect before break

As we have seen previously, the roaming process, even when it relies on the use of two radio cards, always implies that the Wi-Fi client physically disconnects from the current AP before being able to reconnect to the next AP. This means that there is necessarily a time, even a very short one, during which the client is completely disconnected from the network, and the mechanisms put in place to stop packets transmission this period can't fully guarantee the absence of packet loss.

To meet the needs of certain applications for which packet loss during handover is critical, Acksys has developed a particular roaming mode, called "Connect Before Break", which makes it possible to drastically reduce the packet loss rate, and this even with very data throughput.

The operating principle of Connect Before Break is based on the use of a 'ghost' WiFi client, which is actually a clone of the effective client, operating in parallel with the latter by connecting to the same Access Point, but which, instead of ensuring data exchange, will be responsible for carrying out the function of detecting the surrounding Access Points (scanning). We therefore have at any times two perfectly identical clients, one that we will call the ***active client***, which provides traffic with the AP, and the other, called ***passive client***, which analyzes the environment in search of compatible Access Points.

When the signal level of the current AP drops below the roaming threshold, as soon as the ***passive client*** has detected a new AP meeting the roaming criteria, it will leave the current AP and initiate the connection process to this new one. During this time, the ***active client*** remains connected to the current AP and can continue to exchange data packets. It will only disconnect from the current AP when the ***passive client*** has established the connection with the new AP, after advertising the handover request to the entire network, via ARP exchanges, and after checking that the buffers of the current AP and the ***active client*** are empty.

When the ***active client*** has been disconnected, the two clients will swap their roles: the ***passive client*** becomes the ***active client*** and vice versa.

Please note that, unless your product is configured as a NAT router, Connect Before Break requires the use of the 4 addresses format (WDS). This implies that the access points to which he can connect can only be WaveOS Acksys products

Also note that Connect Before Break can operate on a single radio card, but in this case, **you can only use one channel**.

For the implementation of Connect before Break, we strongly recommend that you consult the application note *APNUS0016 Connect Before Break*

V.2.7.8 Connect Before Break with Predictive Linear Handover

The Predictive Linear Handover, or PLH, is a specific operating mode of the Connect Before Break roaming. The PLH algorithm is intended to be adapted to the case of mobiles equipment moving successively and linearly in front of new APs. It is suitable for the following case:

- Vehicles that follow a linear route (a tram, a train, some bus lines)
- Access Points placed at regular intervals on the route
- None of the APs cover two sectors close to the path (the case of a bus that goes around a block is not suitable).
- The arrangement of the antennas favors one direction (e.g. they are directional, or the vehicle obstructs propagation in one direction)

The goal is to avoid the "back lobes" of the antennas pointing in one direction. PLH is intended for situations where we gradually approach, or we gradually move away, a series of AP antennas all oriented in the same direction.

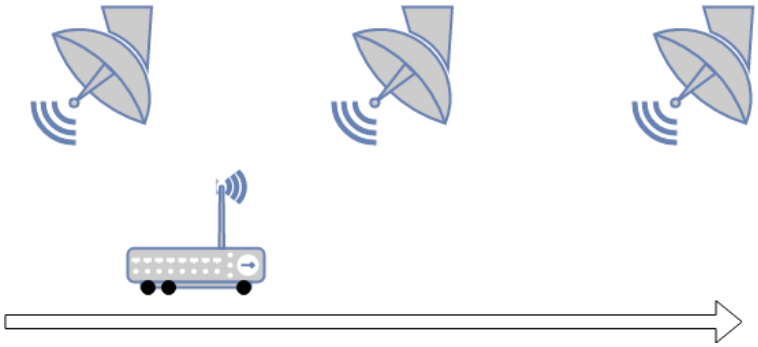
Description of the algorithm:

There are 3 main rules:

1. An AP is "candidate" (to be used as the next association) if its signal level is in a predefined range [min, max] and that it is increasing or decreasing.
2. An AP used for the data link (active AP) is only dropped if it goes out of a predefined threshold range, and there is a candidate AP in range.
3. If the active AP drops below a predefined "urgent" threshold and there is no candidate AP, a state of emergency is raised (but you have to consult it).

There are 2 cases depending on whether the WiFi client (which runs PLH) is placed at the front or at the back of the vehicle.

FRONT PLH

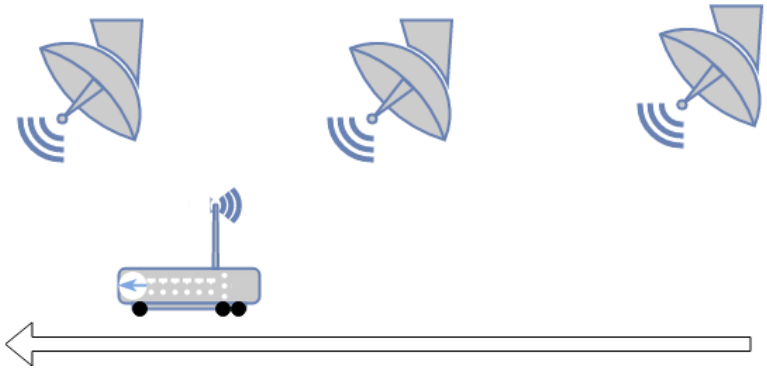


The idea is to reject APs whose signal level decreases. They are supposed to be passed by the vehicle. More precisely, PLH rejects APs whose signal level is lower than one of the preceding values, without time limit as long as the AP remains visible.

In addition, APs whose signal is too high are rejected, on the assumption that they are very close to them and that the overrun is imminent.

Rear PLH (REAR)

It is assumed that the client's antenna is pointed in the opposite direction of movement, and the APs are pointed in the direction of movement:



The idea is to reject APs whose signal increases. More precisely, PLH rejects APs whose signal is greater than one of the preceding values, without time limit as long as the AP remains visible.

In addition, APs whose signal is too high are rejected, on the assumption that they are very close and potentially still on the rear lobe.

"Emergency" state

Here is the list of tests that condition the state of emergency:

- There is no active interface yet OR
- the active interface is not associated OR
- the signal level of the active interface is lower than the emergency threshold OR
- we are in a rear lobe condition: FRONT= active AP almost reached or exceeded; REAR= active AP is approaching. (Normally, in these cases we should have switched to the other radio. If this is not the case, the other radio does not have a satisfactory connection).

The emergency state can be consulted using SNMP OID *statusRoamingUrgent*

V.2.8 WLAN Association Controller

The WLAN Association Controller (WLB) feature is a WaveOS module that is in charge of load balancing, band steering, and client roaming control from Access point.

V.2.8.1 Load balancing

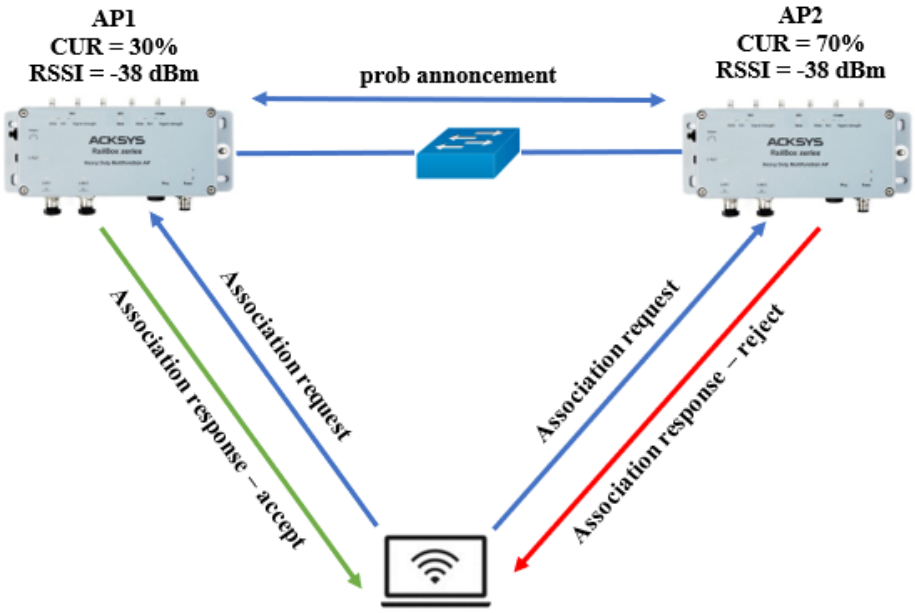
Load balancing allows to control WiFi Stations, or STAs, association in such a way that associates STAs fairly among possible APs within a WLAN with more than one AP.

Each Access Point determines if it is the best AP, and if so, it responds to probe requests and accepts the association request. If the AP is not the best AP, it refrains from responding to probe requests and rejects association requests.

WLB uses Channel Usage Rate (CUR) indicator along with RSSI to elect the best AP. The CUR of an AP refers to the ratio of its number of associated STAs to the maximum number of allowed STAs per AP. Thus, each AP calculates an association score for a STA based on its CUR and its RSSI. APs exchange their number of associated STAs and the RSSI per STA, and decide in a distributed schema which AP should accept a new STA.

At each probe request, the WLB daemon of the AP sends a multicast “probe announcement” message to APs belonging to the multicast group. The probe announcement contains the MAC address of the AP, the number of STAs associated, and the RSSI of a STA. At reception of probe announcement, the receiving AP updates the best AP for a given STA as shown in the following diagram.

At the end, stations are associated to the AP with the best score.

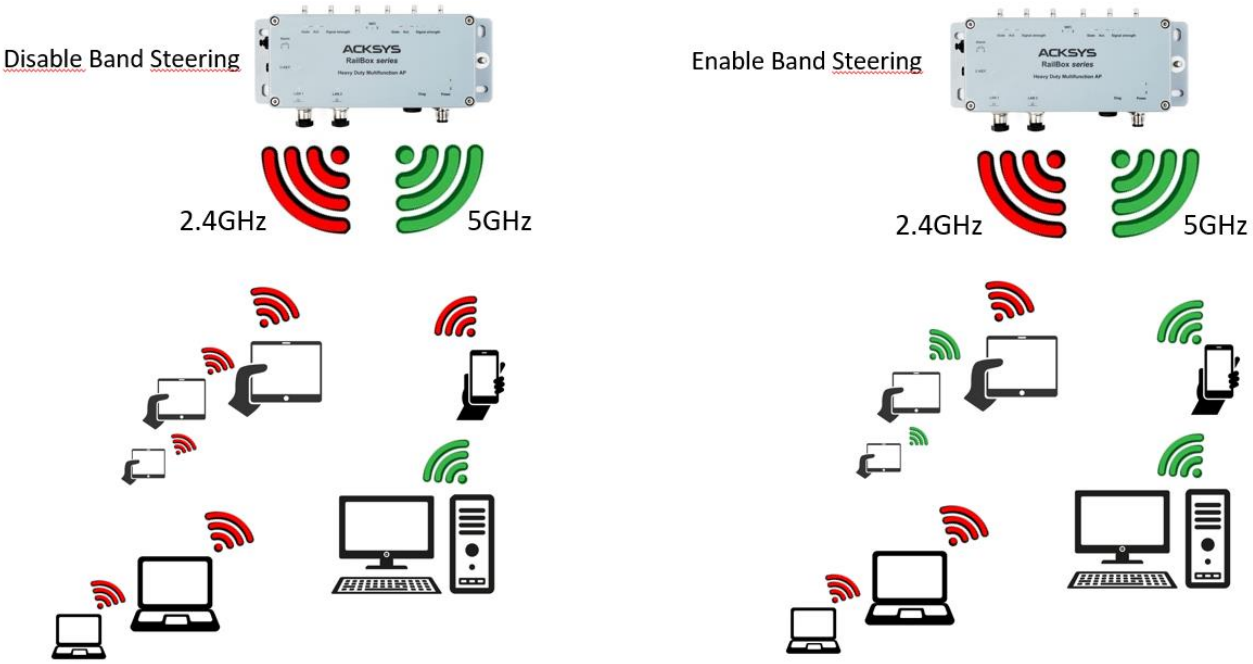


V.2.8.2 Band steering

Band steering enables STAs that are dual-band capable to move to a less congested band of an AP, typically 5 GHz.

With the advancement of "Dual-band" in Wi-Fi devices, customers’ devices now have a choice of connecting to either 2.4 or 5 GHz Wi-Fi networks. However, when connecting to most consumer routers and many access points, the client device determines which band it connects to. The result of letting the client device to connect can result in a very unproportioned distribution of Wi-Fi devices across the 2.4 GHz WiFi network and the 5 GHz band.

Enabling Band steering will direct dual-band devices to connect to the 5 GHz WiFi network. By automatically directing 5 GHz capable devices to that band, we will reduce and improve overall connection quality in both bands.



V.2.8.3 Roaming control

In addition to load-balancing and band-steering, ACKSYS APs can be configured to monitor RSSI per associated station. Roaming control consists of disassociating a station if its RSSI falls below an acceptable threshold. Thus, association requests with RSSI below this threshold are rejected. Note, however, that a second association request from the same client will be accepted unconditionally, unless strict mode is enabled.

V.2.9 Hotspot 2.0

WaveOS now supports Hotspot 2.0, known as *Passpoint*. This is a new wireless standard designed to make it easier and more secure to connect to public Wi-Fi hotspots.

The goal of Hotspot 2.0 networks is to provide cellular-type “roaming” for Wi-Fi networks. As you travel the world, your device will automatically and transparently connect you to available public hotspots. There are a few advantages to this:

- Greater ease of access to public hotspots, and better security.
- Network providers have the option of grouping together and partnering with other providers.
- While many current public Wi-Fi access points are open, insecure Wi-Fi networks, Hotspot 2.0 networks require enterprise-grade WPA2 encryption.

WiFi clients can receive general information about the identity, location and network type of the Acksys Access Point. Clients can also request information from the Access Points about the type of IP address available on the network (IPv4 or IPv6), roaming partners and authentication methods supported, and receive this information in the Access Point information elements.

V.2.9.1 Generic Advertisement Service (GAS) Queries

An Organization Identifier (OI) is a unique identifier assigned to a service provider when it registers with the IEEE Registration Authority. An Acksys Access Point can include the OI of its service provider in beacons and probe the clients answers. If a client recognizes the OI of an AP, it will attempt to associate with this AP using the security credentials related to this service provider.

If the client does not recognize the AP's OI, it can send a Generic Advertisement Service (GAS) request to the AP, to ask for more information about the network before associating.

V.2.9.2 Access Network Query Protocol (ANQP) elements

ANQP information elements (IE) are additional data that can be sent from the AP to the client to identify the AP network and service provider. If a client requests this information via a GAS request, the hotspot AP then sends the list of ANQP capabilities in the *GAS initial frame* indicating support for subsequent IEs. If the client responds with a request for a specific IE, the AP will send a GAS response frame with the configured ANQP IE information.

- *Venue Name*: The place name IE defines the place group and the type of place
- *Domain Name:* this IE specifies the domain name of the AP
- *Network Authentication Type:* If the network has Additional Step Required for Access (ASRA), this profile defines the type of authentication used by the hotspot network
- *Roaming Consortium List:* The IEs of the roaming consortium contain information identifying the network and the service provider, whose security credentials can then be used to authenticate with the AP that transmits this element
- *IP address Availability:* This IE provides clients with information about the availability of versions and types of IP addresses that could be assigned to these clients after they have associated with the AP hotspot

- *NAI Realm:* The NAI Realm profile of an AP identifies and describes an NAI (Network Access Identifier) domain reachable using the AP, and the method that NAI domain uses for authentication
- *3GPP Cellular Network Data:* Defines information for a 3rd Generation Cellular Partnership Project (3GPP) network for hotspots that have roaming relationships with cellular operators
- *Connection Capability:* Define the hotspot protocol and the port capabilities to send in an IE ANQP.
- *Operating Class:* Use this profile to define the channels on which the hotspot is able to operate
- *Operator Friendlyname:* A free text field that can identify the operator and can also give information about the location
- *WAN Metrics:* Provides hotspot clients with information about access network characteristics such as link status and the capacity and speed of the WAN link to the Internet

V.2.9.3 Passpoint Profile Types

In order to facilitate the configuration of a Passpoint, the configuration is stored separately and is (almost) independent of any wireless interface. The configuration consists of several Passpoint configuration profiles; the options in each Passpoint configuration profile share the same purpose.

The Passpoint configuration profile can be summarized in 2 types: HS20 profile and ANQP profile. HS20 profiles configure hotspot 2.0 functionality while ANQP profiles configure ANQP 802.11u functionality.

You will find the description of the different configuration profiles in the Setup menu section (*Passpoint Config Profiles*). Note that the information necessary to fill in these different profiles must be given by the service provider

Profil	Description
HS20 Operator Friendly Name	Use this profile to define the friendly name sent by devices using this profile
HS20 Connection Capability	Use this profile to specify the hotspot protocol and port capabilities
HS20 WAN Metrics	Use this profile to specify the WAN status and link metrics for your hotspot
HS20 Operating Class	Use this profile to specify the channels on which the hotspot is capable of operating
HS20 OSU Provider, Passpoint Icon	Use this profile to define an OSU provider
ANQP Venue	Use this profile to specify the location group and type of locations to send in an IE ANQP in a GAS request response.
ANQP Roaming Consortium	The IEs of the Roaming Consortium contain information identifying the network and the service provider, whose

	security credentials can then be used to authenticate with the AP that transmits this element
ANQP Network Authentication Type	If the network has Additional Step Required for Access (ASRA), this profile defines the type of authentication used by the hotspot network
ANQP IP Address Availability	Use this profile to specify the types of IPv4 and IPv6 addresses available in the access point network.
ANQP Domain Name	Use this profile to specify the domain name of the hotspot operator
ANQP 3GPP Cell Net	Use this profile to set priority information for a 3rd Generation Partnership Project (3GPP) cellular network used by access points that have roaming relationships with cellular operators
ANQP NAI Realm	The NAI Domain Profile for an AP identifies and describes a Network Access Identifier (NAI) domain accessible using the AP, and the method that NAI domain uses for authentication
ANQP Override Element	Additional ANQP elements with arbitrary values can be defined by specifying their content in raw format as a payload hexadecimal. Note that these values will override the contents of ANQP elements that may have been specified in higher layers of the configuration parameters.

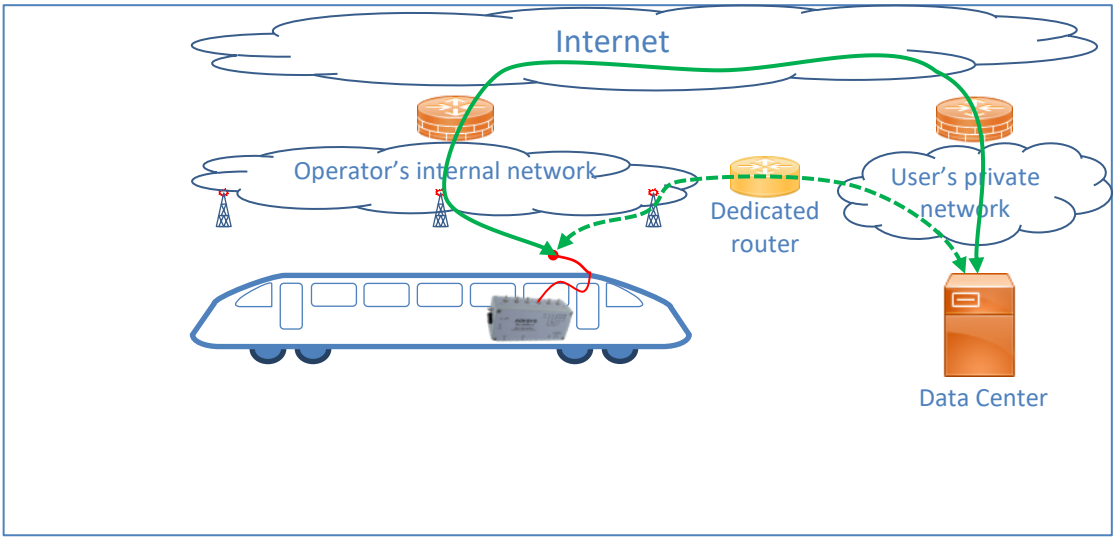
V.3 Cellular interface option

V.3.1 Networking model

When enabled, the cellular interface automatically connects to the provider specified in the selected SIM. The operator is responsible for allocating an IP address to the cellular interface. So, the cellular interface **cannot** be hand-configured with link-layer details like a specific IP address, VLANS, inclusion in layer 2 bridges, radio channel selection, radio protocol and so on.

After connection the product gains access to the operator's private network which is then re-routed to a remote IP network:

- When using a regular personal account, the remote IP network is the Internet. The Internet access is usually provided through an operator-managed NAT gateway, so that the cellular interface of the product cannot be called directly from remote nodes.
- When using a company-level negotiated account, the operator could directly route the access to the company's data center facilities, either through a dedicated link, or through a VPN.



Two important features must be dealt with when using cellular communication:

- Privacy: communication between the products and your data center goes in a first step through the air (with very light privacy) and/or through the Internet in a second step, with equivalent issues. To achieve acceptable privacy, we recommend to set up an encrypting VPN between the product and the data center (even if the operator provides privacy on a part of the path).
- Providing access to local devices: if other devices on the product's LAN are to use the product as a router to Internet or the data center, you must cope with the operator's intermediate NAT. Indeed, the operator's NAT does not know how to route the local devices addresses received from remote sources. You must set up a NAT on the cellular (public) interface of the product to get around this issue.

V.3.2 Configuration

In order to enhance security at installation time, the cellular interface is disabled by default, so you must remember to enable it. Most of the low-level configuration is provided by the SIM module.

Other than that, you must decide if you need to set up a NAT and/or a VPN.

Without a VPN, you probably need a NAT to allow the devices on the Ethernet or the Wi-Fi link to gain access to the Internet. If you use a VPN, having a NAT or not depends on the addressing scheme you use at both the local and the remote ends of the VPN.

You can put the cellular interface into a network zone in order to set extra firewall rules.

Normally the cellular interface becomes the default route when the connection is established, and the configured DNS servers are replaced by the operator-provided ones. These behaviors are generally required but can be disabled.

V.4 Satellite positioning (GNSS) option

The GNSS component which comes with the cellular interface automatically makes use of the four existing satellite systems: GPS (american), Galileo (european), GLONASS (russian), Beidou (Chinese).

Acquiring (“fixing”) the position needs a good reception from satellites. The GNSS antenna must be plugged and oriented toward an unobstructed sky. After a restart or after losing the position, the device needs around 30 seconds to recover, provided at least 4 satellites are in sight of the GNSS antenna.

You can retrieve the current position by four means:

- Displaying on the web interface “Device Information” page
- Reading from the Acksys SNMP MIB (*serviceStatus* section). The position data is refreshed automatically every 2 seconds, and when reading either *positionValid* or *gnssAllPositions.* Please note that The GNSS device acquires the position only **once per second**, so there is no need to read the value at a higher frequency
- If enabled, reading the system log at periodic intervals
- If enabled, connecting to the embedded “gpsd” server. For information about the protocol used, see *http://www.catb.org/gpsd/gpsd_json.html*.

The string displayed in the system log and the string obtained through the ‘gnssAllPositions’ SNMP OID have the same format. It consists in a series of column-separated values in the following order:

Valid flag	1 if position is undefined, 2 if the following data is valid
Dimension	2 if only latitude/longitude are known, 3 if elevation (altitude) is also valid, 0 or 1 if position unknown
Date	Last fix date. YYMMDD (year, month, day) or empty if invalid
Time	Last fix time. If time is available: HHMMSS.ddd (hour, minute, second, dot, milliseconds). If time is unavailable: sssssssss (integer number of seconds since 1/1/1970) as known to the product. Always greater than 1000000.
Latitude	±DD.dddddd degrees from equator, 6 decimal places, a minus sign means south of equator
Longitude	±DD.dddddd degrees from Greenwich, 6 decimal places, a minus sign means west of Greenwich
Altitude	HHH.hhhhhh Height above mean see level, in meters
Speed	kkk.vvvvvv Horizontal displacement speed in kilometers per hour, 6 decimal places
Direction	DDD.dddddd degrees from true north, 6 decimal places, DDD ranges from 0 to 359

The above list may be expanded in the future, by adding to its end.

Example:

```
2:2:180131:095959.000:48.817204:2.007647:0.000000:0.000000
```

V.5 High availability features

V.5.1 Router redundancy with VRRP

In networks such as a transportation system (train, tramway…) which uses Wi-Fi links to communicate with the ground, redundant routing allows setting up a double route, main and secondary, and to detect failures of the main route in order to activate the secondary one. During normal operation of the main route, the secondary route can also be used to transfer data of lesser importance or to implement static load balancing.

When a product is used in IP router mode, you can set up a secondary product to serve as a backup router. This feature uses the VRRP protocol to decide on which product is routing traffic at any given time. The “master” (or “primary”) router is normally used, and the “slave” (or “backup”, or “secondary”) router is used when the master fails.

In the devices around, only one gateway address is set. Depending on availability, this gateway IP address will address either the master or the slave router. Together they form a cluster called “virtual router”.

You can also set up two virtual routers, corresponding to two gateway addresses A and B, and designate one router as master for A and backup for B, and conversely set the other router as master for B and backup for A, thus providing high-availability load-sharing.

Detected failures include Ethernet cable wrenching, Ethernet coupler burnout, Wireless card failure, remote access point failure (in client mode), and of course, power failure of the master. Network breakages between two remote nodes (e.g. two remote switches indirectly connected to the products) are not detected: hence the rest of the network must be redundant as well.

Any detected failure makes the backup router:

- Take over the existing connections
- Advertise the remote devices around that the MAC address of the IP gateway has changed.

When the default is fixed in the master, it resumes, taking back the routing from the backup router.

Three services cooperate to support failover: VRRP detects failures and switches the addressing; connection tracking synchronizes TCP connections between the primary and backup routers; the event manager reports failures.

V.5.1.1 VRRP

The VRRP service handles hardware failures detection and route switching. It implements RFC3768 with slight changes. The VRRP protocol is straightforward: a VRRP master multicasts periodic advertisement frames which inhibit the VRRP backup(s). When the backup ceases to receive the advertisement, it uses gratuitous ARP to inform the network of the new location for the gateway IP address. Then, as the new “master”, it sends “advertisement” frames periodically.

When the master recovers, it negotiates with the backup through the advertisement frames and the real master takes back the routing function.

So, in the master router, the VRRP service detects hardware failures, in the slave, it also monitors the master's health.

Note that the backup can detect the presence of the master, but the master cannot detect the presence of an inactive backup. This is very important because, if the network hardware is only half-functioning (for example the Ethernet link of the master can receive frames but not send them), the system could end up with two active routers at the same address (the master sees no default, and the backup becomes active since it receives no advertisements from the master). The solution to this is instance grouping.

The duration between failure and take-over by the backup depends on many parameters:

- Time to detect the failure (1 to 2 seconds for an Ethernet linkdown, depend on roaming parameters for Wi-Fi failure)
- Advertisement interval. The backup waits up to 4 times the interval before taking over
- Time to reload the connections in the backup (a few ms)
- Time to broadcast the "gratuitous ARP" frame to the network so that switches and hosts know the new MAC address associated to the gateway IP address
- Traffic load. A high network traffic may slow down noticeably the take-over.

VRRP Instances

A VRRP instance is the entity that manages one gateway IP address in one router. It is bound to one subnet.

By this definition, a VRRP instance has the following properties:

- ID — a virtual address identification number, common to the master and the backup. The ID associated to an IP must be unique on the subnet (in case you have several distinct gateways using VRRP)
- Virtual IP address — The address managed by the instance. It must be different from any other IP address assigned to the device, either static or DHCP-provided
- Netmask — Routing information for the virtual IP address
- Network interface — The physical (Ethernet…) or logical (bridge…) subnet to which the virtual IP address is bound

Several other properties are inherited from the group the instance belongs to: the priority (in backup state), the master advertisement period (in master state) and the initial state.

A network interface can be bound to several IP addresses. Typically, one is static and is used for management purposes (to configure and monitor the router) and the other is the virtual gateway address, used by hosts to route packets to other subnets.

VRRP Groups

An IP router interconnects several subnets (LANs). A failure on one subnet must be reported to the other subnets as well, so that remote hosts on all attached subnets stop using the router. To achieve this, the VRRP service manages groups of interdependent subnets. When one subnet fails in the group, it acts as if all subnets had failed and stops advertising on all grouped subnets.

In order to ease configuration, some instances properties are defined at the group level.

- Name — a gateway identification string, can differ from the same group name used in the backup (but using different names is discouraged since it leads to human errors).
- Initial state — The state of all instances at service start, this speeds up the initial state stabilization. Normally the master is initially master and the backup is initially backup, but this is not mandatory.
- Advertisement period — This VRRP parameter is given to the VRRP instances in the group
- VRRP instances list — The instances which are part of the group.
- Connection tracking — If the router is NAT/PAT, VRRP should synchronize connections when the backup becomes active. The connection tracking service should be enabled and configured separately.

The group properties must be identical in the master and in the backup, except maybe for the initial state.

RFC changes

Three enhancements are added to RFC3768:

- Timers are in centiseconds instead of seconds; this feature is taken from VRRP V3 (RFC5798).
- A new “fault” state allows tracking of partial hardware failures. The genuine VRRP protocol only handles complete router shutdowns.
- The master and backup routers have different MAC addresses, i.e. virtual MAC addresses are not supported. Hence, devices using the virtual router must handle the ARP protocol, which is the vast majority, if not all, of IP network devices.

V.5.1.2 Connection tracking

The “connection tracking” service is rather a “connection tracking and replication” service. When the router is in NAT/PAT mode, the connection tracking service synchronizes connection knowledge between the master and the slave. The connection information is sent from the master to the slaves as soon as possible (the order of magnitude is tens of milliseconds but the actual figure depends on the product and network load); there is a slight possibility that a connection which was open just before failure, is not transmitted to the backup router. The user’s application software should be prepared to this and should retry the connection.

A dedicated network link can, and should, be used to transfer connection data: for example, the secondary Ethernet available on some products.

The service is awakened each time a TCP connection is set or torn down, or when an UDP flow is stabilized. Depending on the user’s application there can be a lot of such events. They are grouped together and sent (replicated) in an UDP multicast packet to the backup system that replicates the connection list. The grouping avoids overflowing the network when many connections are present, but induces some delay in the replication.

V.5.1.3 Failures reporting

When the routers change state, an internal event is generated, and you can set the event to generate various actions with the generic “alarms/events” service. You can trigger an action when any given instance or group enter or leaves any given state. When you associate events and actions, you must remember that SNMP actions need a working subnet to propagate.

V.5.1.4 Force routing via the BACKUP

In some cases, it may be useful to deliberately switch from the MASTER to the BACKUP, for example if an on-the-fly reconfiguration of the master is necessary. To do this, we can play on the priority level of the groups: by default, the priority of the MASTER group is fixed at 230 and the priority of the BACKUP group at 200. Using an SNMP command, it is possible to temporarily reduce the priority of the MASTER to zero, and thus force the BACKUP to take over. To do this, you must program the event trigger *SNMP Trigger*, with the *Alter VRRP* action (see section Alarms/events), and as argument, the name of the MASTER group and the offset to be applied to the value of its priority (i.e. -230 if we kept the default value).

Sending OID *adminEventEnable* by SNMP, with the name of our trigger as an argument, will then allow the defined offset to be applied to the priority of the MASTER group (i.e. 230 -230 = 0), which will immediately trigger the switchover to BACKUP, which therefore has a higher priority.

Sending OID *adminEventDisable* will then have the effect of canceling the offset, and consequently will allow to restore the priority of the MASTER group, so the MASTER will take over again.

V.5.1.5 Miscellaneous questions

a. Access points configuration

The access points must allow clients to use several IP addresses and to change them from time to time. ***This requirement rules out some forms of proxy ARP.***

b. Throughput

In load sharing, you must consider the possibility of a failure, where, after takeover, all the data will be routed by one router only. In such a configuration it is therefore advisable to restrain the throughput to half the acceptable throughput. Note that reducing the timeouts make the system faster to react, but reduces the useful throughput, because of the additional load placed upon the CPU and the network.

c. Wi-Fi bandwidth occupation

VRRP and Connection tracking rely on MULTICAST frames. You must consider how this affects air bandwidth:

1. All VRRP frames are transmitted 3 times on the air. In the Master (Wi-Fi client)→AP direction, they are transmitted twice: once in UNICAST to the AP which rebroadcasts them (at low bitrate) to the other potential clients of this AP;
2. in the AP→Backup (Wi-Fi client) direction they are broadcast once at low bitrate.
3. Multicast / broadcast frames from an AP are transmitted at the lowest modulation rate available (1 Mbps in the 2,4 GHz band, or 6 Mbps in the 5 GHz band). You can speed up multicasts by disabling the lowest bitrates (see documentation).
4. As noticed earlier, it is not advisable to use Wi-Fi for connection tracking and replication. The bandwidth is one more reason to avoid this.

The shorter the VRRP period, the more the bandwidth is occupied, the less it is available for useful data exchange.

d. Influence of Wi-Fi handover (roaming) on VRRP takeover delay

In the “client” Wi-Fi function, when the roaming mode is enabled, two kinds of short interruptions of the transmission will occur. The duration of these interruptions must be taken into account when configuring the VRRP “Advertisement periods”, so that no unwanted takeover will take place due, not to a breakdown, but merely to roaming latency.

1. Interruptions due to multichannel scan
   They are periodic and systematic. They are configurable within some limits, using three parameters in the “advanced roaming” tab: *Maximum time off-channel, Maximum time off-channel, Per channel probe response delay.* With a standard AP and the default parameters, the interruption will not exceed 65 ms.
2. Interruptions due to handover from one AP to another
   The interruption duration in this case depends on a large number of factors, such as the kind of security parameters, AP capacity and AP swiftness. Depending on various factors, the duration can vary from 14 ms (no security, fast AP) to more than 300 ms (WPA, RADIUS dialog, certificates control, slow AP…)

The handover process inhibits the detection of Wi-Fi disconnections by the VRRP service: when another AP is available for fast roaming, disconnection detection is disabled, in the assumption that a reconnection to the other AP will quickly follow. If the quick reconnection fails, a timer expires and makes VRRP handle the disconnection. The timer, which represents the maximum time between the loss of the current AP and VRRP failover decision, is computed as follows:

- If the scan cycle period is greater than 2 seconds :

  Timer = (scan interval parameter) + 2s.

- Else, on the assumption the timer is :

  Timer = 2 × (scan interval parameter)

e. Influence of the priority field on VRRP takeover delay

VRRP is designed to handle more than one backup. The “priority” field adjusts the priority between the potentially many backups. The timers which detect a failure of the master depend on this priority field. The higher the priority, the faster the takeover; but for reliability reasons in the priority negotiation, you are advised to use large intervals between values assigned to each device of the VRRP instance (i.e., between the master and the backup). The waiting time for the “advertisement” frames from the master is computed as:

Timeout (in ms) = ((256 – priority) / 256) × 1000 + 3 x AdvertisementPeriod

For example, if the initial role of the product is “backup” and Advertisement period = 100 ms, the default timeout will be

(256 – 200)/256 × 1000 + 3 x 100 = 519 ms (±4 ms)

f. Takeover caused by a Ethernet link loss

Due to limitations in the software and hardware components used, detection of an Ethernet link loss may take up to 2 seconds. Obviously in this case the takeover cannot take place before that delay.

g. Packets are not routed from wireless to wired interfaces! What is wrong?

The advanced settings/bridging mode setting was left to ARPNAT mode. As explained in section *V.2.6.2a*, only a non-bridged wireless interface can route incoming data. The “network” holding the wireless interface must be set to non-bridging, or the client bridging mode must be 4-addresses.

h. SNMP

SNMP OIDs are not yet defined for VRRP configuration. Therefore, it is not possible to configure VRRP using SNMP. However, SNMP traps are defined and can be configured and sent.

V.5.1.6 Link layer redundancy with RSTP

WaveOS features the STP and RSTP protocols. As link layer protocols they are handled by the bridge component. See section *V.1.8.3 Spanning Tree Protocols (STP, RSTP)*

V.6 SNMP agent and ACKSYS MIB

The SNMP protocol defines the dialogue between a management station and a SNMP agent. An SNMP agent runs on each managed system and reports information via SNMP to the managing systems.

With SNMP you can:

- Get the device state
- Change the product configuration
- Manage events

V.6.1 SNMP security

V.6.1.1 SNMP V1 and V2c

Under SNMP V1 and V2c, the security relies on an IP-based access control, mapped to a **Community String**. Authentication of clients is performed with the **community string**, in effect a type of password, which is transmitted in clear text.

The SNMP V1/V2c Communities can be configured in the SNMP AGENT submenu. Please see: *SNMP Agent*

V.6.1.2 SNMP V3

The SNMP v3 protocol provides more sophisticated security mechanisms than SNMP v1 and SNMP v2c. SNMP v3 implements a user-based security model (**USM**) that authenticates and encrypts the requests sent between agents and their managers, and provides user-based access control.

SNMP V3 splits the security into 2 pieces, the authentication / encryption and the authorization.

a. The User based Security Model (USM):

USM provides authentication and privacy (encryption) functions and operates at the message level.

In USM, the administrator can create a list of users:

- Each user has a name (called a **Security Name**), an authentication type (**NONE, MD5 or SHA**) and a privacy protocol (**NONE, DES or AES**) for data encryption.

WAVEOS supports AES128 as AES encryption.

For more details on **USM**, please see “RFC 3415”.

The SNMP V3 users can be configured in SNMP AGENT submenu.

Please see: *SNMP Agent*

b. The View based Access Control Model (VACM):

VACM determines whether a given user is allowed to access a particular MIB object to perform specific functions and operates at the PDU level.

In VACM, the administrator can:

- Assign for each user (or SNMPv1/v2c communities) a **security model**:
  - **V1** community based security model
  - **V2c** community based security model
  - **USM**

  and will then attribute for each pair of **"Security Model, Security Name"** a **Group Name**.
- Define "**Views**" containing a set of MIB objects, where MIB sub trees can be included or excluded.
- Set the **Access Policy** for each **Group**: **Read/write** permissions for a given **View**:
  - Each tuple **"Group Name, Context Name, Security Model, Security Level"** can be assigned a **Read/Write** permission for a given **View**.
  - **Security Level** can be:
    - No authentication.
    - Authentication and no privacy (data encryption).
    - Authentication and privacy (data encryption).

For security model V1 and V2c, security level must be "No authentication".

The Context Name used by WAVEOS inside the agent is always the default context name, which is an **empty string** (For more details on SNMP context please see RFC 5343).

For more details on **VACM**, please see "RFC 3415".

The users' access rights can be configured in SNMP AGENT submenu.

Please see: *SNMP Agent*

V.6.2 Access methods

Requests to SNMP agent can use SNMP V1, V2c or V3, depending on which SNMP security rules have been configured on **WAVEOS**
For SNMP V1 and V2C, the “public” community is configured per default as read/write, and you can manage communities via the Web interface.

Recommended tools

- Net-SNMP, available at *http://www.net-snmp.org/*
- Ireasoning™ MIB browser, available at *http://ireasoning.com/mibbrowser.shtml* (requires JAVA)

V.6.3 Using the Acksys MIB

Obtaining the MIB

The Acksys MIB is included in the *firmware update package* available in the download section of www.acksys.com. The ACKSYS MIB file is self-documented. To read the OIDs documentation please use a text file editor or MIB browser.

Relevant OIDs

The Acksys MIB covers a large range of devices. Hence all OIDs are not relevant to WaveOS. Every OID description contains a firmware tag identifying the firmware which is relevant to this OID. Firmware type and minimum version required are included in the tag, like “[WaveOS Firmware Version 2.8.0.1]”.

All the OIDs described below are relative to the Acksys MIB root:

- .1.3.6.1.4.1.28097
- iso.org.dod.internet.private.enterprises.acksys

The following OIDs are meaningful for WaveOS. Please refer to the MIB to find out numeric OID values and specific description for each item.

acksysProductID	a code identifying product model.
acksysProductSerialNumber	unique identifier assigned to a product.
network-product.administration	core administration functions: adminReset, adminSave, adminApply, adminResetFactory
c-key-management	management functions to erase, save/ restore configuration from/to the C-Key, turn off the C-KEY status led permanently and ignore C-KEY settings. This part also provides a test utility reserved for Acksys production.
networkStatus	current (running) network states, please see section *V.6.4*
networkConfiguration	next-to-be-applied network parameters of the product, see section *V.6.5*
serviceStatus	current (running) state of services.
servicesConfiguration	next-to-be-applied services configuration of the product, see section *V.6.6*

Changing the configuration

When items in networkConfiguration or servicesConfiguration are changed, changes are not saved to permanent memory. Reading the adminSave OID let you know if there are any pending (unsaved) changes: saveNotRequired means no unsaved changes; saveRequired means pending changes exists, you can save them to permanent memory by writing '1' to adminSave.

On another hand, setting adminResetFactory to '1' clears any previous configuration, either saved or not, and reboots the product, thus resetting it to factory settings. The firmware version is kept unchanged, however.

Applying the configuration

To apply the current saved changes, you can either set adminApply to 'enable' (this will not reboot the product), or set adminReset to '1' (which reboots the product). Warning: applying a network configuration change may not get an answer from the agent, since the product networking subsystem is stopped and restarted. If the new modified network is not reachable by the SNMP client, you cannot get an answer from the agent. This is not considered an error.

V.6.4 Understanding network status tables

Current network states of the product are summarized in the tables described below:

- statusIfWlanTable: lists running wireless interface states, like BSSID, channel, security information, connection state, signal level, etc.
  statusIfWlanChannel OID displays the current channel used by the wireless interface. Channel "-1" indicates that the process of channel selection is in progress. It's the same with 0 (in MHz) as frequency in the *statusIfWlanFrequency* OID.
  By default, the *statusIfWlanPreSharedKey* OID is under protection of SNMP V3, only admin_acksys_group can see its result. And, of course, you can modify this configuration in the SNMP AGENT submenu. Please see: *SNMP Agent*
- statusPhyWifiTable: displays the current state of the radio card, like radio card label, enable/disable state, cluster mode, etc.
- statusPhyWifiScanTable: Acksys MIB provides wireless scan service by writing '1' to the *statusPhyWifiScanTableStart* OID. After starting a scan, you can read the *statusPhyWifiScanUpdateTbl* OID to know if current scan is finished: *inprogress* means the scan isn't finished yet; available means the scan is stopped, and then you can see the result in the *statusPhyWifiScanTable*.
  The *statusPhyWifiScanTable* summarizes all available wireless devices in range, on all wireless channels, like access points, mesh points or ad-hoc stations. In this table you can find some useful information like SSID, BSSID, signal level, frequency (in MHz), security, etc. The *statusPhyWifiScanSignal* OID displays the signal level in dBm taken from probe and beacon frames only, which are sent at the lowest available rate. In general, the signal level found for these frames is better than the one from data frames.
- statusSpanningTreeTable: it displays current states of the STP/RSTP bridges, if there are bridges with STP/RSTP enabled in the product.
- statusSpanningTreePortTable:
  This table includes the *statusSpanningTreeTable* and extra information about spanning tree port.

V.6.5 Managing network configuration tables

Network configuration management contains 3 parts which represent 3 layers of OSI model: IP layer (tcpip), Data Link layer (netif) and Physical layer (netphy). You can find out relevant OIDs at each layer.

Note that there is no "repeater" table since this feature is a combination of an AP and a STA (client) with common parameters.

To insert a row in one of the relevant tables, you must set to 'createAndGo' the 'rowStatus' item indexed by the index to be created. To remove a row, you must set to 'destroy' the 'rowStatus' item indexed by the index to be deleted.

CAVEATS:

- It is not recommended to make configuration changes simultaneously with SNMP and the web interface. Changes may take several seconds to propagate from one of these two services to the other.
- SNMP agent does not recognize repeaters created with the web interface. A workaround is shown in the examples below.
- WEB interface does not support WPA-mixed (mixed WPA/WPA2) except mixed WPA/WPA2 PSK for AP. It also doesn't support WPA cipher modes tkip, aes or tkip+aes. Be aware that if you configure one of these modes via SNMP, the WEB interface will display "No encryption".
- The default WPA cipher of AP is AES for WPA2-PSK and WPA2-EAP modes, and TKIP+AES for WPA-PSK and WPA-EAP modes. In the case of client, default cipher is AES for WPA/WPA2-EAP-TLS modes, and TKIP+AES for the other modes. You can also configure other WPA cipher but be aware of WEB interface.

V.6.6 OIDs relevant to IP layer

The OIDs that concern IP layer are about IP settings, routing and firewall management. In the OID tables described below, user can insert or delete rows using the SNMPV2c procedure.

- configIpSubnetTable: lists configurable network interfaces with an IP setting. By default, a network interface can specify only one interface among wireless interface, Ethernet interface, virtual interface, or L2 tunnel GRE interface by using *configIpSubnetInterface*.
  In order to add multi interfaces in a network, you have to set the network as bridge by writing '2' to the *configIpSubnetBridgeEnable* OID, and then add interfaces by managing *configInterfaceTable* (see *configInterfaceDepends* in *section OIDs relevant to Data Link Kayer*).
- configIpZonesTable: general settings of user defined network zones. In this table, you can also enable NAT/PAT (IP Masquerading) then go to *configIpNatIpForwardTable* for further configuration.
- configIpNatIpForwardTable: allows to redirect the input traffic on one zone to a device on private zone when the *configIpZoneNAT* is enabled.
- configIpFirewallTable: used to manage integrated firewall rules on specified zone. The firewall can drop, reject or forward the input traffic from one chosen zone to another device or zone.
- configIpRoutesTable: list of static routes. The static routes indicate over which interface and gateway certain host or network can be reached.

- configIpZoneForwardTable: list of inter-zone forwarding rules. It allows to set the forwarding policies between one zone and other zones. This table is used only for the zone which disables IP Masquerading.
- configIpDscpTaggingTable: list of DSCP tagging rules applied on each incoming frame. The incoming frames matching all the rules in this table will be tagged on DSCP tag. Only routed frames forwarded from one IP network to another can be tagged.

  Acksys MIB provides also management of DOS protection: enabled par default
- synfloodprotection: enable/disable SYN-flood protection
- dropinvalidpacket: drop/accept invalid frames or frames without active connection

V.6.7 OIDs relevant to Data Link layer

Configuration details about wireless interface, virtual interface and bridge are relevant to Data Link layer. In the following described OID tables except configInterfaceTable, user can insert or delete rows using the SNMPV2c procedure.

- configFilterGroupTable: allows to manage layer 2 bridge filter group, see *configFilterGroupRuleTable* for more filter rule details.
- configFilterGroupRuleTable: lists filter rules of all filter groups. Each filter group may contain one or several filter rules. The frames which match at least one rule will be dropped.
- configInterfaceTable: All logical interfaces are listed in this table. The rows are fixed by agent, depend on the following tables. User cannot insert or delete rows. You can manage the network relationship between these interfaces by using *configInterfaceDepends* OID. The network relationship is a dependency between one bridge interface and one or several non-bridge interfaces. In *configInterfaceDepends* OID, you can specify a bridge under one or several non-bridge type interface interfaces like wireless interface, Ethernet interface, L2 tunnel GRE interface or VLAN interface. If you don't respect this rule, the SNMP agent will reject your configuration by sending an error message.
  And also, you can configure the filter group in each interface by setting *configInterfaceFilterGroupIndex* and *configInterfaceFilterGroupDir* OIDs.
  All the interfaces listed in *configInterfaceTable* come from the following tables. You can find further configurations there.
- configIfMeshTable: List of configurable Mesh points. Mesh point supports only SAE as security mode for now.
- configIfBridgeTable: List of MAC bridge networks. You can configure STP/RSTP for your bridges with STP/RSTP activated.
- configIfVlanTable: List of configurable VLAN interfaces.
- configIfStaTable: List of infrastructure clients. In this table you can find the general configurations of client, advanced configurations of security and roaming.
  Each security mode has exclusive configurations. When you define a security mode, you must not forget to set these configurations and you must ignore the configurations of other security modes. Here is a summary about specified security configurations:

SECURITY	SPECIFIED CONFIGURATION	DESCRIPTION
WEP	configIfStaWepKey1 - 4	WEP KEY #1- #4 defined in HEX (characters 0-9, A-F) or ASCII format string.
	configIfStaWepKey	Indicates which one of the 4 WEP keys is currently selected
WPA(2)-PSK	configIfStaKey	Pre-Shared Key with a length from 8 to 63 characters. If its length is 64 characters it will be used directly as hexadecimal format
	configIfStaFastBSSTransitionActivated	Fast transition support (802.11r)
WPA(2)-EAP	configIfStaKey	Password In TLS mode: password associated to the chosen Private Key
	configIfStaEapType	EAP method: TLS, PEAP, LEAP
	configIfStaFastBSSTransitionActivated	Fast transition support (802.11r)
	configIfStaIdentity	Identify only for LEAP/PEAP mode
	configIfStaPrivateKey	You can upload the content of Private key file in PEM format (only in TLS mode) by SNMP-SET. The result is shown by SNMP-GET: 0 : key not set 1 : key is uploaded
	configIfStaCACert	You can upload the content of CA-Certificate file in PEM format (only in TLS mode) by SNMP-SET. The result is shown by SNMP-GET: 0 : key not set 1 : key is uploaded
	configIfStaUserCert	You can upload the content of uploaded User-Certificate file in PEM format (only in TLS mode) by SNMP-SET. The result is shown by SNMP-GET: 0 : key not set 1 : key is uploaded
	configIfStaAuthentication	Authentication type for phase 2 only in PEAP mode
	configIfStaWpaKeyCacheLifeTime	how long the conversation keys are retained in case the client roams back to an already authenticated AP. (in second)

The following OIDs cover configurations exclusive to roaming mode, they can help you configure the roaming client further. Ignore them if the client doesn't enable roaming.

OID NAME	DESCRIPTION
configIfStaRoamingEnable	Client roaming mode activation *[All OIDs below are taken into account when this OID is set to '2'.]*
configIfStaRoamingEnableDBM	If the RSSI of the current AP falls below this value (in dBm), the client will try leaving the current AP and roaming to another AP.
configIfStaRoamingRequiredBoost	Roaming occurs only if the potential AP signal is above the current AP's plus this value (in dBm).
configIfStaRoamingScanPeriod	Delay between two successive scan cycle (in millisecond)
configIfStaRoamingRssiSmoothingFactor	The RSSI of the current AP is computed over the last few beacons received. Select the importance of the last beacon relative to older ones: the RSSI smoothing factor is a value between 1 and 16 that indicates the step of 1/16 (e.g. 3/16, 5/16, 16/16) *In WEB interface it is in percentage format: 6%(1), 13%(2), 19%(3), 25%(4), 31%(5), 38%(6), 44%(7), 50%(8), 56%(9), 63%(10), 69%(11), 75%(12), 81%(13), 88%(14), 94%(15), 100%(16)* *Default:19%(3)*
configIfStaRoamingBeaconTimeout	Beacon interval unit
configIfStaRoamingCurrentApScanThreshold	When the current AP signal is above this level (in dBm), the client ceases to scan. Set to 0 to scan unconditionally. Incompatible with *configIfStaRoamingMaxSignalLevel.*
configIfStaRoamingMinimumStaLevel	The AP's signal is below this level (in dBm), it will not be roaming candidate, but it will still be used if there is no current AP nor better AP. '0' to disable this configuration
configIfStaRoamingAboveLevelThreshold	When the perceived signal level of the current AP passes above this limit (in dBm), the client will try to roam to another AP. '0' to disable this configuration
configIfStaRoamingMaxSignalLevel	APs which are above this level (in dBm) have less priority when choosing the next AP to roam to.
configIfStaRoamingMinRoamDelay	Roaming won't occur before this delay (in ms) has elapsed since the last association.
configIfStaRoamingNoReturnDelay	Roaming won't occur to an AP that was left recently. (in ms, max 180000 ms)
configIfStaRoamingThresholdHysteresis	This value (in dBm) will be added and subtracted to each threshold to set the corresponding threshold hysteresis interval.
configIfStaRoamingOffChanMaxDelay	Maximum delay offchannel during which data must be buffered by the associated AP (in ms)
configIfStaRoamingOffChanProbeDelay	Delay (in ms) for collision avoidance after a channel switch, before sending the probe request
configIfStaRoamingPerChanProbeDelay	Time (in ms) to wait for an answer from the AP.

- configIfAPTable: List of configurable access points. You can find all configurations about general AP settings, securities, MAC filter and frames filter in the table.
  As in the *configIfStaTable*, each security has specified configurations. Focus on the configuration of the security you selected and ignore the other security configurations.

SECURITY	SPECIFIED CONFIGURATION	DESCRIPTION
WEP	configIfAPWepKey1 - 4	WEP KEY #1- #4 defined in HEX (characters 0-9, A-F) or ASCII format string.
	configIfAPWepAuthentication	WEP type: open, share
	configIfAPWepKey	currently used WEP key, a value between 1 and 4 that indicates select one of four WEP keys
WPA(2)-PSK	configIfAPKey	Pre-Shared Key with a length from 8 to 63 characters. If its length is 64 characters it will be used directly as hexadecimal format
	configIfAPPreAuthentication	802.11w security feature activation
	configIfAPWpaGroupRekey	Time interval for rekeying the GTK (broadcast/multicast encryption keys) in seconds.
	configIfAPWpaPairRekey	Time interval for rekeying the PTK (unicast encryption keys) in seconds.
	configIfAPWpaMasterRekey	Time interval for rekeying the GMK (master key used internally to generate the GTK) in seconds.
WPA(2)-EAP	configIfAPKey	Shared Secret with a length from 8 to 63 characters.
	configIfAPPreAuthentication	802.11w security feature activation
	configIfAPWpaGroupRekey	Time interval for rekeying the GTK (broadcast/multicast encryption keys) in seconds.
	configIfAPWpaPairRekey	Time interval for rekeying the PTK (unicast encryption keys) in seconds.
	configIfAPWpaMasterRekey	Time interval for rekeying the GMK (master key used internally to generate the GTK) in seconds.
	configIfAPRadiusIndex	Selected index of configRadiusTable entry

- configRadiusTable: sub-table of Radius server prepared for AP security configuration. It can cover several Radius servers. You can select one Radius server for your AP.

  The selection of the Radius server for an AP is different between the web interface and the SNMP agent. If you change the Radius server in both services, the web interface will prevail. To recover the Radius configuration set by SNMP, first use the web interface to change the AP to a non-Radius mode.
- configDetailsNasId: NAS common identifier for radius servers. It is used for AP in WPA-EAP mode.

V.6.7.1 OIDs relevant to Physical layer

configPhyWifiTable gathers all the physical parameters about a radio card. User cannot insert or delete rows. Number of rows depends on radio card installed in the product.

'0' in *configPhyWifiChannel* indicates that the radio card is configured for multiple channels or automatic channel selection. Please see configPhyWifiChannelList for more channel details. *configPhyWifiChannelList* can contain one or several channels, separated by spaces. 'auto' or '0' in *configPhyWifiChannelList* indicates automatic channel selection.

If the radio card is configured in client roaming mode, *configPhyWifiChannel* and *configPhyWifiChannelList* are ignored, see *configIfStaScanChannels* instead.

V.6.8 Integrity check management

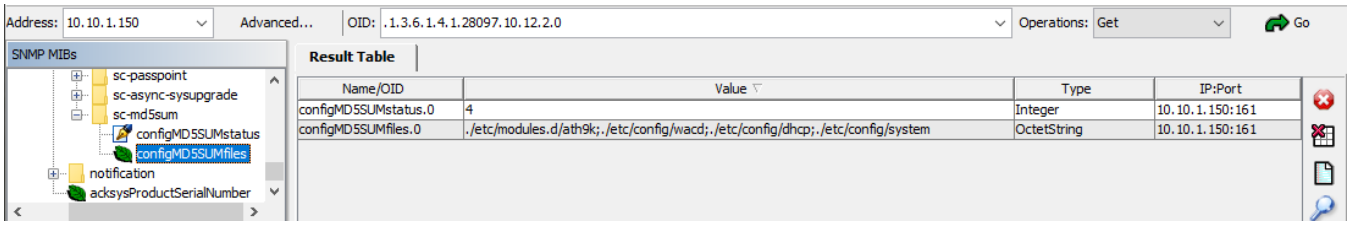
The "Integrity check" service can be used by SNMP. The MIB contains two elements to do this.

serviceConfiguration/configMD5SUMstatus

A set of the OID *configMD5SUMstatus* triggers an integrity calculation on all the files that make up the product. A get will return the number of files modified on the machine compared to the original microcode provided by Acksys. The list of modified files can be obtained using configMD5SUMfiles OID.

serviceConfiguration/configMD5SUMfiles

The OID confiMD5SUM files returns the list of files that have been modified compared to the original micro-code provided by Acksys, the modified files are separated by semicolons.
Eg: */usr/bin/ls;/usr/bin/cat;/usr/bin/ssh*



V.6.9 Managing service configuration tables

Service configuration management gathers the service parameters about web server, DHCP server, DNS relay.

Web server: this part allows you to activate and configure HTTP and HTTPS servers.

DHCP: DHCP service is provided separately by network. One DHCP server independent and ready to setup is prepared for each network interface. Static leases table allows to assign always the same predefined IP address according to the client MAC address.

DNS relay: it is about activation of DNS protection attack.

V.6.10 Using SNMP notifications (traps)

Your product supports the SNMP V2c traps (also called notifications).

The Acksys MIB lists the available SNMP traps under the OID .1.3.6.1.4.1.28097.11 (notification).

To use a trap, you need to configure the trap settings of an event (see section "*Alarms/events*" in the Web interface).

The table below shows the mapping between events and traps.

Event name	Notification name	OID
LAN link	linkAlarm	.1.3.6.1.4.1.28097.11.1
Wireless link	linkAlarm	.1.3.6.1.4.1.28097.11.1
Input power	powerAlarm	.1.3.6.1.4.1.28097.11.3
Digital input	digitalInput	.1.3.6.1.4.1.28097.11.4
Temperature limit	tempExceededAlarm	.1.3.6.1.4.1.28097.11.5
Wireless client assoc.	clientLinkAlarm	.1.3.6.1.4.1.28097.11.6
VRRP state change	vrrpAlarm	.1.3.6.1.4.1.28097.11.7

Variables may be bound in the notification to provide detailed information about the event. Available variables are listed in the MIB for each affected event. You can find these variables under OID .1.3.6.1.4.1.28097.11.255 (notificationBindings).

V.6.11 Examples

These example scripts use SNMP-SET (provided in the Linux net-snmp package). They are meant to run under Linux. Use them as a guideline for other cases.

This script changes the product IP address, and applies the changes:

```
# define a shell macro for snmpset
alias CFGSET="snmpset -m ACKSYS-WLG-MIB -c public -v2c"
# configure it with a new address and netmask
CFGSET 192.168.1.253 configIpSubnetIPv4Addr.\"lan\" a 10.0.1.2
CFGSET 192.168.1.253 configIpSubnetIPv4Mask.\"lan\" a 255.0.0.0
# save and apply without rebooting
CFGSET 192.168.1.253 adminSave.0 i 1
CFGSET 192.168.1.253 adminApply.0 i 2
```

The following script replaces the factory-defined AP interface on radio A, by a Wi-Fi client bridged to the internal bridge, and sets a WPA-PSK key:

```
# define a shell macro for snmpset
alias CFGSET="snmpset -m ACKSYS-WLG-MIB -c public -v2c"
# delete existing AP interface
CFGSET 192.168.1.253 configIfAPRowStatus.\"radio0w0\" i 6
# add a client interface
CFGSET 192.168.1.253 configIfStaRowStatus.\"radio0w0\" i 4
# configure it with WPA/WPA2-PSK
CFGSET 192.168.1.253 configIfStaSsid.\"radio0w0\" s myNewSsid
CFGSET 192.168.1.253 configIfStaSecurityMode.\"radio0w0\" i 3
CFGSET 192.168.1.253 configIfStaWpaVersion.\"radio0w0\" i 1
CFGSET 192.168.1.253 configIfStaWpaCipher.\"radio0w0\" i aestkip
CFGSET 192.168.1.253 configIfStaKey.\"radio0w0\" s "shared psk key"
# set bridge type to L25NAT (therefore, not WDS)
CFGSET 192.168.1.253 configIfStaWds.\"radio0w0\" i disable
# save and apply without rebooting
CFGSET 192.168.1.253 adminSave.0 i 1
CFGSET 192.168.1.253 adminApply.0 i enable
```

The following creates the equivalent of a repeater, starting with the already factory-defined AP:

```
# define a shell macro for snmpset
alias CFGSET="snmpset -m ACKSYS-WLG-MIB -c public -v2c"
# configure the existing AP interface
CFGSET 192.168.1.253 configIfStaWds.\"radio0w0\" i enable
# add a client interface
CFGSET 192.168.1.253 configIfStaRowStatus.\"radio0w1\" i 4
# configure it
CFGSET 192.168.1.253 configIfStaSsid.\"radio0w1\" s "acksys"
CFGSET 192.168.1.253 configIfStaSecurityMode.\"radio0w1\" i none
CFGSET 192.168.1.253 configIfStaWds.\"radio0w1\" i enable
# set MAC address of next AP
CFGSET 192.168.1.253 configIfStaBssid.\"radio0w1\" x 90a4de214f85
# save and apply without rebooting
CFGSET 192.168.1.253 adminSave.0 i 1
CFGSET 192.168.1.253 adminApply.0 i enable
```

V.7 C-KEY handling

Some products of the product line can be equipped with a C-KEY.

Warning: Unlike the “WLg” products series, the C-KEY is never saved or updated automatically in these products.

V.7.1 Factory settings

In this state (Factory state) the C-KEY LED is turned off and the C-KEY contain not useable data.
After the C-KEY is initialized, there is no way to put back the C-KEY in this state.

V.7.2 Understanding configurations and their signature

A C-Key contains:

- a product model identifier;
- an archive of the appropriate configuration files for the model;
- a signature for the archive (the C-Key signature, a MD5 sum).

The product keeps an internal copy of the configuration files, so that it can work with the C-Key removed. The internal copy also has a signature (the internal signature), which is updated in 3 cases:

- when the product is reset to factory settings, the internal signature is cleared before rebooting;
- when the user copies the internal configuration to the C-Key, the internal signature is recomputed so that it is the same as the newly created C-Key signature;
- at boot time, when the C-Key signature is found different from the internal signature, the C-Key configuration and its signature are copied to the internal configuration (you can disable this copy using either the web interface or SNMP).

This procedure has several consequences.

- After a reset-to-factory-settings action, the product reboots and copies the C-Key contents, if valid; to its internal configuration, and uses it immediately; this is a sure path to ensure that the product is using the C-Key configuration;
- if you change the internal configuration, since the internal signature is unchanged, the next reboot will not load from the C-Key; instead, it will use the changed configuration; this situation is shown with a warning in the web interface; it is useful for lab testing;
- if you replace the C-Key with another one containing a different configuration (hence a different signature), it will clear and replace your internal configuration at next power-on. This will not happen if you have previously disabled the C-Key function.

V.7.3 Not using the C-Key

To make sure that the C-Key is never used, you should blank it out (“erase” configuration function). The C-Key LED will then light up in red; you can configure it to disable it.

V.7.4 Replacing a product on the field

Let's imagine a product which is installed, in use and its configuration has been backed up on its C-Key. Now let's imagine that the product was damaged and needs replacement. Here is the procedure that will transfer the configuration from the damaged product "**DP**" to the new one "**NP**".

Requirements: a small screwdriver to unplug and plug back the C-Key.

1) Remove the C-Key on **NP** (if any) and keep it apart; it won't be used.
2) Power off **DP**, disconnect cables and unscrew from its support.
3) Dismount the C-Key from **DP**.
4) Plug the C-Key into **NP** and screw it.
5) Mount **NP** in its location, reconnect the cables.

   If **NP** has been used previously, and you are unsure whether its configuration disables the C-Key:

6) Power up **NP**, wait for the "Diag" LED to turn green.
7) Push the reset button steadily for at least 3 seconds, until the "Diag" LED turns back red; this resets the product to factory settings. Wait until both "Diag" and "C-Key" LEDs turn green.

V.7.5 Working with the C-Key in the lab

In the lab you may not know exactly the internal configuration or the C-Key contents.

You can use the product with the C-Key plugged or unplugged. Always power off the product before plugging or unplugging the C-Key.

We suggest that you disable the C-Key, but let it mounted, while testing various configurations. When you are satisfied with your configuration you can save it to the C-Key. The "C-Key disable" flag itself is not saved to the C-Key.

Remember that a reset to factory settings will clear the "C-Key disable" flag.

Only a configuration action (saving or erasing) will change a C-Key contents.

V.7.6 Programming a set of identical C-Keys

Dedicate a product to prepare the configuration and program the C-Keys.

1) Remove the C-Key from the powered-off product.
2) Reboot and configure the product as needed.
3) In "Tools/Set config/C-Key management", select "Ignore C-Key settings" and "save option".
4) Save and power off
5) Install a C-Key and turn power on. Wait until the diag LED turns green. Remember that after reboot the product will use its new IP address.
6) In "Tools/Set config/C-Key management" menu, click "Copy"
7) Power off the product, remove the programmed C-Key, return to step 5.

V.8 QOS Traffic Class Management

V.8.1 Traffic Classification

Traffic classification corresponds to the categorization of a traffic by a network layer into a number of traffic classes. Each resulting traffic class can be treated differently in order to differentiate the service implied for the user.

The product will act as a network scheduler that will classify packets in a traffic stream based on the content of some portion of the packet header of a particular protocol, into separated individual flows and queues that have different priorities in term of packet egressing.

The product will manage the traffic classes defined in the standard IEEE 802.1p (for Vlan priority) at the Ethernet layer, in the DiffServ standard at the IP layer, and in WMM of IEEE 802.11e standard for IEEE 802.11 networks (WLAN).

V.8.2 802.1p traffic classes

The IEEE 802.1p standard defines the class of service (CoS) as a 3-bits field called the Priority Code Point (**PCP**) within an Ethernet frame header when using VLAN tagged frames as defined by the IEEE 802.1Q standard. It specifies a priority value of between 0 and 7 inclusive that can be used by QoS disciplines to differentiate traffic.

PCP	Traffic Types	Product Internal Traffic classes
0	Best Effort	Depends on Diffserv (see below)
1	Background	1
2	Spare	2
3	Excellent Effort	3
4	Controlled Load	4
5	Video	5
6	Voice	6
7	Network Control	7

The product will map the IEEE 802.1p priorities 1 → 7 to the internal traffic classes 1 → 7.

The IEEE 802.1p priority 0 will be considered as no priority set, and then the Diffserv priority will be used instead.

V.8.3 DiffServ traffic classes

DiffServ uses a 6-bit differentiated services code point (DSCP) in the 8-bit Differentiated services Field (DS field) in the IP header for packet classification purposes. The DS field and ECN field replace the outdated IPv4 TOS field.

The product will only use the first 3 bits of DS field which represent the Class selector of DiffServ, to map to the internal traffic classes 0 → 7.

In case that IEEE 802.1p priority > 0 is present, the Diffserv priority will not be used.

Class Selector Values		Product Internal Traffic classes
DS field	Class	
000XXXXX	CS0	0
001XXXXX	CS1	1
010XXXXX	CS2	2
011XXXXX	CS3	3
100XXXXX	CS4	4
101XXXXX	CS5	5
110XXXXX	CS6	6
111XXXXX	CS7	7

V.8.4 WMM Traffic Classes

WMM defines 4 Access Categories for **802.11** networks (WLAN) to handle the QoS data traffic, with 4 levels of priorities 0→3 (with 0 being the highest priority and 3 the lowest one):

WMM Access Categories	Priority
AC_BK (background)	3
AC_BE (best effort)	2
AC_VI (video)	1
AC_VO (voice)	0

WMM also specifies a mapping between the LAN's Layer 2 (802.1d) Class of Service and the WLAN's WMM access categories.

802.1p PCP	WMM Access Categories	
	WMM Access Categories	Priority
0	AC_BE (best effort)	2
1	BK (background)	3
2	BK (background)	3
3	AC_BE (best effort)	2
4	AC_VI (video)	1
5	AC_VI (video)	1
6	AC_VO (voice)	0
7	AC_VO (voice)	0

The product adds the following mapping between the LAN's Layer 3 Diffserv field and the WLAN's WMM access categories, that will be used when 802.1p priority = 0, and when there is no VLAN but there is Diffserv field.

Diffserv Class	WMM Access Categories	
	WMM Access Categories	Priority
CS0	AC_BE (best effort)	2
CS1	BK (background)	3
CS2	BK (background)	3
CS3	AC_BE (best effort)	2
CS4	AC_VI (video)	1
CS5	AC_VI (video)	1
CS6	AC_VO (voice)	0
CS7	AC_VO (voice)	0

V.8.5 Traffic Class to Queue Mapping

V.8.5.1 Queue definition

When the network scheduler wants to classify a packet that cannot egress due to traffic congestion, it puts it in a queue.

Each interface on the product has it owns queues where packets are stored before **egressing**.

Each **queue** has its own **priority** in term of packet **egressing**:

Packets in a Queue with a better priority will be sent first.

V.8.5.2 Queues of Ethernet Interfaces

Ethernet Interfaces manage **8** queues in parallel**, Queue 0→7 with priorities 0→7**, with 0 the highest priority and 7 the smallest one.

V.8.5.3 Queues of Wireless interfaces

Wireless Interfaces manage **4** queues in parallel, **Queue 0→3 with priorities 0→3**, with 0 the highest priority and 3 the smallest one.

V.8.5.4 Queue mapping

The queue mapping defines the association between a traffic class and a queue priority.

The queue priority will permit to the network scheduler to know the order in which the packets are sent to the network.

For Wireless interfaces, WMM imposes the traffic class to queue mapping. The queue priority corresponds to the WMM access categories priorities.

V.8.6 Queue Management

As in a same queue, we can have several traffic classes, and in a traffic class we can have several streams of different origins, we may also need to deal with the bandwidth sharing inside a same queue.

The queue management corresponds to how to deal with traffic in the same queue.

The product offers 2 types of queue management:

- **FIFO** Queue: the packets exit the queue in the same order they entered it, without worrying about bandwidth sharing.
- **FAIR** Queue: the traffic inside a queue is divided in multiple flows, and then all flows are fairly served for egress.

V.8.7 GRE Tunnels

The product manages the traffic class inheritance of the packets encapsulated by the GRE Tunnels.

If a GRE tunnel encapsulates VLAN with a VLAN priority (PCP) > 0, it will convert the encapsulated VLAN priority to a DiffServ Class for its own enclosing IP packets.

IF the VLAN priority (PCP) = 0, or if the encapsulated packet is not a VLAN, it will inherit the encapsulated Diffserv field.

V.9 Train Communication Network (TCN)

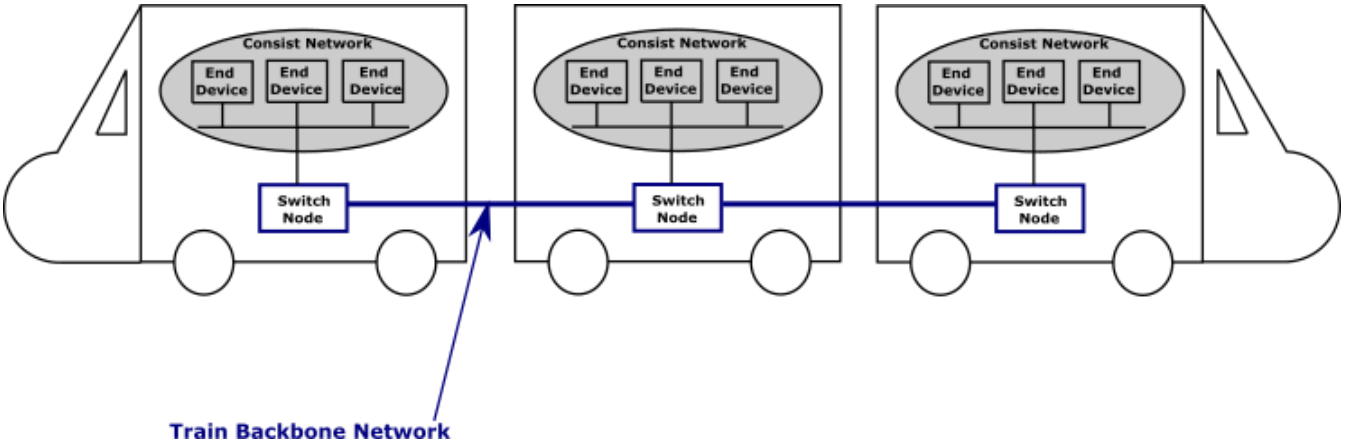
Train communication network (TCN) defines a complete network for digital communication on-board in trains.

NOTE: in this section the words “coach” and “carriage” have the same meaning.

V.9.1 Train backbone

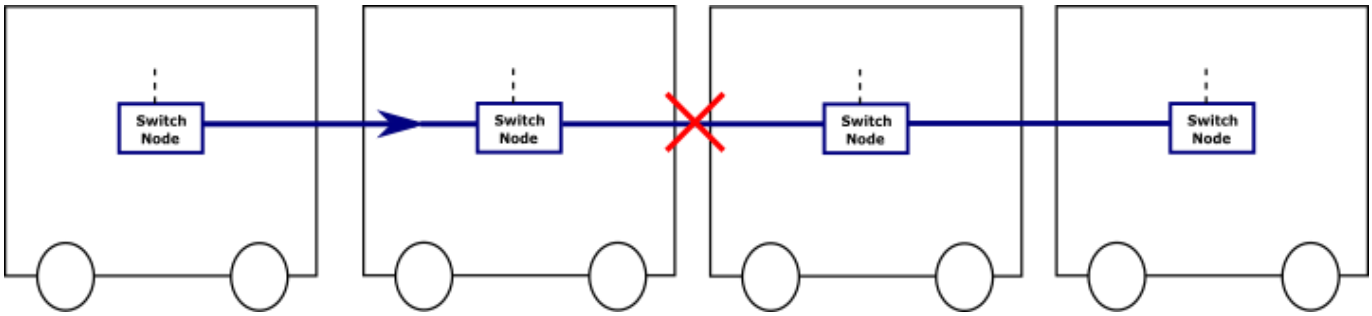
The train communication network consists of a train backbone network represented by a sequence of nodes (switches) arranged in a linear topology.

Each switch node connects a subnetwork (a Consist network) to the train backbone.



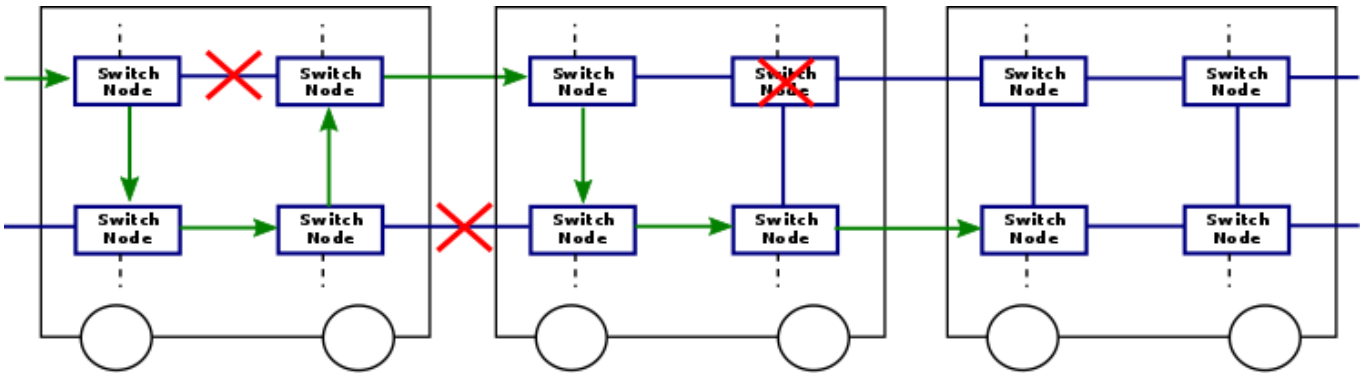
V.9.2 Link failure in linear topology

A link failure in a linear topology will break the communication between the 2 sides of the train.



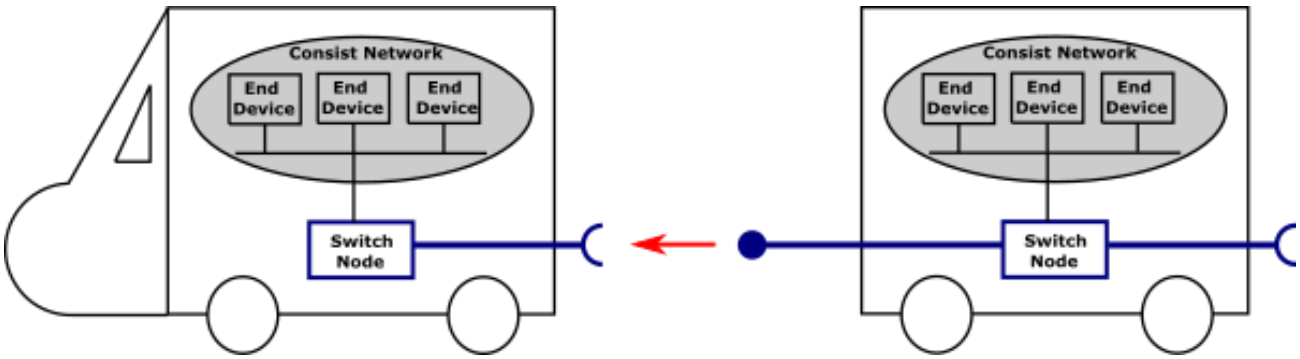
V.9.3 Ring topology

A ring topology allows building a redundant network by providing alternative paths in case of a link failure.



V.9.4 Carriage coupling

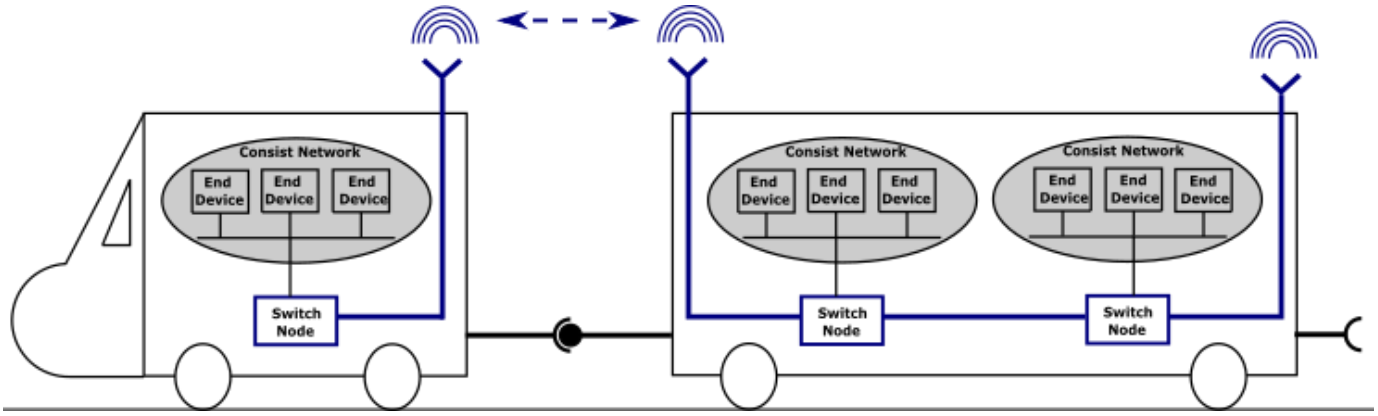
The carriage coupling is the mechanism for connecting rolling stock in the train.



Since network wiring between carriages may be difficult or often impossible, particularly in case of refurbishment operations because of aging or poor-quality connectors, WiFi has naturally established itself as the most efficient solution by allowing redundancy, reliability and high-speed networking.

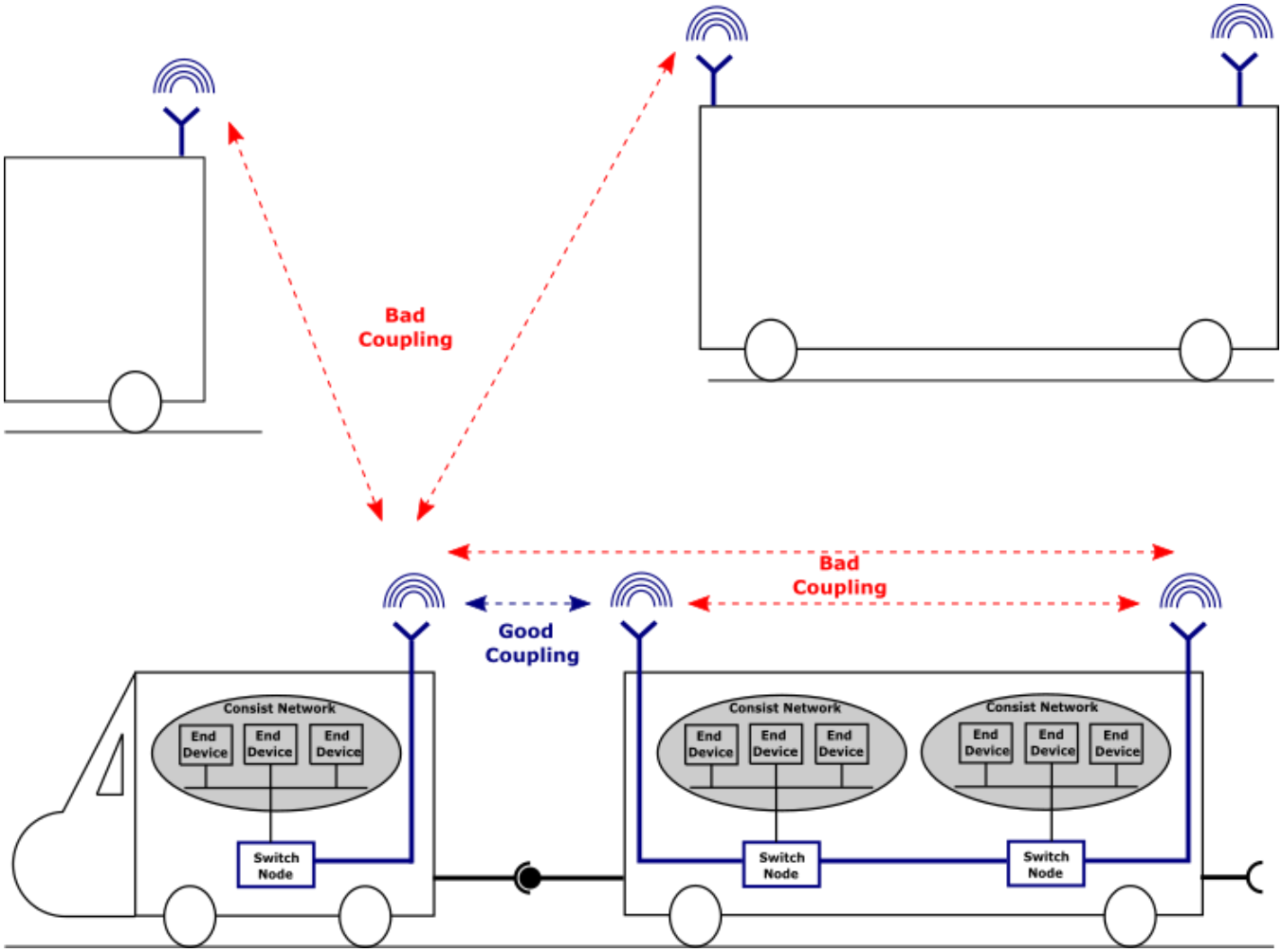
V.9.5 Wireless carriage coupling

The wireless carriage coupling will consist on the discovery and association with the neighboring carriage.



V.9.6 Neighbor discovery

The Neighbor discovery over wireless channels is made difficult by the broadcast nature of the wireless medium, as wireless broadcasting causes a frame to be received also by nodes that are not physical neighbors.



In order to avoid bad coupling, we have to make sure that each switch node only receives signal from the closest valid switch node.

The following methods are available to make sure to comply with the above rule:

- Use a directional antenna in order to focus radiations on the desired coach
- Use as possible low gain antenna and/or RF attenuators
- Increase space between two trains
- Use the Link establishment threshold to exclude undesired switch nodes (see SRCC parameters).

All these methods allow to get rid of bad coupling problems. Nevertheless, since there are many different coach types, it is mandatory to perform a system calibration, to find out the combination of methods and the optimal parameter values, in order to get the best results.

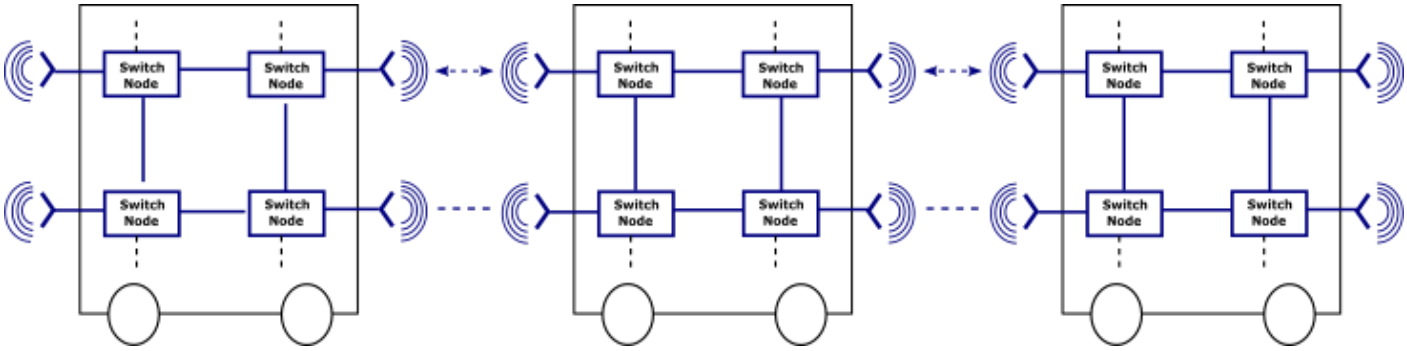
In order to avoid bad couplings from the same coach, every switch node must be aware of its own internal topology to avoid association with the internal nodes of the carriage.

V.9.7 Topology discovery

The topology discovery will consist of the detection by each node of all the other internal nodes of its carriage, and must precede the neighbor discovery step.

V.9.8 ACKSYS's Smart Redundant Carriage Coupling (SRCC)

Smart Redundant Carriage Coupling (SRCC) is a service that automates the wireless coupling of adjacent carriages to establish a redundant *link-layer* backbone, using secured Wi-Fi connections and Ethernet links.



Picture V-9: Example of redundant Ethernet backbone configured with SRCC

For SRCC configuration, please see: *SRCC configuration*

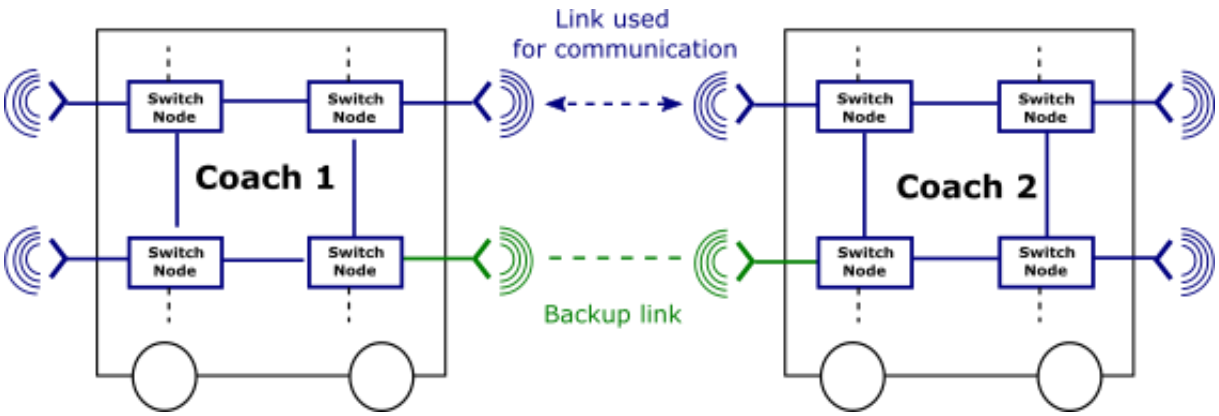
V.9.9 Operating mode

SRCC starts by the discovery of the internal topology of each carriage, then in a second step the discovery of the neighboring carriage. It will automatically choose the right partner for coupling among all the potential devices around.

Once the partner is elected, SRCC will automatically establish a secured link between both devices linking the internal network of both carriages.

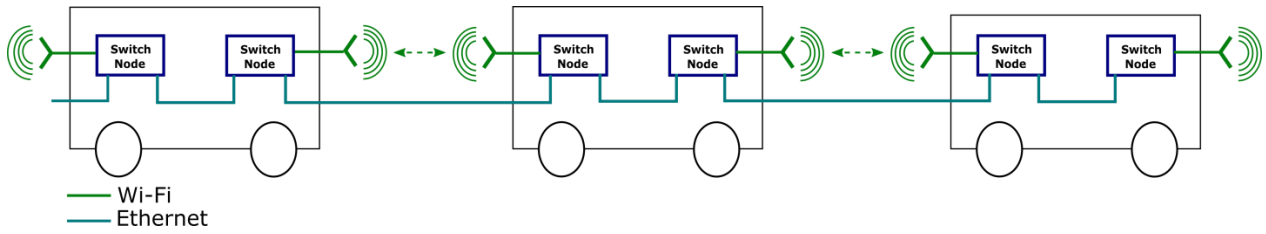
If coaches are separated later, SRCC detects the drop of RF link, closes the link on both sides and restarts the detection process.

If 2 wireless links are possible between adjacent coaches, SRCC will set one for communication and the second one for backup to achieve a redundant link between the carriages.



V.9.10 Redundant mixed mode

This mode is another popular architecture. In this case, an Ethernet connection is available between coaches. This Ethernet link is secured by a wireless link.



Picture V-10: SRCC Redundant Mixed Mode

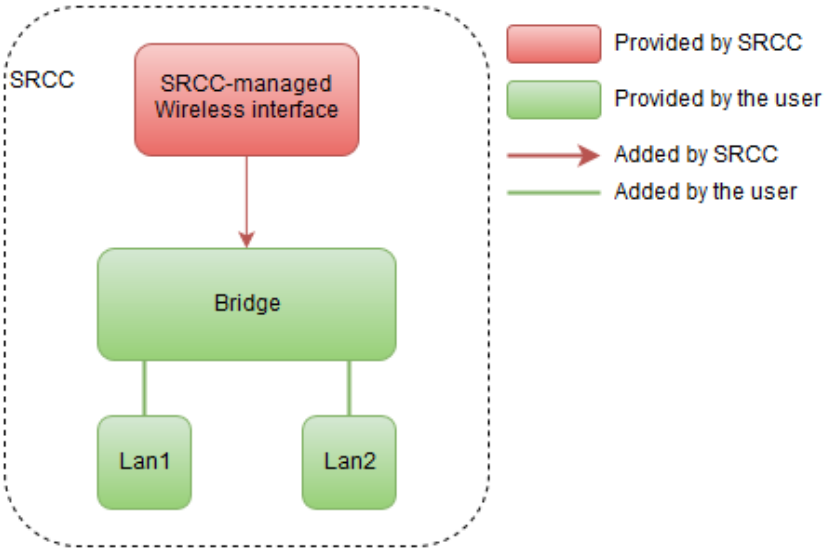
The redundancy is not as full as in the ring topology but it allows an inter-carriage link failure or a wireless failure.

Moreover, this architecture is especially relevant when switch nodes embed the Ethernet bypass feature. This allows not breaking the architecture when a switch node fails.

The weakness is the internal Ethernet link. This link requires a very low failure rate in order for the system to be resilient to failure.

V.9.10.1 Prerequisites

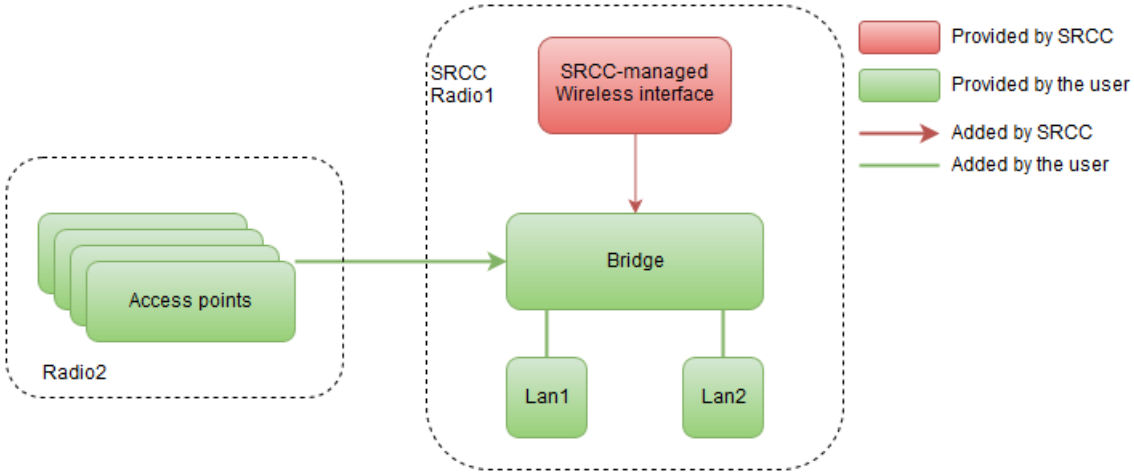
SRCC requires some pre-configuration in order to work correctly. Basically, the user must create a bridge and add Ethernet interfaces to it. **In a redundant or ring topology, it is mandatory to activate RSTP for this bridge**.



Picture V-11: Internal structure of the SRCC switch

If the product is equipped with two radio cards, the second one can implement some roles (APs or client) and then add them to the bridge in order to connect them to the backbone.

This allows, for example, on-board service access points (with or without VLAN) on the second radio while the first one is dedicated to the backbone (thanks to SRCC). The diagram below shows this possibility.



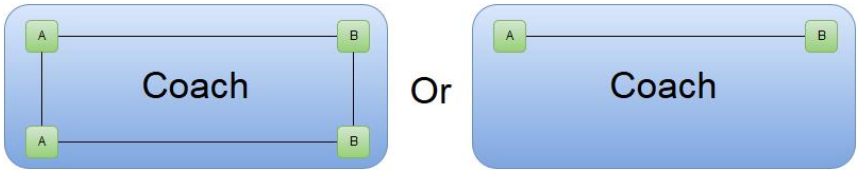
Picture V-12: Internal structure with service APs

V.9.10.2 Topology discovery

At startup, the SRCC service present in each switch node will perform, for a configurable duration, a topology discovery of the other switch nodes internal to the coach. Each SRCC product will then be aware of the coach structure. Any non-existent or faulty unit will be detected at this stage.

To perform a successful mapping of the coach, SRCC will rely on a pre-configured *Coach end* type: type End A and type End B, to know if 2 switches nodes are on the same side or not of a given coach.

Two devices on the same end of a coach must have the same *Coach end* type, and two devices on opposite coach's end must have opposite *Coach end* type:



In case of Redundant Mixed Mode, the *Coach end* type becomes irrelevant. In this mode, the inter-carriage Ethernet link provides a way to discover all the devices of the train in one time. At the end of the topology discovery each product will have a list of all devices of the train. Knowing products of his own train allows SRCC to exclude products not listed (i.e.: products from another train) when setting up the wireless link.

It's important to notice that **all the products of the coach must be powered up on at the same time**. If not, some lately powered up products might be considered non-existent by theirs partners. The topology discovery phase duration can be reduced or extended in order to accommodate with specific power up sequences.

During this step, no wireless interface is created nor allowed on the SRCC associated radio card.

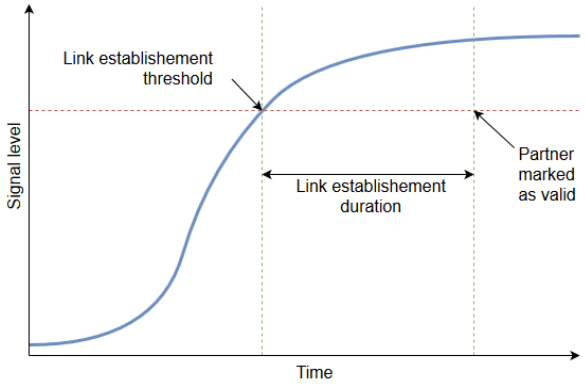
Terminal product

The Ethernet topology discovery process expects to find at least one product at the other end of the coach. Else it will automatically believe to be installed in the last carriage of the train. This may provide an additional level of redundancy if customer routing/control devices are redundantly installed at each end of the train and two SRCC products fail at the same end of a coach.

V.9.10.3 Neighbor discovery

Once the topology discovery is complete, SRCC starts the wireless detection process. At the end of the detection, a final partner is chosen among all valid potential partners.

A partner is considered valid if its signal level is stronger than a given threshold (Link establishment threshold) during more than a given duration (Link establishment duration).



Picture V-13: Partner validation process

The choice between all available partners is based to a large extent on signal level between all stations and devices information (i.e.: not only based on direct signal level).

In case of Redundant Mixed Mode, if the product is in the list established by the topology discovery, a "boost" coefficient is applied. This way, products in the list are boosted and are more likely to be chosen[1] (excluding devices from trains on other railtracks).

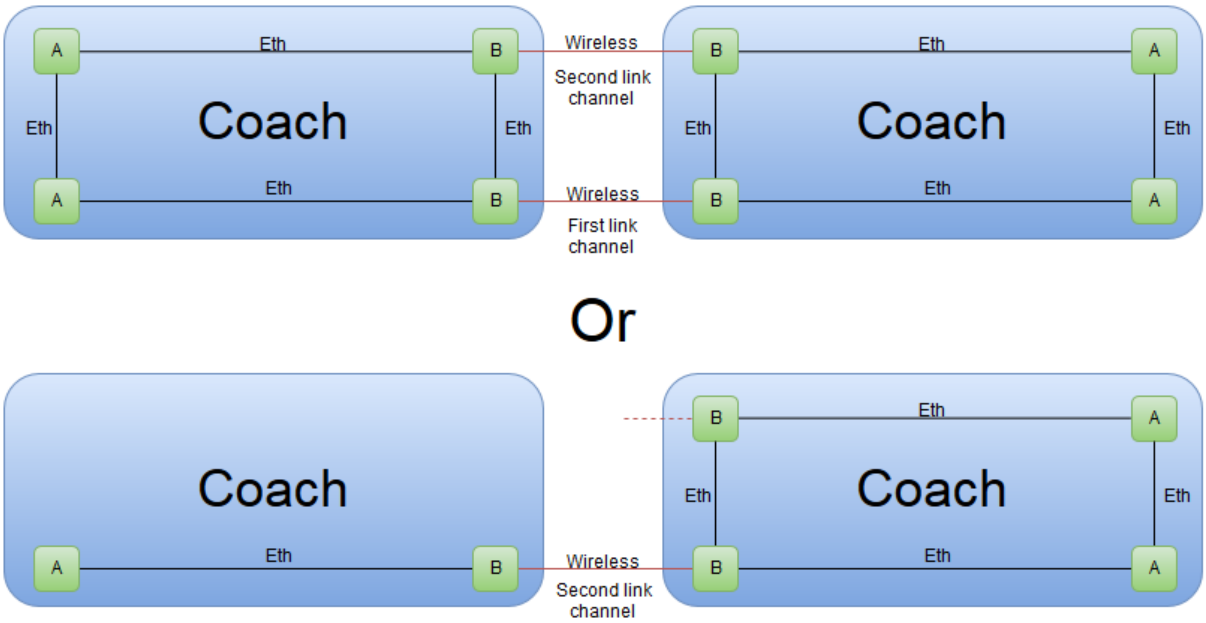
If the inter carriage link is faulty during the topology discovery, devices not discovered will only not take advantage of the boost.

[1] But this is not systematic. So, if the product in the other carriage was missed during the topology discovery, it still has an opportunity to be the chosen wireless partner, due to a good RF signal level, in preference to another detected product farther in the train.

V.9.10.4 Link establishment

Once all partners are identified, each of the switches nodes is assigned a wireless role (access point or client). These devices will create up to two wireless AP-Client links with a unique SSID and a strong, unique, key to ensure privacy.

The user must provide 2 channels (first link channel and second link channel), one for each of the potential links. They will be used by SRCC in an arbitrary order. The channel allocation among links cannot be predicted and is the result of SRCC's internal computation.



Picture V-14: Example of channel allocation among wireless links

Inside the device, the wireless link is then bridged with the Ethernet network and allows data to transit from one coach to another.

The devices remain in this state as long as the link is not lost (see below). As long as the devices stay in this mode, the link is established and data can flow across the coaches.

V.9.10.5 Summary: initialization outline

In the SRCC initialization sequence, the main stream (i.e. processing when the setup is stable and choices are obvious) is as follows. Steps below are numbered as they appear in the system log.

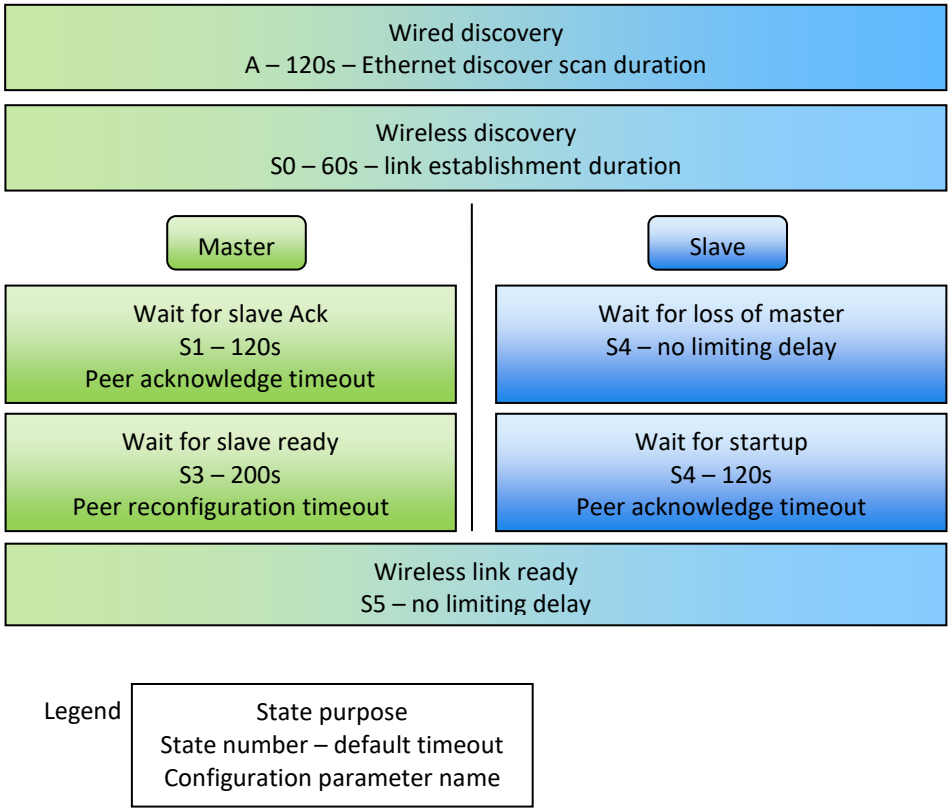
Both products of the wireless link (one in each coach) check its own wired network to find its partners in the coach (step A).

Then both products broadcast wireless beacons to advertise its wired network to the products in the other coach (step S0). Each product learns its peer wireless product in the other coach, and its role in the pair: master (access point) or slave (client).

The master waits for a confirmation from the slave and then sends a startup message (step S1). Then it waits for the slave to start (step S3) and starts itself in AP role (step S5).

On its side, following S0, the slave acknowledges the waits for a startup message from the master (step S4). When it arrives, the slave starts itself in client role (step S5).

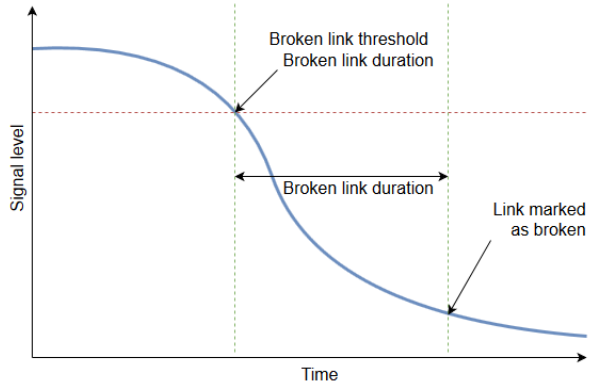
There are various reasons to abort this initialization process, due to weak signal, peer mismatch or timeouts (steps S2 and S6); in these cases, the initialization is restarted at step S0 or S1.



V-1 smooth initialization outline

V.9.10.6 Partner loss

If the train is split, the signal between both sides will fall as the carriages move away from each other. SRCC will track this signal level and if it drops below a given threshold (Broken link threshold) during more than a given duration (Broken link duration), the link will be considered broken. The following diagram illustrates this phase.



Picture V-15: Example of channel allocation among wireless links

As soon as the link is marked broken, the device restarts the neighbor discovery phase and tries to find a potential new partner again.

V.10 Security Management

You should ensure that the network access to your product is secured and so avoid unauthorized access of a hacker. To achieve this, you should configure your product to restrict access to your product to a network segment or a group of authorized users.

V.10.1 HTTP/HTTPS server

You have the possibility to protect the access to the web interface with a password:

- Username: root
- Password: Per default there is no password set

You can also activate the HTTPS server so that the data exchange with the server is encrypted.

A default low security self-signed certificate is used if you do not provide one.

We strongly recommend to upload your own certificate (It must be a PEM file containing both the certificate and its unencrypted private key).

Please see *Web Server* for product configuration.

V.10.2 Bridge mode

In bridge mode, you can control the access to the product with the *bridge vlan* management:

Use a vlan for the configuration management of the product in the network segments that contain the authorized users.

Allow this vlan only on the port connected to this network segment, and on the bridge upper layer interface.

Please see *Enable the Bridging VLAN* for product configuration.

V.10.3 Router mode

In router mode, you can control the access to the product with:

The acceptance policy for local services. You should set it to disabled for Network zones that don’t contain authorized users.

Firewall to block the input traffic that is destined to your product.

Please see *Routing/FireWall* for product configuration.

V.10.4 SNMP access

Per default, there is no security activated on the SNMP agent, and every SNMP v1/v2c user can access all the public and private OIDs.

To protect the SNMP access, you have to change the SNMP access configuration, for example by limiting the “view” read/write rights to certain OIDs.

You can also create a SNMP v3 secured user.

Please see *SNMP Agent* for product configuration.

V.11 Rogue AP detector

V.11.1 Rogue Access Point concept

A rogue access point is a wireless access point that has been installed on a secure network without explicit authorization from a local network administrator, whether added by a well-meaning employee or by a malicious attacker.

Rogue access points and their clients undermine the security of an enterprise network by potentially allowing unchallenged access to the network by any user or client in the nearby area. Rogue access points can also interfere with the operation of your enterprise network.

Rogue access points can impact your wireless network in many ways:

- They can create security holes in your network:
  - By allowing a hacker to conduct a "man-in-the-middle" attack, where the attacker makes independent connections with the victims and relays messages between them, making them believe that they are talking directly to each other over a private connection, when in fact the entire conversation is controlled by the attacker.
  - Send fake SSIDs advertising attractive features such as free Internet connectivity. Once a user connects, the fake SSID is added to the client's wireless configuration and the client begins to broadcast the fake SSID, thereby infecting other clients.
  - Provide a conduit for the theft of company information.
- They can negatively impact your WiFi performance:
  - By imposing unmanaged RF contention or interference.
  - By flooding the network with useless data, creating a denial of service.
  - If plugged in with a LAN instead of a WAN port, they can inject DHCP to the network which can cause problems.
  - When users try to connect to them thinking they are not valid access points and they cannot get to the proper resources due to VLAN differences, which can also generate a lot of help desk calls to your IT department.

V.11.2 Rogue Access Point attack

The Rogue Access Point is installed on a secure network without explicit authorization from a local network administrator, whether added by a well-meaning employee or by a malicious attacker.

Rogue Access Points are often named "Evil Twin". In the IEEE 802.11 standard for Wi-Fi, there are only two identifiers that allow users to recognize an AP: the Service Set Identifier (SSID) and the Basic Service Set Identifier (BSSID). However, these identifiers can be easily spoofed. Cloning a legitimate AP generates an Evil Twin AP.

The "Evil Twins" or RAP can exist in two forms:

- coexistence
- replacement.

In both cases the RAPs use the same SSID as the allowed APs.

In the first case (coexistence), the legitimate AP and the Evil Twin coexist in the same place. The attacker increases the signal strength of the RAP to force users to connect to it, as the IEEE 802.11 standard states that WLAN clients must connect to the AP with the strongest signal.

In the “Replacement” type, the Evil Twin replaces the legitimate access point by shutting it down, thanks to an active attack on it. To remain undetectable by its victims, the RAP must have a valid Internet connection (or connectivity to the same network as the access point) while in the former case, it could relay packets through the legitimate AP, as long as it can connect to the latter.

V.11.3 Rogue Access Point Detector

Rogue access point detection is an important component in securing your wireless network. Rogue access point detection does two things: detection and alert. Whatever you decide to install on your network, it has to have the ability (from the beginning of your RF design) to be able to detect rogue access points and alert the network administrators.

The RAP detection module uses the classic whitelist approach, where we use information from the configuration profile regarding SSIDs and their expected BSSIDs.

The parameters scanned by the RAP Detector are:

- SSID,
- BSSIDs,
- Channel,
- Encryption,
- Signal strength.

Since SSID or BSSID are likely to be bypassed (BSSID spoofing: RAP emitting the same SSID and MAC address as legitimate ap), we also compare the type of encryption used by the access point. (OPEN = Open, WEP = Wired Equivalent Privacy, WPA = Wi-Fi Protected Access version 1, 2 and 3).

Another heuristic implemented by the detection module is the variation in signal strength. The algorithm uses a user-expected authorized RSSI (auth_rssi) for the authorized AP, and the RSSI value read must fall within the allowable range of [auth_rssi - delta; auth_rssi + delta]. (The value of the delta is 15db.) An alert is triggered when the RSSI read leaves this interval.

V.12 Internet Protocol V6 – IPv6

V.12.1 What is IPv4?

IPv4 stands for Internet Protocol version 4. It is the underlying technology that makes it possible for us to connect our devices to the web. Whenever a device accesses the Internet, it is assigned a unique, numerical IP address such as 99.48.227.227. To send data from one computer to another through the web, a data packet must be transferred across the network containing the IP addresses of both devices.

V.12.2 What is IPv6?

IPv6 is the next generation Internet Protocol (IP) address standard intended to supplement and eventually replace IPv4, the protocol many Internet services still use today. Every computer, mobile phone, home automation component, IoT sensor and any other device connected to the Internet needs a numerical IP address to communicate between other devices.

V.12.3 Why Support IPv6?

IPv4 does have one significant difference: it utilizes a 128-bit IP address. Due to this limited size its widespread usage from the proliferation of so many connected devices IPv4 is running out of addresses.

IPv4 uses a 32-bit address for its Internet addresses. That means it can provide support for 2^32 IP addresses in total of around 4.29 billion. That may seem like a lot, but all 4.29 billion IP addresses have now been assigned, leading to the address shortage issues we face today.

IPv6 utilizes 128-bit Internet addresses. Therefore, it can support 2^128 Internet addresses—340,282,366,920,938,463,463,374,607,431,768,211,456 of them to be exact. The number of IPv6 addresses is 1028 times larger than the number of IPv4 addresses. So, there are more than enough IPv6 addresses to allow for Internet devices to expand for a very long time.

Key benefits to IPv6 also include:

- No more NAT (Network Address Translation)
- Auto-configuration
- No more private address collisions
- Better multicast routing
- Simpler header format
- Simplified, more efficient routing
- True quality of service (QoS), also called "flow labeling"
- Built-in authentication and privacy support
- Flexible options and extensions
- No more broadcast

To summarize the main benefits:

Benefits of IPv6	IPv4	IPv6
IPv6 has massive address abundance	4.29 x 109 = 4.3 billion addresses - far less than even a single IP address per person on the planet.	3.4 x 1038 = 340 trillion trillion trillion addresses - about 670 quadrillion addresses per square millimetre of the Earth's surface.
IPv6 networks are easier and cheaper to manage	Networks must be configured manually or with DHCP. IPv4 has had many overlays to handle Internet growth, which demand increasing maintenance efforts.	IPv6 networks provide autoconfiguration capabilities. They are simpler, flatter and more manageable, especially for large installations.
IPv6 restores end-to-end transparency	Widespread use of NAT devices means that a single NAT address can mask thousands of non-routable addresses, making end-to-end integrity unachievable.	Direct addressing is possible due to vast address space - the need for network address translation devices is effectively eliminated.
IPv6 has improved security features	Security is dependent on applications - IPv4 was not designed with security in mind.	IPSEC is built into the IPv6 protocol, usable with a suitable key infrastructure.
IPv6 has improved mobility capabilities	Relatively constrained network topologies restrict mobility and interoperability capabilities in the IPv4 Internet.	IPv6 provides interoperability and mobility capabilities which are already widely embedded in network devices.
IPv6 encourages innovation	IPv4 was designed as a transport and communications medium, and increasingly any work on IPv4 is to find ways around the constraints.	Given the numbers of addresses, scalability and flexibility of IPv6, its potential for triggering innovation and assisting collaboration is unbounded.

V.12.4 IPv6 address format introduction

The text form of the IPv6 address is **aaaa:bbbb:cccc:dddd:eeee:ffff:gggg:hhhh**, where each character is a hexadecimal digit, representing 4 bits. Leading zeros can be omitted. The double colon (::) can be used once in the text form of an address, to designate any number of 0 bits.

In this example:

- **aaaa:bbbb:cccc** is the site prefix: Public topology, allocated to your site by an ISP or RIR
- **dddd** is the subnet ID: Private topology (site topology: internal to your site).
  Same concept as IPv4, subnet associated with a single HW link
- **eeee:ffff:gggg:hhhh** is the interface ID: Automatically configured from interface's MAC address or in EUI-64 format (Extended Unique Identifier).

To simplify the address the 00 can be omitted:
2001:0db8:3c4d:0015:0000:0000:1a2f:1a2b ⇔ 2001:db8:3c4d:15::1a2f:1a2b

Note: only leading zeros are omitted. Trailing zeros are not omitted

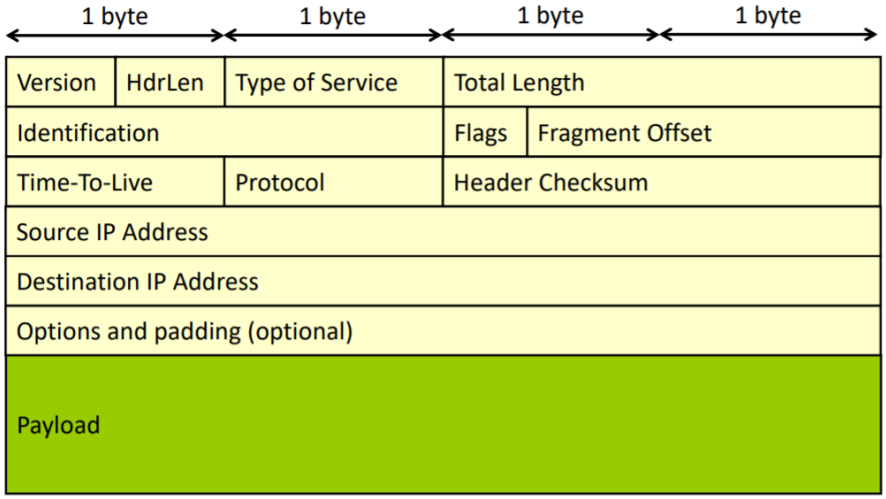
2001:0db8:**0012**::/48 = 2001:db8:12::/48
2001:db8:**1200**::/48 ≠ 2001:db8:12::/48

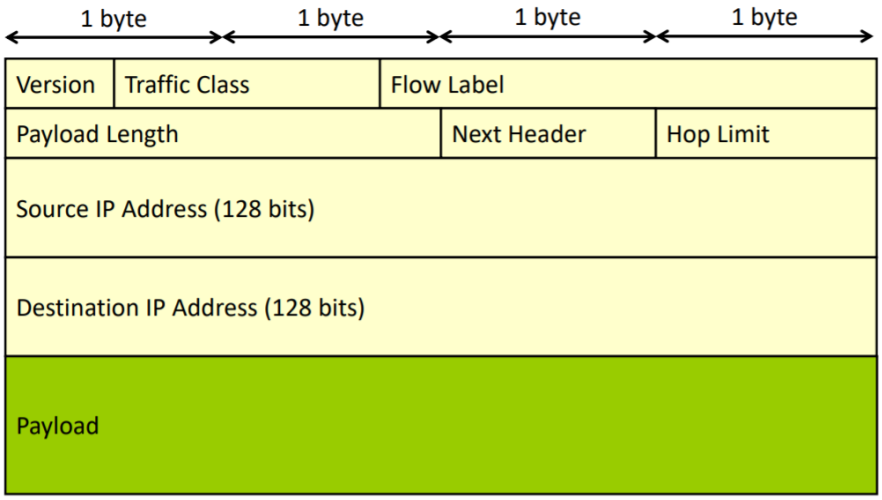
Note: Some special IPv6 prefixes are reserved:

- 2002:: /16→ IPv6 to IPv4 routing
- fe80:: /10 → link-local address
- ff00:: /8 → multicast address

To summarize we can compare the respective IP v4 and v6 datagrams:

IPv4





V.12.5 Class of IPv6 address

There are two general classes of IPv6 addresses:

- Unicast
  - Same as IPv4, but with the addition of link-local addresses

- Multicast
  - Inherent to the IPv6 protocols, in particular Neighbour Discovery (ND) (RFC 4861)
  - All multicast addresses fall under ff00::/8
  - IPv6 does not have an IP subnet broadcast addresses
  - It uses link-local multicast within subnets instead

V.12.6 IPv6 address types

V.12.6.1 Unicast Address

Link-Local address (⇔ LAN):

Only in the local network, not valid outside

Example: Link-local address, Acksys MAC address 00:09:90:00:5a:db

- FE80::290:E8FF:FE00:5ADB

Global Unicast address: Unique in the Internet.

- Example: [2001:db8::1]:80 or URL: http://[2001:db8::1]:80

Example: Calculate Global Unicast with site prefix = aaaa:bbbb:cccc:
Subnet ID=0 and IPv4 = 10.11.16.1 (=0x0A0B1001)

- AAAA:BBBB:CCCC::A0B:1001

V.12.6.2 Multicast Address

Reminder: FF00:: /8 is a multicast address

8 bits	4 bits	4 bits	122 bits
11111111	Lifetime	Scope	Network prefix .. Group ID
ff00	*0 or 1*	*1,2,5,8,e*	*Multicast ID*

1 – Node (interface local scope)
2 – Link local scope
5 – Site local scope
8 – Organisation local scope
e – Global scope

0 – Permanently, globally assigned, well-known IANA
1 – Non-permanently assigned muticast address (dynamically assigned)

- Permanent IPv6 Multicast Addresses (FLGS = 0)
- Group IDs in the range of 0x00000001 to 0x3FFFFFFF
- Permanent IPv6 Multicast Group Identifiers (FLGS = 0)
- Range 0x40000000 to 0x7FFFFFFF

Example:

Network Time Protocol (NTP) being assigned the group ID 0x40404040

- Dynamic IPv6 Multicast Addresses (FLGS = 3)

  Examples: refer to RFC 3307

  FF02::1 = all hosts multicast address (local network), FF05::1 (site)

  FF02::2 = all routers multicast address (local network)

V.12.7 Services supporting IPV6 addressing

- *HTTP/HTTPS for products web interface*
- *Syslog pushes*
- *NTP in Client mode*
- *SNMP*
- *RADIUS authentication by making it possible to address a remote authentication server in IPv6*
- *Static routing*
- *Firewalling*
- *Routing*
- *Bridge*
- *Bridge WIFI (ARPNAT & WDS)*

V.13 Asynchronous System Upgrade

Customers need sometimes to upgrade the firmware of routers at time where operation teams are off duty (e.g. trains must be stopped to upgrade the routers). Additionally, it's very difficult to schedule hundreds of upgrades (so of file uploads) at the same time to avoid bandwidth overload.
With the Asynchronous Upgrade feature the operator can:

- Upload the FW when the train is driving or in depot, so long it has an internet access,
- Upgrade the FW only when the train is no more driving so the router can be restated.

The objective is to separate the transfer of the firmware and the upgrade itself. The user can download the firmware and perform a system upgrade later. There are several options for the system upgrade:

- Program to run immediately,
- Schedule the upgrade at a specific date and time.

Firmware transfer from files server toward router is independent of the system upgrade function. Regardless of the method used for transmission, the upgrade function checks whether the file is a valid firmware.

Note:
With Railbox V2, when a system update is scheduled, the firmware is immediately saved in the eMMC, which allows data to be preserved when the product is not powered.
With other products, since the firmware can only be saved to RAM, once a restart is performed, the scheduled or pending update will be lost.

V.14 System Integrity Check

As part of the security improvements WaveOS integrates an integrity verification system. It is a technical component of the operating system which makes it possible to check the integrity of the files which compose it. This feature allows the customer to know if the product has not been damaged or modified intentionally or accidentally.

The integrity check of the file system is based on the calculation of the checksum or "fingerprint" of each file that composes it. During the compilation of WaveOS, all the checksums were stored in a reference file, and the integrity verification process compares the fingerprints of each file against the reference:

- If the checksums are identical, the integrity of the product is guaranteed to be identical to that produced by ACKSYS.
- If the result is different then the product may be corrupted.

To calculate the hash of a file (condensate), a hash function is applied to its contents: this is a function that calculates a unique digital hash based on the MD5 calculation algorithm (compliant with RFC 1321 of 1992). This integrity check is one of the many features requested by a machine intrusion detection system (HIDS) and allows you to know if a file has not been maliciously modified by a malicious individual.

The integrity check functionality is available via an SNMP interface to allow customers to perform this check remotely.

Note: a command line check is also possible via SSH or the serial port.

The verification includes 3 tasks:

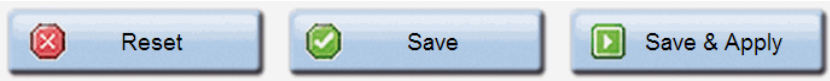
- Keep current file analysis by md5sum.
- Definition of an Object Identifier (OID) in the SNMPD interface allowing:
  - launch the analysis on demand
  - to know if an analysis is in progress.
- Result in the system log file in the form:
  - One message per modified file, the message must contain the beginning of a characteristic string as well as the name of the modified file with its condensate;
  - A message giving the result of the analysis, with a characteristic chain start and the result.

The typical use case is to allow the user - via an SNMP command - to verify that WaveOS files have not been modified on the target platform.

VI WEB INTERFACE REFERENCE

VI.1 Setup Menu

With this menu you can configure the wireless interface(s) and the networking properties. At the bottom of most **SETUP** pages, there are two or three buttons:



After changing parameters, press **Save** to record in permanent memory the parameters changed in this page. In this case the changes will not be applied immediately, but only after a restart, or after a subsequent **Save & Apply**.

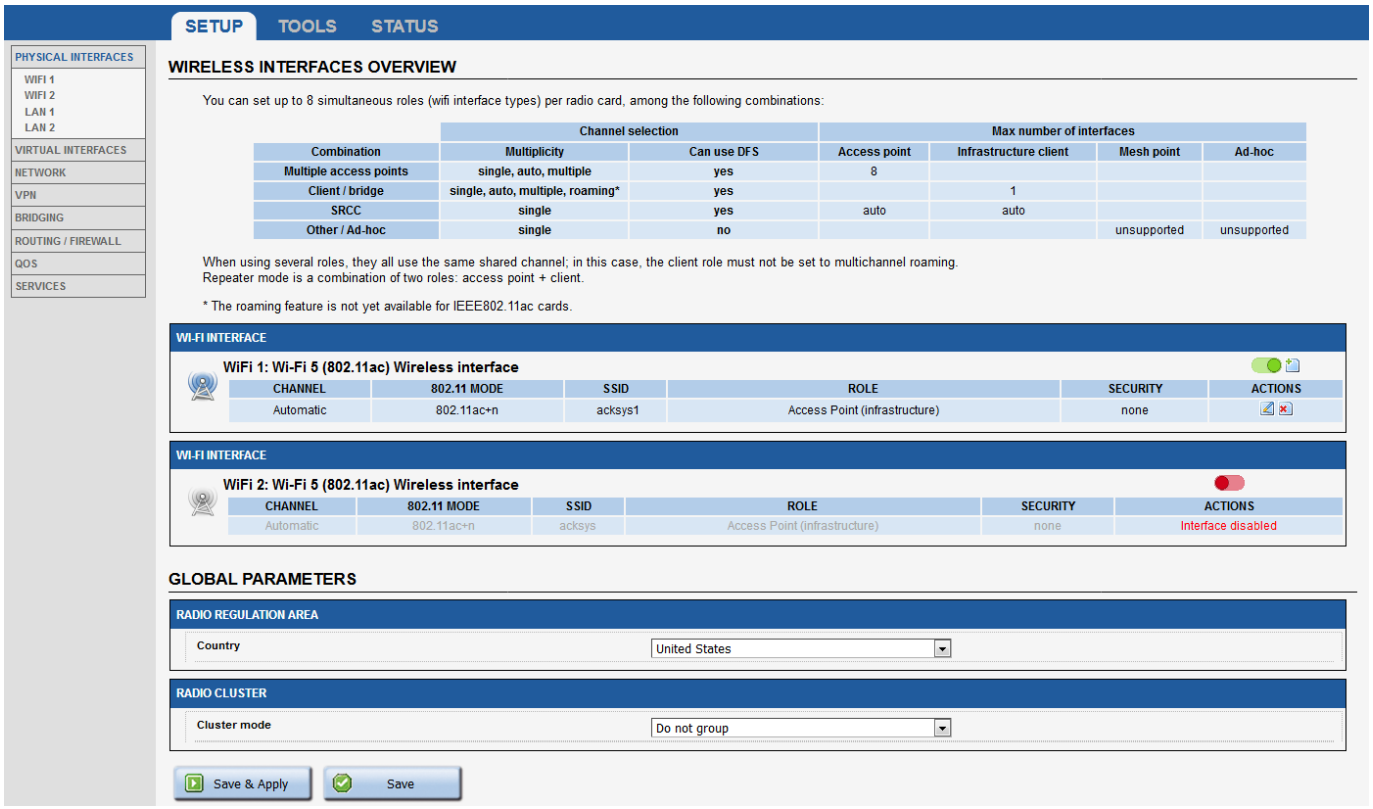
Press **Save & Apply** to record the parameters, and then apply all configuration changes made in any page up to now.

Press **Reset** (if available) to revert the data in the form to previous values (the values displayed after the last **save**)

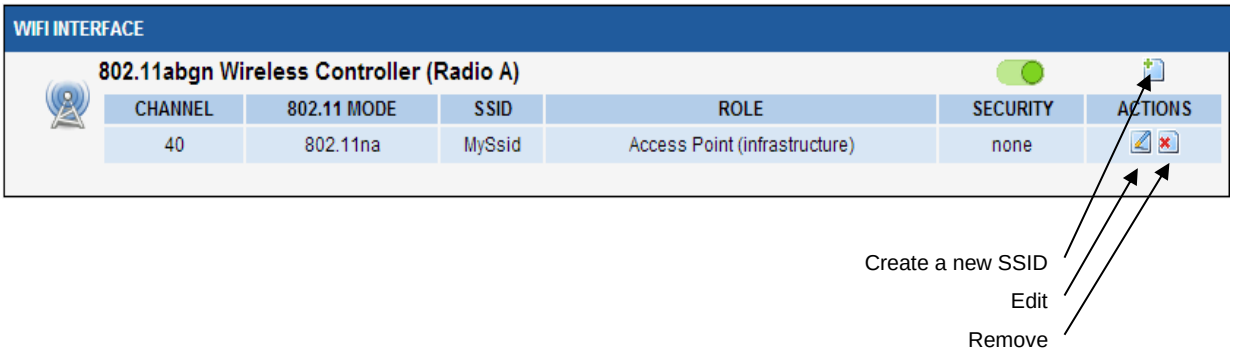
VI.1.1 Physical interfaces

Wireless overview section:

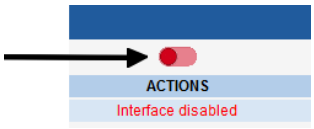
This page lists the most significant properties of the radio cards, organized by SSID. In the bottom of the page you can change global Wi-Fi properties.



The **WIFI INTERFACE** frame summarizes the main settings of each WiFi interface



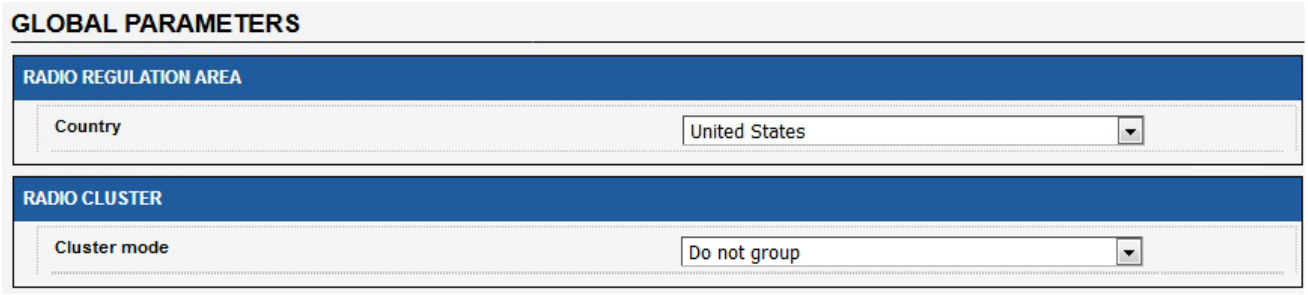
By default (factory settings), the radio cards are disabled.
It's your responsibility to activate them with this button:



Enabling or disabling a radio card will only be applied after a **Save & apply**

Click the **Remove** button to delete this SSID. Click the **Edit** button to open the radio window and edit this SSID properties.

Global parameters section:



Country:

The regulation rules of the selected country will determine the channels and transmission powers you can use. Additionally, in client role the product will use the country provided by the AP in its beacons.

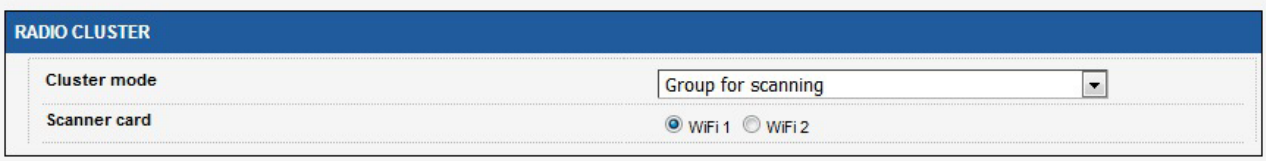
Cluster mode:

You can cluster the radio cards so that one radio is used to scan multiple channels while the other connects to AP's and transfers data. In this mode, the scanning process does not disturb data transfers, but the scanner radio is reserved for this use.

When ***Group for scanning*** is selected, the scan for APs occurs on one radio card. The results are given to the other radio card so that it can select the best AP for roaming purposes. This implies that the AP signal levels must be the same for both cards; hence **their antennas positions, polarities and cabling must be very close to each other**. The roaming trigger level boost should not be set too small, to account for residual differences.

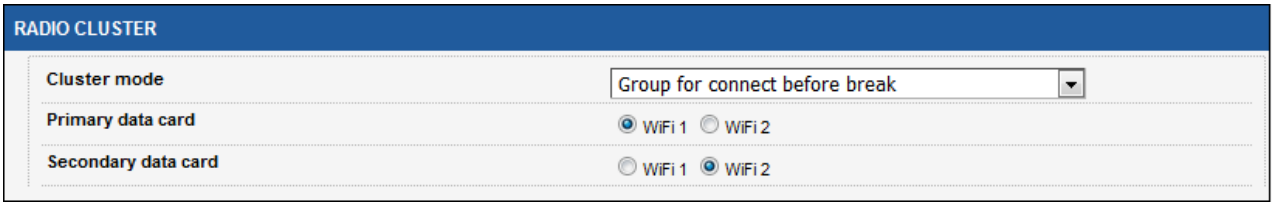
In this mode, the roaming parameters are taken from the configuration of the radio card used for data transfers.

When ***Group for scanning*** is selected, you can choose the card that will be used for scanning with the **Scanner card** radio buttons.



When ***Group for connect before break*** is selected, the behavior of the two radio cards is quite similar to that of ***Group for scanning*** mode, but the functions of the two cards will be swapped, completely transparently, each time a roaming occurs. This operating mode is detailed in section Connect before break.

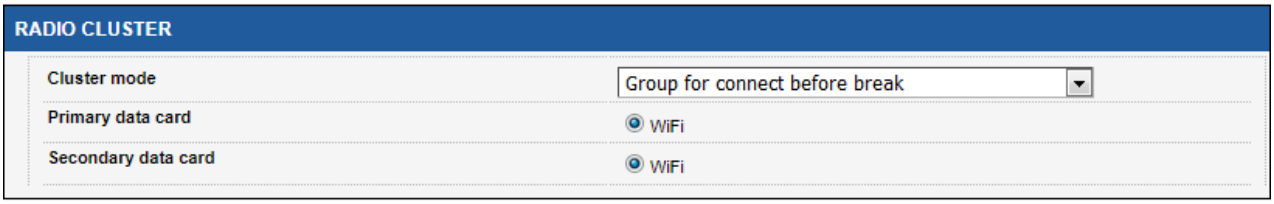
The WiFi 1 interface is selected by default as the primary card, but since it's a temporary state, this has, in most cases, no incidence on the operation.



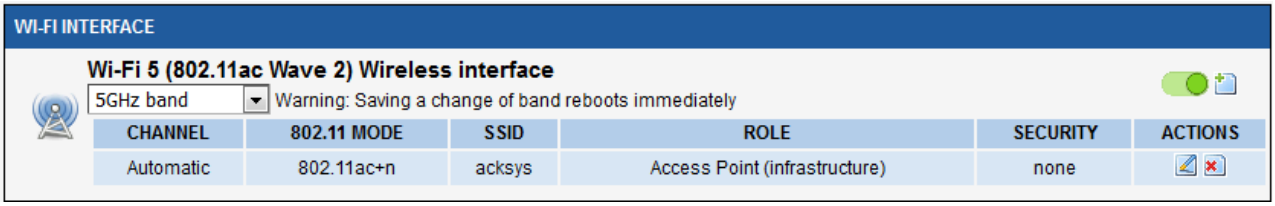
In this mode, it is possible to ask the same radio card to perform both functions, but note that in this case, you can only roam on a single radio channel.

For dual radio products, simply select the same radio card for both functions:

Configuration for single radio products:



Case of 802.11ac Wave 2 products:



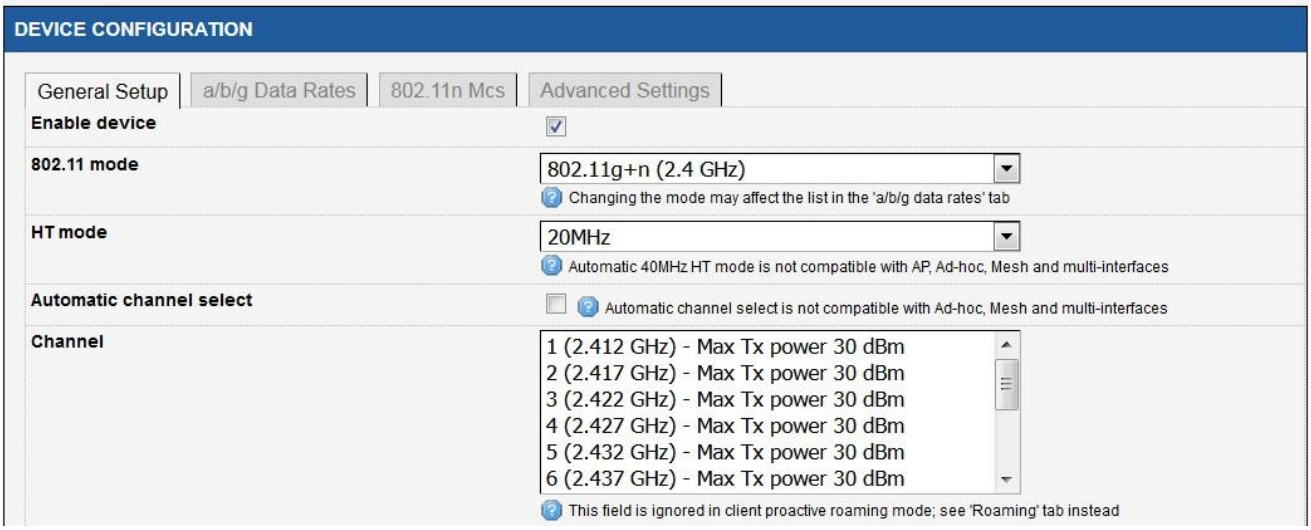
For products such as the Railbox/6xA0, equipped with 802.11ac Wave 2 radio, you must select the frequency band (5GHz or 2.4GHz) before proceeding with the Wireless configuration.

VI.1.1.1 Wireless/Radio

a. SETUP/PHYSICAL INTERFACES/WIRELESS SETTINGS/DEVICE CONFIGURATION

General Setup tab:

This section gathers all the settings common to each SSID you may create on a radio card.



Enable device:

If this checkbox is checked, the radio card is enabled and is able to communicate. Uncheck it to disable the radio card.

802.11 mode:

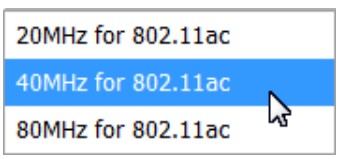
- The 802.11g+n mode operates in the 2.4GHz band (802.11g) and is compatible with 802.11g and 802.11n devices.
- The 802.11a+n mode operates in the 5GHz band (802.11a/h) and is compatible with 802.11a/h and 802.11n devices.
- The 802.11ac+n mode operates in the 5GHz band and is compatible with 802.11ac, 802.11a/h and 802.11n devices.

Note: a product configured in 802.11a+n/ac+n cannot communicate with another one configured in 802.11g+n because they are using different frequency ranges.

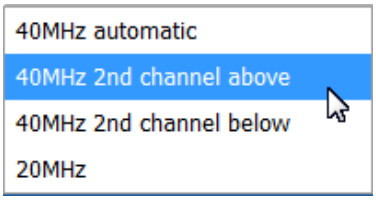
HT (High Throughput) mode:

In 802.11n and 802.11ac mode, you can use the default **HT20** mode, which uses a single 20MHz channel, just like the legacy 802.11a & 802.11g modes. But to increase the bandwidth, you have the possibility to aggregate two or four consecutive 20MHz channels, to work respectively on a 40MHz (HT40) or 80MHz (HT80) channel.

In **802.11ac** mode, you can aggregate two or four 20MHz channels. The primary channel, which is the channel on which the AP sends its beacons to signal itself is automatically determined.



In **802.11n** mode you can aggregate only two adjacent 20MHz channels, to work on a 40MHz channel.

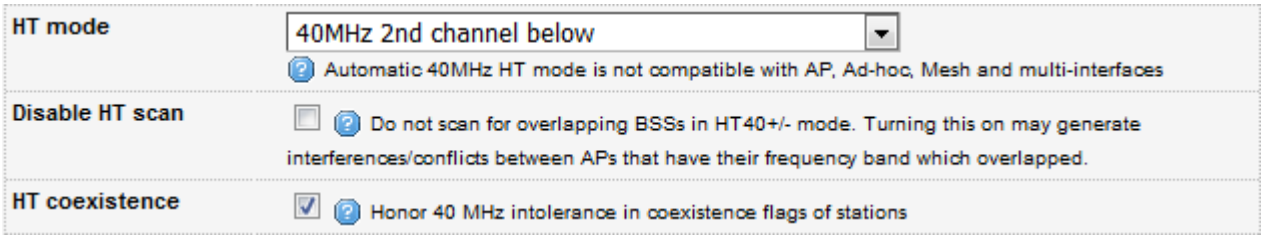


The primary channel is selected in the **Channel** section (see below). You can choose to fix the secondary channel as the

one immediately above the primary channel, or as the one immediately below the primary channel. You can also set 40MHz automatic, and let the unit make the choice.

40MHz automatic is not compatible with AP, Ad-hoc, Mesh and multi interfaces.

When HT40 mode is selected, two additional options appear:



Disable HT scan:

When this option is activated, the system will not check for the presence of other APs on the 40MHz width of the operating channel, which can favor the appearance of interference and degrade the quality of the communication.

HT coexistence:

With this option, the system will abandon the aggregation to free the secondary channel if it is used by other APs

Automatic channel select (ACS):

Depending on the product role, the channel can be selected automatically:

- AP role: At startup, the AP will select the channel among all the ones allowed in your country. In order to limit the choice to specific channels, do not check ACS, but use the channels multi-selection box instead.
- Client role: The client will scan all channels allowed in your country. In order to limit the channel scan list, do not check ACS, but use the channels multi-selection box instead. If the client is set in roaming mode, this channel list is superseded by the one in the roaming tab.
- Other roles: The other roles (mesh portal, ad-hoc) support only one channel, this parameter is not available and you must select a channel from the dropdown box.

Note: ACS is unavailable in “40 MHz second channel below” mode.

Channel:

According to the selected **802.11 mode** and the regulation rules of the selected country, a list of channels is available for selection. **This is not used for infrastructure client modes,** as they use all the allowed channels for scanning (possibly limited by roaming parameters).

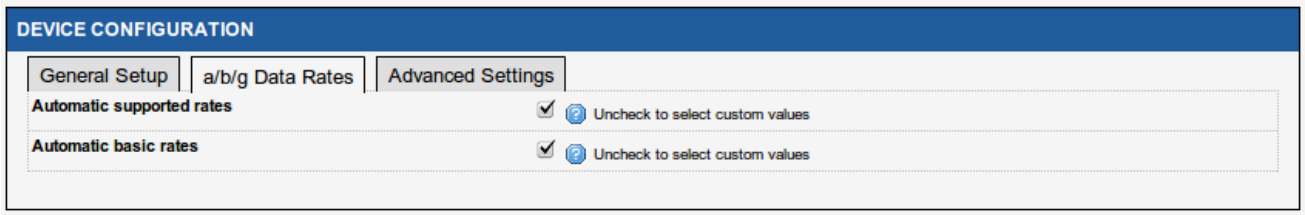
In some cases, a single radio card can handle multiple Wi-Fi roles simultaneously. In this case any “client” function must be set to only scan the common channel. See also section *V.2.1.5 Virtual AP (multi-SSID) and multifunction cards*

See chapter *Appendix – 802.11 Radio channels* for more details on the available channels.

You can select several channels so that the AP will select the cleanest one, and will be able to switch to another if a radar is detected on the current one. To select multiple channels on classic browsers, use the Ctrl+click shortcut.

Note: remember that channels subject to DFS incur a checking delay (CAC time) before use. See section *V.2.4 Radio channels and national regulation rules* for more information.

a/b/g Data Rates tab:



Automatic supported rates:

This option allows you to restrict the rates that your Access Point advertises as supported to the clients.

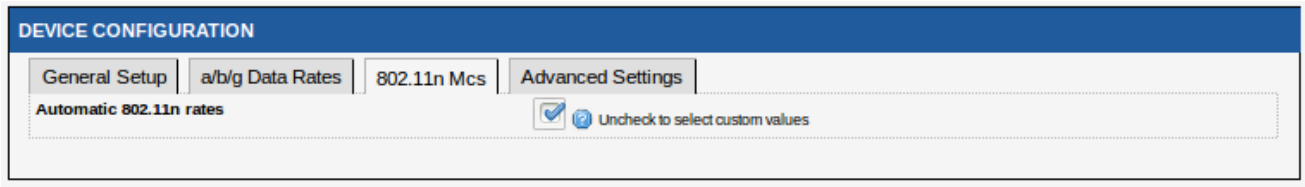
Automatic basic rates:

This option allows you to modify the rates that must be supported by others devices to be able to communicate with your Access Point. **Warning**: every basic rate must also be in the supported rates set.

NOTE ON DESELECTING THE LOWEST RATES:
Management, broadcast and multicast frames are sent using the lowest basic rate selected. You can increase performance with this type of frame by only selecting rates higher than the default but this will affect the area coverage (see the output power table given in your product Quick Start guide).

Since the radio card does not try low rates, retransmissions (when a frame is lost) will happen faster and will take less bandwidth. After association with the Access Point, the auto-adaptive rate control algorithm (MINSTREL algorithm) will converge faster as well.

802.11n MCS tab:

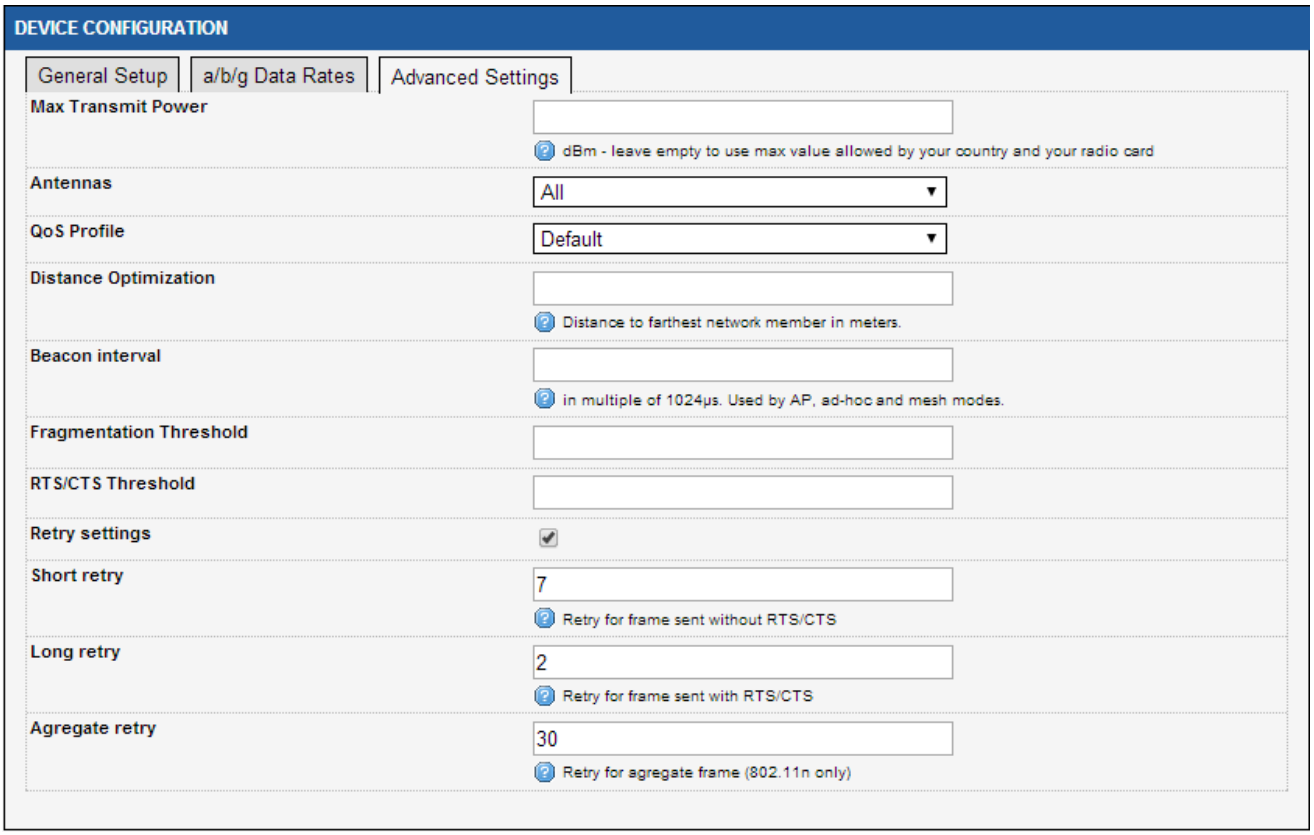


This option allows you to restrict the MCSs that your Access Point advertises as supported to the clients.

In the same manner as a/b/g rates, only selecting highest MCSs in a stream allows to increase performances for broadcast and multicast frame. The drawbacks are also the same as the a/b/g case.

This option is not available with 802.11ac radio cards.

Advanced Settings tab:



Max transmit power:

The transmit power is normally computed automatically based on the regulation rules for the given channel and the capabilities of the radio card. This option sets an upper bound on the transmit power. Note that the transmit power is distributed between the configured antennas.

Antennas:

Unused antennas can be disabled here, thus concentrating transmit power on the remaining antennas. You can disable the third antenna, or both the second and third. In order to take advantage of 802.11n multiple spatial streams, you must use at least as many antennas as spatial streams. The transmit power is distributed between the configured antennas.

QoS Profile:

This option allows choosing between the two QoS profiles defined in the SETUP/QOS/WMM page:

- Default: uses the factory defaults for all WMM parameters
- User: allows you to use the user defined WMM parameters

Distance Optimization:

Use this option if your link is larger than 300 meters. This option will update some Wi-Fi internal timeouts but will not increase or decrease the output power. The distance to the farthest device should be used.

Beacon interval:

This option allows configuring the interval between two beacon frames.

Beacons are used by APs, mesh nodes and ad-hoc stations to advertise their capabilities and settings (HT mode, SSID…) to other devices.

The default settings depend on the 802.11 mode.

If you decrease the Beacon interval you consume more bandwidth on the channel, and you can decrease the global Wi-Fi performance; but you will detect connection losses faster.

Fragmentation Threshold:

This option configures the maximum 802.11 frame size in 802.11a/b/g mode in bytes. Frames that exceed this threshold are fragmented.

RTS/CTS Threshold:

The Wi-Fi standard uses the RTS/CTS protocol to avoid collisions in the air.

This option defines the size of the 802.11 a/b/g frames subject to this protection. Frame exceeding this size are sent under CTS/RTS protocol.

Use CTS/RTS when you have much interference on your channel and a poor performance on the Wi-Fi; or when you have hidden stations (e.g. in an exchange between stations A and B, a third station which is visible by A but not by B, hence interfering with B when it sends to A). On other case this protection decreases the global Wi-Fi performance.

Retry settings:

Unicast data frames are normally acknowledged. If the transmitter does not receive the acknowledgment, it must resend the frame.

In 802.11n, several frames can be aggregated into one big frame called an A-MPDU. Independent frames are acknowledged by an individual ACK frame, while A-MPDU frames are acknowledged by a single “block acknowledge” frame containing one acknowledgment for each subframe in the A-MPDU. Unacknowledged frames are resent in a later A-MPDU.

When you check this option, you can control the number of retries.

Short retry:

This is the number of retries for a physical data frame (single or A-MPDU).

Long retry:

This is the number of retries for a physical data frame (single or A-MPDU) sent with the RTS/CTS protocol.

Aggregate retry:

This option configures the number of retries for a frame aggregated into an A-MPDU (each 802.11 frame sent in A-MPDU frame).

b. SETUP/PHYS. INTERFACES/WIRELESS SETTINGS/INTERFACE CONFIGURATION

This section is duplicated for each SSID. Settings only apply to the selected SSID.

Note: Various roles in the **Interface configuration** section have an **Advanced settings** tab, which you must not confuse with the **Advanced settings** for the **Device configuration** section just above.

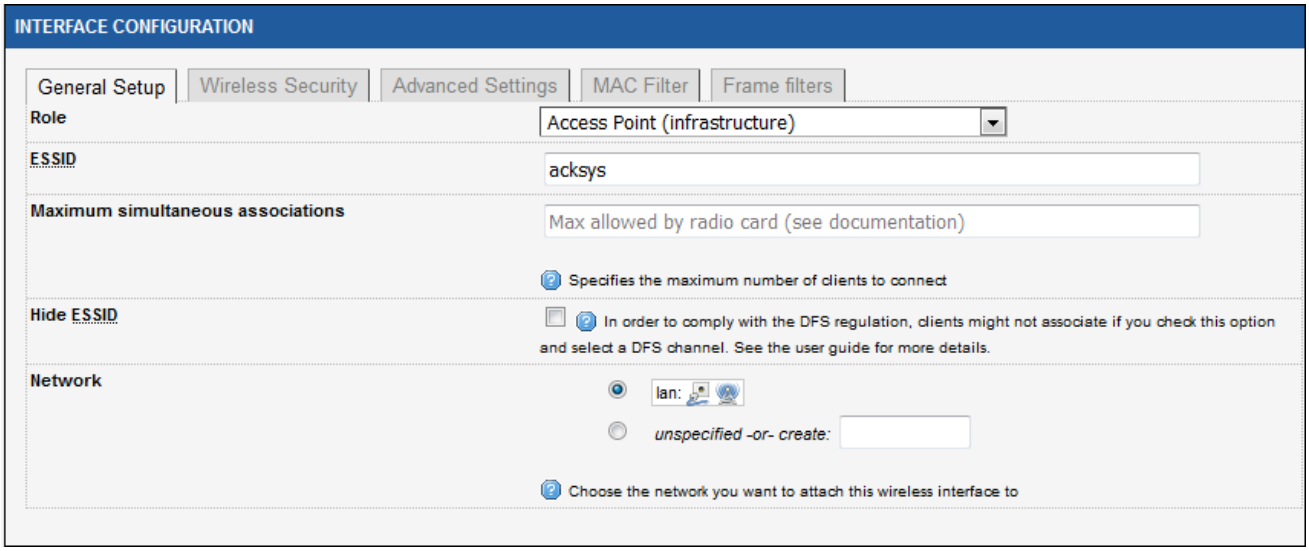
Loops pitfall in products with more than one radio

In products equipped with more than one radio card, you can create a wireless loop by activating one radio as Access Point with some SSID, and the other radio as Client with the same SSID.

Since the factory default is to have both radios bridged together internally and set to AP role, with the same SSID, you can fall in this trap by simply activating both radios and changing one of them from AP role to client role.

The product quickly enters a high-priority data transfer radio 1/wireless/ radio 2/internal bridge/radio 1. Then, the only way to recover is to reset the product to factory settings.

General Setup, Access Point Mode



Role: Supported roles are:

- Access point
- Isolating Access Point
- Client (connecting to an Access Point)
- RogueAP (WIDS)
- Mesh (802.11s)
- Point to multipoint station (ad-hoc)
- SRCC

See a detailed description of the modes in section *V.1.*15.*1 Wireless architectures* and *V.9.8 ACKSYS's Smart Redundant Carriage Coupling (SRCC)* for SRCC.

ESSID:

This is the wireless network name. See section *V.1.15.1 Wireless architectures* for more details.

Maximum simultaneous associations:

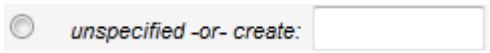
Specifies the maximum number of clients allowed to connect on the Access Point. This parameter is also used for load balancing: if the service is activated, you must define the maximum simultaneous association.

Hide ESSID:

This option allows you to not broadcast the SSID on the network. This means that your clients need to know the SSID beforehand, since scanning will not reveal the SSID of the AP. Please check section *Radars detection overview (DFS)* for more details about hidden SSID and DFS considerations.

Network:

This option allows selecting the network where the interface is added. In the default factory settings, all the physical interfaces (Ethernet and radio ports) are bridged in the **lan** network 

If you fill in the field to the right of 

and validate, this will create a new network. In this case, your radio interface will be automatically added to this new network and removed from the current one, so please be careful and only use this feature if you have a very clear idea of what you want to do.

Please see section *Network* for more details on network management.

Mesh ID (only in Mesh mode):

This option replaces the ESSID when the Mesh mode is selected. It has the same purpose.

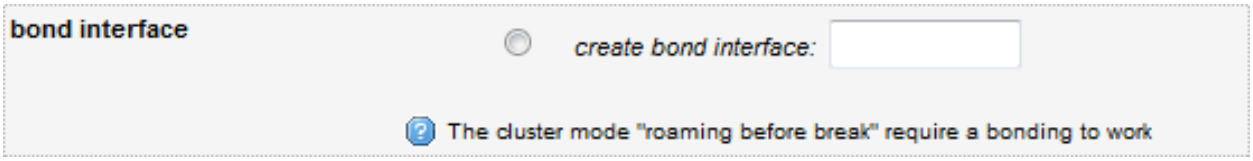
General Setup tab, Client mode

Multiple ESSIDs:

When this is checked, a multi-selection field, Wireless network nicknames, replaces the single ESSID field. You can select several SSIDs with their security parameters, and the client will associate to any AP advertising one of these combinations. In case several matching APs are in range, you can prioritize the SSIDs.

When using multiple ESSIDs, the roaming features are not available, and the security is defined together with the corresponding ESSID in a separate menu.
See section Wireless SSIDs

When **Connect before Break** is selected in the **Cluster mode** from the **Global Parameters**, the **Network** field is replaced by **bond interface.** You must give a name to this interface.

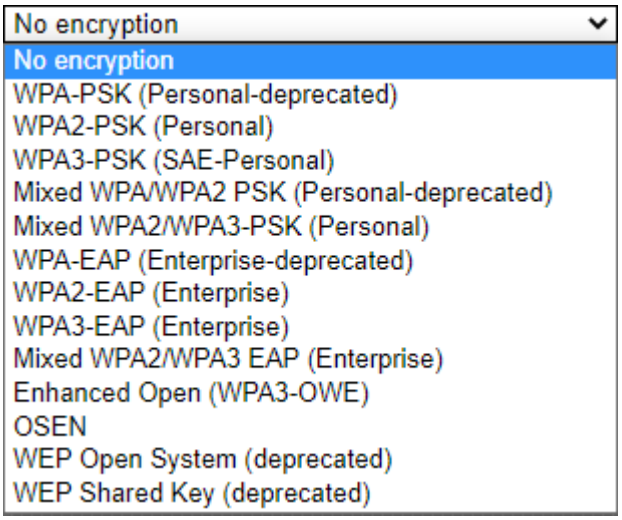


Wireless Security tab:

This menu allows you to choose the type of wireless security you want to apply on this SSID. The different security schemes are described in the *Wireless security* section.

Security:

Supported modes are:



NOTE 1: The Enterprise client automatically adapts to any kind of WPA/WPA2 Enterprise access point, except in one case: Using the EAP-TLS method with WPA2-Enterprise enforces the use of the CCMP protocol; it connects only to a WPA2-Enterprise access point offering CCMP.

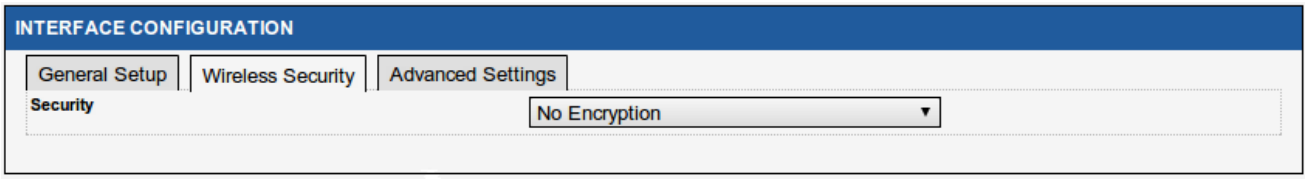
According to the choice you've made, some properties will appear or disappear.

Fast Transition Support (802.11r):

This box appears only for clients in any of the WPA/WPA2 modes. Check this box to allow use of the 802.11r protocol against APs that support it, resulting in a reduction of the time necessary to authenticate when roaming.

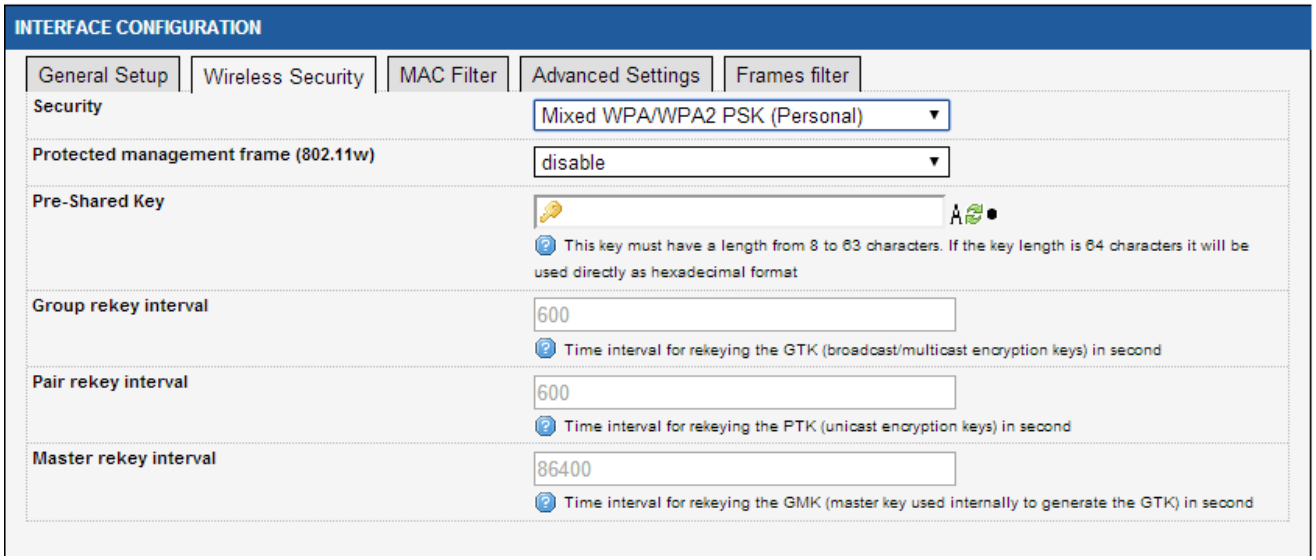
You need to properly configure the APs, their mobility domain and NAS ids to take advantage of this feature.

Wireless Security tab, No Encryption mode:



Nothing to configure here.

Wireless Security tab, WPA-PSK, WPA2-PSK, WPA3-PSK & PSK Mixed Modes:



Protected management frame (802.11w):

Enable/disable the 802.11w security feature. This option is hidden in WPA3-PSK and mixed WPA2/WPA3-PSK. For more information, please read section *Protected management frame (802.11w)*

Pre-Shared-Key:

The pre-shared key may be from 8 to 63 printable ASCII characters or 64 hexadecimal digits (256 bits). The green arrow icons on the right allow to display the key in clear text while you are typing it in.

Group rekey (AP mode only):

interval: Time interval, in seconds, for rekeying the GTK (broadcast/multicast encryption keys).

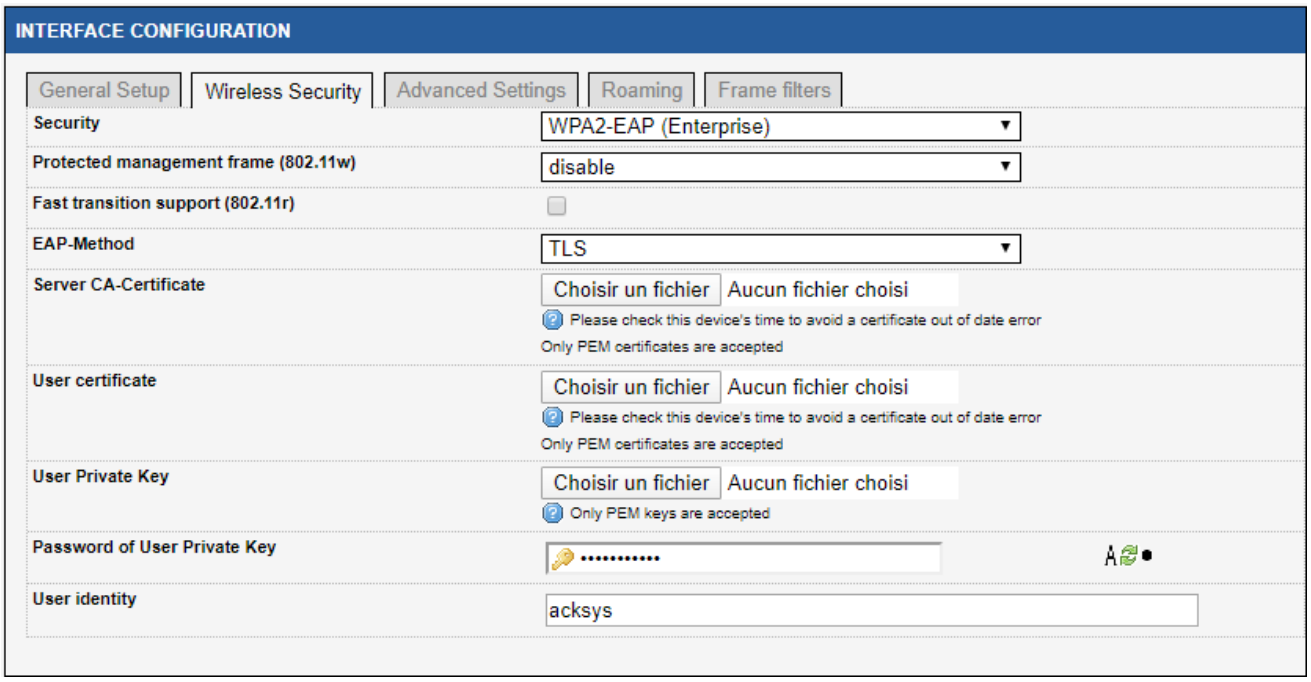
Pair rekey interval (AP mode only):

Time interval for rekeying the PTK (unicast encryption keys) in seconds.

Master rekey interval (AP mode only):

Time interval for rekeying the GMK (master key used internally to generate the GTK) in seconds.

Wireless Security tab, WPA-EAP, WPA2-EAP, WPA3-EAP & EAP Mixed in Client Mode:



Protected management frame (802.11w):

Enable/disable the 802.11w security feature. This option is hidden in WPA3-EAP and mixed WPA2/WPA3-EAP. For more information please read section *Protected management frame (802.11w)*

Fast Transition Support (802.11r):

In any of the WPA/WPA2 modes, check this box to allow use of the 802.11r protocol against APs that support it, resulting in a reduction of the time necessary to authenticate when roaming. You need to properly configure the APs, their mobility domain and NAS ids to take advantage of this feature.

For more information, please refer to section *Fast Transition Support (802.11r)*

Server CA-Certificate:

Selects the location of the CA-Certificate file to be uploaded. Certificates and keys must be provided in PEM format. *This format is defined by the OpenSSL project. It's a text file identifiable by its first line beginning with "-----BEGIN" and the binary data encoded using the base64 method.*

EAP-Method:

This field contains the EAP-Method to be used.
Available methods are: TLS, PEAP, LEAP.

NOTE: The Enterprise client automatically adapts to any kind of WPA/WPA2 Enterprise access point, except in one case: Using the EAP-TLS method with WPA2-Enterprise enforces the use of the CCMP protocol; it connects only to a WPA2-Enterprise access point offering CCMP.

EAP-Method TLS:

User certificate:

Selects the location of the user certificate file to be uploaded. Must be provided in PEM format.

User Private Key:

Selects the location of the Private Key file to be uploaded. Only PEM private keys are allowed.

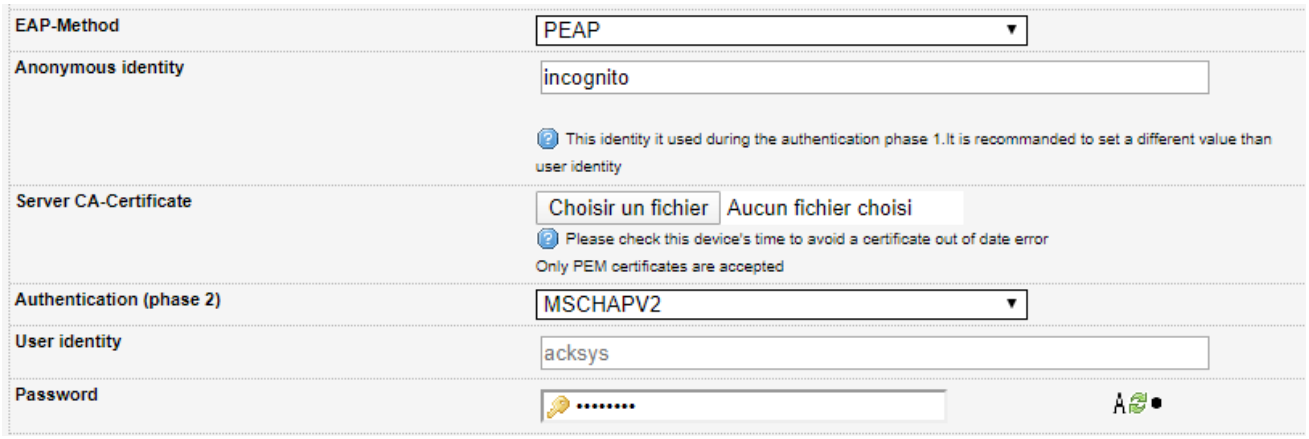
Password of User Private Key:

Password associated to the chosen Private Key.

User identity:

This field gives the login to use during EAP-TLS authentication. In this authentication method, this field is rarely used by the RADIUS server. The default value is *acksys*

EAP-Method PEAP:



Anonymous identity:

This value allows to configure the identity that will be sent in phase 1 of the protocol. It's not used by the RADIUS server, but it's a necessary element for the establishment of the TLS tunnel. As this field is clear on the network, we recommended, for security reasons, to set a value different from the login used for authentication.
If this field is left empty, the identity used by the authentication method (User identity) will be used.

Authentication (phase 2):

This field contains the Authentication method. To date, only MSCHAPV2 is available

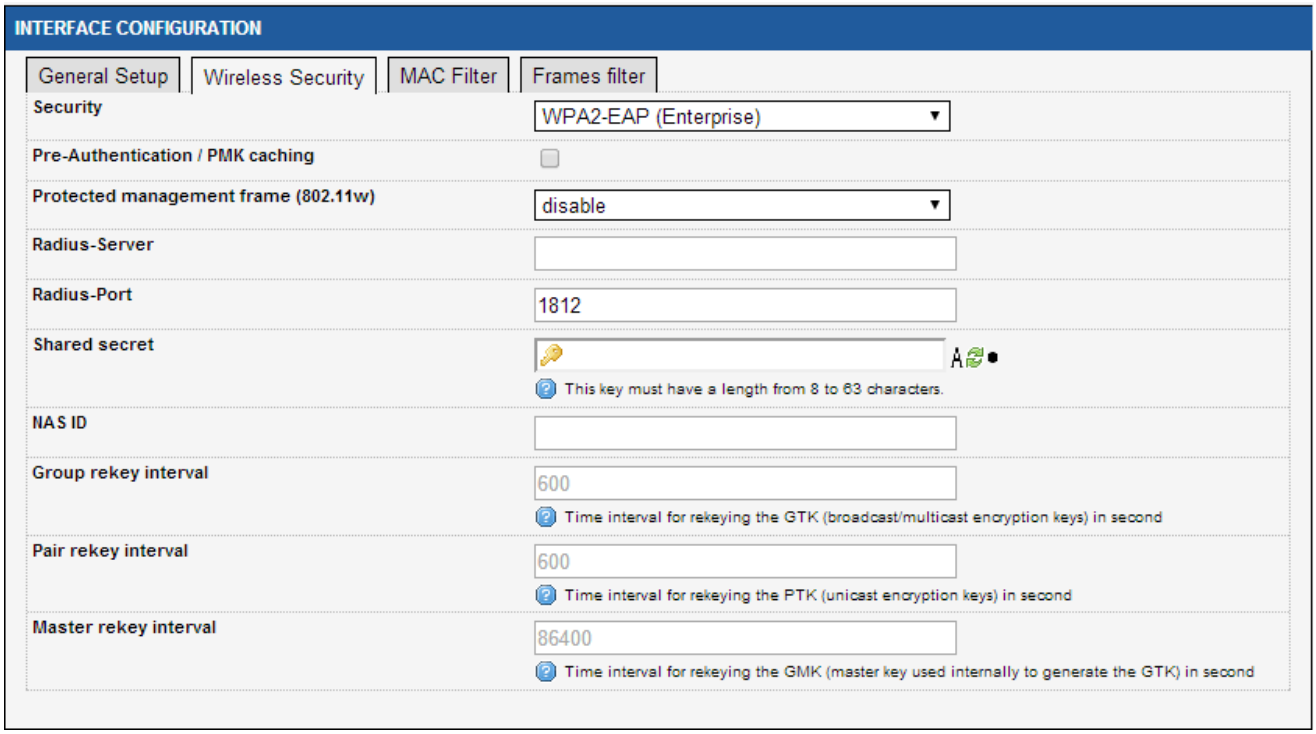
User identity:

Identity used for the authentication.

Password:

Password associated to the User identity

Wireless Security tab, WPA-EAP, WPA2-EAP, WPA3-EAP & EAP Mixed in AP Mode:



Pre-Authentication / PMK caching:

In any WPA/WPA2-EAP mode, check this box to allow use of pre-authentication/PMK caching. For more information, refer to *Pre-authentication / PMK caching*

Protected management frame (802.11w):

Enable/disable the 802.11w security feature. This option is hidden in WPA3-EAP and mixed WPA2/WPA3-EAP. For more information please read section *Protected management frame (802.11w)*

Radius-Server: IP address or URI of the radius server.

Radius-Port: Radius server UDP port.

Shared secret: Password shared between the access point and the radius server.

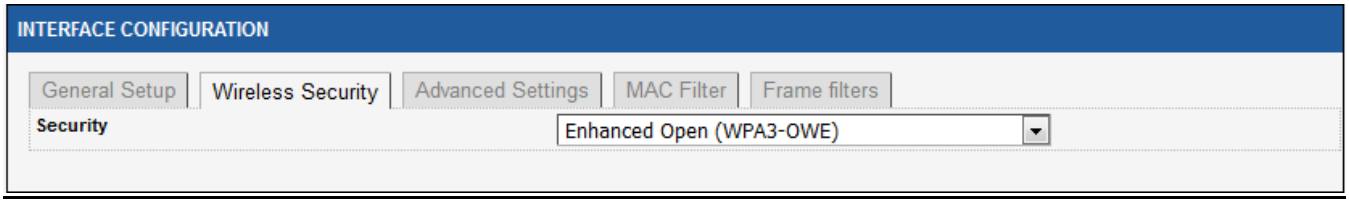
NAS ID: Network Access Server ID. This value may be used by the radius server instead of the IP address.

Group rekey interval: Time interval for rekeying the GTK (broadcast/multicast encryption keys) in seconds.

Pair rekey interval: Time interval for rekeying the PTK (unicast encryption keys) in seconds.

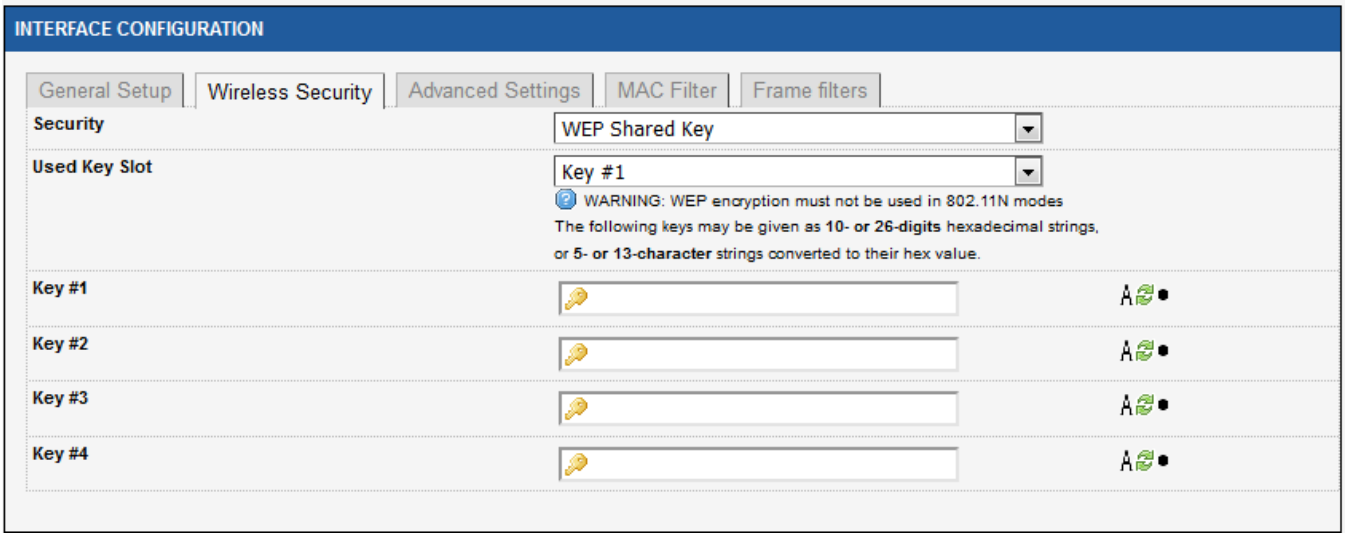
Master rekey interval: Time interval for rekeying the GMK (master key used internally to generate the GTK) in seconds.

Wireless Security tab, Enhanced Open (WPA3-OWE):



Nothing to configure here.

Wireless Security tab, WEP Open System & WEP Shared Key:



Use Key Slot:

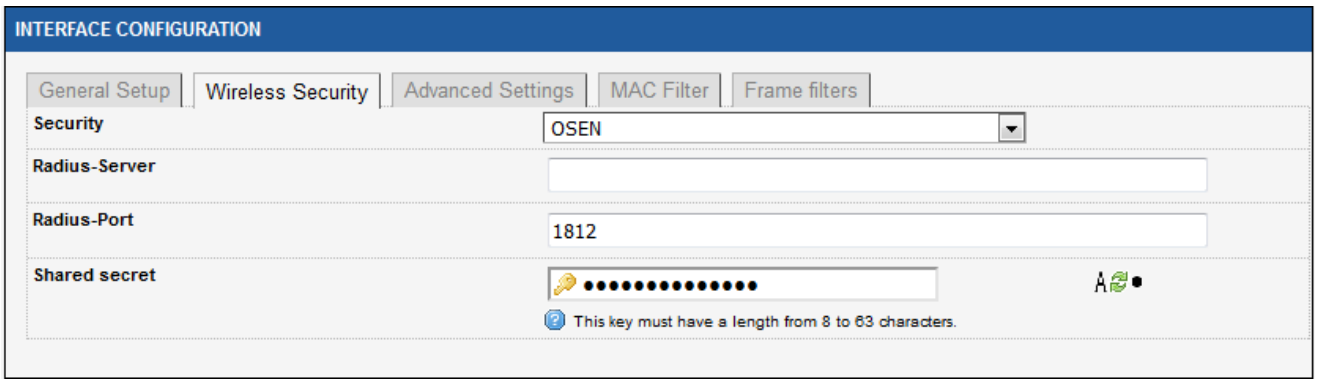
This field selects the currently used WEP key.

Key #1 to #4:

Contain the WEP key. Keys are defined by entering a string in HEX (hexadecimal - using characters 0-9, A-F), or ASCII (alphanumeric characters) format.

ASCII format is provided so that you can enter a string that is easier to remember. The ASCII string is converted into HEX for use over the network. Four keys can be defined so that you can change keys easily. A default key is selected for use on the network.

Wireless Security tab, OSEN:



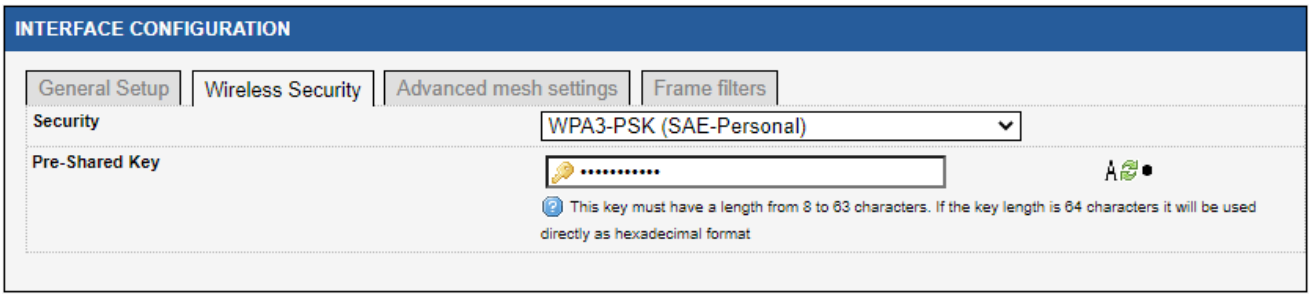
Osen security mode is reserved for Hotspot 2.0 r2 mode

Radius-Server: IP address or URI of the radius server.

Radius-Port: Radius server UDP port.

Shared secret: Password shared between the access point and the radius server.

Wireless Security tab, SAE Mode (in mesh mode):



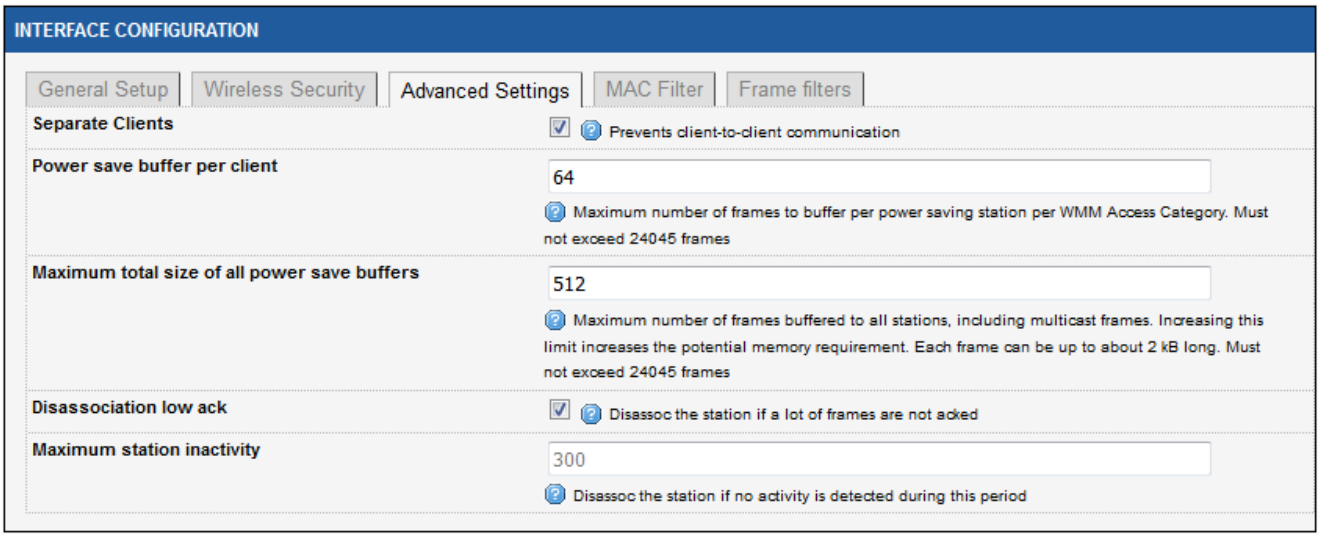
Security:

Choose between no encryption and WPA3-PSK.

Pre-Shared key:

Enter here the MESH network shared key.

Advanced settings tab in Access point mode



Separate Clients:

This option is only available when the **Isolating Access Point** role is selected. When **Separate Clients** is checked, wireless clients won't be able to communicate between them (this is not possible in **Access point** mode). See section Infrastructure Mode for more details.

Power Save buffer per client:

Define the maximum number of frames that can be queued for each client

Maximum total size of all power save buffers:

Maximum number of frames that can be buffered for all the stations

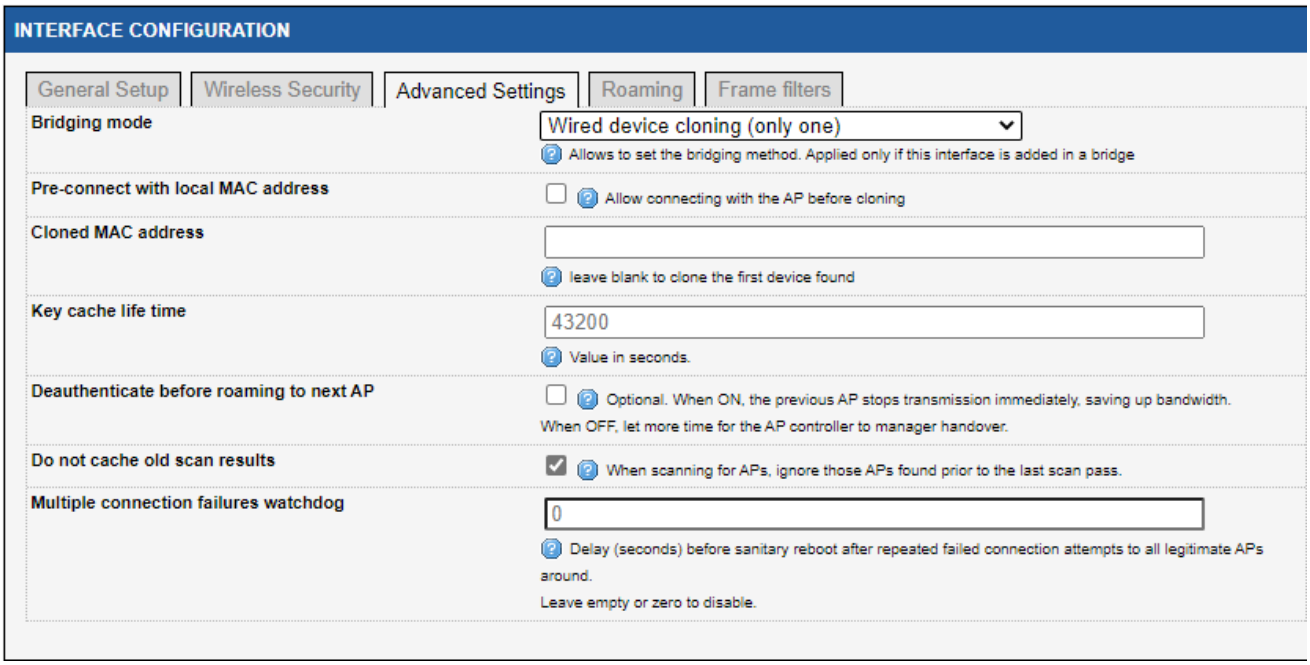
Disassociation low ack:

With this option set, when more than 50 packets sent by the AP are not acknowledged by the client, the client is disconnected.

Maximum station inactivity:

Idle time in seconds after which the client will be disconnected. Default is 300 seconds (5 minutes)

Advanced settings tab in Client mode



Bridging mode:

This option allows selecting the bridging method (Please see section *Wired to wireless bridging in infrastructure mode* for more details) that will be used if this interface is added to a bridge (please see section *Network* for more details).

The available methods are:

- ARPNAT (default value)
- 4 addresses format (WDS)
- Wired device cloning
- PROFINET device cloning.

When **Connect before Break** is selected in the **Cluster mode** from the **Global Parameters,** you must select 4 addresses format (WDS).

Please read the section *Cloning* for more details on cloning mode.

Pre-connect with local MAC address:

This option exists only with Wired device cloning or Profinet device cloning. If checked, this allows the product association to an Access Point with the local Wireless adapter MAC address when no Ethernet or Profinet equipment is detected. In this case, if cloning to the Ethernet or Profinet equipment occurs some time later, the ARP table of the remote devices will no longer be valid. So, these remote devices won't be able to access to the product until the ARP table is refreshed.

Cloned MAC addr:

This field exists only with Wired device cloning or Profinet device cloning. Fill this field, if you want to force the MAC address used for the cloning. Leave blank to clone the first device found.

Key cache life time:

This field exists only with WPA/WPA2 EAP. If your AP supports the Opportunistic key caching (OKC) or the pre-authentication, this option allows configuring the life time for each PMK. The default value is 43200 seconds (12 hours).

Deauthenticate before roaming to next AP:

When this option is selected, the client can de-authenticate the current access point before the client roam to the next access point, which frees up the frequency more quickly. This option can be left unchecked to allow more time for an access point controller to handle the transfer, or to ensure compatibility with previous versions of WaveOS.

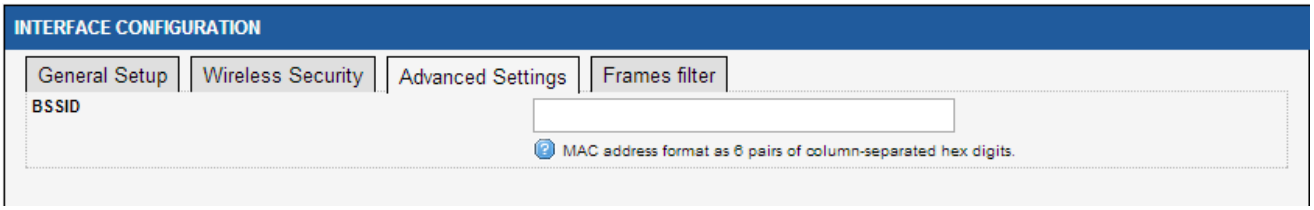
Do not cache old scan results:

When checked, the scan results of the previous scan cycle is not merged with the results of the current scan cycle. This option is checked by default.

Multiple connection failures watchdog:

This option allows triggering a reboot of the equipment in the event of systematic failure of connection to the access points, when there are candidate APs within range. The value is expressed in seconds.

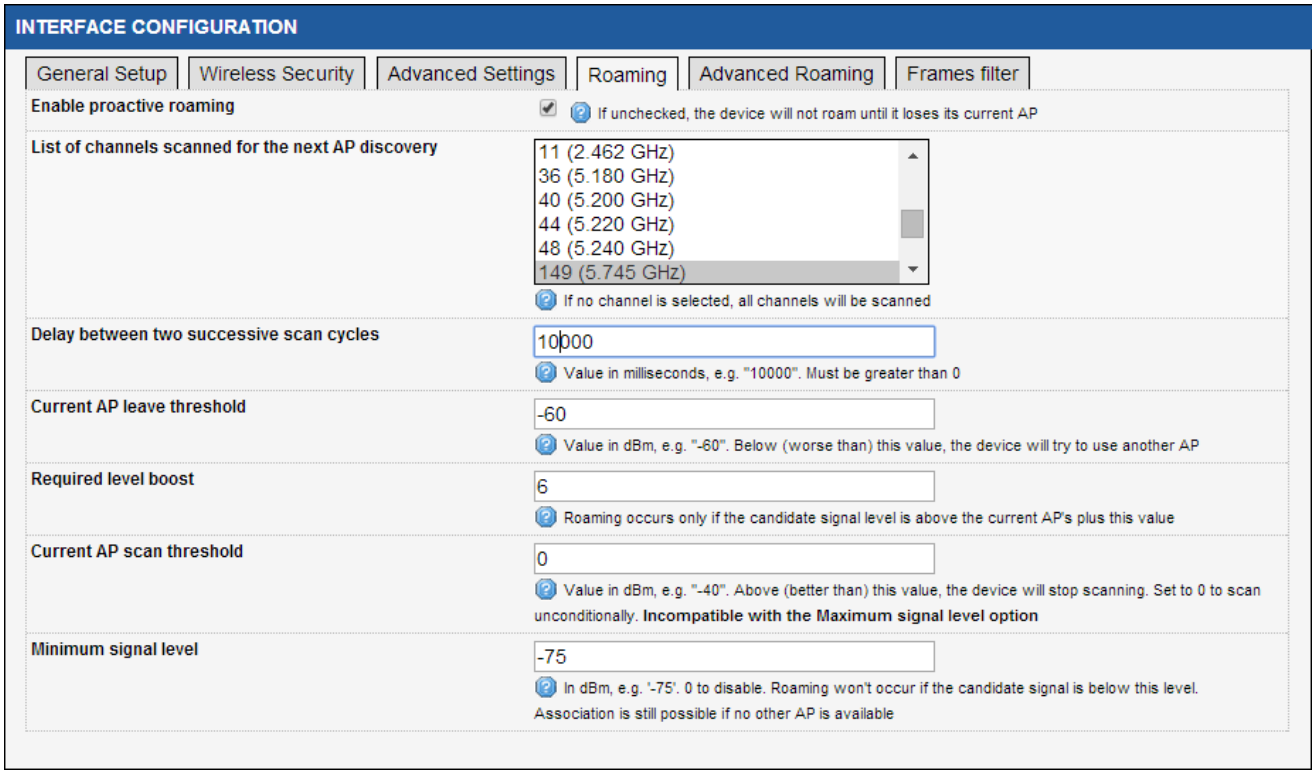
Advanced settings tab in Point to multipoint station (ad-hoc)



BSSID:

This option allows setting the BSSID for this interface, in MAC address format, as six pair of column separated hex digit (ex: 12:34:56:78:9A:BC).

Roaming tab (only in Client mode):



*If the bridging mode is set to **4 addresses format (WDS)**, Proactive Roaming must be enabled ONLY when the Connect before Break mode is selected.*

Enable proactive roaming:

Check this checkbox to enable the fast-roaming features.

List of channels scanned for the next AP discovery:

Choose here the channels that will be scanned for AP discovery. This selection supersedes the list of channels from the Device configuration box above.

Using more than one channel allows a denser repartition of the Access Points, as they will not interfere with each other. But, unless you are using a dual radio product, this will reduce the data throughput for the client, because the scanning process must periodically leave the AP channel (and thus stop transmitting) in order to scan other channels.

With single radio products, the best throughput will be achieved if you use only one channel. If possible, do not select more than three or four channels.

Delay between two successive scan cycles:

This value represents the time (in milliseconds) between scan cycles.

Current AP leave threshold:

If the RSSI of the current AP falls below this value (in dBm), the client will try leaving the current AP and roaming to another AP.

Note: in previous versions this parameter was named *Current AP minimum signal level*.

Required level boost:

Minimum improvement in signal level that the new (target) AP must exhibit over the old (current) one, to allow roaming to actually occur.

Current AP scan threshold:

When the current AP signal is above (better than) this level, the client ceases to scan for better APs.

Minimum signal level:

APs whose perceived signal is below this level will not be candidates for roaming, i.e., they will never be preferred to the currently associated AP. But it will still be used if there is no current nor better AP.

Advanced Roaming tab (only Client with proactive roaming enabled):

INTERFACE CONFIGURATION

General Setup | Wireless Security | Advanced Settings | Roaming | Advanced Roaming | Frame filters

Excessive signal detection threshold

0

In dBm, e.g. '-30'. Leave empty or 0 to disable. Roaming will occur when the current AP signal crosses and exceeds this value, and there is an acceptable candidate around.
This allows elimination of approaching AP antennas that will be soon overtaken

Maximum signal level

0

In dBm, e.g. '-30'. Leave empty or 0 to disable. Must be greater or equal to the 'Excessive signal detection threshold'. Roaming will occur whenever the current AP signal is above this value, and there is an acceptable candidate around. When selecting the next AP, the ones above this value are considered last

Maximum time above maximum level

0

In number of scan cycles. Leave empty or 0 to disable. Maximum time allowed with a signal level superior to Maximum without a disconnection when no other APs are available for roaming. Furthermore, when this option is activated, the client will not connect to any AP superior to Maximum.

Maximum time under minimum level

0

In number of scan cycles. Leave empty or 0 to disable. Maximum time allowed with a signal level inferior to Minimum without a disconnection when no other APs are available for roaming. Furthermore, when this option is activated, the client will not connect to any AP inferior to Minimum.

Minimum roaming interval

0

In ms. Leave empty or 0 to disable. Roaming won't occur before this delay has elapsed since the last association

No-return delay

0

In ms. Leave empty or 0 to disable, max 180000 (3 mn). Roaming won't occur to an AP that was left recently (before this delay gos elapsed). The delay is cleared for APs that are not around anymore

Threshold hysteresis

2

Value in dBm, e.g. "2". Hysteresis used for all thresholds. This value will be added and substracted to each threshold to set the corresponding threshold hysteresis interval

RSSI smoothing factor

Last beacon weight: 19%

The RSSI of the current AP is computed over the last few beacons received. Select the importance of the last beacon relative to older ones. This value commands a decaying factor. Default: 19%

Beacon timeout

7

Value in beacon interval units

Probe on beacon timeout

☑ When beacon time out occurs, probe the current AP for the last time in the hope that deauthentication won't be needed if the AP answers.

Maximum time off-channel

125

In ms. Maximum delay offchannel (during which data must be buffered by the associated AP). Several channels will be scanned without returning to the base channel, until this delay is exhausted. An upper limit of 10 times the beacon interval of the current AP is enforced

Offchannel adaptation delay

30

In ms. Adaptation delay after a channel switch, before sending the probe request or accepting beacons. Reducing below 30 ms speeds up scanning but decreases AP detection likelihood

Per channel probe response delay

30

In ms. Time to wait for an answer from the access points.
For DFS channels, where probes are forbidden, a floor value of 108 ms is enforced to ensure beacon detection

Roaming log info

- ☑ Display scan process while associated
- ☑ Display scan process while un-associated
- ☑ Display best bssid selection comparison
- ☑ Display roaming parameters
- ☑ Log filtered table of APs used to select the best AP (limited to line buffer available space)
- ☑ Include unfiltered APs in the above table (show all APs seen)
- ☑ Display reasons for filtering out APs at INFO level instead of DEBUG
- ☑ Display roaming state changes
- ☐ Display linear roaming (PLH) details

Select which roaming log info will show in product log.
To show the log you must to set the wireless client log level to roaming or more and general log level to notice or more in 'log settings' section.

Excessive signal detection threshold:

When the perceived signal level of the current AP passes above this limit, the client will try to roam to another AP, in the assumption that the current one will soon suddenly drop, due perhaps to the use of directional antennas.

Maximum signal level:

APs that are above this level have less priority when choosing the next AP to roam to.

Maximum time above maximum level:

Maximum time allowed, in number of scan cycles, with a signal level superior to Maximum without a disconnection when no other APs are available for roaming. Furthermore, when this option is activated, the client will not connect to any AP superior to Maximum.

Maximum time under minimum level:

Maximum time allowed, in number of scan cycles, with a signal level inferior to Minimum without a disconnection when no other APs are available for roaming. Furthermore, when this option is activated, the client will not connect to any AP inferior to Minimum.

Minimum roaming interval:

This parameter allows to impose a minimum delay, in milliseconds, between the last association to an AP and the next roaming.

No-return delay:

In areas with many walls, an AP that was left because it became too far away, may appear very good for a short time, due to radio waves bounces. To avoid roaming back to this kind of APs, which you know to be far, you can add a delay here.

Threshold hysteresis:

In order to avoid oscillating behaviors when the measured received signal is unstable (which is usually the case), the scan, leave and excessive thresholds are, in fact, interpreted as intervals of width ± hysteresis centered on the threshold.

RSSI smoothing factor:

Thresholds are compared to the average power of the beacons received from the current AP. The smoothing factor adjusts the pace at which old beacons are forgotten in the moving average calculation.

Beacon timeout:

The number of consecutive missing beacons from the current AP that will cause disassociation and search for a new AP. The corresponding duration depends on the beacon interval set in the AP.

Probe on beacon timeout:

When set, before disassociation due to missing beacons, the client will send a short data frame and will not disassociate if this frame is acked.

Maximum time off-channel:

When scanning another channel, the current AP is told to buffer incoming data until the client returns to the channel of the AP. Some APs have insufficient buffers and loose data in the meantime. This parameter limits the duration where the scanner is scanning on other channels, so it returns to the AP channel before the AP buffers are exhausted.
This duration must be set greater than the sum of the two next parameters. It will be further reduced automatically to the duration of the AP beacon interval. Its precision is about 10 ms.

If this parameter is large enough, the scanner can switch channels and send probes several times before returning to the current AP channel.

Off-channel adaptation delay:

Adaptation delay, in ms, after a channel switch, before sending the probe request or accepting beacons. Reducing below 30 ms speeds up scanning but decreases AP detection likelihood.

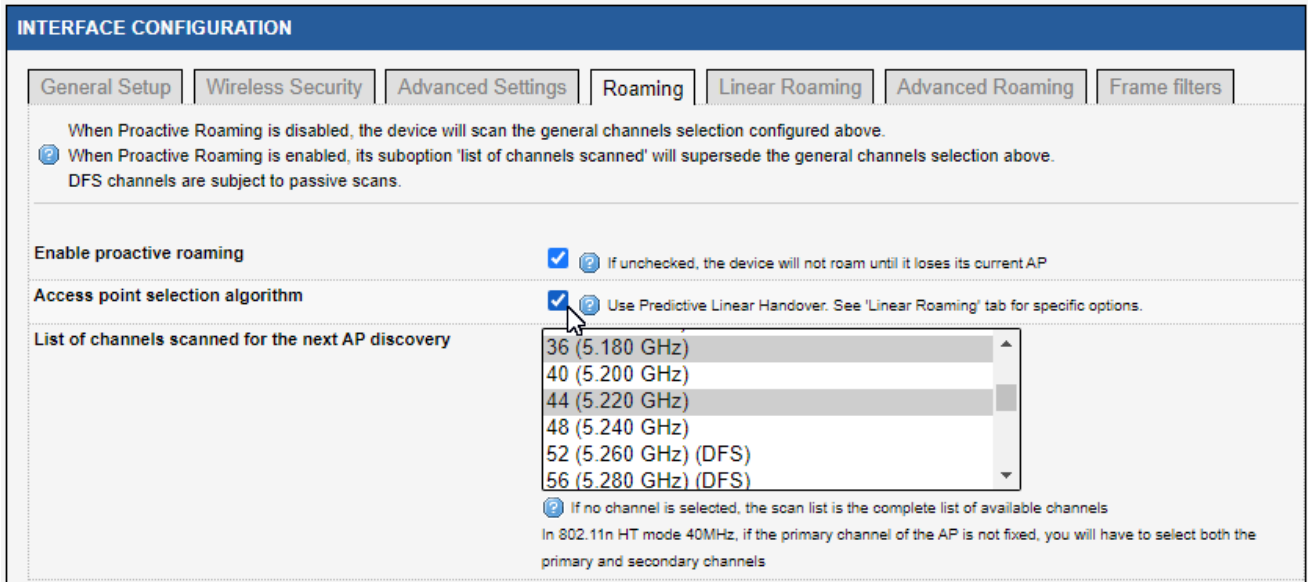
Per channel probe response delay:

The time the scanner will stay on the scanned channel after sending a probe request, waiting for probe responses or beacons. To tune this parameter, you must account for the traffic on the channel and the swiftness of the AP (or its controller) at answering probe requests.
For DFS channel, where probes are forbidden, a floor value of 108ms is enforced to ensure beacon detection.

Roaming log info:

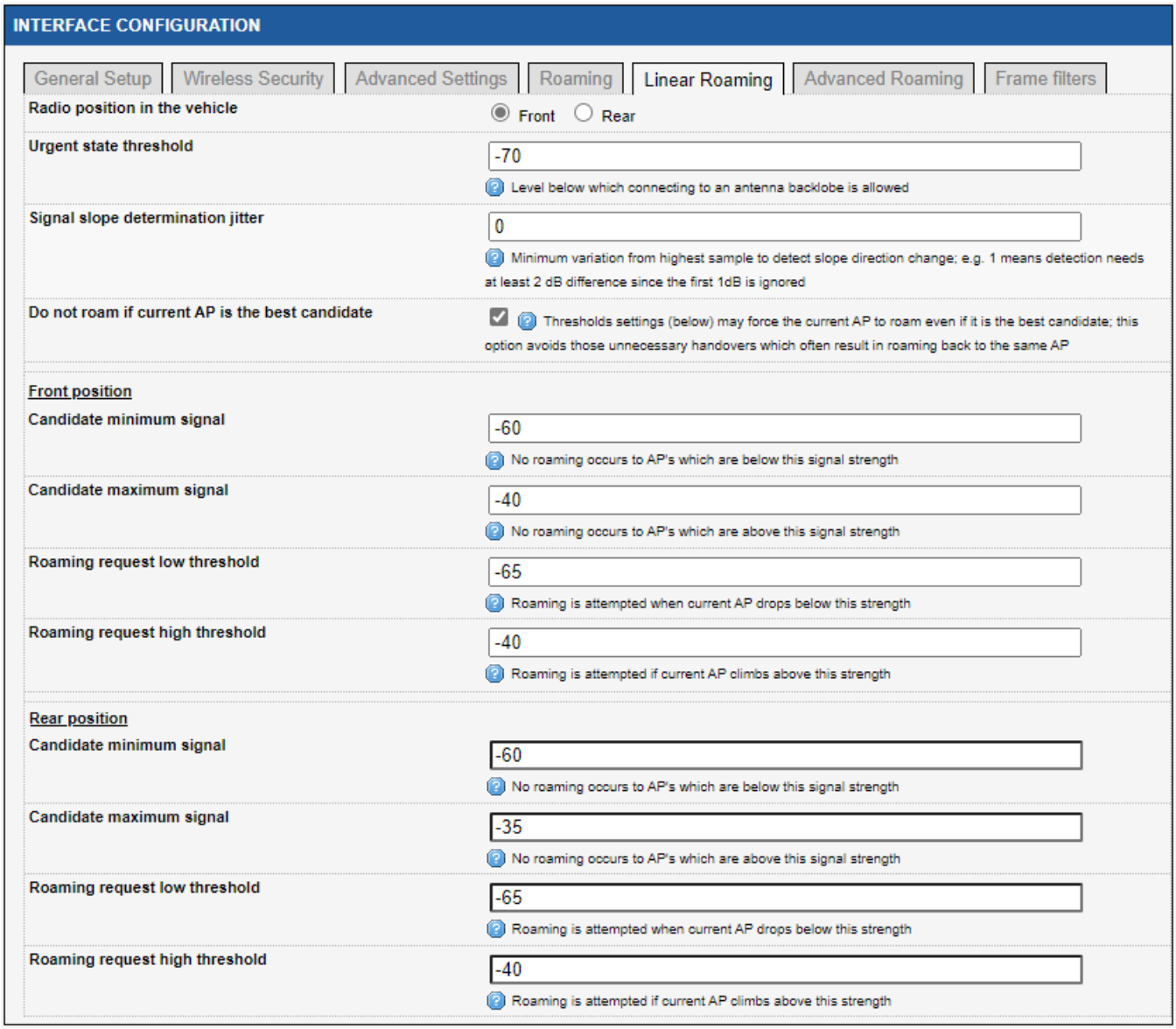
Select the roaming information that must be displayed. Please note that the Wireless log level must be set to **Roaming** or higher (see section 0 Log settings)

Roaming tab with CBB (only in Client mode):



Access point selection algorithm selection box appears only when Connect Before Break is selected. When selected, a new tab is visible: **Linear Roaming**

Linear Roaming (Only in Client mode with CBB):



Radio position in the vehicle:

Indicate here whether the product is mounted at the front of the vehicle or at the rear. This allows the software to adapt its analysis to variations in the signal level.

Urgent state threshold:

This is the maximum signal level below which connection to an antenna backlobe is allowed.

Signal Slope determination jitter:

Give here the minimum variation compared to the highest sample which will allow to detect the slope direction change. Attention, the first dB is ignored, which means that for the value 1, the detection requires at least 2 dB of difference.

Do not roam if current AP is the best candidate:

The configuration of the different thresholds can lead the algorithm to cause roaming when the current AP is the best candidate. This option allows to avoid this behavior and thus to limit the number of unnecessary roaming, which most of the time results in roaming back on the same AP

Candidate minimum signal (Front position & Rear position):

For roaming to an AP to be authorized, the signal strength of this AP must be equal to or greater than this value.

Candidate maximum signal (Front position & Rear position):

For roaming to an AP to be authorized, the signal strength of this AP must be equal to or less than this value

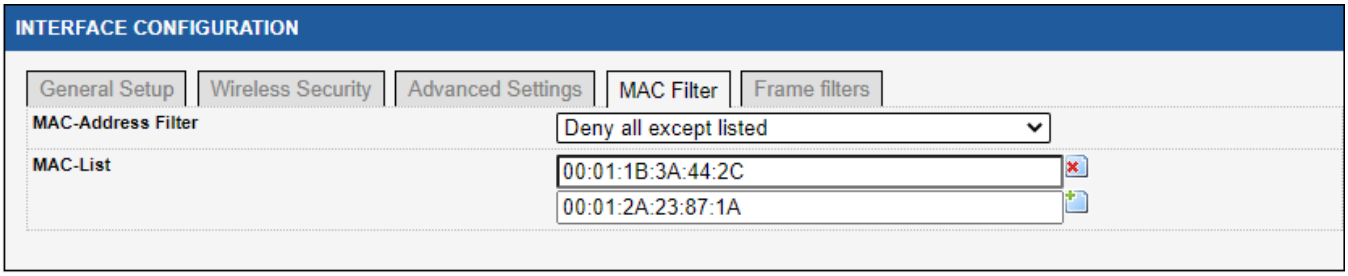
Roaming request low threshold (Front position & Rear position):

Roaming is authorized when the signal strength of the current AP drops below this value.

Roaming request high threshold (Front position & Rear position):

Roaming is authorized when the signal strength of the current AP goes above this value.

MAC filter tab (only in Access Point modes):



MAC-Address filter:

You can specify a list of client MAC addresses that will be either allowed or denied. Let the filter disabled if you do not require it. **WARNING**: this must not be used alone as an effective security feature, since MAC addresses are is easy to masquerade.

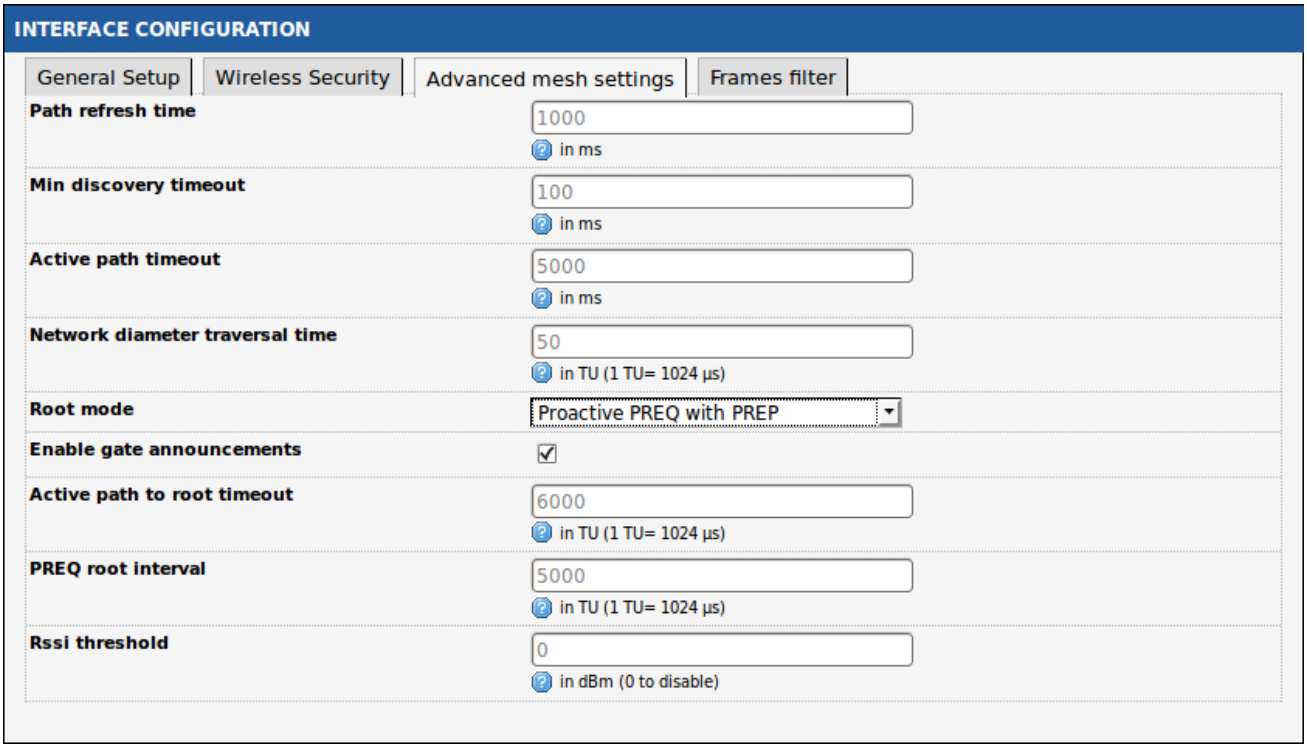
MAC-List:

Enter the client MAC address to deny or allow. Enter MAC addresses as hexadecimal strings, with a separating column every two digits.

Click the **add** icon on the right of the last field to add a new address.

Click the **remove** icon on the right of any field to remove it from the list.

Advanced mesh settings tab (only in 802.11s mode):



Path refresh time:

When data is sent through a previously discovered path which is due to expire soon (i.e., in less than the *path refresh time* parameter), an early discovery is started, so that the path will be already renewed when it should have expired. This removes data latency due to expired path renewal. *path refresh time* must be less than *active path timeout*.

Min discovery timeout:

When a path discovery request is sent, it will be resent if no response is received after min **discovery timeout**. This discovery timeout is doubled after each successive timeout for the same path. This value must be greater than twice the "network diameter traversal time", so that the timeout covers both a request and its response crossing the largest possible path in the network.

Active path timeout:

This is the delay during which a path is considered valid, i.e. it can be kept in cache tables and used before a renewal becomes mandatory. The target of a path discovery inserts this value in its response to the requester. The requester can use the path during this time at most, after which it must renew the discovery (in case the target has moved).

Network diameter traversal time:

This is an estimate of the time needed for an HWMP frame to propagate across the mesh.

Rssi threshold:

This is the threshold (in dBm) below which a plink will be closed if already established or not allowed to start the peering process if not. Enter 0 to disable this feature.

Root mode:

This indicates whether this station is a root node, and how it advertises this fact to other stations. A root node sends periodical broadcasts to inform all the other nodes of its existence. This can speed up routing decisions in some cases. Several stations can be set in root mode in the same mesh, but the broadcast messages overhead reduce useable bandwidth.

Three root modes are available. For details on how they work, see the IEEE 802.11-2012 standard, chapter 13.

- Proactive PREQ: the root station periodically sends out a broadcast HWMP PREQ frame that establishes a data path from any node to the root.
- Proactive PREQ with PREP: the root station periodically sends out a broadcast HWMP PREQ frame that establishes a data path from any node to the root, and requires the nodes to answer back with a HWMP PREP frame that establishes the reverse data path from the root to any node.
- Proactive RANN: the root station periodically sends out a broadcast HWMP RANN frame advertising its address (receiving stations then request a path to the root with a unicast PREQ).

The next parameters vary depending on the exact root mode.

Enable gate announcements (root mode only):

This flag should be set if this product has access to a network outside the mesh, which holds always true since bridging networks is the purpose of these products. The flag is sent to all other nodes to advertise the fact that MAC addresses outside the mesh might be reached through this root node.

Active path to root timeout (root mode only):

This is the same as **Active path timeout** but is used only in proactive PREQ sent by this root node.

PREQ root interval (PREQ root modes only):

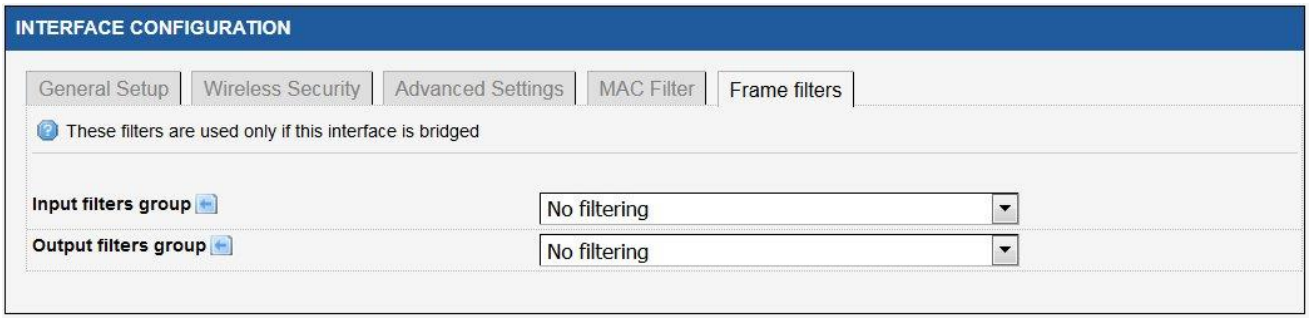
This value represents the time between proactive PREQ broadcasts.

RANN root interval (RANN root mode only):

This value represents the time between proactive RANN broadcasts.

Frames filter tab:

Wireless interfaces included in a bridge-type network interface can filter frames as they pass along.



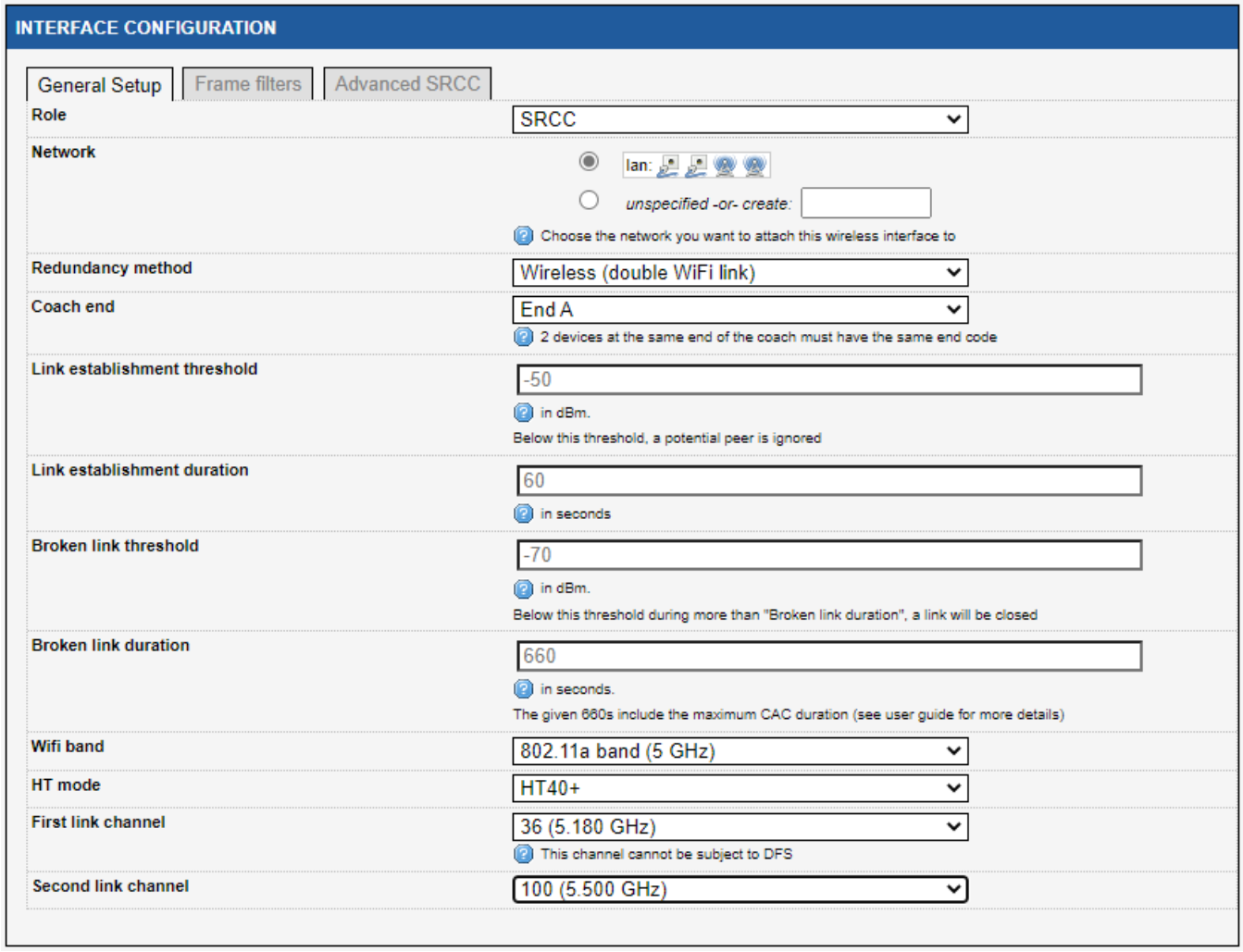
Input filter group/Output filter group:

Choose one of the filters prepared in routing/firewall/bridge filter section.
For more information about filters group, please see Bridge filter

SRCC configuration

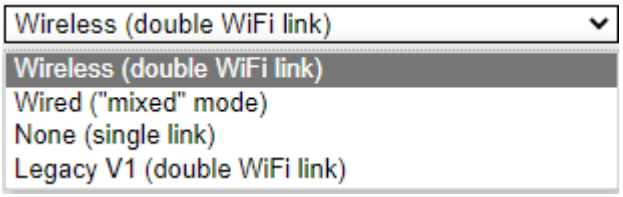
In order for SRCC to work correctly, all the parameters (except the *Coach end* type) in the two following sections must be identical on every product of a train.

General Setup:



Network: The network to which SRCC will add its wireless interface.

Redundancy method: Choose the appropriate mode from:



Coach end: All products on the same coach edge must have the same *Coach end* type, either *End A* or *End B* (whatever it is).

Link establishment threshold & Link establishment duration:

A potential partner is considered valid if its signal level stays over **Link establishment threshold** during more than the **Link establishment duration**.

Broken link threshold and Broken link duration:

If an established link's signal drops below **Broken link threshold** during more than **Broken link duration**, the link is considered broken, and SRCC start its wireless detection process again.

The broken link duration includes the DFS CAC time. This explains the 660s default value which is 600s (European CAC time for weather channels) and 60s (for the broken link duration itself). You can reduce this value according to your current DFS CAC time, see *III.5.6 Radars detection overview (DFS)* for usual values.

See *V.9.8 ACKSYS's Smart Redundant Carriage Coupling (SRCC)* for more information about the above last four parameters.

The parameters below allow the user to configure the final wireless link:

Wi-fi band:

The Wi-Fi frequency range for the final links. Choose 802.11a for the 5GHz band and 802.11g for the 2.4GHz band. *Please note that 802.11ac Wave 2 product, such as the Railbox/66A0, can't use 2.4GHz radio band for SRCC*

HT mode:

Depending on your application needs, you can dramatically increase the link bandwidth by selecting HT80 ieee80211.ac mode

First link channel:

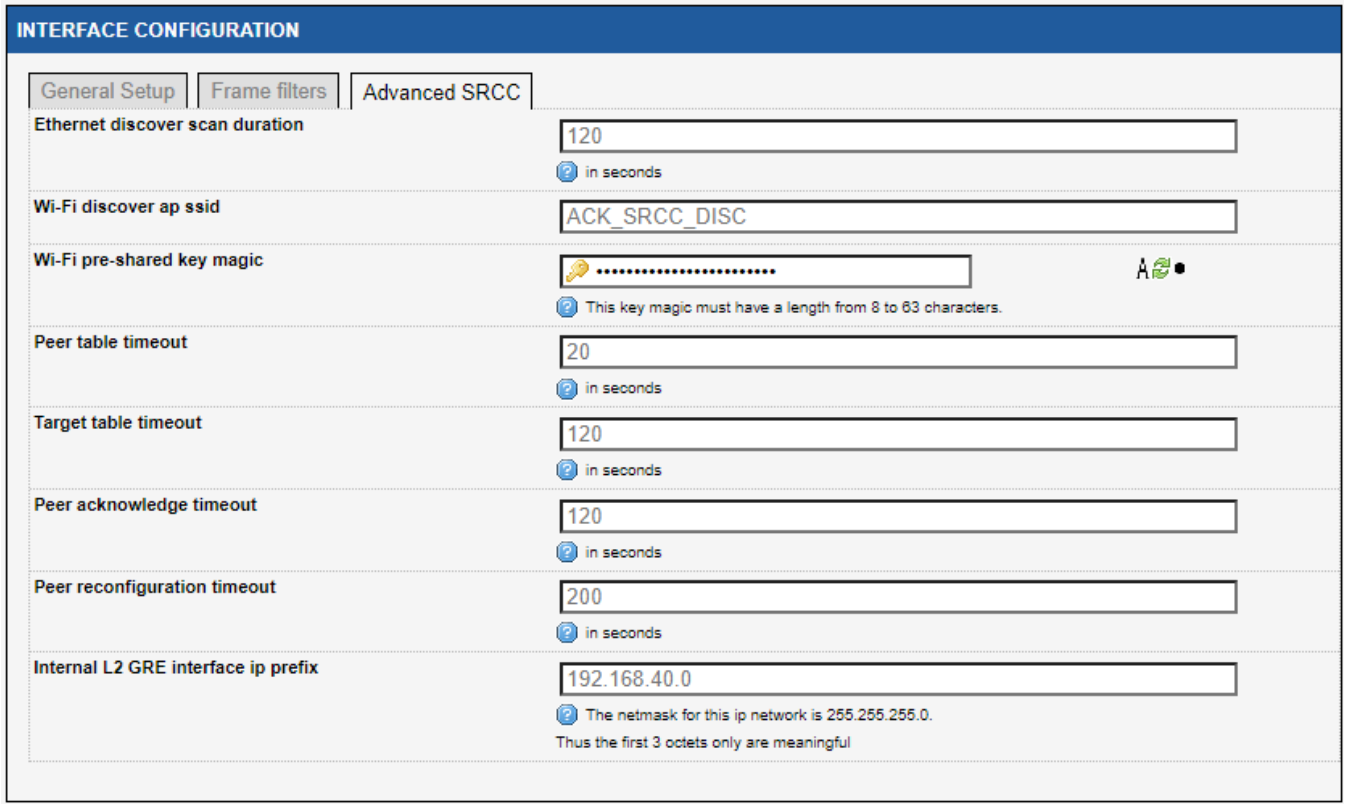
This is the wireless channel associated with the first SRCC final link. DFS channels have been removed from the list since SRCC uses it for its wireless discovery. This way, the discover process will not be stopped by a DFS event.

Second link channel:

This is the wireless channel associated with the second SRCC final link. Even if the products are configured in non-redundant topology, both channels are required.

Advanced SRCC parameters:

These settings are for experienced users only. Change them with great care.



Ethernet discover scan duration:

This is the global duration of the Ethernet topology discovery scan. As explained in the technical reference section, all the SRCC devices in the same coach must be powered up at the same time. If this is not the case, this parameter will help you adjust the time window where all SRCC devices can scan each other during the power-up sequence.

Wi-Fi discover ap ssid:

This is the SSID used by the wireless scan process to discover other potential partners.

Wi-Fi pre-shared key magic:

This key allows the user to define his own key, so that it can be different for each user.

Peer table timeout:

During the wireless discover process, if a potential partner's signal level is correct (over the Link establishment threshold) and suddenly disappears, this partner will be erased from the partner (peer) list after a Peer table timeout duration.

Target table timeout:

This is the same as peer table timeout, but expressed for the whole cell – the group of wireless peers on the other carriage. See SRCC technical reference for more details. If the cell is not valid for more than Target table timeout, it will be removed from the list.

Peer acknowledge timeout:

This is the duration the Master waits for the answer from all partners after sending its proposed cell architecture.

Peer reconfiguration timeout:

This is the duration the Master waits for all the partners to switch to their final roles.

Internal L2 GRE interface IP prefix:

SRCC's internal uses a GRE L2 tunnel. This GRE interface is configured with a C class IPV4 address. This parameter offers the user a way to customize the IP in case of conflict between the default IP address and its network.

This parameter represents the GRE interface IP prefix. Only the first three bytes are significant (the last one is ignored). If the final role is AP, the last digit will replace with 1 and with 2 in case of client final role.

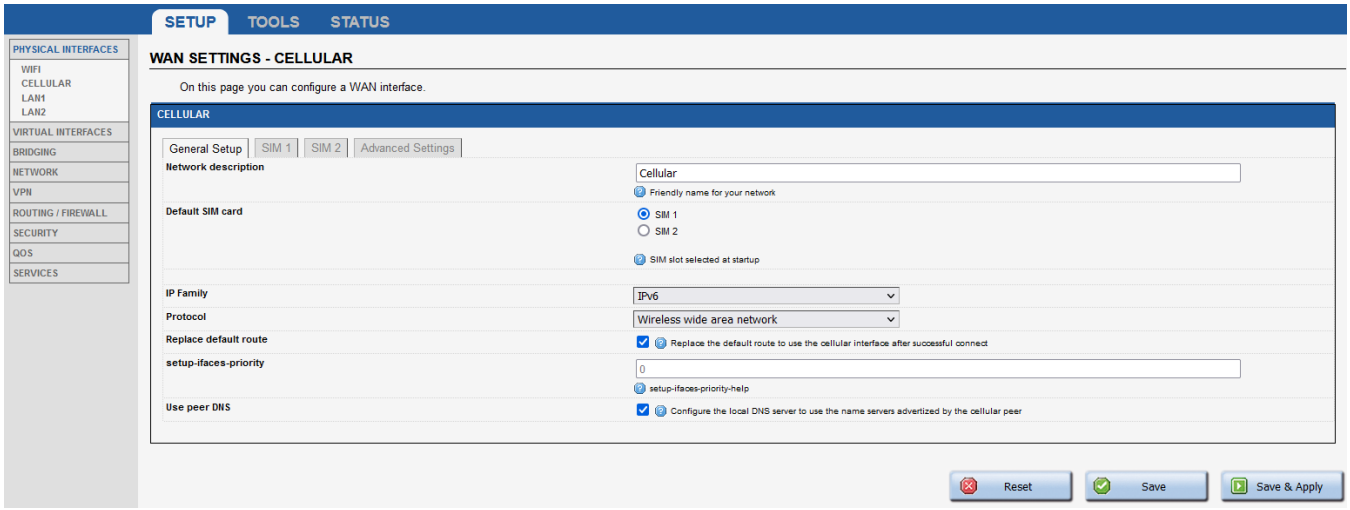
For example:

User prefix: A.B.C.D

Final role	IP
AP	**A.B.C.1**
Client	A.B.C.2

VI.1.1.2 Cellular (on some models)

General Setup:



Enable interface:

The cellular interface is disabled by factory settings. Check this box to use the interface.

Network description:

Friendly name for your network.

IP Family:

Allows to connect to an Ipv6 APN. Default is Ipv4

Default SIM card:

The SIM slot which is first selected at startup.

Protocol:

DHCP are supported on the both IPv4 and IPv6 interface. The operator must provide an IP address through a DHCP server.

Replace default route:

If checked, the default gateway pulled from the DHCP server will override the current one upon connection.

Default gateway metric:

The priority of the DHCP provided default gateway.

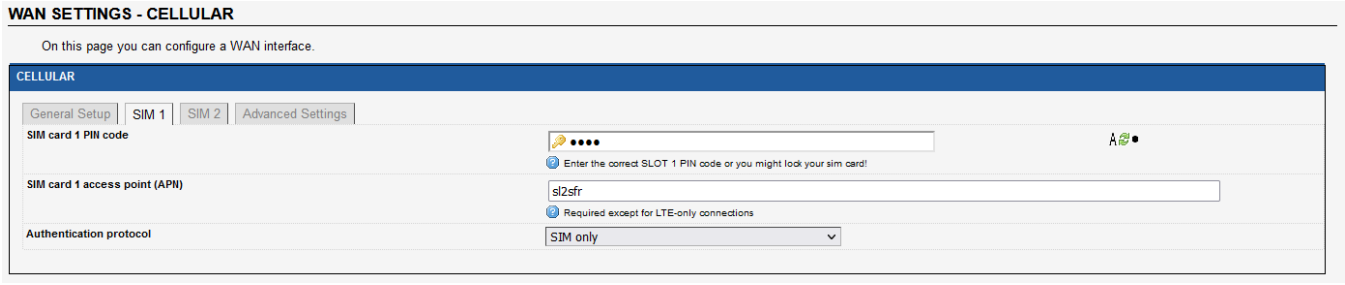
If two default routes are possible, when using "replace default route" only the Cellular route will survive; when using "default gateway metric" both routes will survive but only the one with lowest metric will be used.

Use peer DNS:

Normally, the DNS addresses pulled from the DHCP server are added to preconfigured DNS. Unchecking this will avoid using the operator provided DNS at the benefit of other sources (like LAN servers).

SIM 1 / SIM 2:

Each of the two tabs configures a SIM slot. Both can be filled in, regardless of the presence of the SIM in its slot.



SIM card PIN code:

PIN code. The double arrow icon displays the password in clear text.

SIM card 2 access point (APN):

Operator provided APN.

Authentication protocol:

Operator provided authentication information. **SIM only** will use the authentication token embedded in the SIM. Other schemes require explicit username/password, see below.

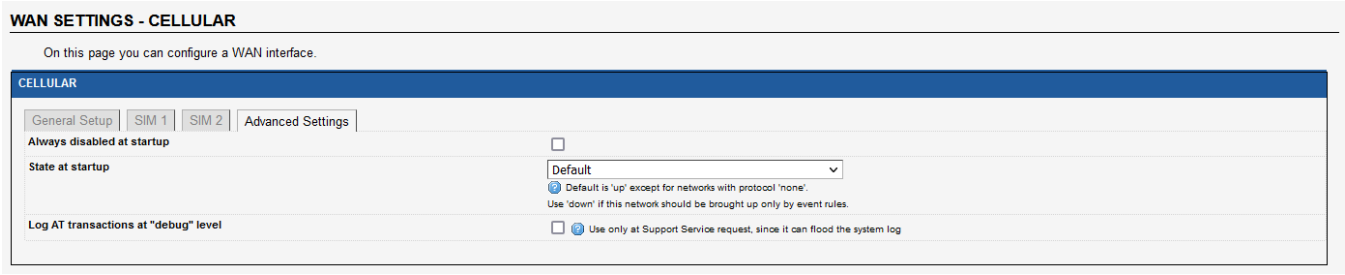
PAP/CHAP user name (only in PAP, CHAP or PAP/CHAP mode):

Username authenticating this Mobile Equipment.

Password (only in PAP, CHAP or PAP/CHAP mode):

Password associated to this username. The double arrow icon displays the password in clear text.

Cellular Advanced Settings:



State at startup:

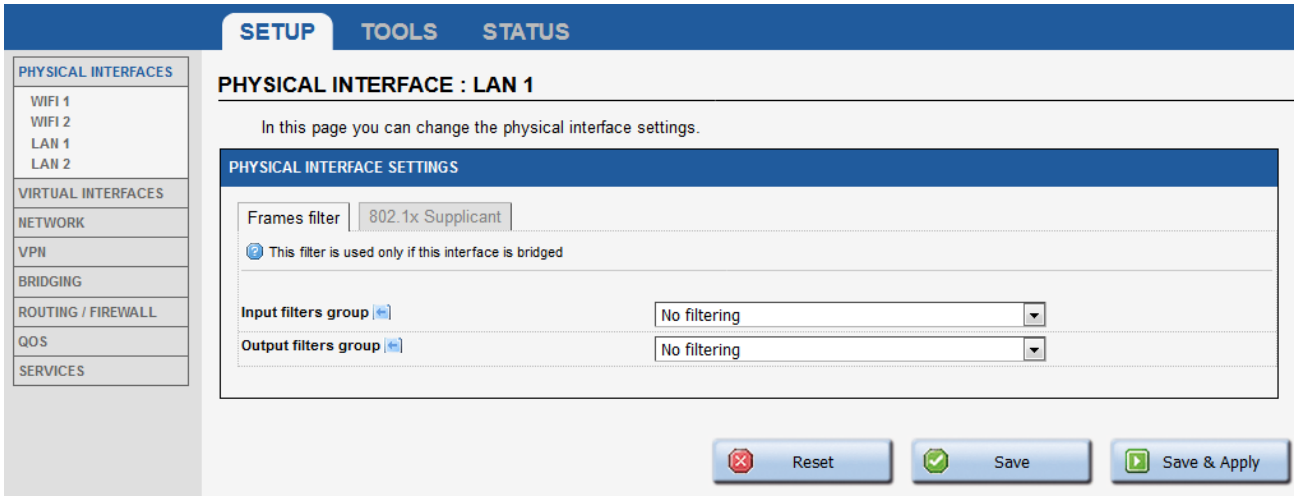
When **down** is selected, the cellular will not try to connect to the operator after boot, and will need a specific action from the *Events/Alarms service* to start.

Log AT transactions at “debug” level:

Log detailed configuration and status transactions between WaveOS and the cellular card. Use only at Support Service request.

VI.1.1.3 Physical Interface: LAN

Frames filter



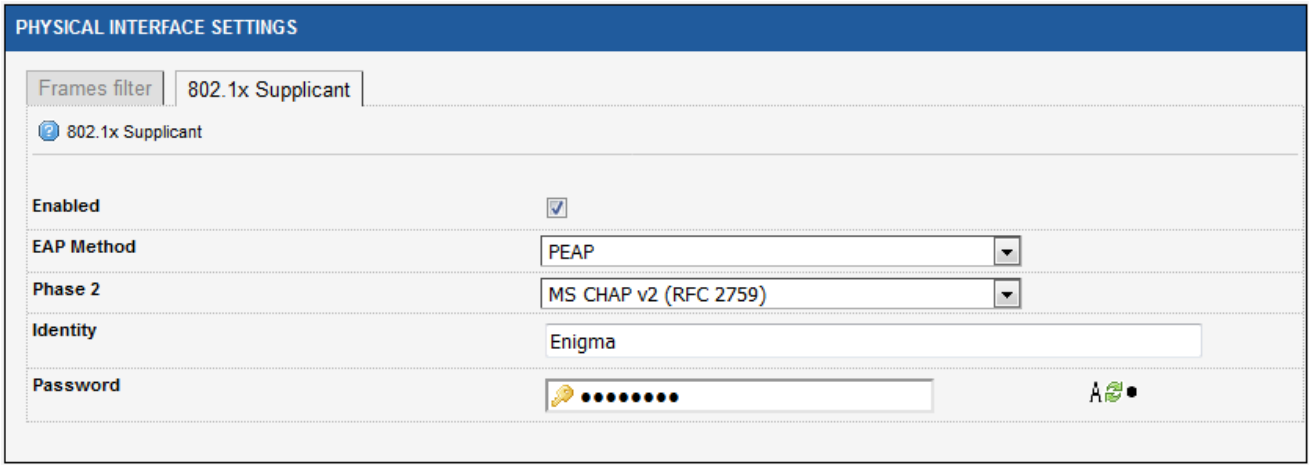
This page allows to apply input or output filters on the Ethernet interfaces of the product.

Input/Output filters group:

Choose one of the filters prepared in *routing/firewall/bridge filter* section. For more information about filters group, please see Bridge filter

802.1x Supplicant

In this tab you can activate 801.1x authentication on the Ethernet ports. To date, only the supplicant mode is supported.



EAP-Method:

Select the EAP-Method to be used, PEAP or TLS

Phase 2:

This field contains the Authentication method. Only MSCHAPV2 is available.

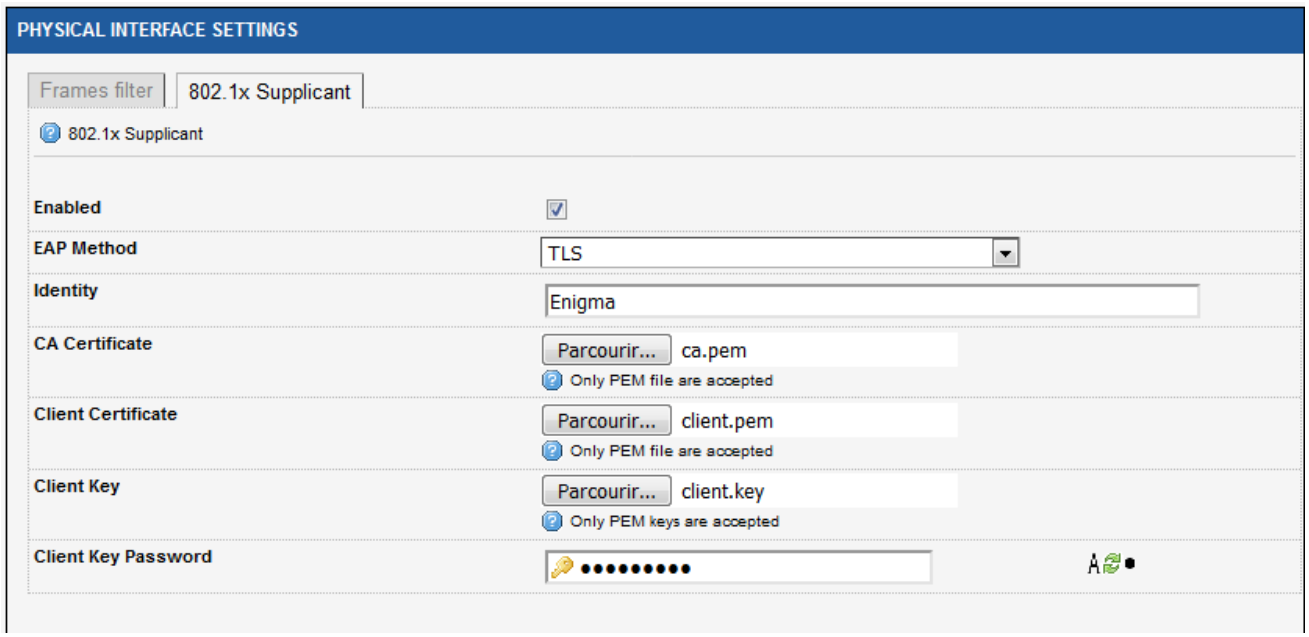
Identity:

Identity used for the authentication.

Password:

Password associated to the User identity

EAP-Method TLS:



Identity:

This field gives the login to use during EAP-TLS authentication.

CA-Certificate:

Selects the location of the CA-Certificate file to be uploaded. Certificates and keys must be provided in PEM format (see note below).

Client certificate:

Selects the location of the Client certificate file to be uploaded. Must be provided in PEM format.

Client Key:

Selects the location of the Key file to be uploaded. Only PEM private keys are allowed.

Client Key password:

Password associated to the Client Key.

NOTE: The PEM format is defined by the OpenSSL project. It's a text file identifiable by its first line beginning with "-----BEGIN" and the binary data encoded using the base64 method.

VI.1.2 Virtual interfaces

This section allows managing virtual interfaces.
A virtual interface is attached to a physical interface.
You can add a several virtual interfaces on one physical interface.

For 802.1q tagging, the virtual interface adds a 802.1q tag on egress traffic and removes the tag on ingress traffic.

VI.1.2.1 802.1q Tagging

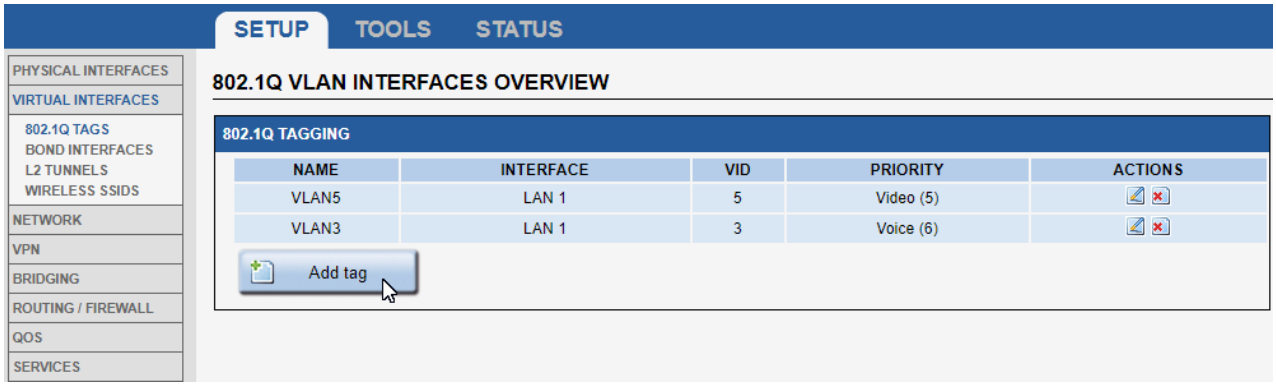
802.1q tags are used to split a common physical link into several virtual LANs (VLANs) in order to isolate the traffics pertaining to groups of devices. Each group is given a different VLAN ID which is used to mark the data frames exchanged within the group. Then, only devices configured to use the VLAN tag can communicate with other devices inside the group.

From a physical LAN interface in the product, you can define virtual interfaces that are used just like an independent physical LAN interface.

After creating the virtual interface, you must add it to a network to use it.

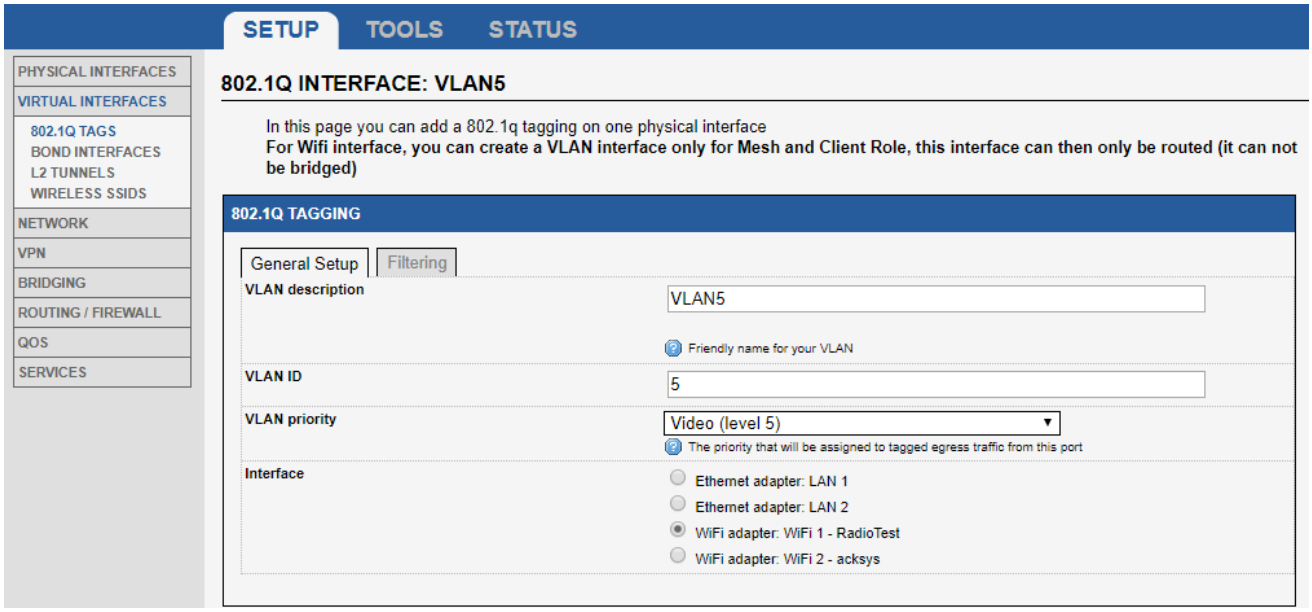
VLAN Interfaces overview:

This page displays the list of actual virtual interfaces created.



Click the **Remove** button to remove the virtual interface
Click the **Edit** button to open the virtual interface configuration page
Click the **Add tag** button to create a new virtual interface.

VLAN configuration:



VLAN description

Enter a friendly name for this interface (optional).

VLAN ID

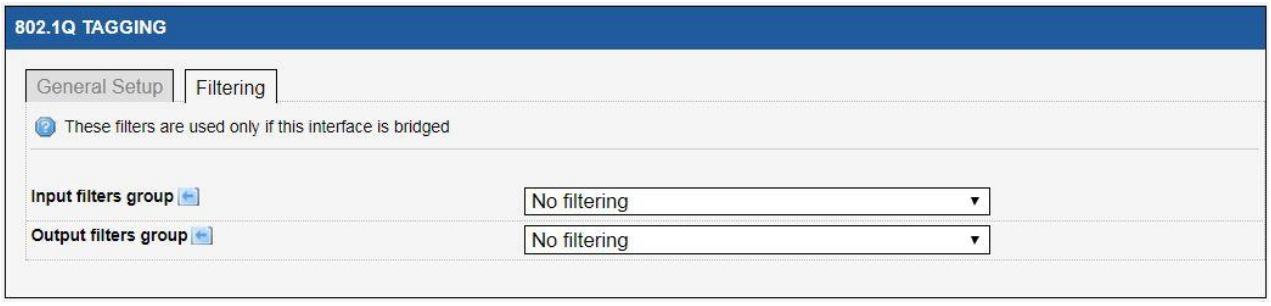
Enter the id for virtual interface. If you need to create several VLAN IDs on top of the same physical interface, you can use the space character to separate the IDs. Example: 5 10 120

VLAN priority

Select the priority that will be assigned to tagged egress traffic from this port.

Interface

Select the physical interface on which you create the virtual interface.
For Wi-Fi interface, you can create a VLAN interface only for Mesh and Client Role. This interface can then only be routed (it cannot be bridged with other interfaces).

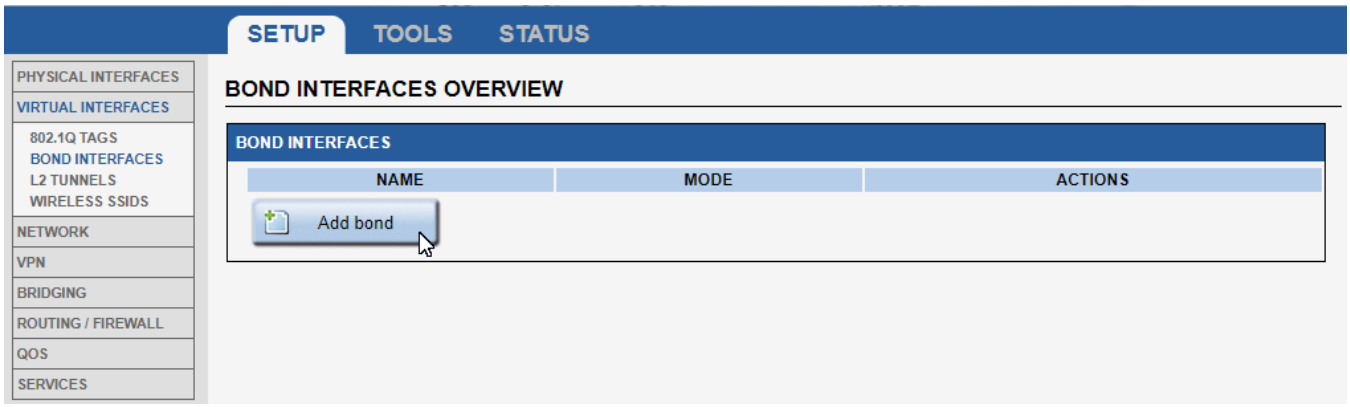


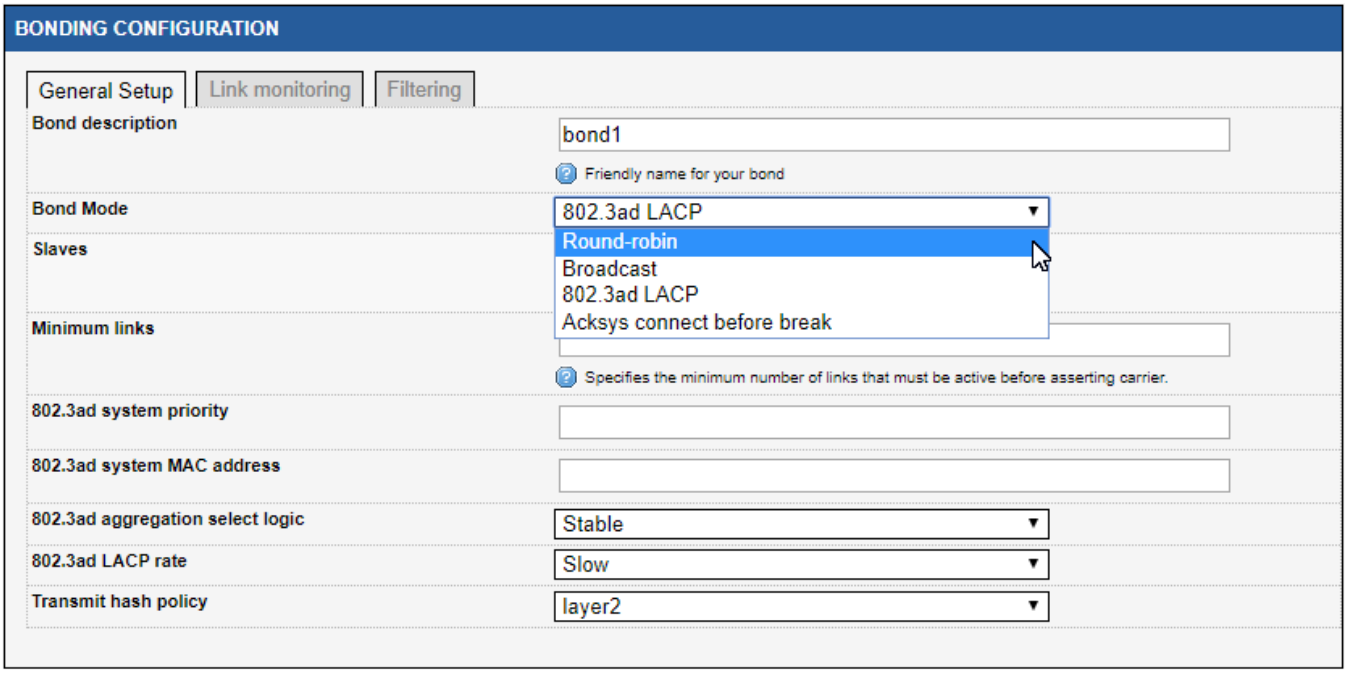
Input filter group/Output filter group:

Choose one of the filters prepared in routing/firewall/bridge filter section.
For more information about filters group, please see Bridge filter

VI.1.3.1 BOND INTERFACES

Bonding makes it possible to aggregate several network cards so as to increase bandwidth and have "high availability". A bonding interface is also created automatically when using Connect Before Break mode. Click **Add bond** to add a new bond interface.





Bond description:

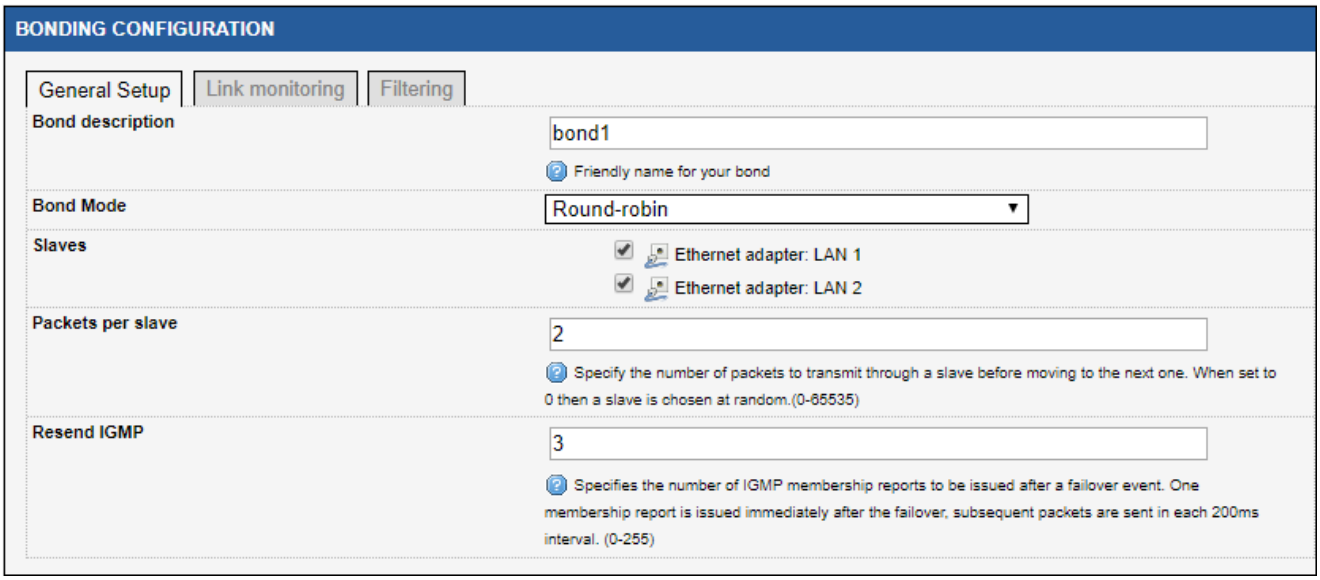
Symbolic name of you bond interface.

Bond Mode:

Selection of the required bond mode: Round Robin, Broadcast, 803.3ad LACP, Connect before break. These modes are described in the following pages.

Round-Robin Mode

Round-Robin mode is used for load balancing. The transmission of packets is done sequentially on each of the cards active in the aggregate. This mode increases bandwidth and manages fault tolerance.



Slaves:

The two Ethernet interfaces (LAN 1 and LAN 2) must be selected.

Packets per slave:

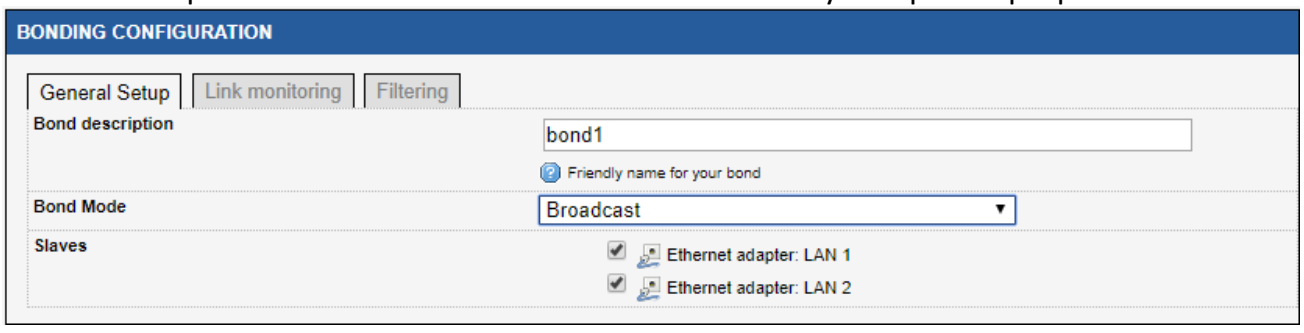
Specify the number of packets sent on a slave interface before moving to the next. The value can vary from 1 to 65535. The default value is 1. If you enter 0, the value will be chosen randomly.

Resend IGMP:

Specifies the number of IGMP membership reports to be issued after a failover event. One membership report is issued immediately after the failover, subsequent packets are sent in each 200ms interval. (0-255)

Broadcast Mode

This method is based on broadcast policy which consists in transmitting everything on all slave interfaces. It provides fault tolerance. This can be used only for specific purposes.

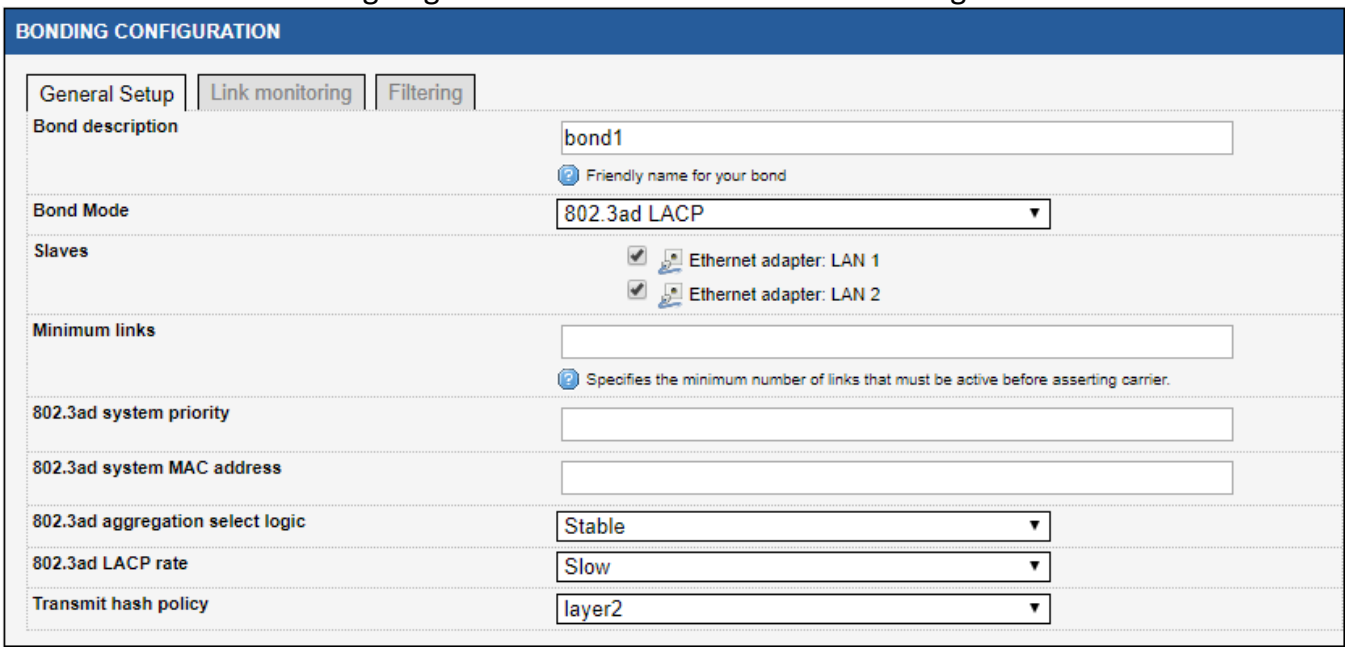


Slaves:

The two Ethernet interfaces (LAN 1 and LAN 2) must be selected.

802.3ad LACP

This mode is known as Dynamic link aggregation mode which creates aggregation groups having the same speed. It requires a switch that supports IEEE 802.3ad dynamic link. The selection of slaves for outgoing traffic is based on a transmit hashing method.



Minimum links:

Specifies the minimum number of physical links that must be active for the bonding interface carrier to be mounted. The default value is 1 and must remain at 1.

802.3ad system priority:

Allows to define the priority of the link, which will be managed by the 802.3ad switch. The highest priority is 1, and the lowest 65535. The default is 65535.

802.3ad system MAC address:

By default, the virtual MAC address of the bonding interface is used. This field allows to define another value.

802.3ad aggregation select logic:

Specifies the 802.3ad aggregation selection logic to use. The possible values and their effects are:

Stable The active aggregator is chosen by largest aggregate bandwidth. Reselection of the active aggregator occurs only when all slaves of the active aggregator are down or the active aggregator has no slaves.

Bandwidth The active aggregator is chosen by largest aggregate bandwidth. Reselection occurs if:

- A slave is added to or removed from the bond
- Any slave's link state changes
- Any slave's 802.3ad association state changes
- The bond's administrative state changes to up

Count The active aggregator is chosen by the largest number of ports (slaves). Reselection occurs as described under the "bandwidth" setting, above.

The bandwidth and count selection policies permit failover of 802.3ad aggregations when partial failure of the active aggregator occurs. This keeps the aggregator with the highest availability (either in bandwidth or in number of ports) active at all times.

802.3ad LACP rate:

Option specifying the rate at which we will ask our link partner to transmit LACPDU packets in 802.3ad mode. The possible values are

- **Slow :** Request partner to transmit LACPDUs every **30 seconds**
- **Fast :** Request partner to transmit LACPDUs every **1 second**

Transmit hash policy:

This parameter allows to define the strategy that will be used to choose which port will be selected for each type of exchange:

Layer2 All bonding ports are used if the data flow consists of packets with different source MAC addresses or different destination MAC addresses.

Layer2+3 All bonding ports are used if the data flow consists of packets with different source MAC addresses or different destination MAC addresses, or different source IP addresses or different destination IP addresses

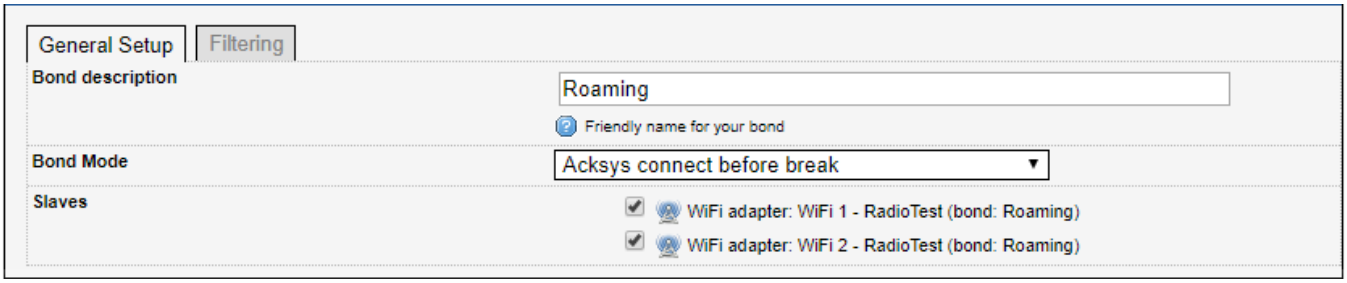
Layer3+4 All bonding ports are used if the data flow consists of packets with different MAC source addresses or different MAC address destinations, different source IP addresses or different destination IP addresses, different source ports or different destination ports

Encap2+3 Same as Layer 2+3, but if we detect that the packet is encapsulated in a tunnel protocol (GRE for example), data will be extracted from the tunnel to be processed

Encap3+4 Same as Layer 3+4, but if we detect that the packet is encapsulated in a tunnel protocol (GRE for example), data will be extracted from the tunnel to be processed

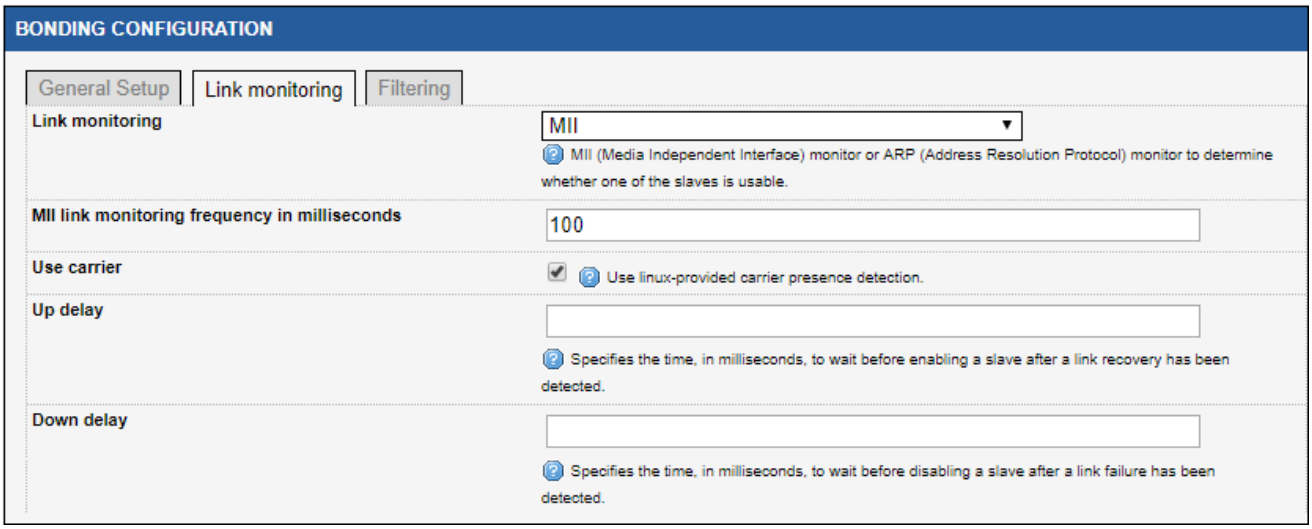
Connect before break

The bond for connect before break is usually created via the *SETUP/Physical interface* page, please refer to Global parameters/Cluster Mode



Link monitoring using MII

The Link Monitoring tab is used to define the parameters for monitoring the links of the slave ports of the bonding interface. When choosing the MII option, the physical link of the interfaces is tested



MII link monitoring frequency in milliseconds:

Defines the frequency at which the physical link of each port is testes. Default is 100ms.

Up delay:

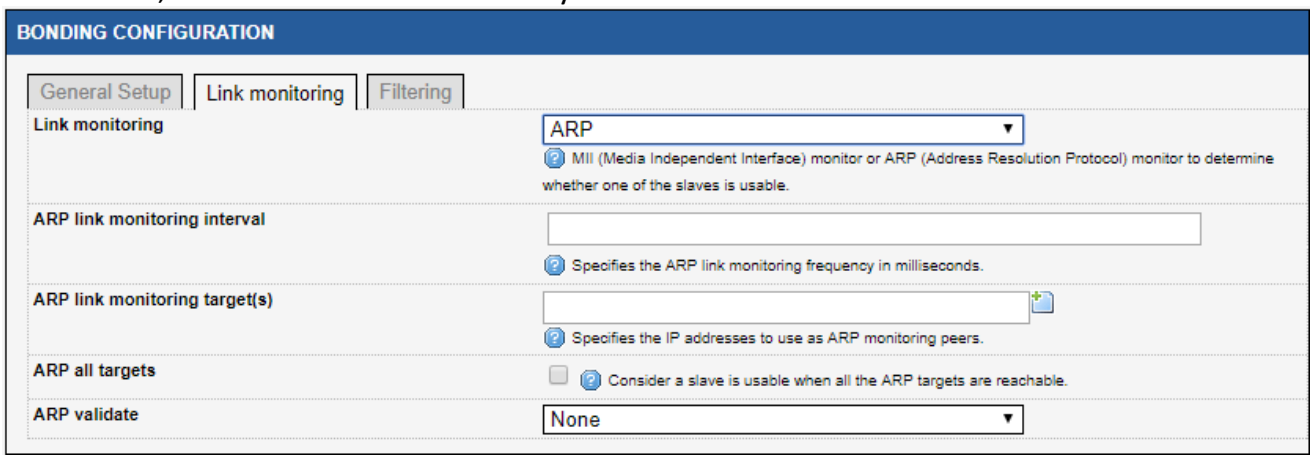
Specifies the time, in milliseconds, to wait before enabling a slave port, after detection of the recovery of the physical link.

Down delay:

Specifies the time, in milliseconds, to wait before disabling a slave port, after detection of a physical link failure.

Link monitoring using ARP (only in Round Robbin or Broadcast mode)

In this case, the control of the continuity of the links is based on ARP traffic.



ARP link monitoring interval:

Specifies the time intervals at which ARP requests are sent, in milliseconds.

ARP link monitoring target(s):

Here we define the IP addresses to which we must send ARP requests to monitor the links.

ARP all targets:

If this box is checked, it means that a slave will be considered usable only if all the specified IP addresses respond to the ARP requests.

ARP validate:

Here we define the criteria that will allow to decide if an interface is usable. The slave interface which gave its MAC address to the bonding interface is called the ***active interface***. The other slaves are called ***backup interfaces.*** The different options are:

None: (default): We check if there has been incoming and outgoing ARP traffic recently on the interface to determine if it is usable

Active: We look if there has been incoming and outgoing ARP traffic recently on the interface, and for the active interface, we examine the content of incoming and outgoing ARP

Backup: We check if there has been incoming and outgoing ARP traffic recently on the interface, and for the backup interface, we examine the content of incoming and outgoing ARP

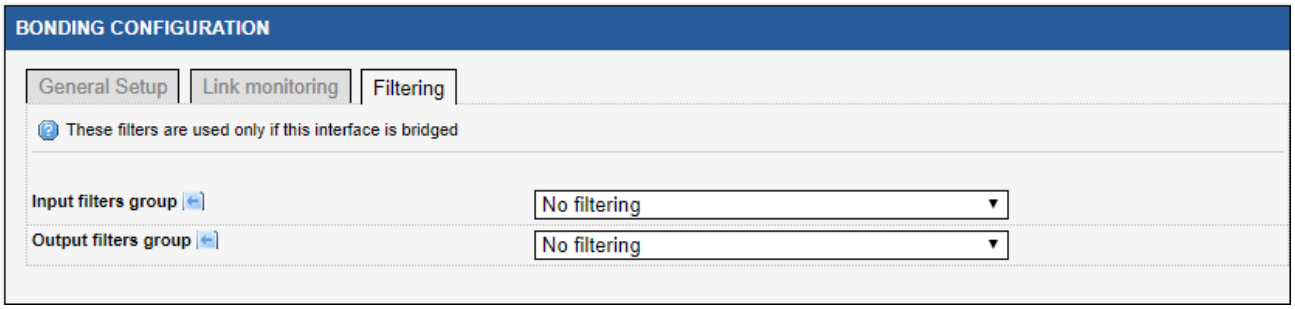
All: We examine all ARPs on all bonding interfaces to determine if they are usable.

Filter: We check if there has been recent ARP traffic entering the interface to determine if it is usable

Filter active: We check if there has been recent incoming ARP traffic on the interface, and for the active interface, we examine the content of incoming and outgoing ARPs.

Filter backup: We check if there has been incoming ARP traffic recently on the interface, and for the backup interface, we examine the content of incoming and outgoing ARPs.

Filtering tab



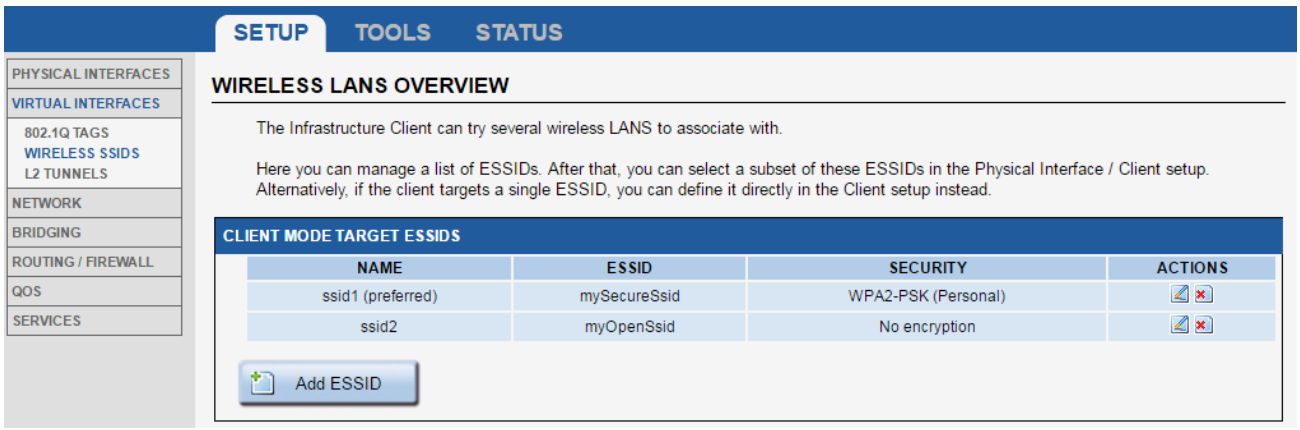
Input filter group/Output filter group:

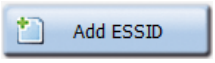
Choose one of the filters prepared in routing/firewall/bridge filter section.
For more information about filters group, please see Bridge filter

VI.1.3.2 Wireless SSIDs

The wireless SSID section is used to configure several SSIDs and enable them on the client role of the Wireless interface.

Wireless SSID overview

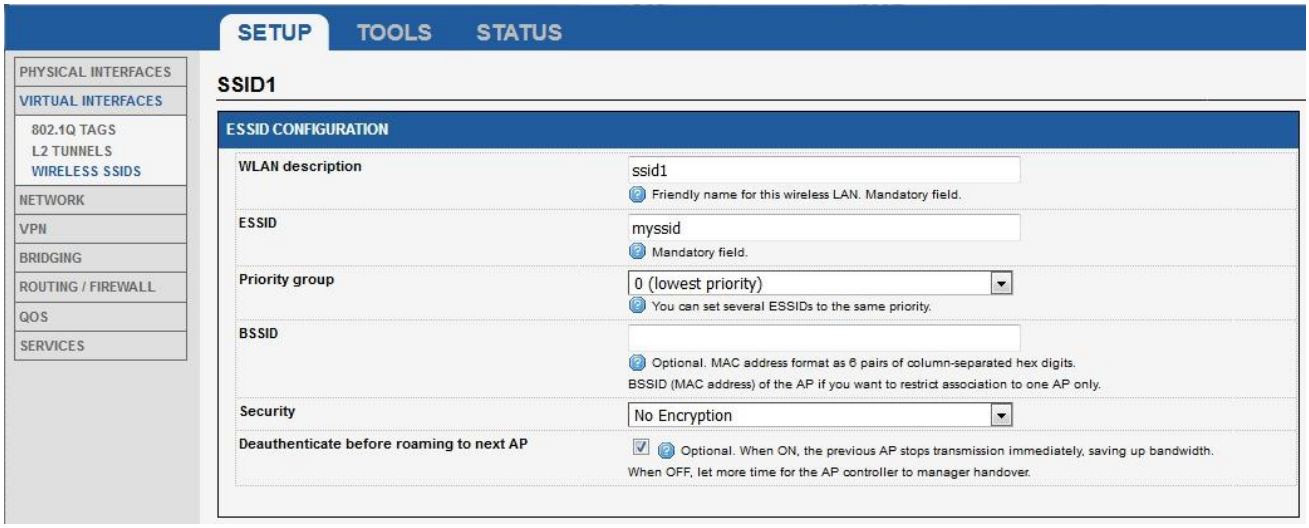


Use the 

button to add a SSID specification

Use  button to edit the parameters, use  to suppress an SSID specification

Wireless SSID configuration



WLAN description (optional):

Enter a friendly name for this SSID.

ESSID:

Network name (also called SSID).

Priority group:

The scan process will choose the AP with the SSID of highest priority. If you have several APs advertising SSIDs of the same priority, the AP with the best signal will be chosen.

BSSID (optional):

Set the BSSID of the AP if you want to restrict association to one AP only.

Security:

Select the security policy. For more information on the security parameter please read the section *Wireless Security tab*:

VI.1.3.3 L2 Tunnels

In this section, you can configure Layer 2 tunneling with GRE.

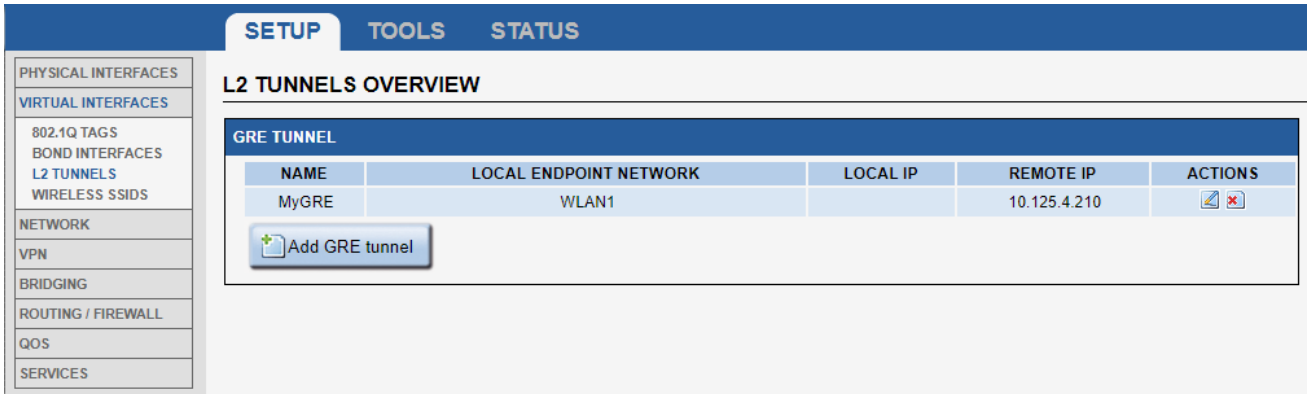
The GRE encapsulation adds L2, L3 and GRE headers to the original L2 frame. This overhead will reduce the network MTU (Because the L2 frame is limited to 1524 octets on 802.3 networks).

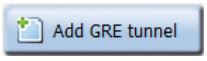
NOTE: The 802.11 networks support a larger frame than 802.3 networks. If your GRE tunnel traverses 802.11 networks only, it is recommended to increase the MTU on the GRE interface and the network bearing the 802.11 physical interface, to allow using the maximum 802.3 MTU for the original L2 frame.

For example, setting the GRE and WiFi interfaces MTU to 2000 is sufficient to encapsulate frame sizes up to the 802.3 MTU.

L2 TUNNELS Overview

In this page, you can create a GRE tunnel:



Use 

button to add GRE interface

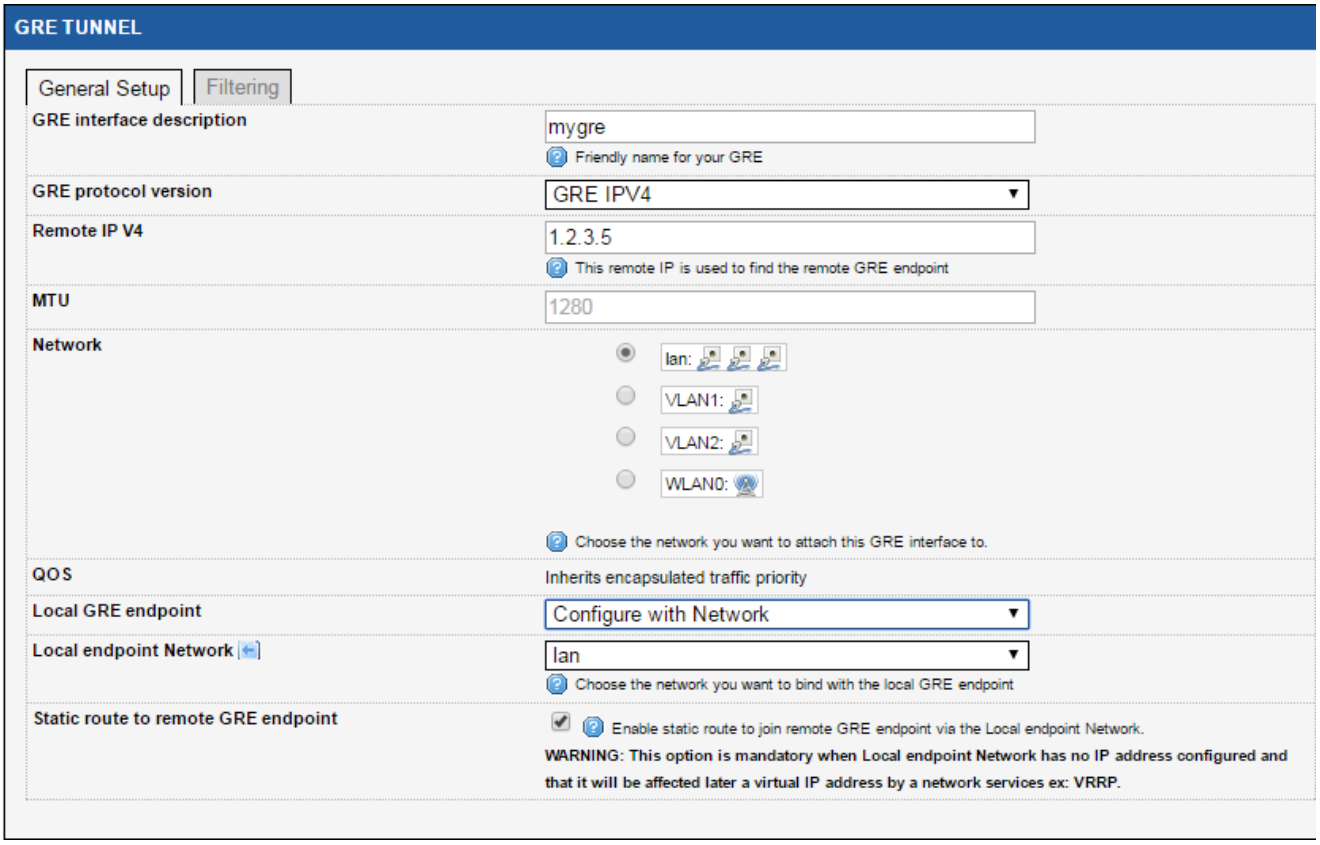
Use  button to edit GRE tunnel parameters

Use  button to suppress GRE tunnel

GRE TUNNEL configuration page

In this page, you can configure the GRE tunnel

General Setup tab



GRE interface description

Friendly name for your GRE interface

GRE protocol version

Always GRE IPV4

Remote IP V4

IP of the remote endpoint of the tunnel

MTU (Maximum transmit unit)

The maximum size of L2 frames encapsulated in the GRE tunnel

Network

Add GRE tunnel interface in selected network.

Local GRE endpoint

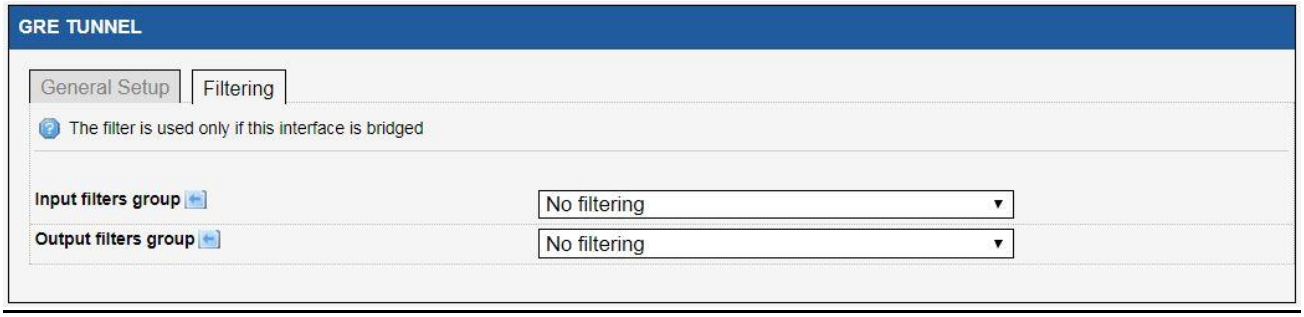
Choose between:

- **Configure with IP V4 address**
  - **Local IP V4:** This local IP is used to find the local GRE endpoint.

    WARNING: if this IP is not valid when GRE interface is created, tunnel will be routed via a default Gateway. This case can be encountered when this IP correspond to the IP of a wireless interface or a virtual interface that is created after the GRE tunnel. The solution is that instead of using a local IP for the local endpoint configuration, we bind the Local endpoint of the tunnel to a Network that contains the given interface with the given IP (see section below).
- **Configure with Network:**
  - **Local endpoint Network:** Choose the network you want to bind with the local GRE endpoint
  - **Static route to remote GRE endpoint:** Enable static route to join remote GRE endpoint via the Local endpoint Network.

    WARNING: This option is mandatory when Local endpoint Network has no IP address configured and that it will be affected later a virtual IP address by a network services ex: VRRP.

Filtering tab

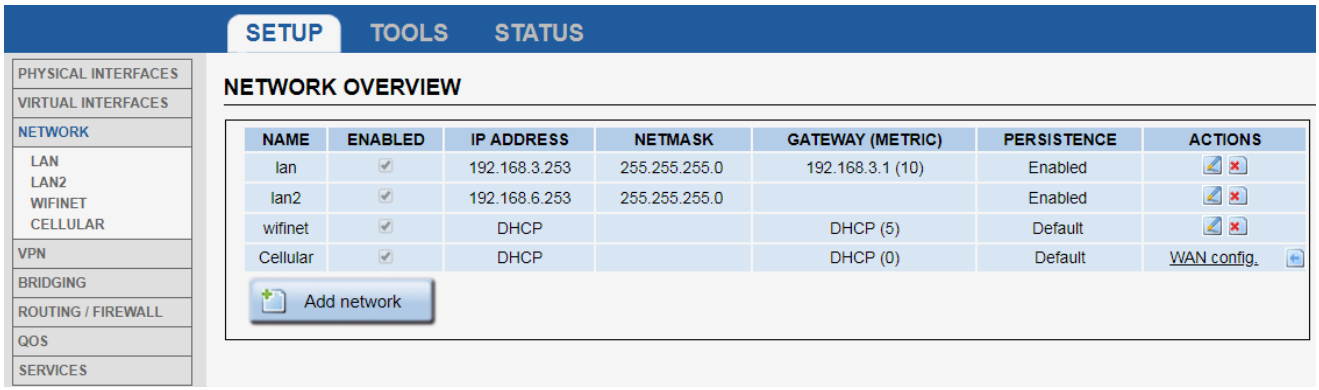


Input filter group/Output filter group:

Choose one of the filters prepared in routing/firewall/bridge filter section.
For more information about filters group, please see Bridge filter

VI.1.4 Network

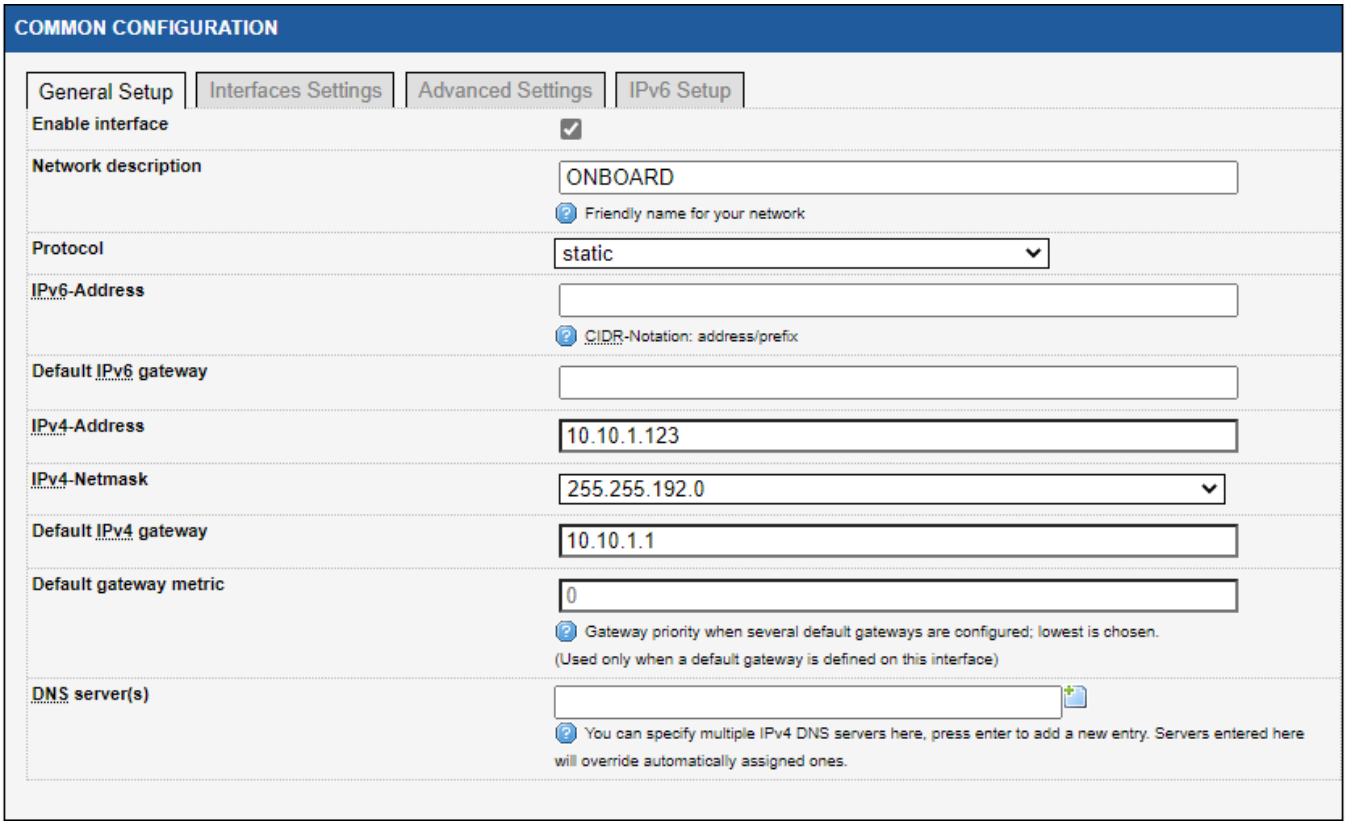
This page displays the current network configuration.



Click the **Remove** button to remove the network.
Click the **Edit** button to open the network configuration page.
Click the **Add network** button to create a new IP network.

VI.1.4.1 Network configuration

General setup:



Enable interface

This checkbox allows you to temporarily disable the LAN interface without losing your configuration.

Network description

Friendly name for your network.

Protocol

Choose **DHCP** if you have a DHCP server in the network and you want to assign an IP address to the device. In this case, you do not need to fill in the fields shown above except possibly **DNS-Server**

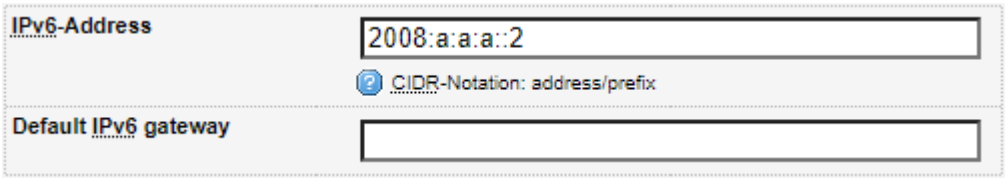
Choose **static** if you do not have a DHCP server in the network or if, for any other reason, you need to assign a fixed address to the interface. In this case, you must also configure the fields shown below.

Note that you cannot choose **DHCP** if you have enabled the **DHCP Server** option on the DHCP page; the AP cannot be both a DHCP client and a DHCP server.

Choose **SLAAC to** allows devices to generate their own IP address without a DHCP server

IPV6 address and Default IPV6 gateway:

These fields allow to add an IPV6 address and gateway to some services, and accept CIDR type address syntax.



Delegated prefix length (for ULA Addresses)

Ipv6 network addresses prefix between 1 and 128

IPv4-Address (only in static mode)

The IP address of the AP on the local area network. Assign any unused IP address in the range of IP addresses available for the LAN. For example, 192.168.0.1.

IPv4-Netmask

The subnet mask of the local area network.

Default IPv4-Gateway

The IP address of the router on the local area network. Use 0.0.0.0 if no gateway is defined.

Default Gateway Metric

When several Networks are configured, with their own gateway, the *Default Gateway Metric* allows to introduce a priority between these gateways. The gateway with the lowest Metric will be chosen.

DNS-Server:

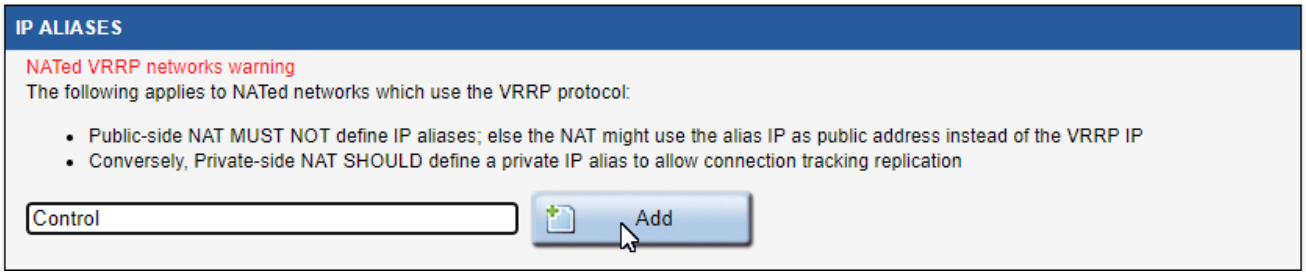
The IP addresses of the DNS server(s) you want to use. If you selected the DHCP protocol, you can choose to use the value defined in the menu TOOLS/System, or you can define a new Hostname, specific to this network.

IPV6 Global configuration:

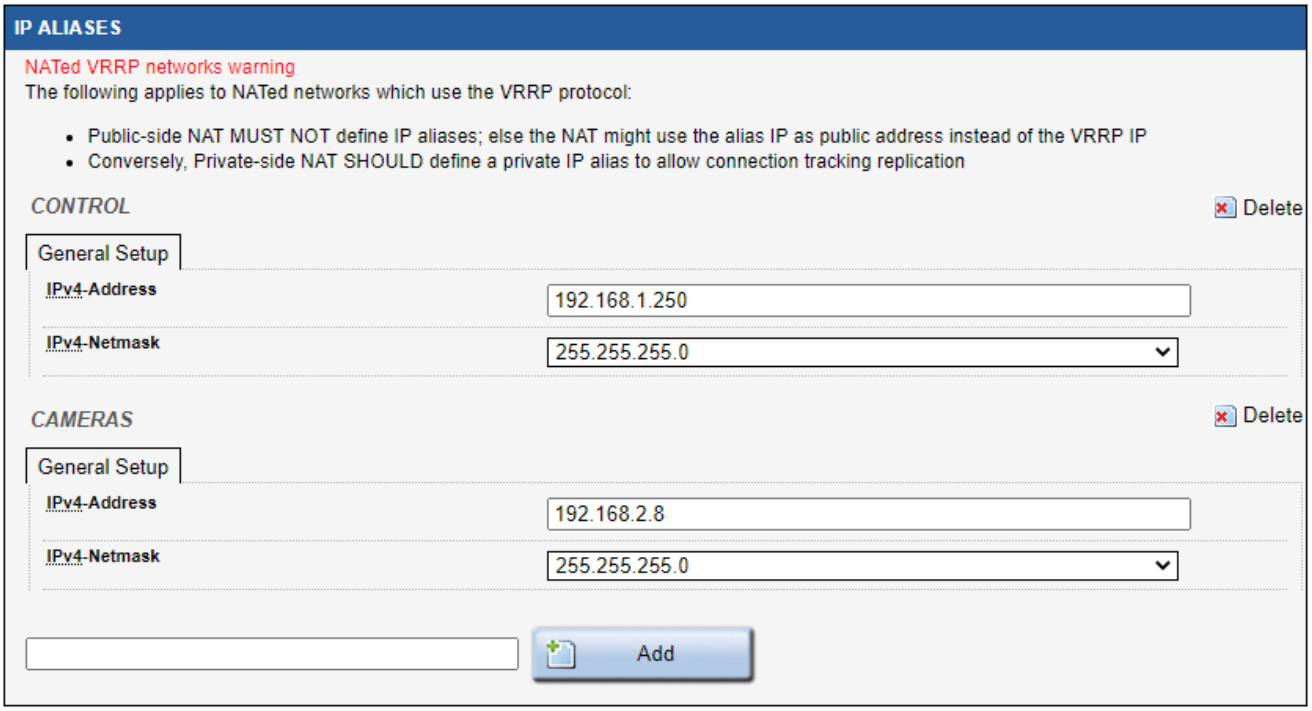
This field accepts IPv6 ULA Prefix and allows to add a unique local Address for a private network

IP Alias:

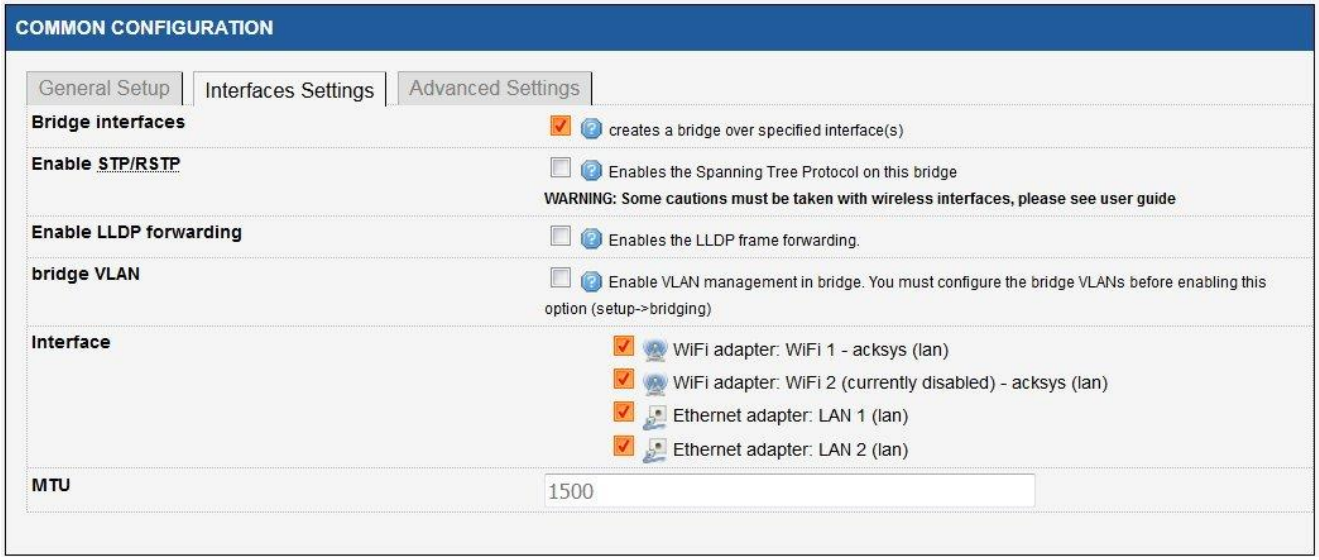
IP aliases can be useful if you need an access to your device from different networks, for example when your product is configured in router mode, and acts as a gateway for different subnets



To add an IP alias, enter a mnemonic and click Add, then enter the desired IP address, and the associated subnet mask.



Interfaces Settings:



Bridge interfaces:

If checked, all interfaces in this network are linked with the software equivalent of an Ethernet switch.

Enable STP/RSTP:

If checked, the STP/RSTP (Spanning Tree Protocol) will be activated on this bridge. If you choose to not use STP/RSTP, you have to set up your devices to avoid network loops by yourself.

Some cautions must be taken with wireless interfaces, please see *Spanning Tree Protocols (STP, RSTP).*

Enable LLDP forwarding:

Check this box if the internal bridge must forward the LLDP Multicast frame.

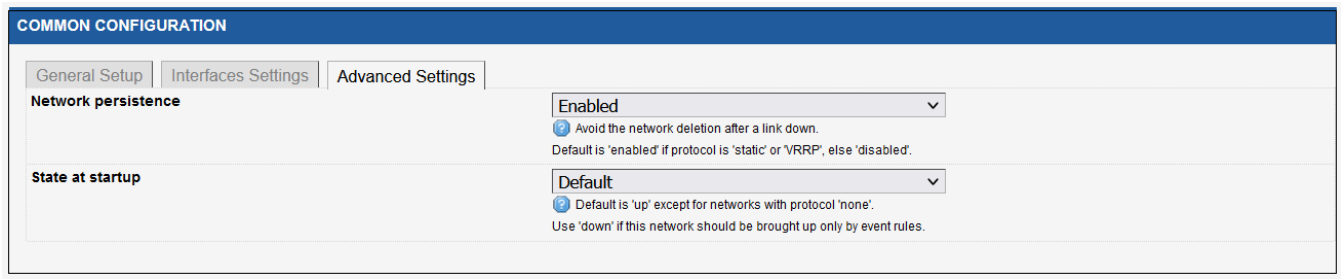
Bridge VLAN:

Enable VLAN management in the bridge. Please see: *Vlan Management*

Interface:

This is the list of available network interfaces. Disabled (greyed) interfaces are already used in another network. For bridge networks, select all the interfaces you want to bridge together into the LAN being configured. For simple networks, select the one interface to configure.

Advanced Settings:



Network Persistence:

When this option is enabled, the IP setting (routes, gateway, virtual interfaces, etc.) remains persistent when the physical interface loses its connection. This makes it possible, for example, to avoid systematic sending of DHCP requests when an interface loses the link.

Default value is *enabled* for static protocol (fixed IP) and *disabled* for all the other protocols (DHCP, VRRP).

Cellular (on some models)

When present, this is an alias entry pointing to the Cellular configuration in the “Physical interfaces” submenu. See Cellular in that section.

State at startup

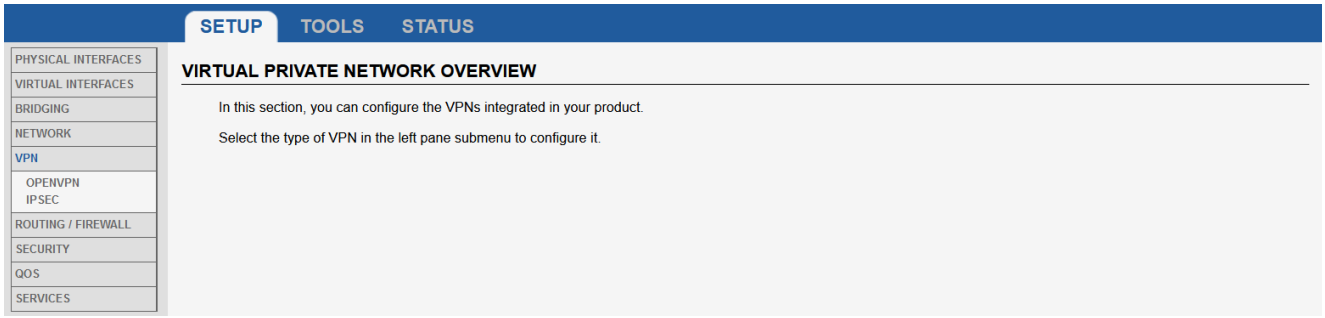
Gives the network status at startup. The default state is "Up", except for networks whose protocol is "none". Use "Down" only if this network is to be activated by an event

VI.1.5 VPN

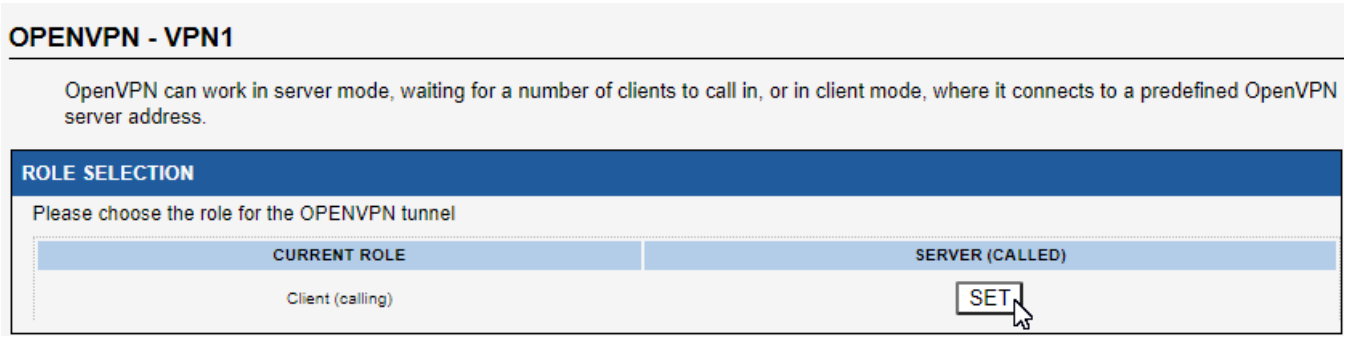
The VPN Configuration section lists VPN instances currently existing on the device where it is possible to configure OPENVPN and IPSEC.

VI.1.5.1 OPENVPN

This page allows to create an OPENVPN or an IPSEC VPN interface



To create a new OpenVPN instance, click on **Add instance**, this will open the OpenVPN configuration page.



The ROLE SELECTION section allows to change the role from Client to Server and vice versa.

Attention, when changing the authentication method or the role, the following sections will be updated accordingly.

CONFIGURATION

Basic settings | Advanced settings

Enable virtual network	☑
OpenVPN instance description	vpn1 Friendly name for this VPN instance
Remote OpenVPN server address	110.25.250.16 Remote OpenVPN server address
VPN subnet local tunnel endpoint IP address	10.8.0.2 IP address of the local VPN tunnel endpoint, not used in TLS client mode since it is pulled from server
VPN subnet mask	255.255.255.0 Subnet mask of the VPN tunnel subnet, not used in TLS client mode
VPN subnet remote tunnel endpoint IP address	10.8.0.1 IP address of the remote VPN tunnel endpoint This IP will be used as default gateway to route via the VPN tunnel. This is not the system default gateway, but default gateway to use in routes created by openvpn and where gateway is not filled.

OPENVPN - VPN1

OpenVPN can work in server mode, waiting for a number of clients to call in, or in client mode, where it connects to a predefined OpenVPN server address.

CONFIGURATION

Tunnel settings | Auth/Crypto | Client settings

Enable virtual network	☑
State at startup	Default Default is 'up' except for networks with protocol 'none'. Use 'down' if this network should be brought up only by event rules.
OpenVPN instance description	vpn1 Friendly name for this VPN instance
Role	Client (calling)
Protocol	UDP Favor UDP, as TCP leads to potential conflicts in the TCP over TCP redundancy mechanisms
Listener port	1194 UDP or TCP port that the server will listen to, and that the client will call
Data channel compression	☐ Use fast LZO compression
Tunnel type	L3 (IP) tunnel Only L3 tunnels are supported
VPN subnet local IP address	10.8.0.1 IP address of the local VPN endpoint, not used in TLS client mode since it is pulled from server
VPN subnet mask	255.255.255.0 Subnet mask of the VPN subnet, not used in TLS client mode
Tunnel MTU	1500 Encapsulated MTU, adjust to avoid fragmentation; the default of 1419 allows the default SHA1 digest
Keepalive period	10 Keepalive period (seconds). Every such time, a packet is sent to each peer to elicit a response.
Keepalive timeout	30 Keepalive timeout (seconds). Connection terminates if no traffic is received from the peer for such time.

State at startup

Gives the VPN network status at startup. The default state is "Up", except for networks whose protocol is "none". Use "Down" only if this network should be brought up only by event rules.

OpenVPN instance description

This is the friendly name you give to this VPN instance.

Role

The role can be Server or Client. The server waits for clients to call in. The Client calls the server to initiates the connection.

Protocol

Protocol can be UDP or TCP. Favor UDP, as TCP leads to potential conflicts in the TCP over TCP redundancy mechanisms. You must ensure that the routers between the Client and the Server open the ports necessary to authorize the packets of the selected format.

Listener port

This is the UDP or TCP port listened by the Server, waiting for a Client to call. Default is 1194.

Data channel compression

Check this box if you want the data passing through the tunnel to be compressed. Fast LZO compression is used.

Tunnel Type

Only L3 tunnels are supported.

VPN subnet local IP address

Virtual IP address of this VPN endpoint.

VPN subnet mask

The subnet mask associated to the IP address of this VPN endpoint.

Tunnel MTU

Encapsulated MTU, should be adjusted to avoid fragmentation; the default of 1419 bytes allows the default SHA1 digest.

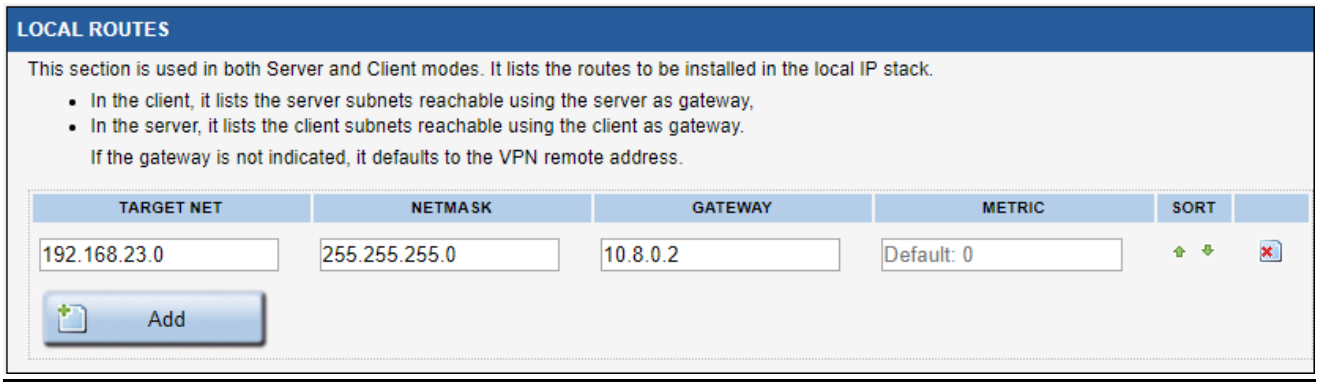
Keepalive period

The keepalive mechanism verifies that the VPN link is always valid. A probe is sent by each peer at the frequency defined by this parameter. The keepalive period is given in seconds.

Keepalive timeout

This is the Keepalive timeout value, in seconds. The connection is closed if no packet is received for a period longer than this period of time. The **Keepalive timeout** value must be greater than the **Keepalive period**

LOCAL ROUTES



This section allows to define the routes to be installed in the local IP stack.

TARGET NET:

Destination subnet.

NETMASK:

Destination subnet mask.

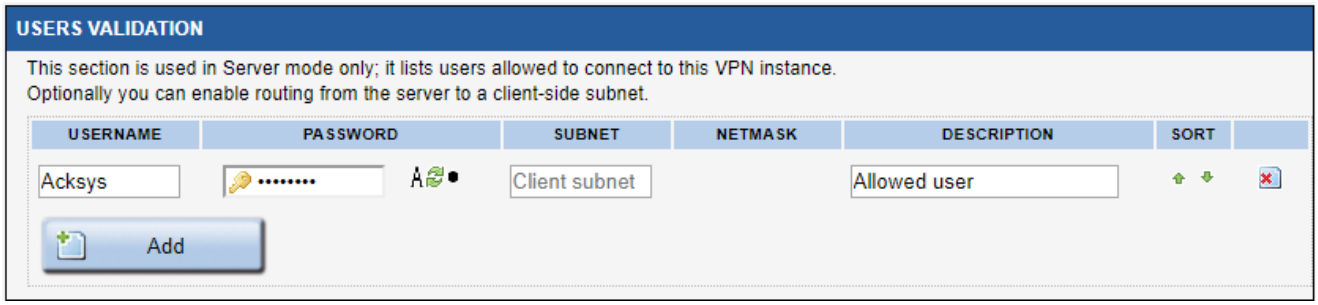
GATEWAY:

The gateway that must be used to reach the target network. If left blank, the gateway defaults to the VPN remote address.

METRIC:

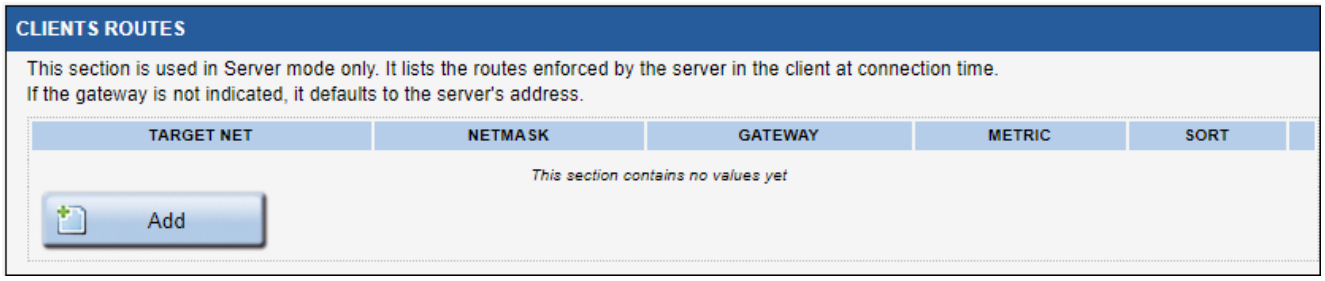
Sets the metric for this route.

USERS VALIDATION



This section is used in Server mode only; it lists users allowed to connect to this VPN instance. Optionally you can enable routing from the server to a client-side subnet.

CLIENTS ROUTES

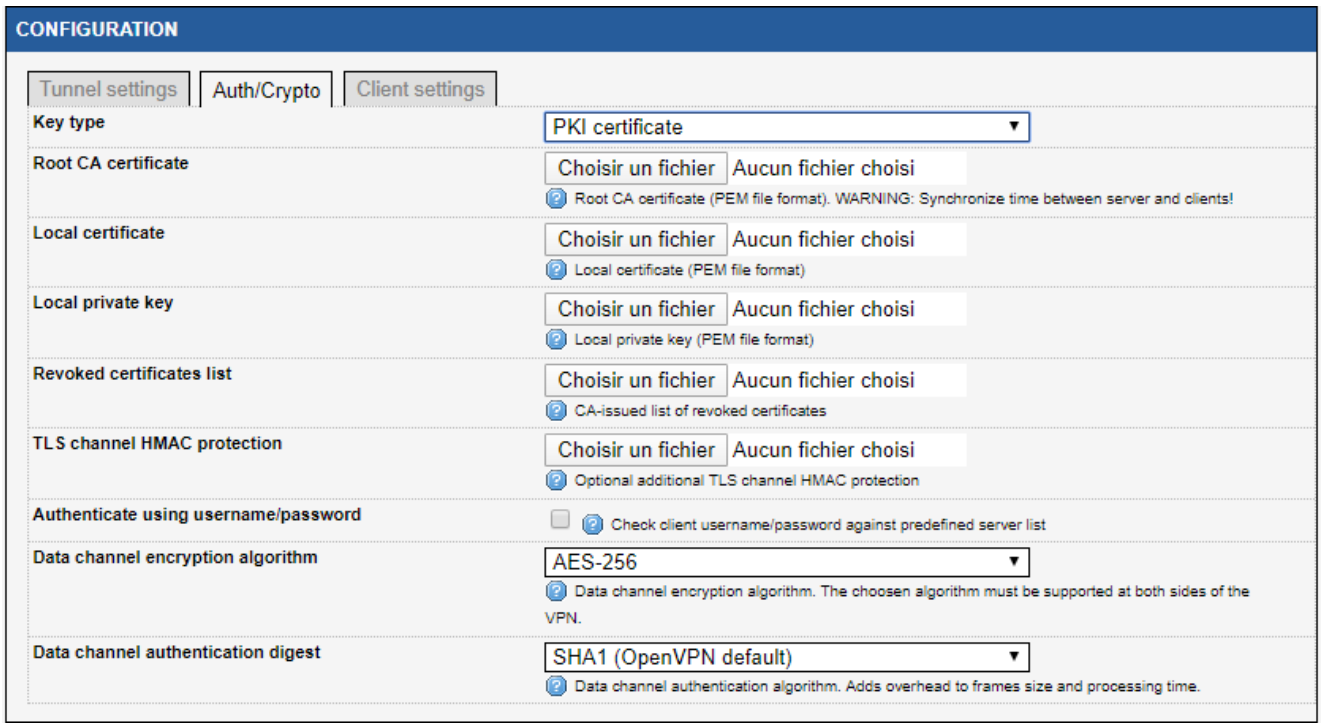


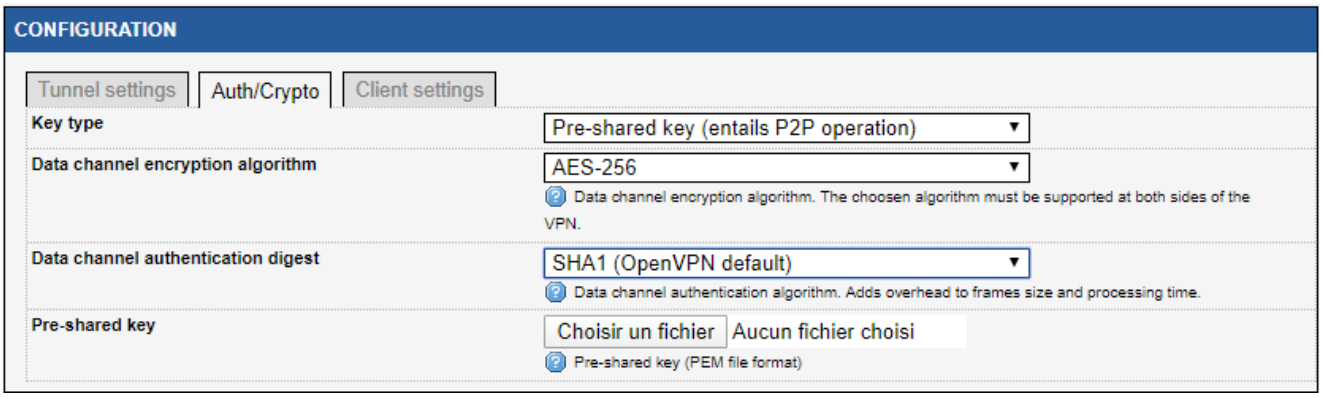
This section is used in Server mode only. It lists the routes enforced by the server in the client at connection time. If the gateway is not indicated, it defaults to the server's address.

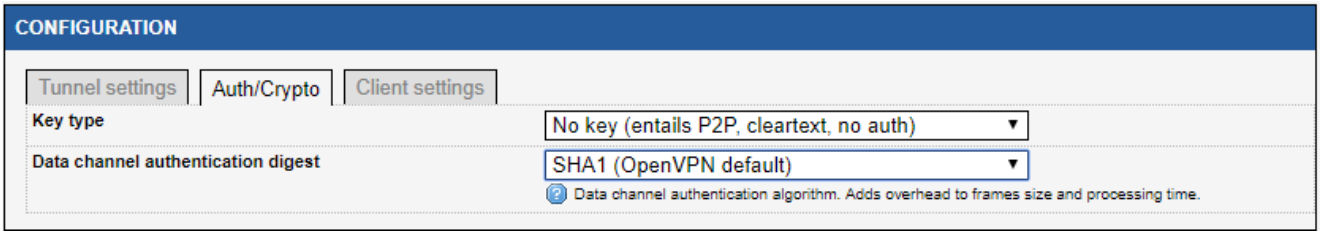
Warning, the routes can only be enforced by the server with TLS VPN authentication: you must choose **PKI certificate** in the **Auth/Crypto** tab described below.

AUTH/CRYPTO

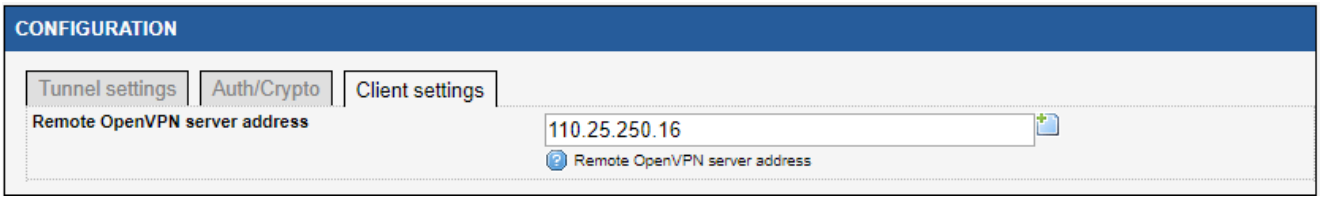
These pages allow define the credentials, encryption and authentication methods for your VPN tunnel. For more information about the definitions of these fields, please refer to the OpenVPN documentation: https://community.openvpn.net/openvpn/wiki/SecurityOverview







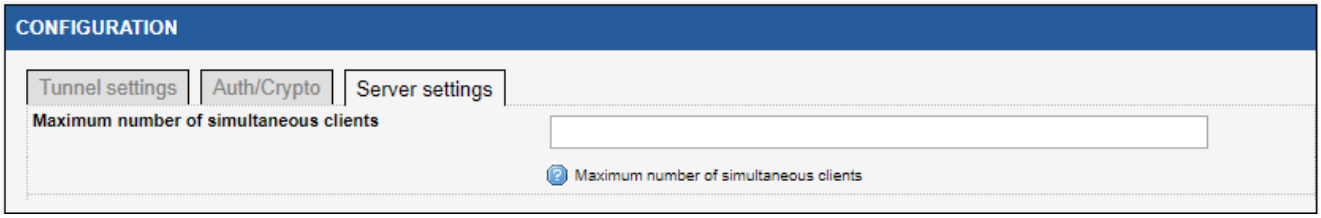
Client settings



Remote OpenVPN server address:

This is the remote OpenVPN server address.

Server settings

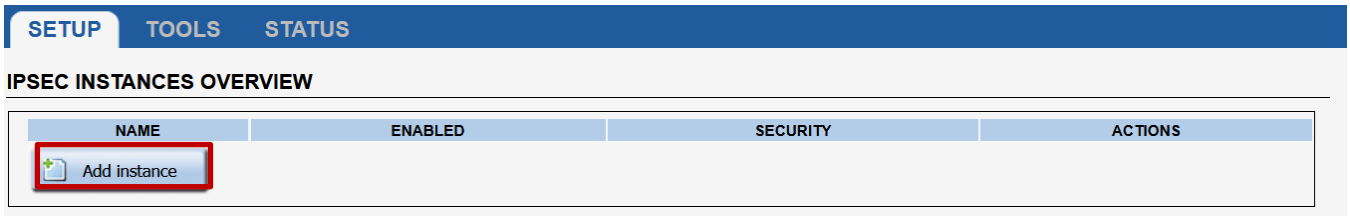


Maximum number of simultaneous clients:

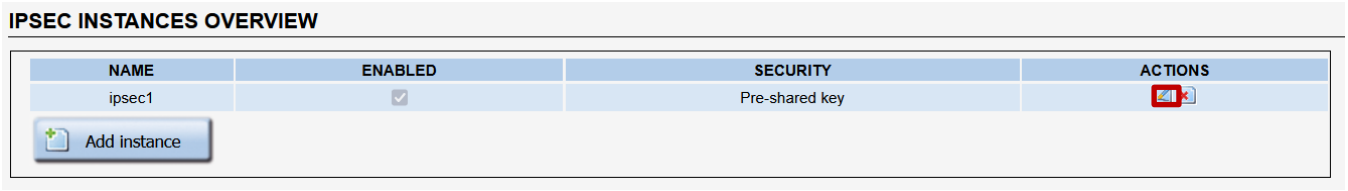
This setting allows you to limit the number of clients that can connect to your server simultaneously. This allows to optimize the use of the physical resources of your product.

VI.1.5.2 IPSEC

To create a new IPSEC instance, click on "**Add" instance**, this will open the IPsec button:

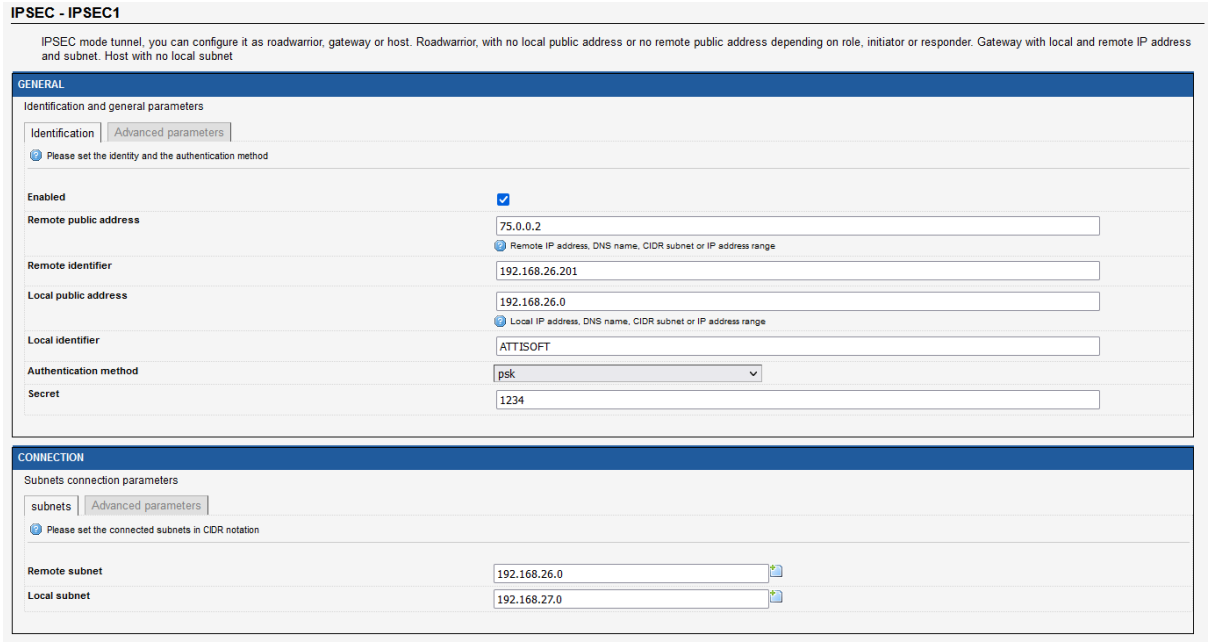


Click the "Edit" button located next to the newly create instance: c

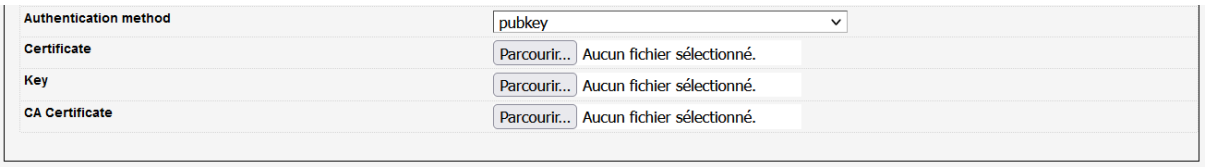


Redirection to the instance's configuration page where it is possible to configure the instance with IPV4 or IPV6 addresses.

The General settings section is used to configure the main IPsec parameters. Refer to the table below for information on the configuration fields located in the General and connection settings section.



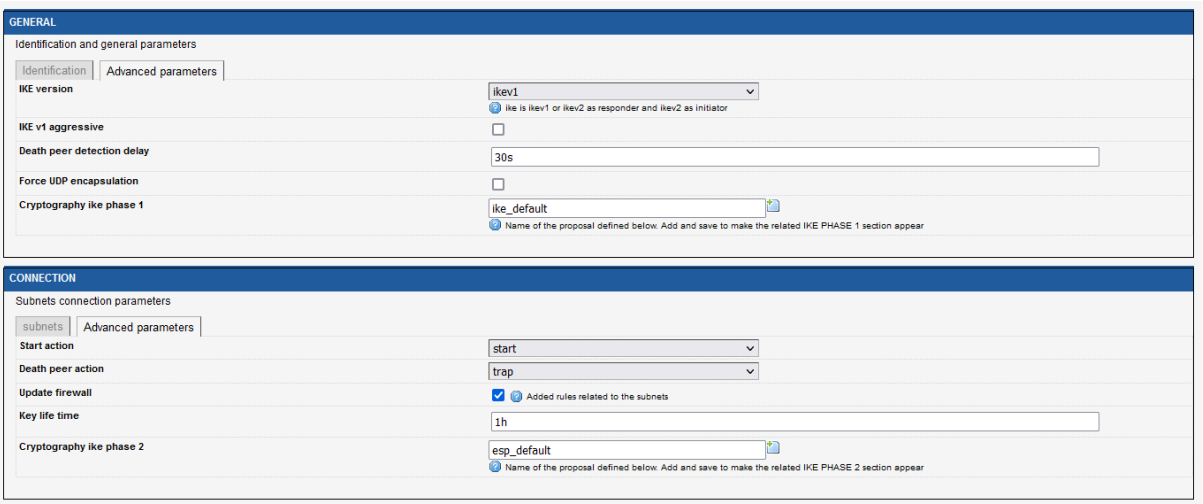
PubKey



Field	Value	Description
Enable	off | on; default: **on**	Turns the IPsec instance on or off.
Remote public address	host | ip; default: **none**	IP address or hostname of the remote IPsec instance.
Remote identifier	ip | string; default: **none**	Defines how the right participant will be identified during authentication. • **IP** - Internet Protocol address. **FQDN** - identity defined by fully qualified domain name. It is the complete domain name for a host.
Local public address	ip | string; default: **none**	Defines how the user (left participant) will be identified during authentication. • **IP** - Internet Protocol address. **FQDN** - identity defined by fully qualified domain name. It is the complete domain name for a host.
Local identifier		
Authentication method	Pre-shared key | X.509; default: **Pre-shared key**	Specify authentication method. Choose between Pre-shared key and X.509 certificates.
Pre-shared key: Pre shared key	string; default: **psk**	A shared password used for authentication between IPsec peers before a secure channel is established.
X.509: Key	.pem file; default: **none**	A public key file.
X.509: Local Certificate	.pem file; default: **none**	A local certificate file.
X.509: CA Certificate	.pem file; default: **none**	A certificate authority file.

Advance settings

Advanced settings section is used to configure the advanced main parameters of an IPsec connection refered to the table below.



Field	Value	Description
IKE v1 aggressive	off | on; default: **off**	Turn aggressive mode on or off for outgoing connections. Aggressive mode performs fewer exchanges (a total of 4 messages) than Main mode (a total of 6 messages) by storing most data into the first exchange. In aggressive mode, the information is exchanged before there is a secure channel, making it less secure but faster than main mode. Aggressive mode is available only with IKEv1; if IKEv2 is selected this field becomes hidden.
Force encapsulation	off | on; default: **off**	Forces UDP encapsulation for ESP packets even if a "no NAT" situation is detected.
Local firewall	off | on; default: **on**	Adds necessary firewall rules to allow traffic of this IPsec instance on this device.
Update firewall	off | on; default: **on**	Adds necessary firewall rules to allow traffic of from the opposite IPsec instance on this device.
Key live time	integer; default: **none**	Defines timeout interval, after which a CHILD_SA is closed if it did not send or receive any traffic.
Dead Peer Detection	off | on; default: **off**	A function used during Internet Key Exchange (IKE) to detect a "dead" peer. It used to reduce traffic by minimizing the number of messages when the opposite peer in unavailable and as failover mechanism.
Dead Peer Detection: DPD action	Start | Trap | Clear | None; default: **Restart**	Controls the use of the Dead Peer Detection protocol where notification messages are periodically sent in order to check the liveliness of the IPsec peer.
Dead Peer Detection: DPD Delay	integer; default: **none**	The frequency of sending R_U_THERE messages or INFORMATIONAL exchanges to peer.
Dead Peer Detection: DPD Timeout	integer; default: **none**	Defines the timeout interval, after which all connections to a peer are deleted in case of inactivity.

VI.1.6 Bridging

In this section, you can configure the bridging services integrated in your product.

VI.1.6.1 STP/RSTP

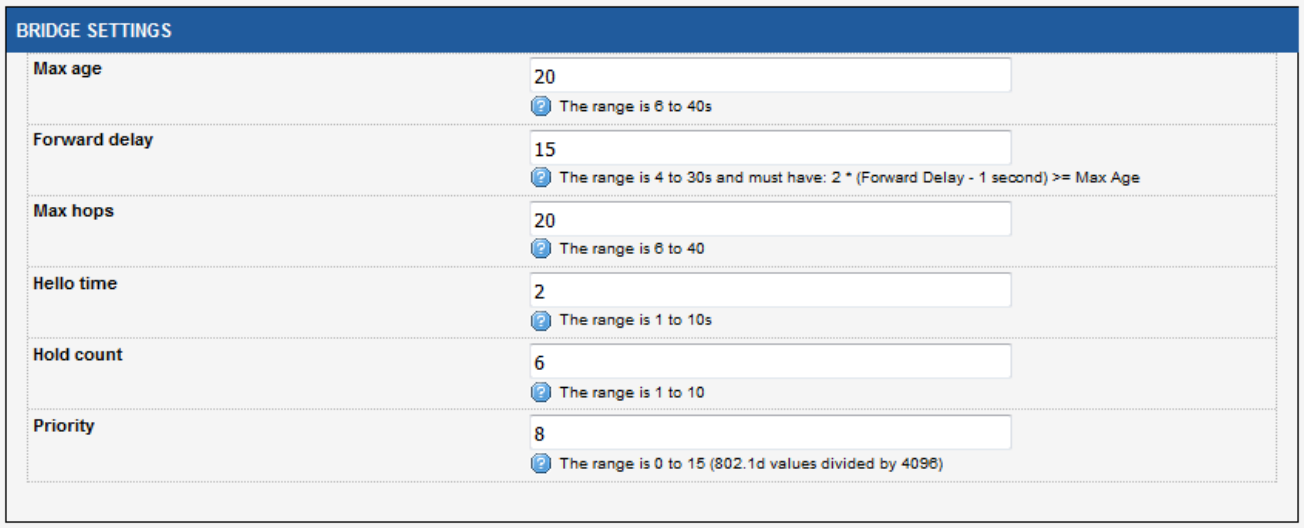
In this section, you can configure STP/RSTP for your Network Ports and Bridges.
To configure STP/RSTP on a given Network, Bridge must be enabled.

STP/RSTP overview

NETWORK	BRIDGE STATUS	STP/RSTP STATUS	BRIDGED INTERFACE	ACTIONS
lan	Enabled	Disabled	WiFi adapter: WiFi 1 - Acksys WiFi adapter: WiFi 2 - Service Ethernet adapter: LAN 1 Ethernet adapter: LAN 2	

Click edit button to change the STP/RSTP parameters for the given bridged network

STP/RSTP Bridge settings



Max age

The maximum age of the information transmitted by the Root Bridge.

Forward delay

The delay to transition Root and Designated Ports from Discarding to Learning or from Learning to Forwarding states.

Max hops

The maximum number of hops the BPDU can be forwarded.

Hello time

The interval between periodic transmissions of Configuration Messages by Designated Ports.

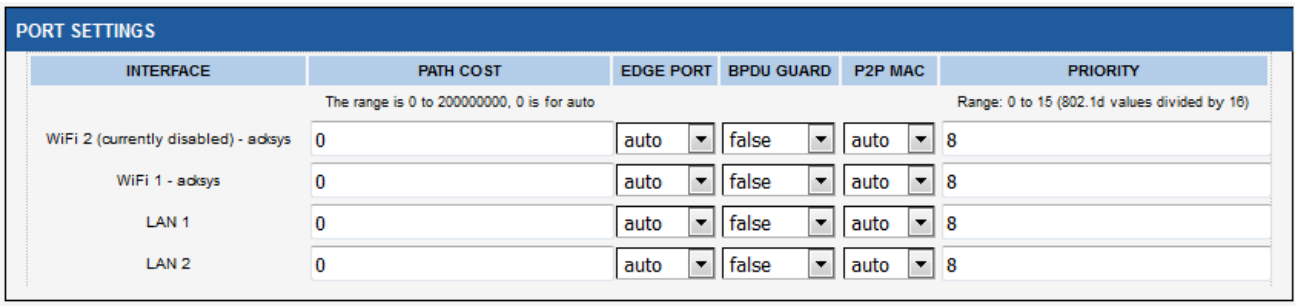
Hold count

The maximum number of BPDUs that can be sent in one second

Priority

Bridge priority in the STP/RSTP topology, the range is 0 to 15, with 0 the highest priority and 15 the smallest one. It will permit to select the root bridge.

STP/RSTP Port settings



Path Cost

The Port's contribution, when it is the Root Port, to the Path Cost to reach the Root Bridge. When set to 0, the value will be calculated automatically depending on the port speed. The port offering the lowest cost to the root bridge will become the root port, and all other redundant paths will be placed into blocking state.

Edge Port

Initial edge state of the port. If set to true, initial state will be set to edge port, if set to false, the initial state will be set to non-edge port, and if set to auto, the product will detect automatically the port type. The RSTP will make transition the edge ports directly to forwarding state.

BPDU Guard

Set it to true on edge ports (port attached to a LAN with no other bridge attached), if you want the port to be disabled upon the reception of a BPDU.

P2P Mac

This will set the initial point-to-point link state. If set to true, the initial link state will be set to point-to-point link (Direct link between two bridges (without an intermediate equipment like a hub between the two bridges)), this will help designated port to transition faster to forwarding state. If set to auto, the product will detect automatically the link type

Priority

Port priority inside the bridge. If in the bridge, several ports offer the same path cost, STP/RSTP will use the port priority to elect the root port. The range is 0 to 15, with 0 the highest priority and 15 the smallest one.

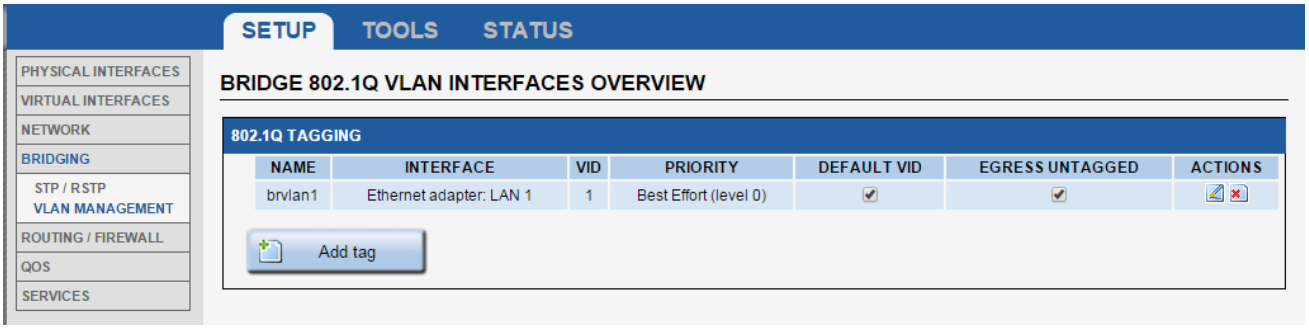
VI.1.6.2 Vlan Management

In this page you can manage the 802.1q tagging on the bridged ports.

For each interface included in a bridge you can specify the supported VLANs.

VLAN Interfaces overview

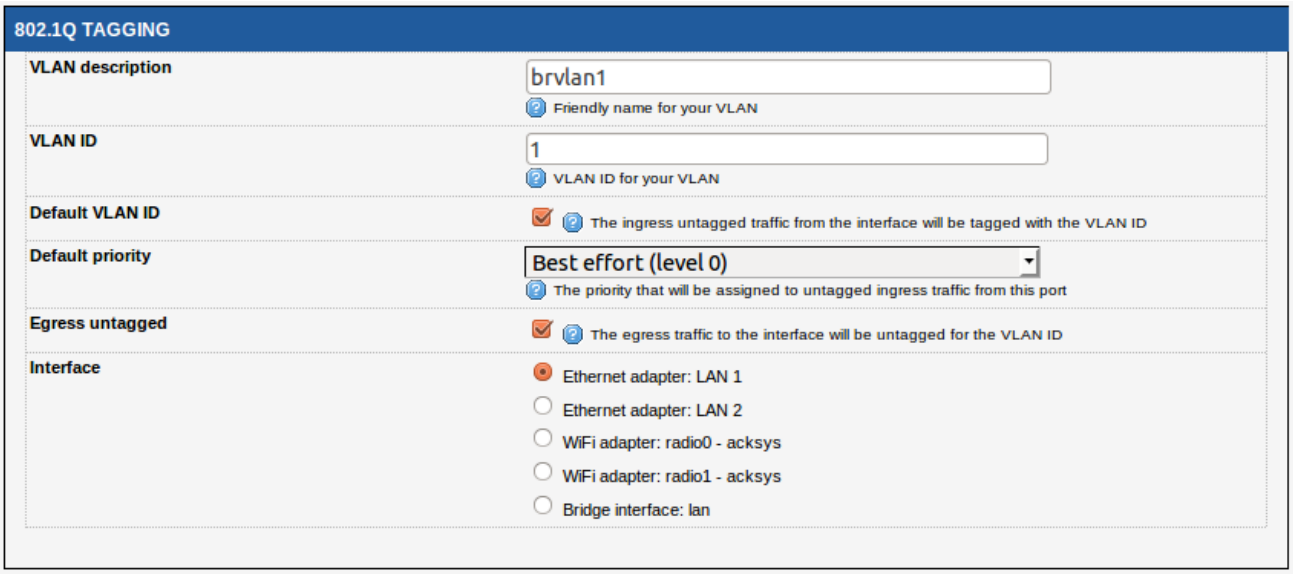
The overview lists all configured combinations of ports and VLANs.



Click on **Add tag** button to add VLAN configuration on one port.

Click the Edit button  to define or change the VLAN properties

Port configuration page



VLAN description:

Friendly name for the setting.

VLAN ID:

The VLAN ID.

Default VLAN ID:

If checked, all ingress untagged traffic will be placed in the VLAN. Only one VLAN per port can be the default.

Default priority:

Select the priority. This option is available only if default VLAN ID is checked.

Egress untagged:

If checked, the VLAN tag will be removed from the frame before forwarding.

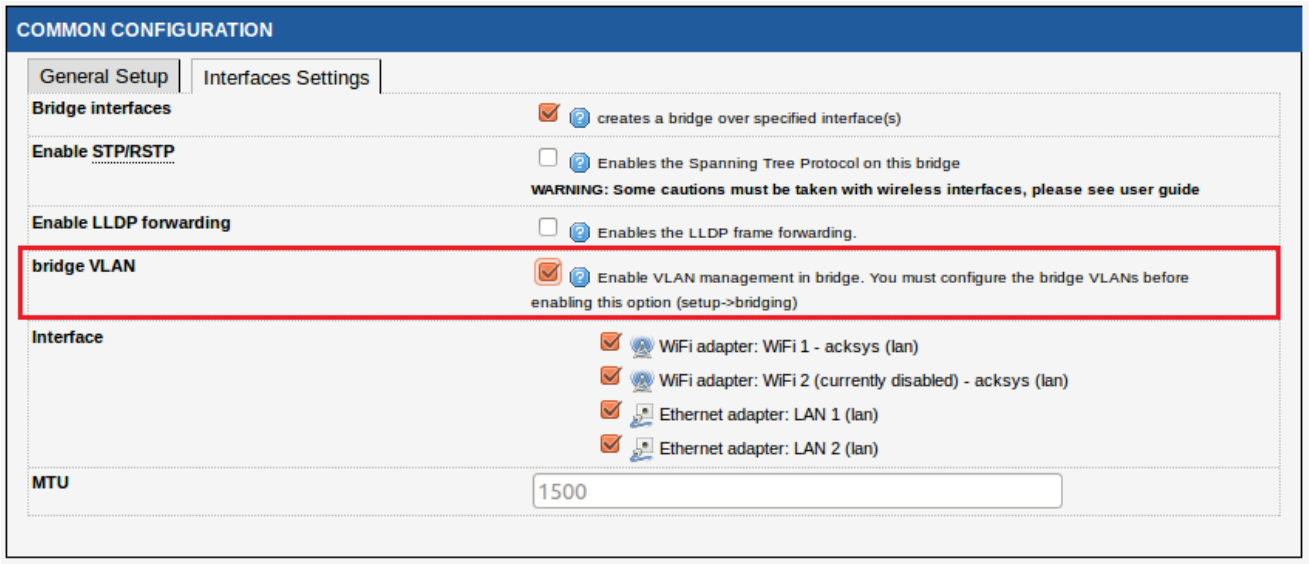
Interface:

Selects the port to apply the VLAN settings to.

All relevant VLANs should be configured on every interface of the bridge.

Enable the Bridging VLAN

You can enable Bridge VLAN in the submenu **NETWORK/Interface Settings**.



When you enable the Bridge VLAN, the untagged frames will be dropped for security reasons. All untagged frames should be placed in a specific VLAN by configuring a default VLAN on the originating port.

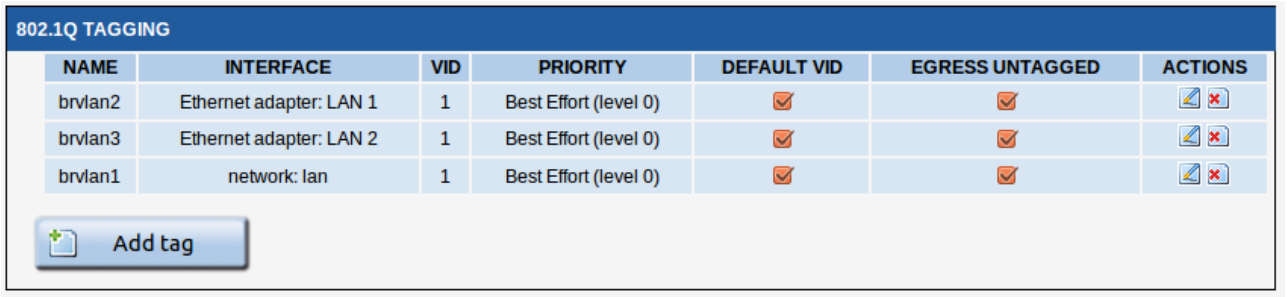
If you want to access the product through a port without VLAN tags:

Add VLAN on the **Bridge interface** itself (bridge upper layer interface), check **default VID** and **egress untagged** option on the required port

Add the same VLAN on all interfaces where you want access the product. Check the **default VID** and “egress untagged” option.

This VID value must not be in use by another VLAN (or its traffic will be mixed with non VLAN traffic).

The pictures below show a simple configuration to have a product access from LAN 1 or LAN 2 without VLAN.

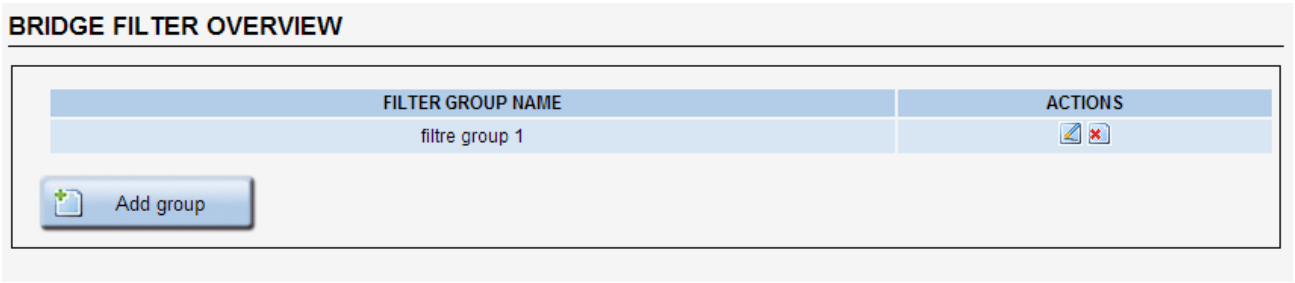


VI.1.6.3 Bridge filter

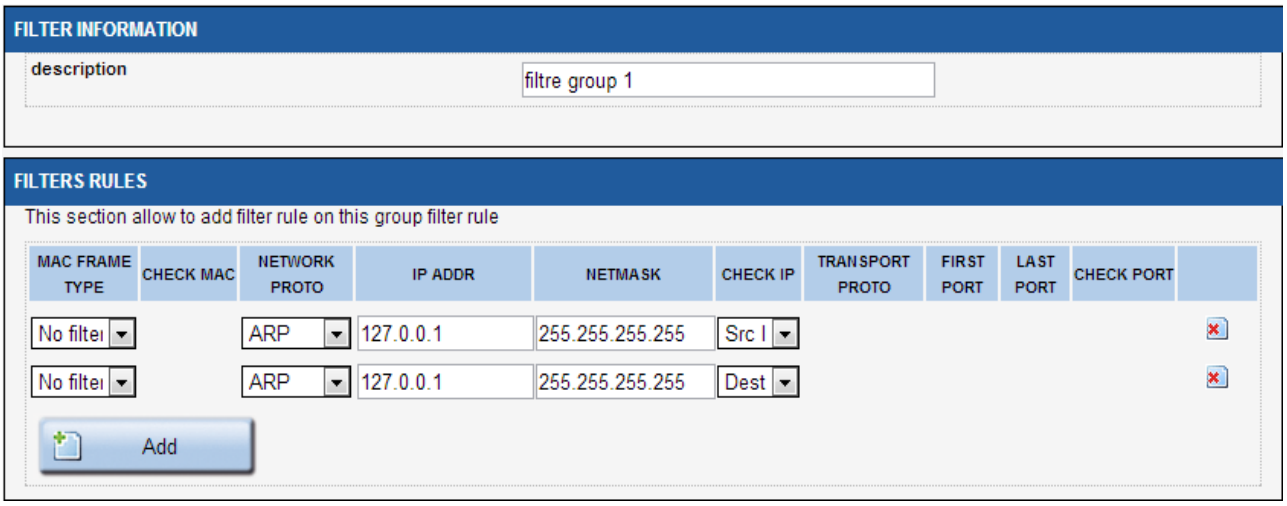
In this section you can manage layer 2 (link-level) filter groups.

Each filter group may contain several rules and may be affected to one or more Ethernet or Wireless interfaces, provided they are included in a bridge. The filter drops the frame if one rule matches in group.

Add group



Edit group



Description:

You can assign a symbolic name to the group.

Mac frame type:

Select the layer 2 frame type.

- No filter: No test on mac layer
- Unicast: Check if the frame is unicast type.
- Broadcast: Check if the frame is broadcast type.
- Multicast: Check if the frame is multicast type.

Check MAC:

This field is visible, only if Mac frame type is different from *no filter*

- Src Addr: Check the frame type on source MAC address field
- Dest Addr: Check the frame type on destination MAC address.

Network Proto:

Select the layer 3 protocol

- No filter: No test on Layer 3
- ARP: Check if it is an ARP frame
- IP: Check if it is an IP frame
- Custom: Enter the protocol number. For example, 0x800 for IP frame.

IP addr & Netmask

These fields are visible only if the Layer 3 protocol is set to IP or ARP.
With these fields you can select the par of IP address.

IP address	Netmask	Result
192.168.1.3	255.255.255.255	The frame match only for frame with IP address 192.168.1.3
10.10.0.0	255.255.0.0	The frame match for all IP address in 10.10.x.x
127.0.0.1	255.255.255.255	The frame match for the IP address assigned to the product on this interface

Check IP:

This field is visible only if the layer 3 protocol is set to IP or ARP.

- Dest IP: Check on the destination IP field in the frame. For ARP protocol the *Target IP address* field was used.
- Src IP: Check on the source IP field in the frame. For ARP protocol the *Sender IP address* field was used.

Transport proto:

This field is visible only if the layer 3 protocol is set to IP.

- UDP: Check if the transport protocol is UDP
- TCP: Check if the transport protocol is TCP
- ICMP: Check if the transport protocol is ICMP

First port & Last port

These fields are visible only if the transport protocol (Layer 4) is set to UDP or TCP.
Check if the frame used the port between first and last port.

Check Port

This field is visible only if the Transport protocol (Layer 4) et set to UDP or TCP.

- Src: Check on source port.
- Dest: Check on destination port.

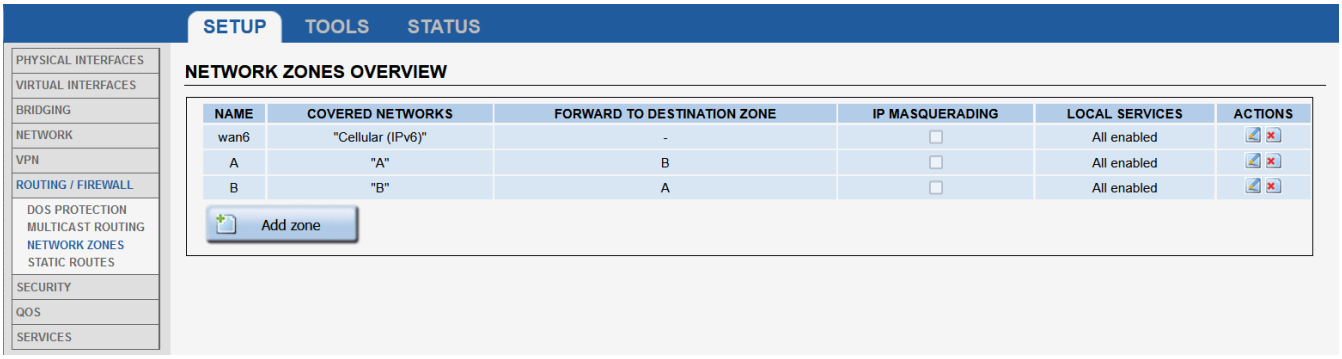
VI.1.7 Routing / Firewall

VI.1.7.1 Network zones

The routing rules are applied on a network zone. Zones are aggregates of networks which share the same forwarding rules. You can define zones and distribute networks between them. In each network zone you can:

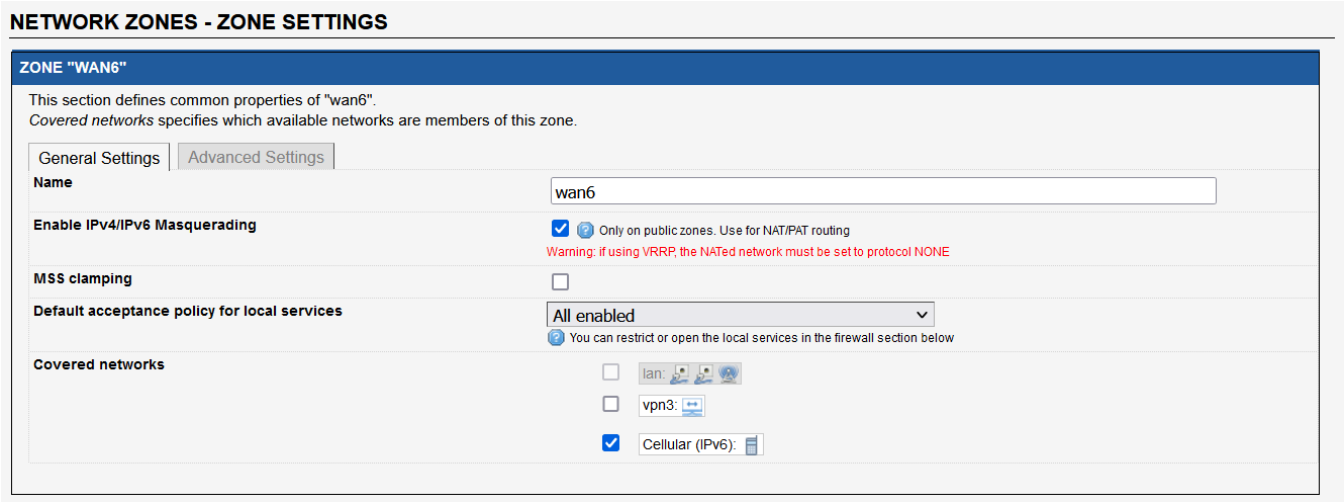
- Set the forwarding rules towards other zones
- Set the NAT/PAT filtering rules
- Set the NAT 1:1 translation rules
- Set the firewall rules

Zones Overview



Click the **Add zone** button to create a new zone.
Click the **Edit** button to open the zone configuration page.
Click the **Remove** button to remove the zone.

General Zones settings



Name:

Friendly name for the zone.

Enable IPv4/IPv6 Masquerading:

Enables NAT/PAT on this zone. Check this option only on zones which contains public interfaces for IPv4 or IPv6

MSS clamping:

Reduces the MSS (Maximum Segment Size) if the interface uses a smaller MTU.

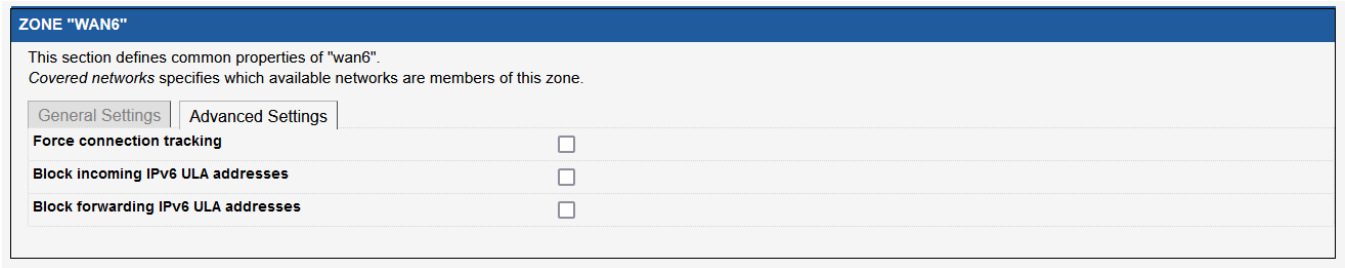
Default acceptance policy for local services:

Enables or disables the local services from this zone. You can restrict or open the local service in the firewall section.

Covered networks:

Select the networks covered by this zone by checking the relevant boxes.

Advanced Settings



Force connection tracking:

By default, the firewall disables the connection tracking for a zone if the NAT/PAT (IP Masquerading) is not enabled. Disabling the connection tracking increases the routing performance. Check this option to enable connection tracking on this zone. You should do this only with customized versions of the firmware that require it.

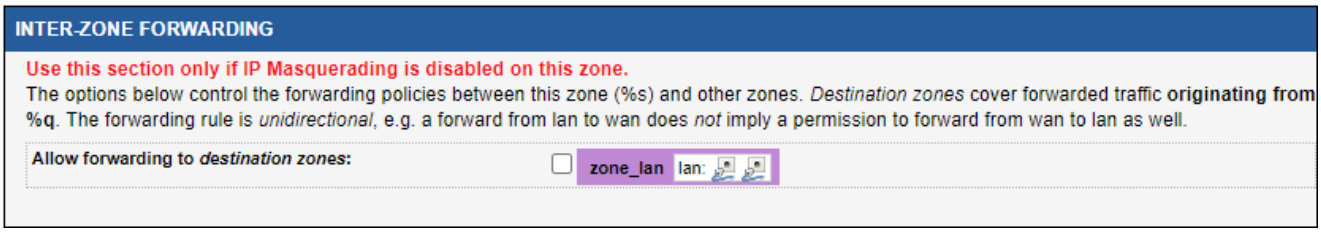
Block incoming IPv6 ULA addresses:

By default, the firewall disables IPv6 ULA addresses for a zone if the NAT/PAT (IP Masquerading) is not enabled.

Block forwarding IPv6 ULA addresses:

By default, the firewall disables forwarding IPv6 ULA addresses for a zone if the NAT/PAT (IP Masquerading) is not enabled.

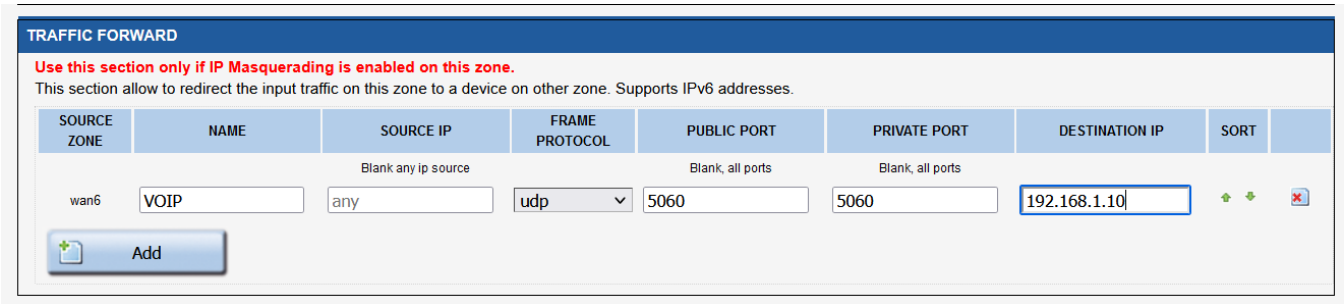
Inter-zone forwarding



This section is used only if IP Masquerading is disabled on this zone.

Select the zones where all traffic from this zone is forwarded without restriction. If you want to forward only part of the traffic, use the firewall section.

Traffic forwarding



Use this section to forward traffic to the private side when the NAT/PAT (IP Masquerading) is enabled. For each frame received by this zone with matching source IP, frame protocol and public destination port, the frame's destination port and destination IP address will be rewritten as specified.

Name:

Rule name. You can assign a symbolic name to the rule.

Source IP:

Sets the expected source IP of the input frame. If this field is blank, any IP match.

Frame Protocol:

Sets the expected protocol type: UDP, TCP, TCP & UDP or all.

Public port:

Sets the expected destination port of the input frame on this zone. You can specify either a single port or a port range (using a dash "- "between the starting and ending ports). If this field is blank, any port will match.

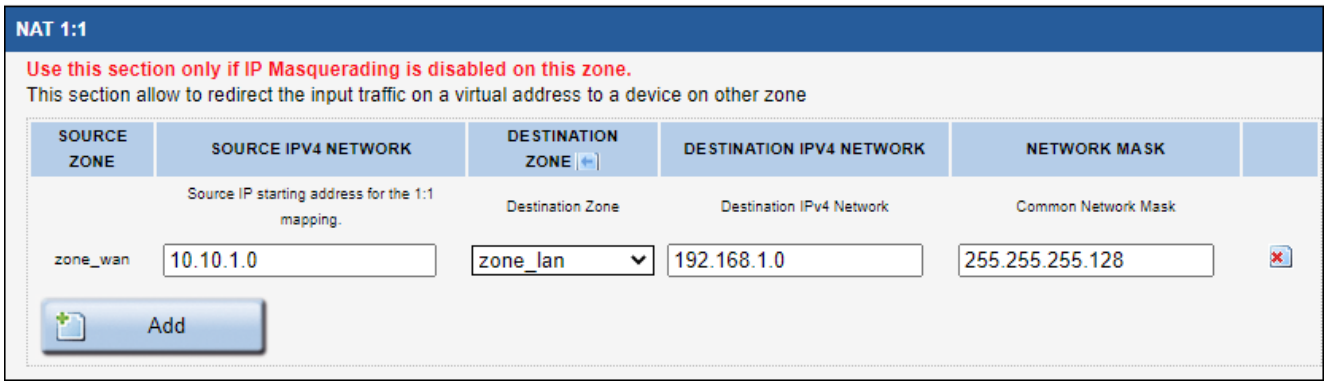
Private Port:

The NAT/PAT will replace the original destination port by this private port in the frame before sending it on the private side. If this field is blank, the port (or port range) is left unchanged. If a public port range is used, the private port must be a port range of the same width.

Destination IP:

The NAT/PAT will replace the original destination IP address by this private IP address in the frame before sending it on the private side. **This field cannot be blank**.

NAT 1:1



Use this section to define the virtual IVPV4 networks that will be used to forward traffic from the source zone to the defined destination zone network. IP Masquerading must be disabled to use NAT1:1.

Source IPV4 Network:

Define the starting virtual address used for the 1:1 mapping.

Destination Zone:

Select here the destination zone among the different zones previously created.

Destination IPV4 Network:

Define the physical destination IPV4 Network. This subnet must be accessible in the destination zone.

Network Mask:

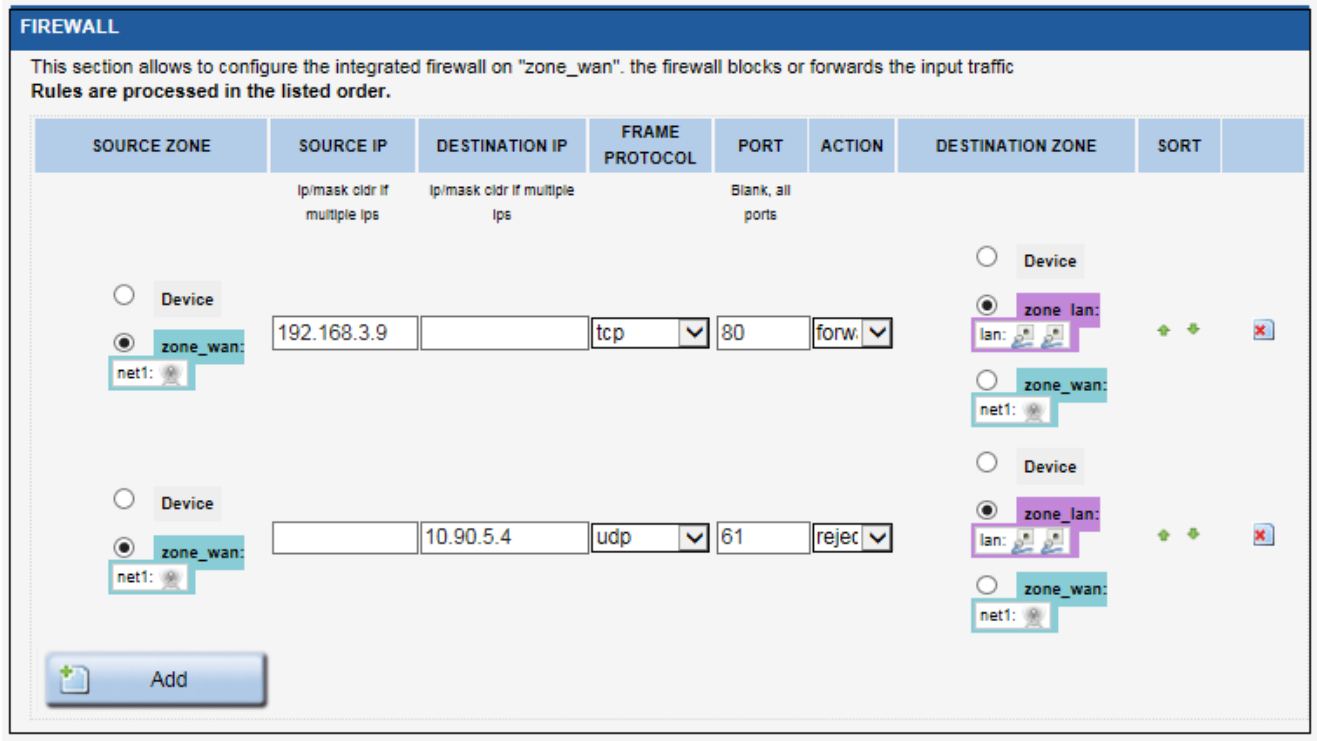
The network mask defines the size of the translated network:

255.255.255.255	⇨	1 translated IP addresses
255.255.255.192	⇨	64 translated IP addresses
255.255.255.128	⇨	128 translated IP addresses
255.255.255.0	⇨	256 translated IP addresses
255.255.0.0	⇨	65 536 translated IP addresses
255.0.0.0	⇨	16 777 216 translated IP addresses

Please note that, on the source network, it is necessary to define the router as the default gateway, or to create a static route to the router, to be able to access the translated subnets of the destination zone.

On the destination networks, the return path to the source network must also be defined in the same way. Creation of IP aliases may be required for this purpose.

Firewall



This section it used to restrict or allow the use of services provided on the device (locally in the product) or in another zone.

Source IP:

The IP source address of the packets to be filtered.

Destination IP:

The IP destination address of the packets to be filtered.

Frame protocol:

The protocol type: TCP, UDP, TCP & UDP, ICMP, GRE, all

Port:

The destination port of the traffic. The port identifies the service.

Action:

One of:

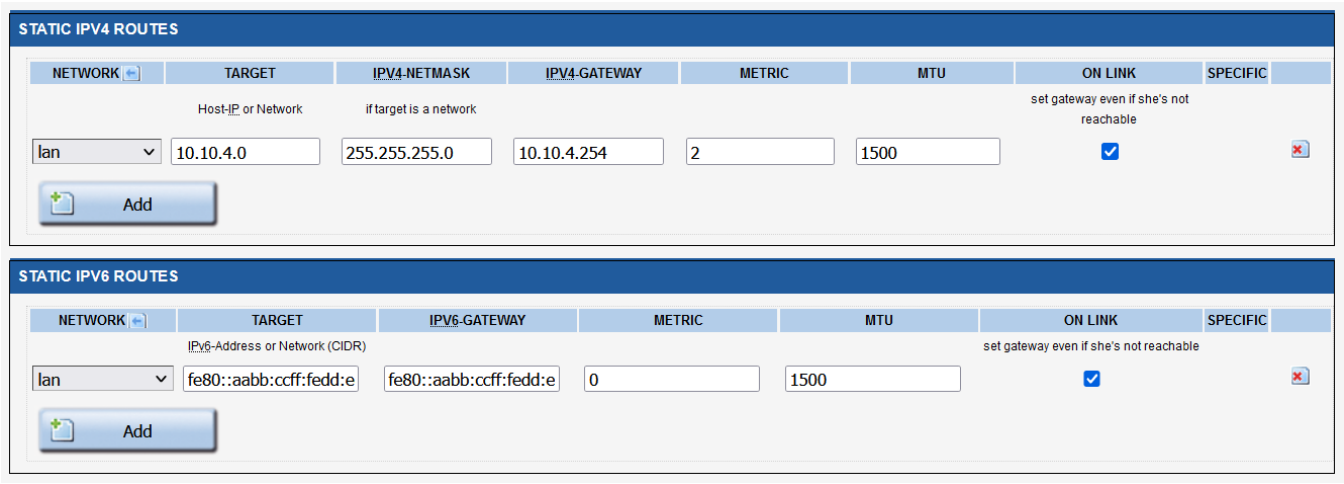
Forward:	Forward traffic to the destination zone or device
Reject:	Drop packet and send ICMP message to the traffic source
Drop:	Drop packet without ICMP message.

Destination zone:

Zone where traffic will be forwarded.

VI.1.7.2 Static routes

In this section you can add a static route in the device.



Target:

Destination host or network IP address.

IPv4/IPv6-netmask:

If the target is a network, you must set this field to the correct netmask.
If the target is a host, you can leave this field blank.

Metric:

Sets the metric for this route. Leave blank to use the default of 64.

MTU:

Set the MTU for this route. Leave blank to use the computed value.

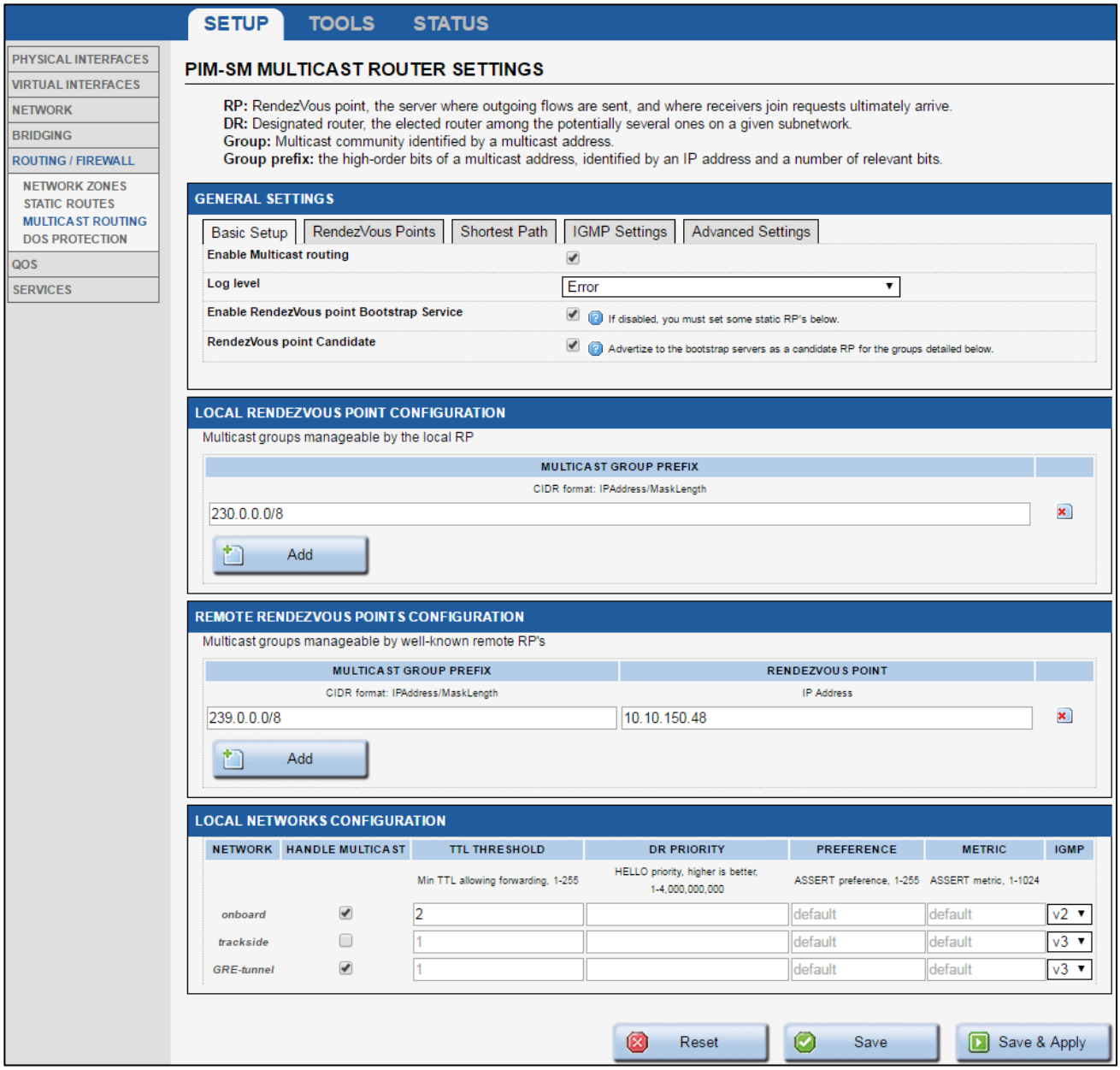
Specific:

This column indicates the static routes that are automatically created by network services.

WARNING: modifying/deleting routes marked as SPECIFIC could prevent corresponding services to work properly.

VI.1.7.3 Multicast routing

In this page you configure the PIM-SM multicast router.



The **General settings** section sets various router options.

The **Local rendezvous points configuration** section sets the list of multicast groups that this device is willing to handle as their rendezvous point.

The **Remote rendezvous points configuration** section associates groups to remote rendezvous points addresses, so that this device does not need a BSR to provide this association.

The **Local networks configuration** lists the local network interfaces available for multicast routing. It is a mirror of the list in the **setup/network** overview page. It allows disabling some interfaces, or changing various performance details.

General settings Basic setup tab

Enable multicast routing:

Check this to enable the multicast router and all the dependent functionalities.

Log level:

Ajdusts the quantity of messages sent to the system log. Warning: the system log must be set to at least the same level in order to handle the messages.

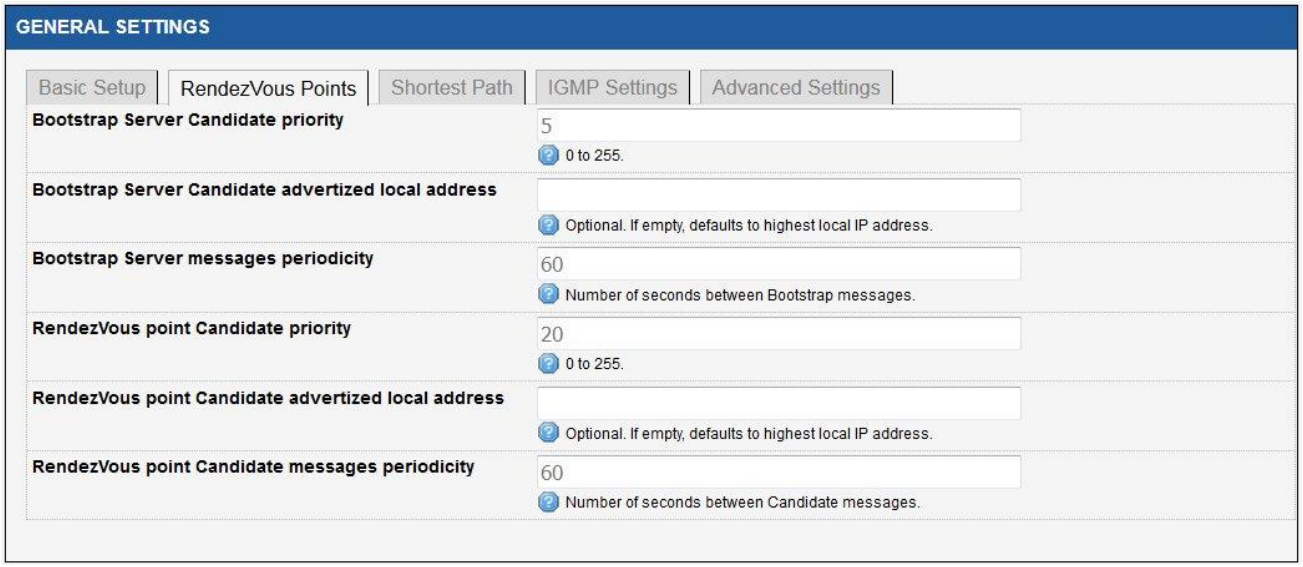
Enable Bootstrap Service:

Check this to allow this device to be a BSR candidate.

RendezVous Point candidate:

Check this to allow this device to be a RP for the groups listed in the **local rendezvous point configuration** section.

Rendezvous Points tab



BSR candidate priority:

Priority in election process if several candidates are present (highest priority wins).

BSR local address:

Routers are multi-homed, they have several IP addresses. This is the IP address that will be used for the purpose of the BSR protocol. Leave blank to use the default value which is the highest IP address of the enable interfaces.

BSR message periodicity:

Also called [BS_Period]. Association between a multicast group and its RP is cached in the routers. The duration of this cache is normally 2.5 times the periodicity of RP messages (allowing to lose two messages over 3). But if this duration is smaller than [BS_Period], it will be adjusted to 2.5 x [BS_Period] to respect RFC5059 constraints

RP candidate priority:

Priority in election process if several candidates are present (highest priority wins).

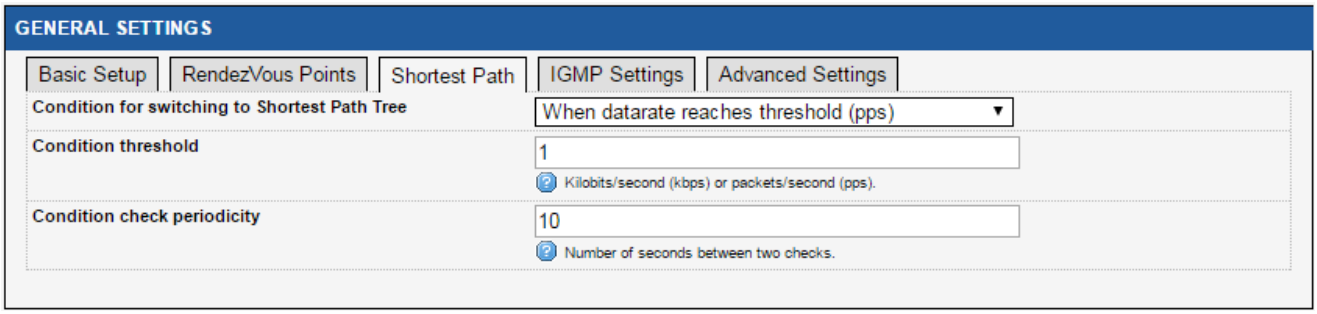
RP local address:

Routers are multi-homed, they have several IP addresses. This is the IP address that will be used for RP election in the BSR protocol. Leave blank to use the default value which is the highest IP address of the enable interfaces.

RP candidate messages periodicity:

Duration between two successive **RP-Cand** PIM messages (advertising willingness to handle configured groups).

Shortest path tab



Condition for switching:

switching the path from RP traversal to shortest can be triggered when throughput exceeds a configured value. Choose the trigger type: it can be **never** (no switching), or expressed in packets per second or bits per second.

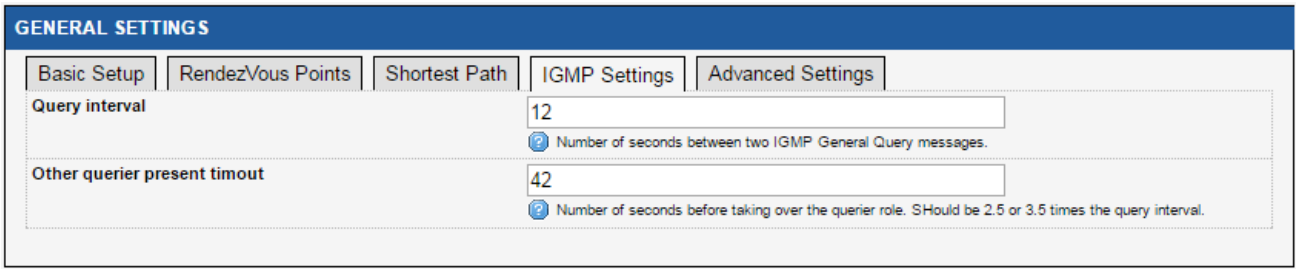
Condition threshold:

which throughput will trigger the switch to SPT. The unit depends on the above choice.

Condition check periodicity:

the maximum delay between the time the trigger condition becomes true and the time the SPT switch is initiated.

IGMP settings tab



Condition threshold:

which throughput will trigger the switch to SPT. The unit depends on the above choice.

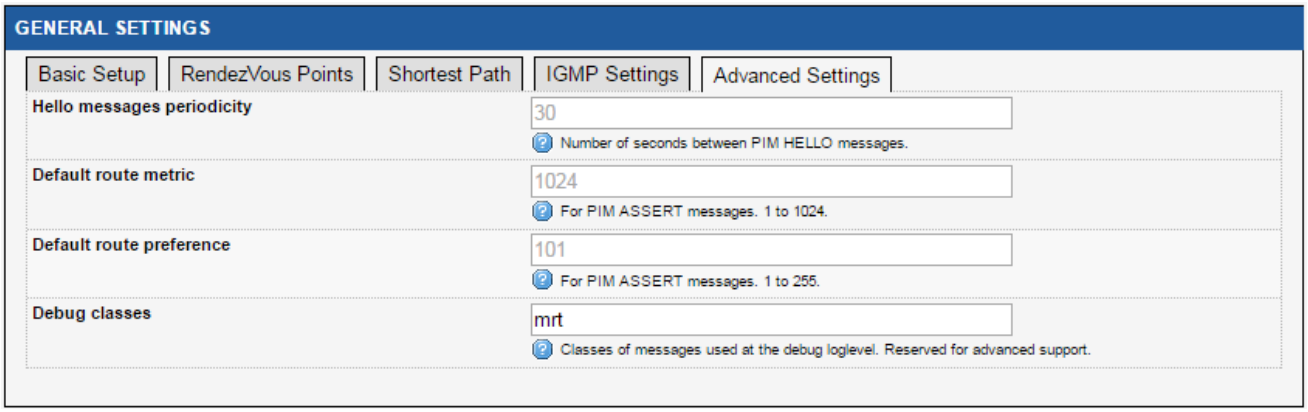
Query interval:

the delay between two successive IGMP queries.

Other querier present timeout:

the delay after the last IGMP query was seen on a network interface, before this router takes over the IGMP querier role on this interface, in the assumption that the previous querier went down.

Advanced settings tab



Hello periodicity:

duration between two successive “HELLO” PIM messages (advertising existence and priority of a PIM router).

Default route metric:

the route metric value sent in ASSERT messages if no metric is set for the network interface where ASSERT is sent.

Default route preference:

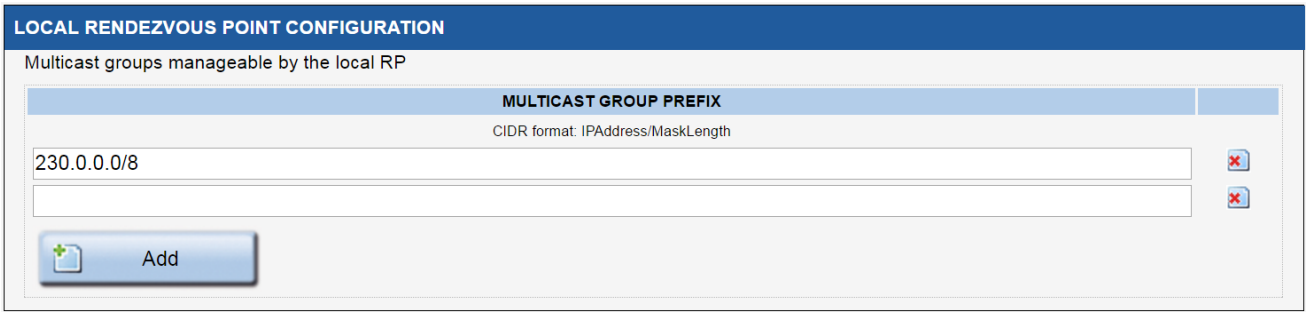
the preference metric value sent in ASSERT messages if no preference is set for the network interface where ASSERT is sent.

Debug classes:

when the log level is set to “Debug”, this comma-separated field indicates the classes of debug messages sent to the log. This field is reserved for advanced technical support.

Local rendezvous point configuration

Here you enter the list of groups for which this router plays the rendezvous point role.



ADD button:

click here to add a new block of groups.

Red cross buttons:

click here to delete a block of groups.

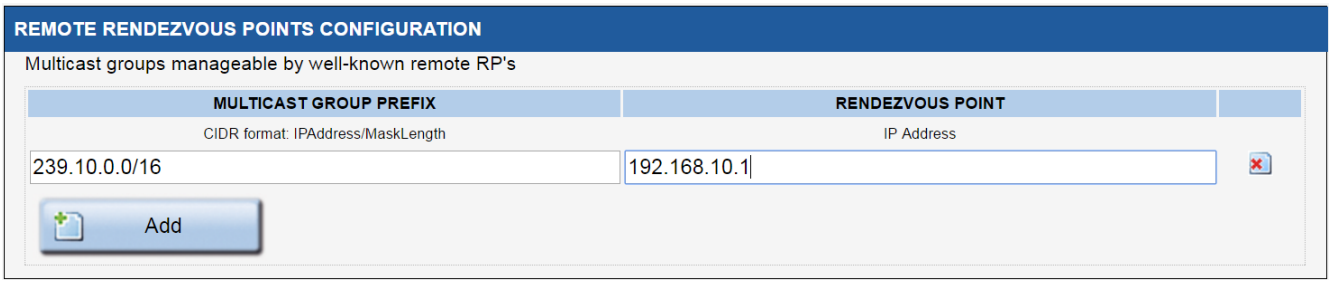
Multicast group prefix:

in each line, write the prefix (the common beginning) of group IP addresses, followed by a “/” and the number of significant bits in the prefix.

This router will handle all groups beginning with one of the prefixes in the list.

Remote rendezvous points configuration

Here you list groups that are handled by a remote RP but you cannot rely on a BSR to advertise it. BSR is still used for other groups.



ADD button:

Click here to add a new block of groups.

Red cross buttons:

click here to delete a block of groups.

Multicast group prefix:

the common beginning of group IP addresses, followed by a "/" and the number of significant bits in the prefix.

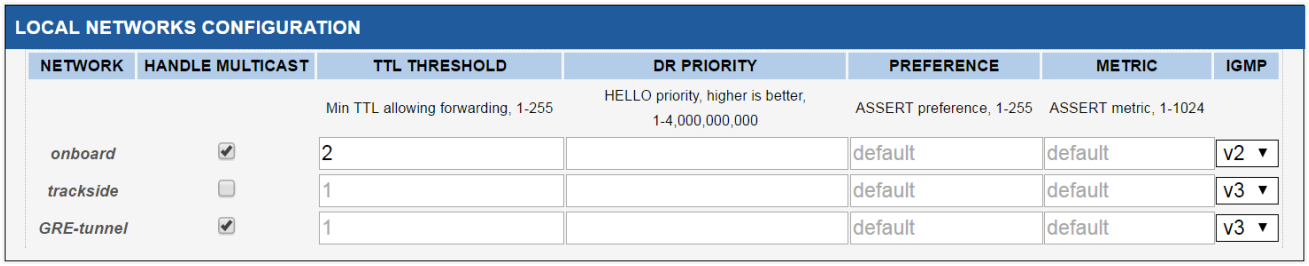
Rendezvous point:

enter the address of the rendezvous point managing this group block.

This router preloads the list at startup and uses these associations to find the remote RP for the designated groups. For the purpose of RP election, these static associations have a priority of 1 (highest).

Local networks configuration

Here you give parameters related to each network interface.



Network: the friendly name of the network interface.

Handle multicast:

whether the PIM router will ignore this network.

TTL threshold:

drop outgoing multicast data with a lower TTL.

DR priority:

this router's priority for Designated Router election on this network.

Preference:

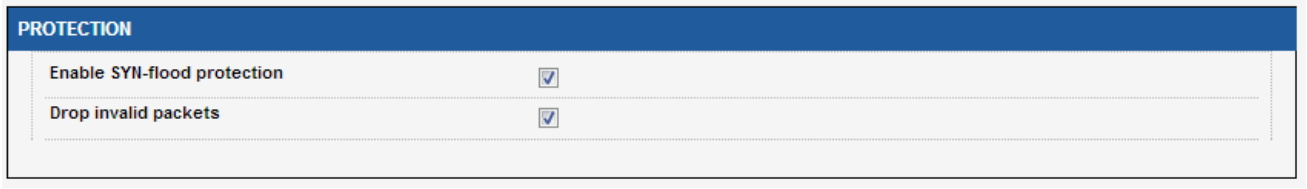
the preference metric value sent in ASSERT messages. Defaults to the value set in the **advanced settings** tab.

Metric:

the route metric value sent in ASSERT messages; represents the distance between this router and the RP being targeted. Defaults to the value set in “advanced settings” tab.

IGMP: set to **v2** to enforce IGMPv2 compatibility.

VI.1.7.4 Denial Of Service (DOS) protection



Enable SYN-flood protection:

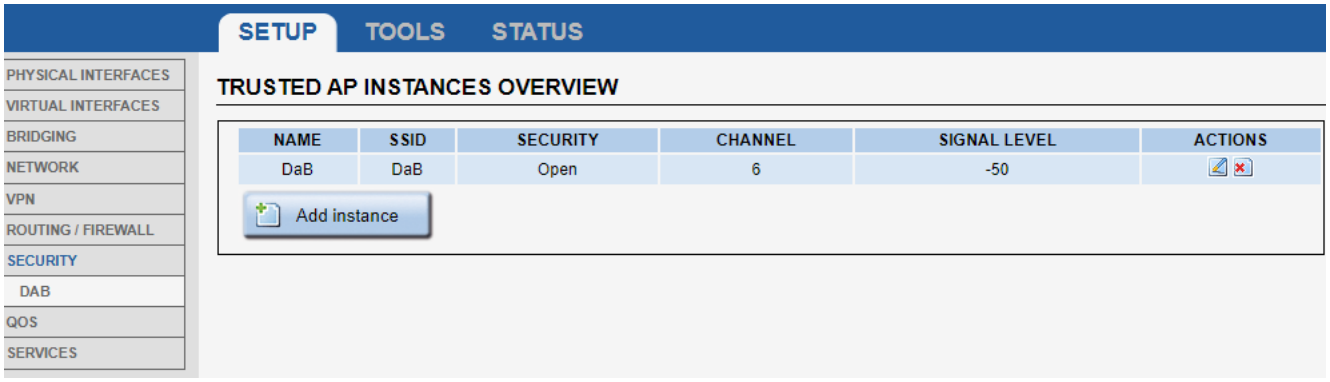
The syn-flood attack consists in filling the victim’s resources by creating many half-opened connections. It is explained in details on *http://en.wikipedia.org/wiki/SYN_flood*

Drop invalid packets:

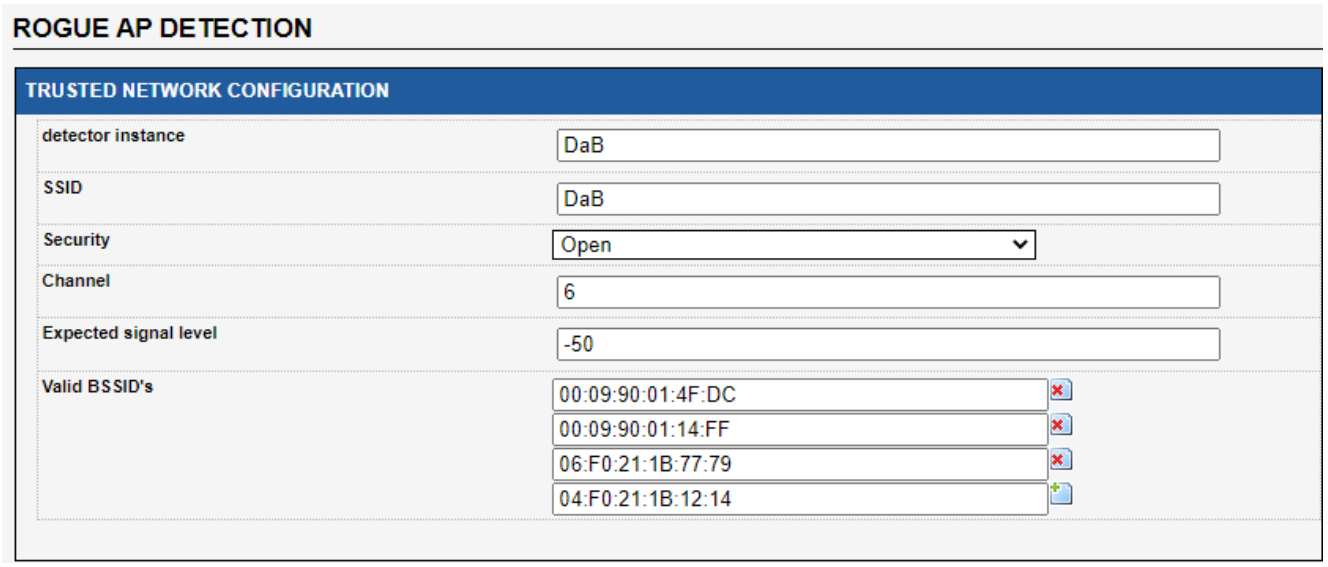
Drop invalid frames or frames without active connection.

VI.1.8 Security

This page allows to create a Rogue AP Detector instance



To create a new Rogue AP Detector instance, click on **Add instance**, this will open the Rogue AP Detection configuration page.



Detector Instance

This is the friendly name you give to this Rogue AP Detector instance.

SSID

The SSID to monitor.

Security

The security mode applied on this SSID.

Channel

The channel to monitor.

Expected signal level

The minimum signal level the monitoring radio card must measure.

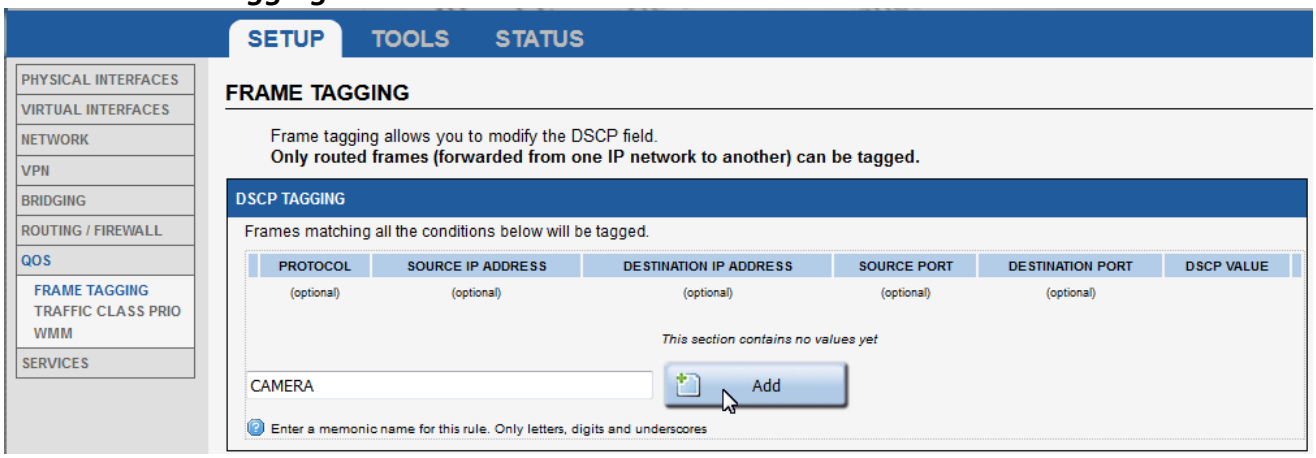
Valid BSSID's

The list of BSSIDs (MAC addresses) of all the APs allowed to emit this SSID.

For more details on this functionality, please consult section Rogue AP detector

VI.1.9 QOS

VI.1.9.1 Frame tagging



The DSCP tag applies on each incoming frame (from any interface) that matches the following criterions:

PROTOCOL

The IP protocol type. This can be TCP, UDP or ICMP.

SOURCE IP ADDRESS

The source IP address of the incoming frame. Wildcards are not allowed.

DESTINATION IP ADDRESS

The destination IP address of the incoming frame. Wildcards are not allowed.

SOURCE PORT

The source port of the incoming frame. This parameter is valid for TCP & UDP protocols only (see above). You can specify either a single port or a port range

DESTINATION PORT

The destination port of the incoming frame. This parameter is valid for TCP & UDP protocols only (see above). You can specify either a single port or a port range

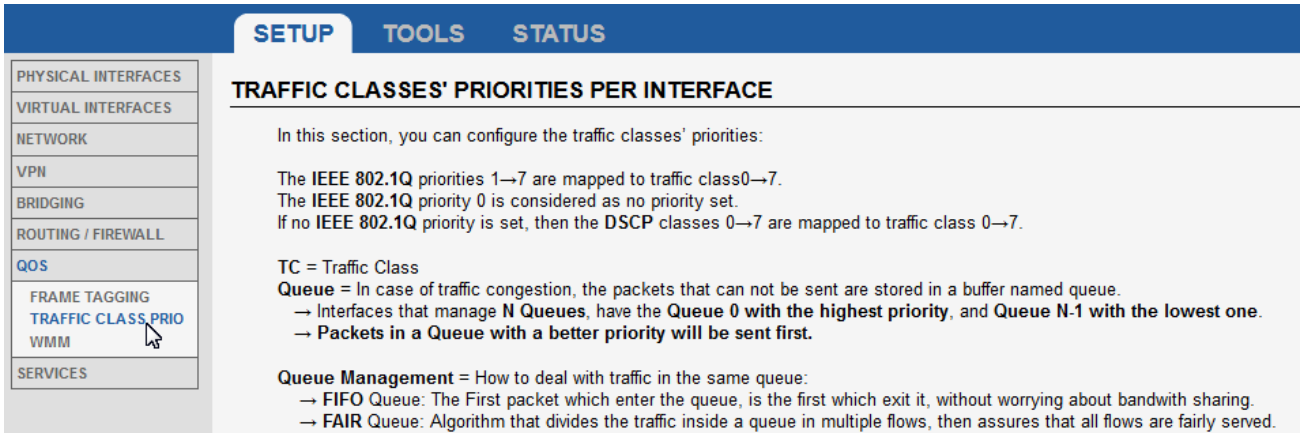
DSCP VALUE

The value to be written in the DSCP field (6 bits) of the IP frame.
You can use the following table to set WMM valid tags:

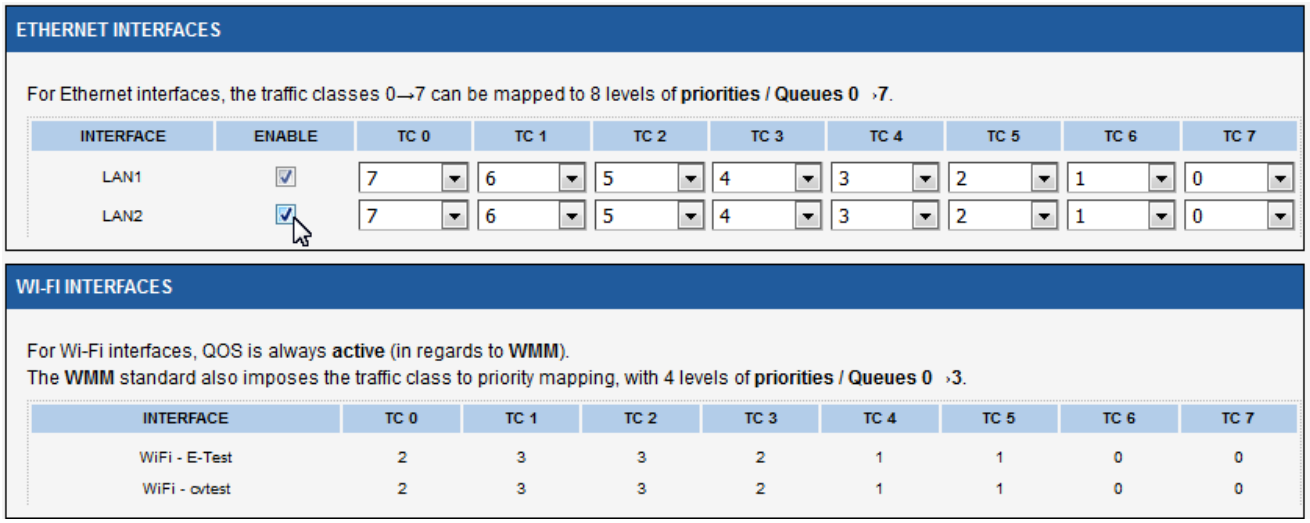
WMM valid tags	
DSCP field value	***WMM Queue***
8 or 16	Background (BK)
0 or 24	Best effort (BE)
32 or 40	Video (VI)
48 or 56	Voice (VO)

VI.1.9.2 Traffic Class Priorities

This submenu allows configuring the QoS traffic class management.

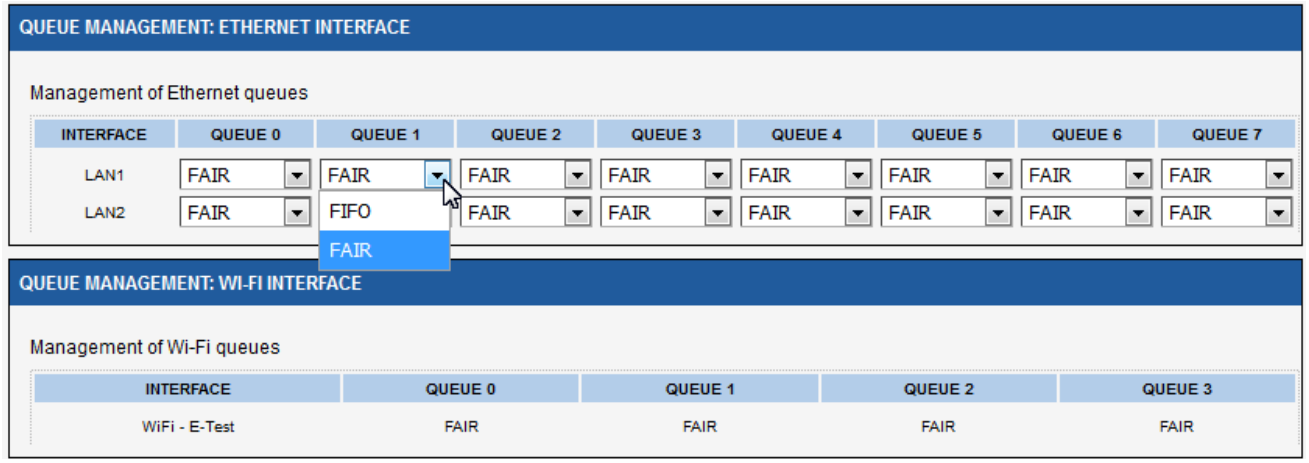


Traffic Class to queue mapping



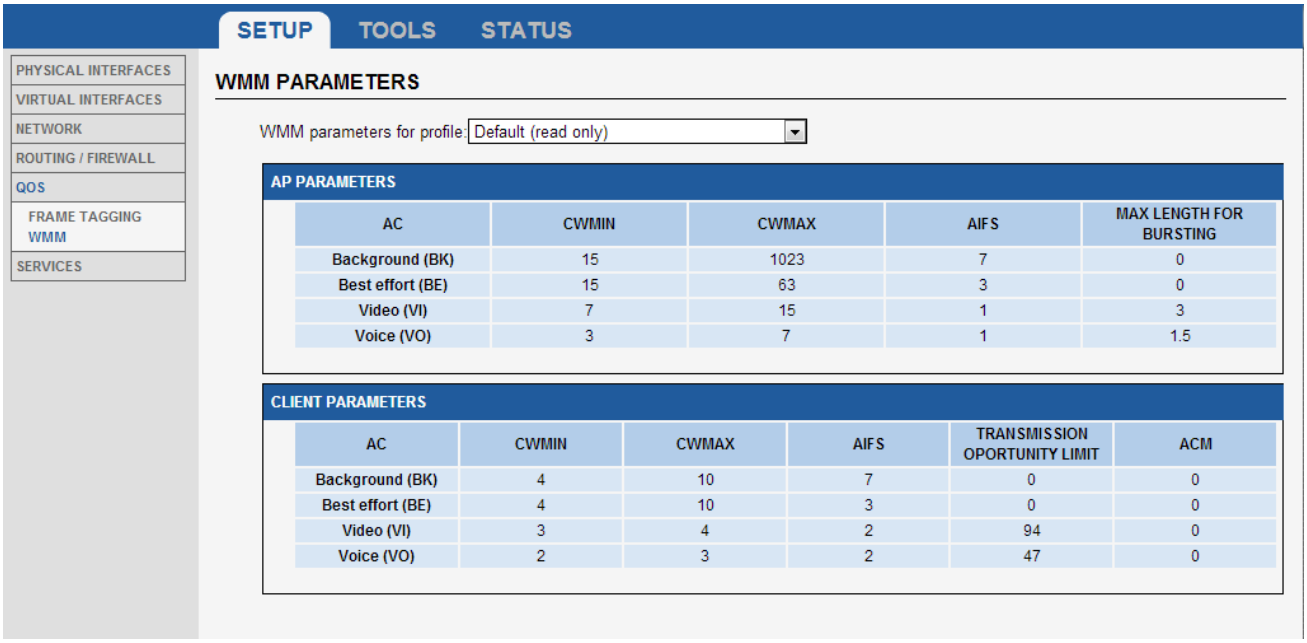
To map a traffic class to a given queue/priority, check the **enable** box and select the Queue number for each TC_x traffic class. For Wi-Fi interfaces, WMM is always active and the queue mapping is imposed and cannot be changed

Queue management



To select the queue management type, select the queue type for each **QUEUE n**

VI.1.9.3 WMM



The page displays the WMM parameters for the selected profile. WMM (a.k.a. WME) is always available.

WMM parameters for profile

This listbox allows you to select **User** or **Default** QoS parameters. Default QoS parameters are given for reference and cannot be modified.

AP PARAMETERS:

This table allows you to change the WMM parameters for the four Access Point Tx queues (BK, BE, VI, VO).

CWMIN

Defines the minimum contention window size (expressed in number of time slots). Allowed values are 1, 3, 7, 15, 31, 63, 127, 255, 511, 1023.

CWMAX

Defines the maximum contention window size (expressed in number of time slots). Allowed values are 1, 3, 7, 15, 31, 63, 127, 255, 511, 1023.

AIFS

Defines the arbitration inter-frame spacing value for the current queue size (expressed in number of time slots). Allowed values are 0 to 255.

MAX LENGTH FOR BURSTING

Defines the maximum burst length (expressed in milliseconds with precision of 0.1 ms). Allowed values are 0 to 100000ms.

CLIENT Parameters:

This table allows you to change the WMM parameters sent by the CLIENT in its management frame.

CWMIN

Defines the minimum contention window size (expressed in number of time slots). Allowed values are 0 to 12.

CWMAX

Defines the maximum contention window size (expressed in number of time slots). Allowed values are 0 to 12.

AIFS:

Defines the arbitration inter-frame spacing value for the current queue (expressed in number of time slots). Allowed values are 1 to 255.

TXOP_LIMIT:

Defines the tx opportunity limit duration (expressed in number of time slots). Allowed values are 0 to 65535.

ACM:

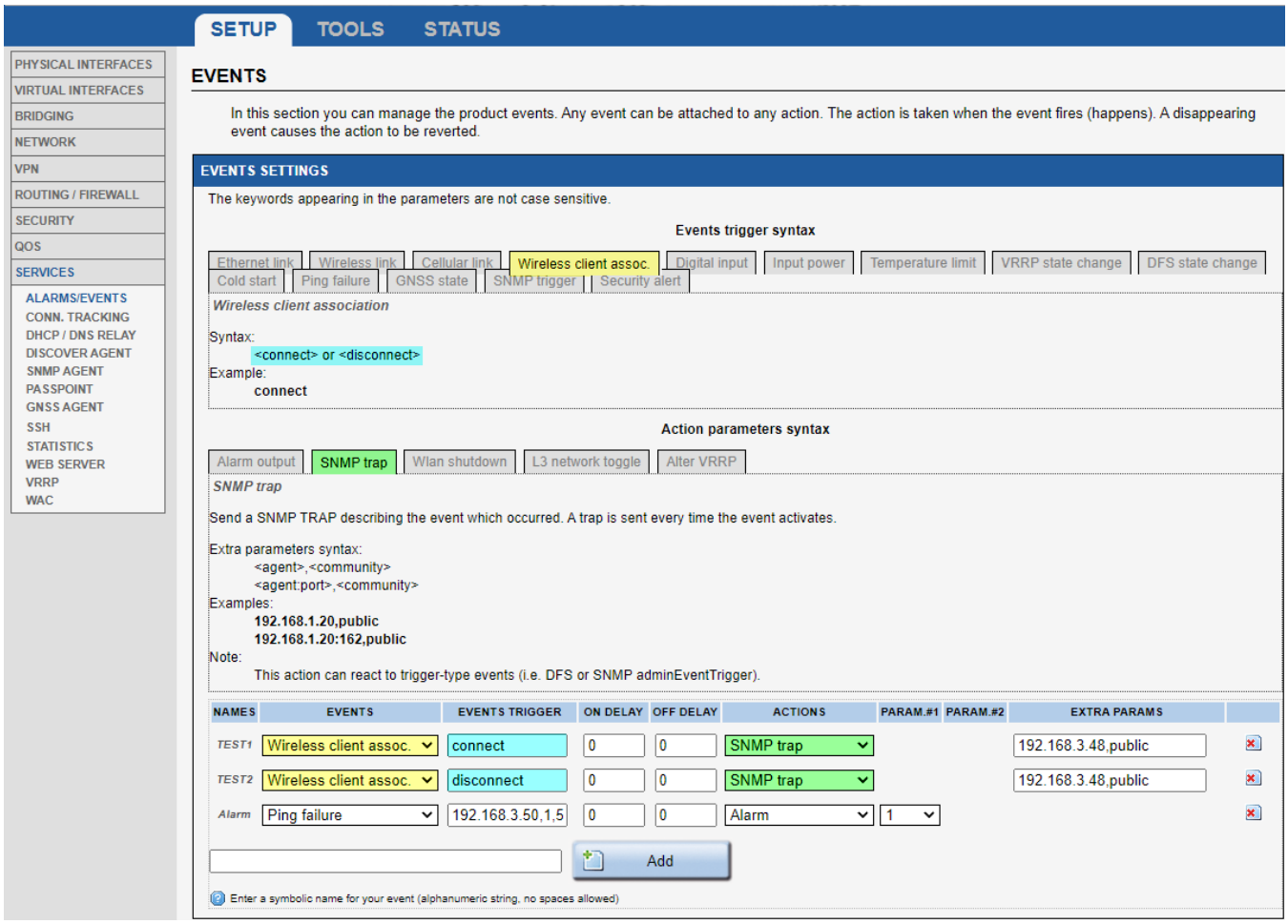
Defines the Admission Control Mandatory for the current queue. Allowed values are 0 and 1.

VI.1.10 Services

VI.1.10.1 Alarms / events

This page allows you to monitor various events in order to trigger actions. Using the **Add** button, you can define several triggers and give them mnemonic names.

Once trigger names have been created, you can set their event source and their associated action. The event source and the action may need extra parameters depending on their type. A summary help is displayed above the events table.



Enter a symbolic name for your event and click the Add button to add a new entry.

Events:

Ethernet link: The state is up when the link is up on the physical interface.

Wireless link (in Access Point mode): The state is up when one client is connected on any of the access points running on the product.

Wireless link (in Client mode): The state is up when the bridge is connected to one Access point.

Cellular link (only with LTE products): The state is up when the cellular link is established.

Wireless client assoc: The event can be linked only with the **SNMP trap** action. It sends a notification when a client associates or dissociates with one access point.

Digital input (Only on product with digital input): The state is 1 when the digital input is active. Some products, such as the Airbox, have several Digital Input.

Input Power (Only on product with 2 input powers): The state is on, when the input power is powered.

Temperature limit: The event is triggered when the temperature exceeds the trigger.

VRRP state change: The event is triggered when VRRP state enters or leaves the given value.

DFS state change: The event is triggered when the DFS status changed

Cold start: The event is triggered when the product has finished booting.

Ping Failure: An ICMP ECHO Request (ping) is periodically sent to a remote host. If no ICMP ECHO Response is received for several consecutive periods, the event is triggered.

GNSS state (only with LTE products): The event is triggered when the GNSS position stabilizes and can be queried. It deactivates when the position fixing is lost.

SNMP trigger: The event is triggered by the following SNMP OIDs:

adminEventEnable	enables action for the named alarm
adminEventDisable	disable action for the named alarm
*adminEventTrigge*r	execute action for the named one-shot alarm

The name of the alarm to use as argument is the symbolic name defined when you create the event (column “NAMES”).

Security alert: This event is intended to notify the user when the product firmware detects a security threat. Currently only **Rogue AP detection** service is implemented. This event doesn’t need to be disabled; it is fired as often as necessary.

Depending on the product model, some event sources may be marked as *Not available*. Please note that an **Event/Alarm** created with a *Not available* event source will never be triggered

Actions:

Alarm output: This action only exists in some products. Some products, such as the Airbox, have several digital outputs that can be programmed as alarms. When triggered, the alarm contact will be activated as specified in the product *quick installation guide*.

SNMP: The **SNMP Trap** action, when triggered, will send the relevant trap to the specified manager address using the specified community.

Wlan shutdown: the **Wlan shutdown** action, when triggered, will shut down the associated radio interface.

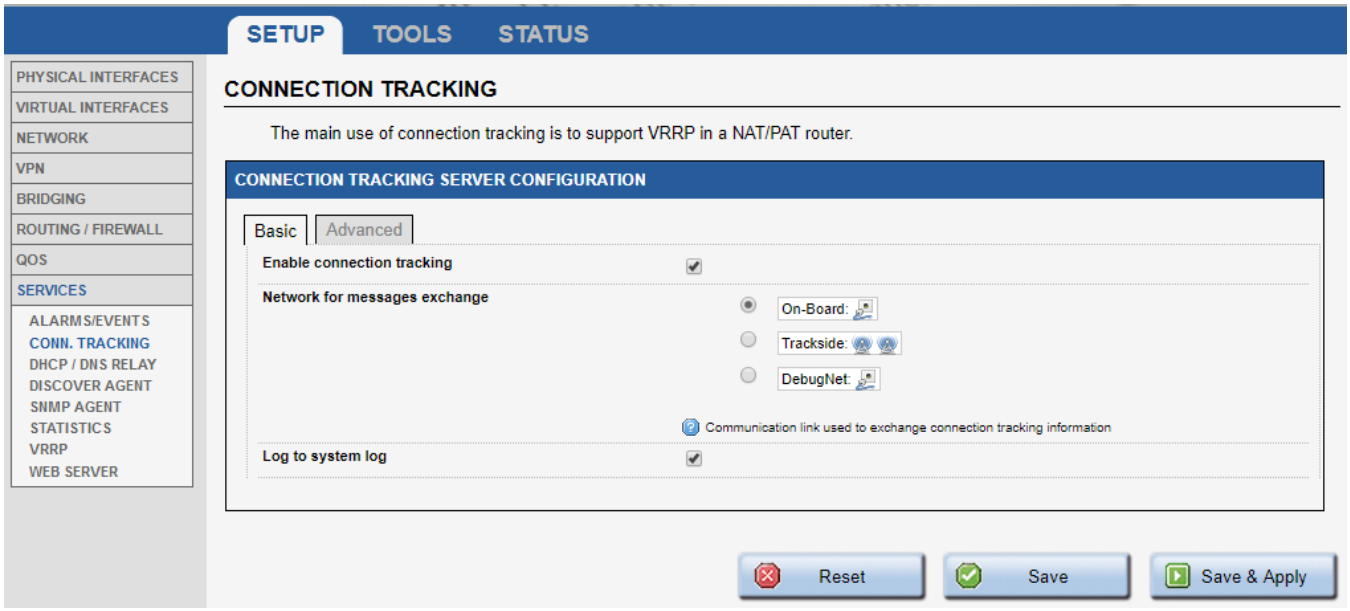
L3 network toggle: switch the specified network up or down

Alter VRRP: This action allows priority of a VRRP group to be changed, by applying the offset parameter to the current priority of the VRRP group, and then can be used to causes a switch over from the MASTER to the BACKUP. It is in principle triggered by an SNMP trigger.

VI.1.10.2 Connection tracking

This page enables the connection tracking and replication service.

When connection tracking is required in the VRRP configuration page, you must enable and configure it here.



Basic tab

Enable connection tracking:

this enables the connection replication service.

Network for messages exchange:

network device used to send connection descriptions to the backup router. You can use either a subnet used by VRRP, or a dedicated network. Since this link must be reliable, a dedicated link is preferred, and a wired link is preferred over a wireless link.

Log to system log:

event messages are sent to the system log to be read later by an administrator.

Advanced tab

Multicast IPv4 address:

the multicast destination address used to send connection replication messages. It can be changed if some other user application uses the same multicast address.

Conntrack group:

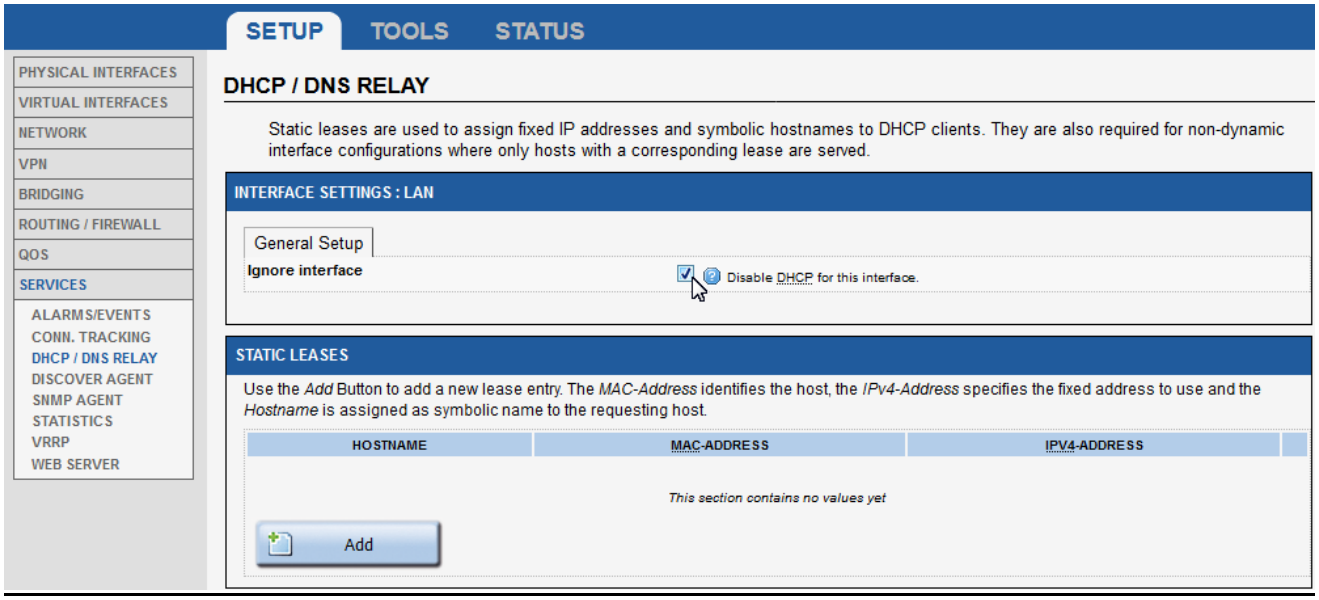
the replication service uses a standard protocol named conntrack. If several instances of this service exist in other devices of the subnet, you can tag messages for your backup by dedicating a “group number”.

Process priority:

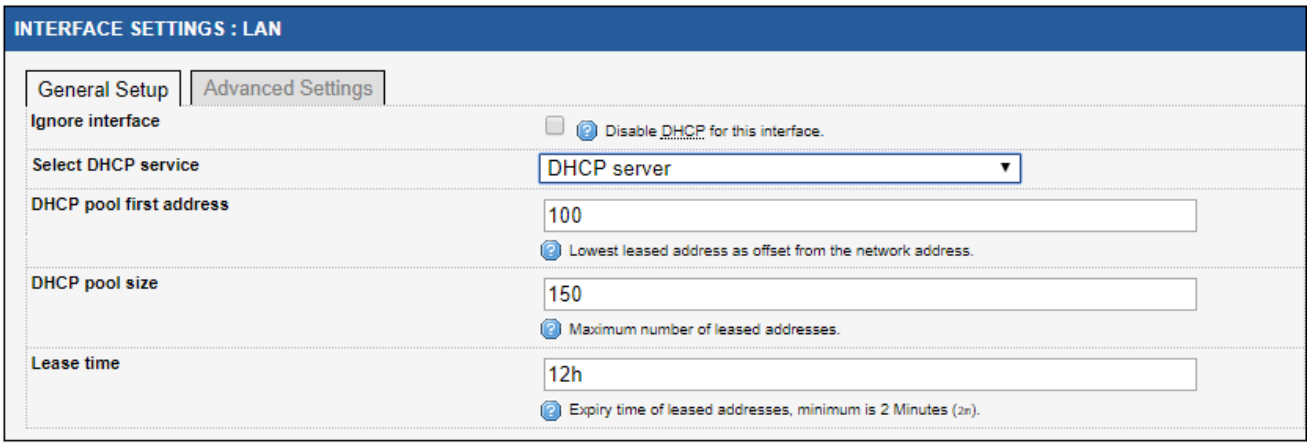
the higher the priority, the faster the replication, but also the higher the network load dedicated to replication. Also, a high priority with many connections may adversely affect the roaming delay.

VI.1.10.3 DHCP/DNS RELAY

To activate service DHCP server or DHCP relay, uncheck the **Ignore Interface** box:



Interface settings: DHCP Server General Setup:



Select DHCP service:

Allows to choose service DHCP server or DHCP relay. Default is DHCP server

DHCP pool first address:

First IP address of the DHCP pool. ATTENTION: this is interpreted as an offset relative to the network address.

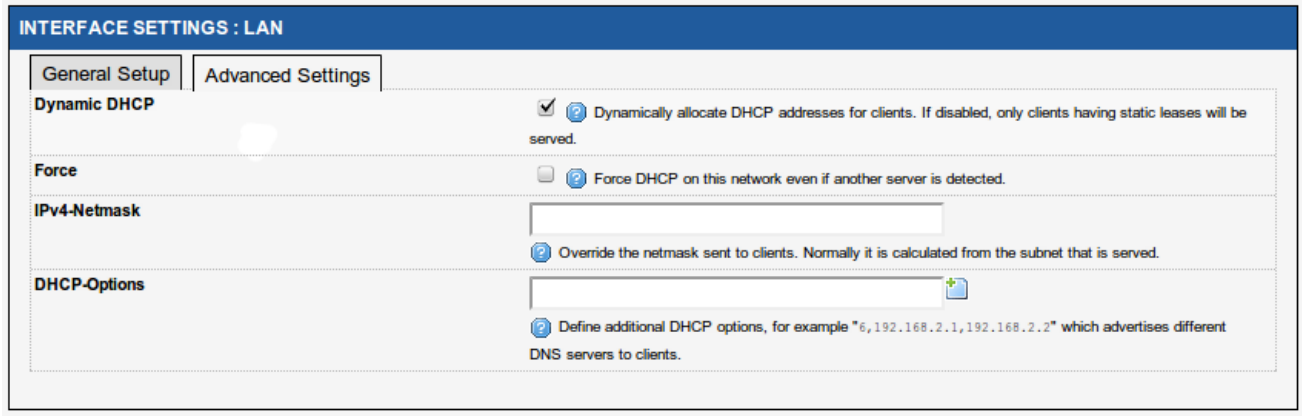
DHCP pool size:

Maximum number of leased addresses.

Lease time:

This represents the time during which a given IP address remains valid. After this time, the client needs to renew his lease.

Interface settings: DHCP Server Advanced Settings:



Dynamic DHCP:

If unchecked, only **static leases** will be authorized (see below)

Force:

By default, the DHCP service doesn't start if it detects the presence of another DHCP server on the network. If this option is checked, the DHCP server won't check for the presence of another server before starting.

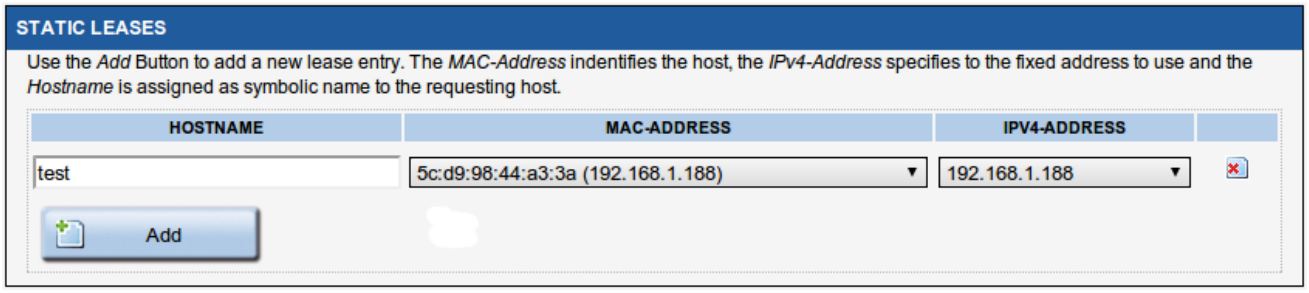
Ipv4-Netmask:

This option overrides the default netmask value sent to DHCP clients.

DHCP-Options:

This field allows you to enter an additional DHCP option (enclosed into quotes). Syntax depends on the option itself. See DHCP RFCs for more information about DHCP options.

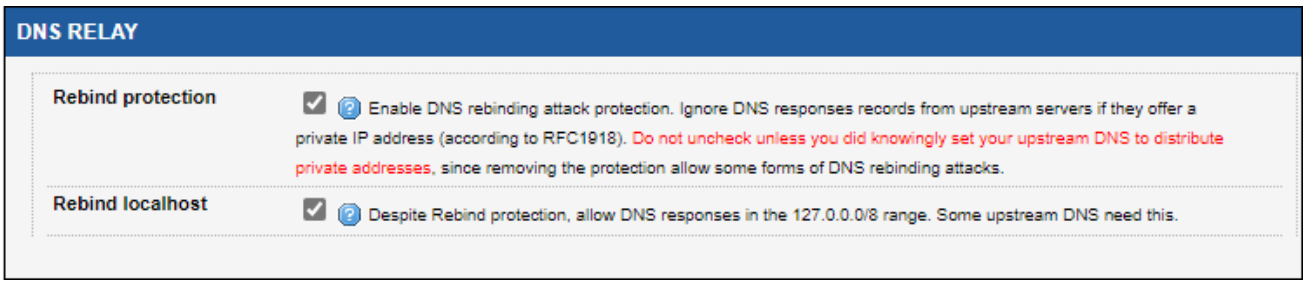
STATIC LEASES:



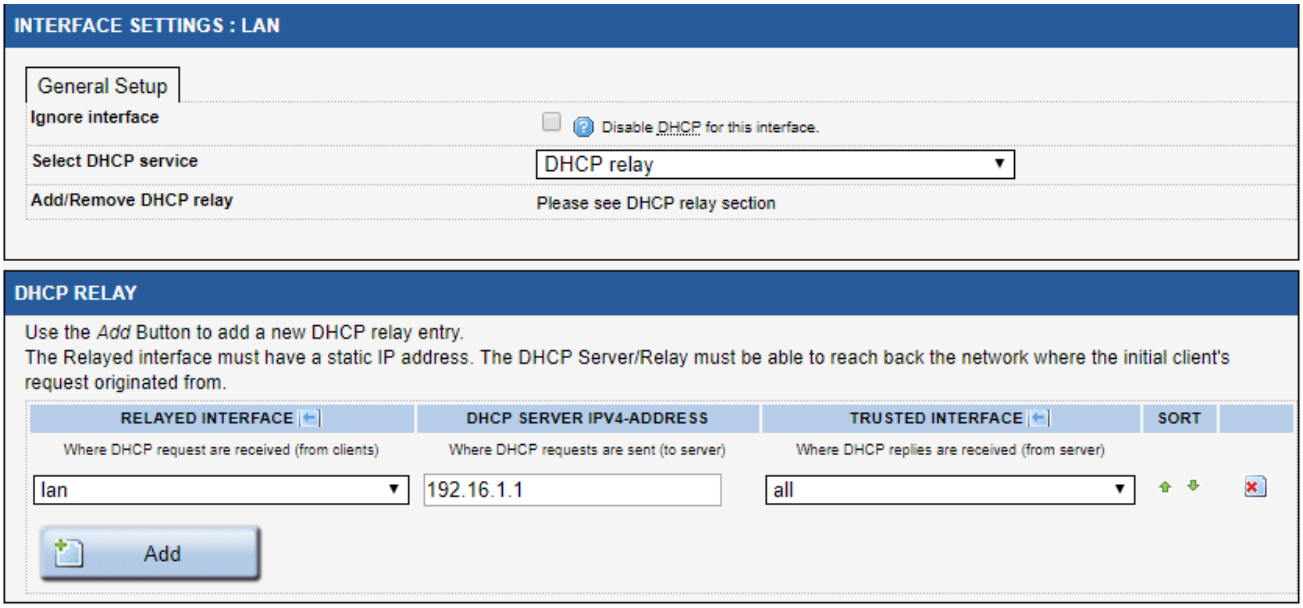
Active only in DHCP server mode, this option allows to always give the same predefined IP address according to a given client MAC address.

DNS relay

These options enable DNS protection Attack.



DHCP RELAY



Use the **Add** button to add a new DHCP relay entry

RELAYED INTERFACE

The interface (defined in SETUP/NETWORK) on which the DHCP clients are connected. DHCP requests are received on this interface

DHCP SERVER IPV4-ADDRESS

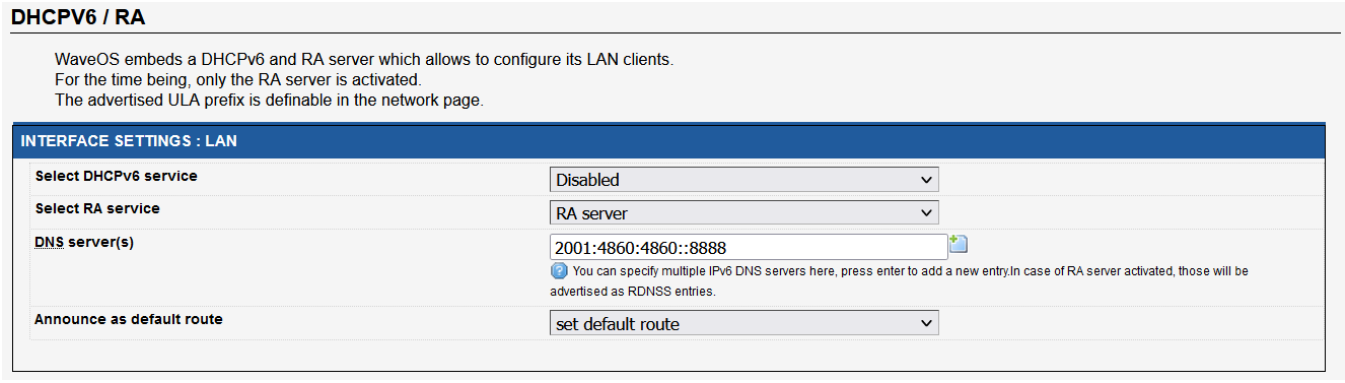
The IP address of the DHCP server. DHCP requests from clients are forwarded to this address

TRUSTED INTERFACE

This is the interface (defined in SETUP/NETWORK) on which we authorize the reception of responses to DHCP requests. In the general case, we will choose "all"

VI.1.10.4 DHCPv6

DHCPv6 and RA server allow to configure LAN clients but, in this version, only RA server feature is available to be enabled.



Select DHCPv6 service

Allows to enable or disable service DHCP server but this feature is disable in this release

Select RA service

Allows to enable or disable service RA (Router Advertisement) server.

DNS server(s)

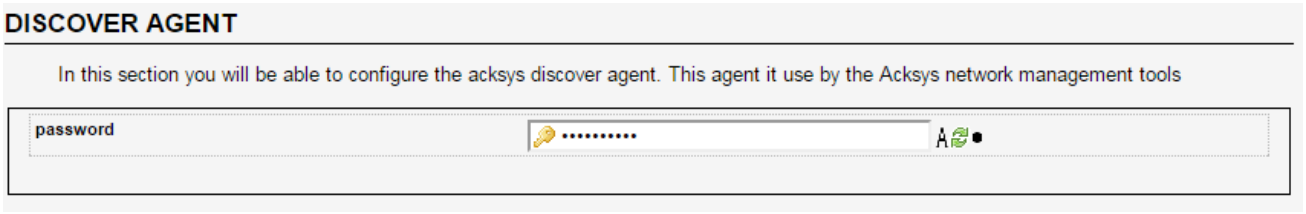
DNS server advertised by the RA server

Announce as default route

Allows to configure the default router: set default route |Ignore if no GUA prefix|Always ignore (default= default route)

VI.1.10.5 Discover Agent

This page will be able to configure the discover agent included in WaveOS. This agent it used by WaveManager to automatically find the Acksys products.



Password

Enter your password. This password will be used for example when you will set the product IP by WaveManager.

VI.1.10.6 Passpoint

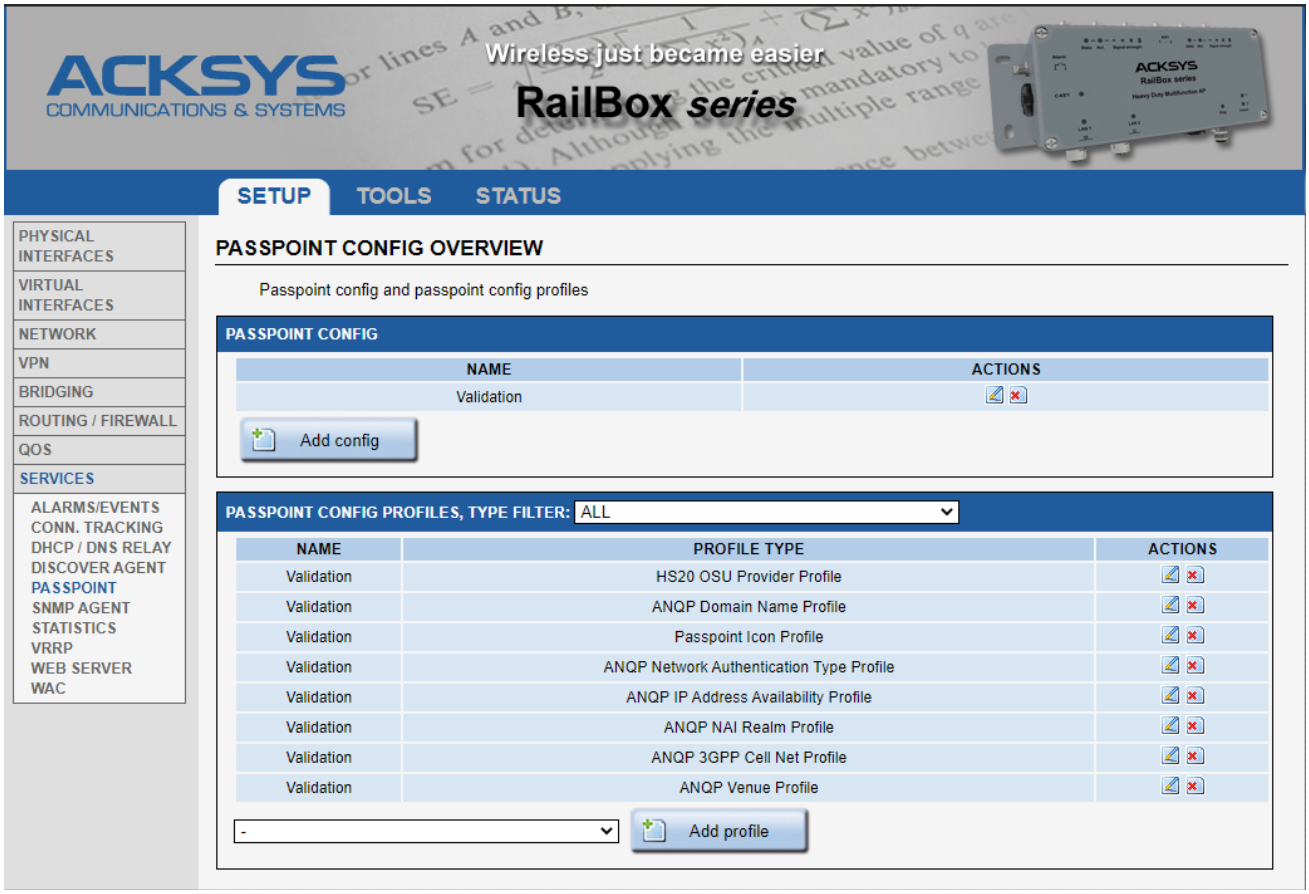


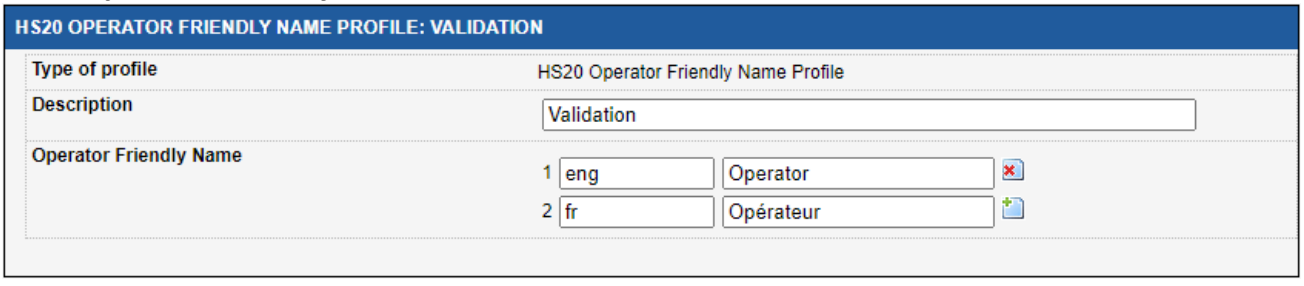
Figure 2: Page Passpoint Config Overview

Before adding a Passpoint configuration, you must define the profiles that will be used. All the necessary information must be given to you by your provider

Passpoint Config Profiles

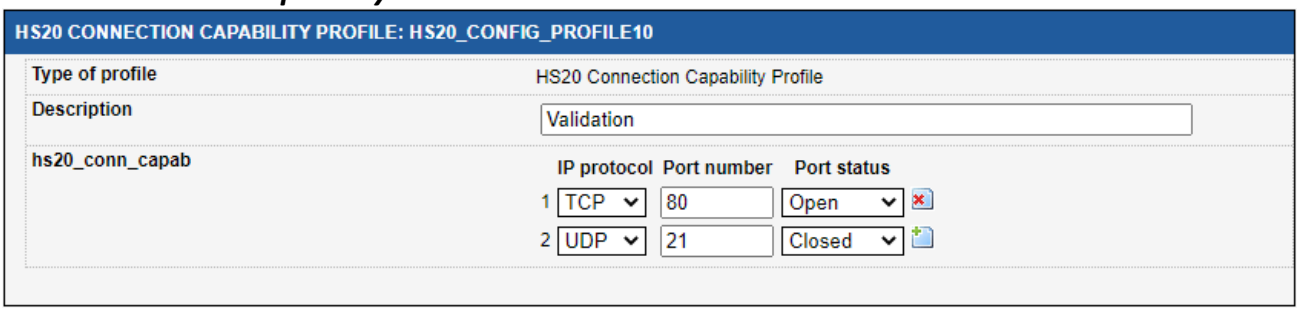
The Passpoint configuration profile can be summarized in 2 types: HS20 profile and ANQP profile. HS20 profiles configure hotspot 2.0 functionality while ANQP profiles configure ANQP 802.11u functionality.

HS20 Operator Friendly Name



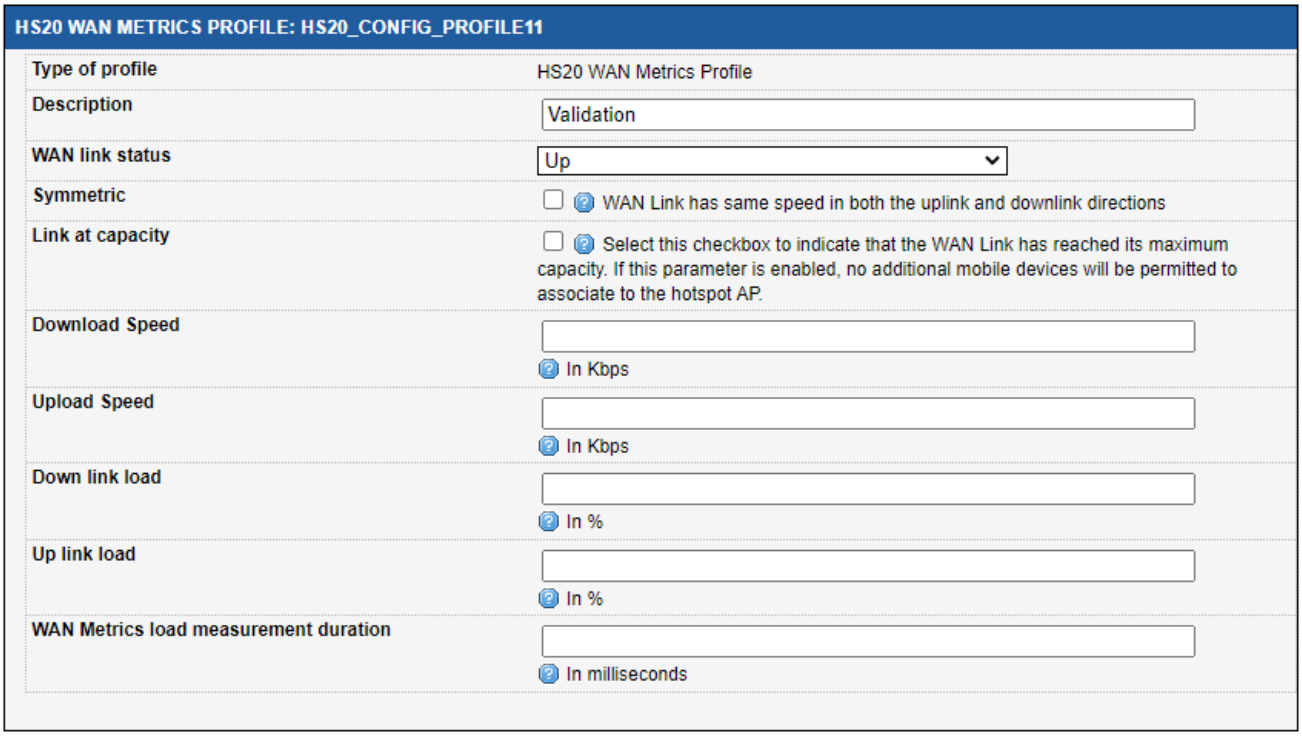
Operator friendly name: This parameter can be used to configure one or more operator friendly name entries. Each entry has a two- or three-character language code (ISO-639) and an operator name string.

HS20 connection capability



Hs20_conn_capab: This can be used to publicize the type of IP traffic that may be sent by the hotspot (eg due to a firewall allowing/blocking protocols/ports).

HS20 WAN metrics



Symmetric: Check this box if the WAN link has the same speed in both uplink and downlink directions

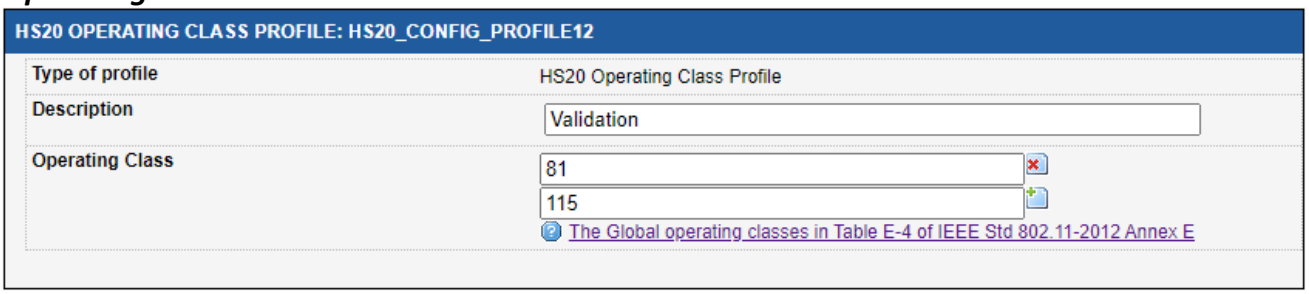
Link at capacity: Check this box to indicate that the WAN link has reached its maximum capacity. If this setting is enabled, no additional mobile devices will be allowed to associate with the hotspot access point.

Download/Upload speed: Estimate of the current WAN link downlink/uplink speed in kbps.

Down/Up link load: Current load of the downlink/uplink WAN connection in percentage.

WAN metrics load measurement duration: Duration of downlink/next load measurement in milliseconds; 0 if the load cannot be determined.

Operating class



Operating class: List of operating classes used by BSS in this SSE. The global operating classes in Table E-4 of the *IEEE 802.11-2012* appendix E standard define the values that can be used in this context. (https://tinyurl.com/yxs4ctde)

In this example: 81 and 115 indicate the AP to use channels 1-13 and 36, 40, 44, 48. See the tables below.

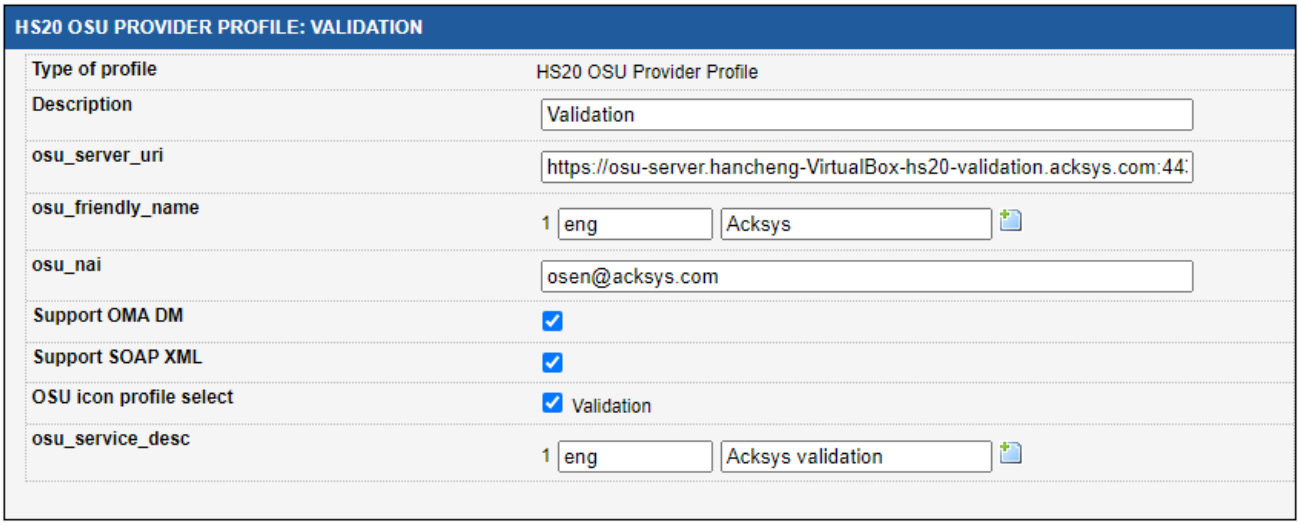
Table E-4—Global operating classes

Operating class	Nonglobal operating class(es)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Behavior limits set
1–80		Reserved	Reserved	Reserved	Reserved
81	E-1-12, E-2-4, E-3-30	2.407	25	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13	
82	E-3-31	2.414	25	14	

Table E-4—Global operating classes *(continued)*

Operating class	Nonglobal operating class(es)	Channel starting frequency (GHz)	Channel spacing (MHz)	Channel set	Behavior limits set
111	E-3-25,26,27,28,29	4.0025	5	182, 183, 184, 185, 186, 187, 188, 189	
112	E-3-2,3,4,5,6	5	20	8, 12, 16	
113	E-3-12,13,14,15	5	10	7, 8, 9, 10, 11	
114	E-3-21,22,23,24	5.0025	5	6, 7, 8, 9, 10, 11	
115	E-1-1, E-2-1, E-3-1	5	20	36, 40, 44, 48	
116	E-1-22, E-2-5, E-3-36	5	40	36, 44	PrimaryChannelLowerBehavior

HS20 OSU PROVIDER



OSU server URI: If a client chooses this OSU (*Online Signup Server*) Provider, he will use this URI for registration.

OSU friendly name: A human readable name to identify the OSU Provider.

OSU NAI: The identifier with which a client connects to an OSEN AP defined by Passpoint config.

OMA DM: OSU server supports OMA DM (Open Mobile Alliance Device Management) provisioning protocol (Hotspot_2.0_Specification_v2.0: 8.3 Provisioning using OMA DM)

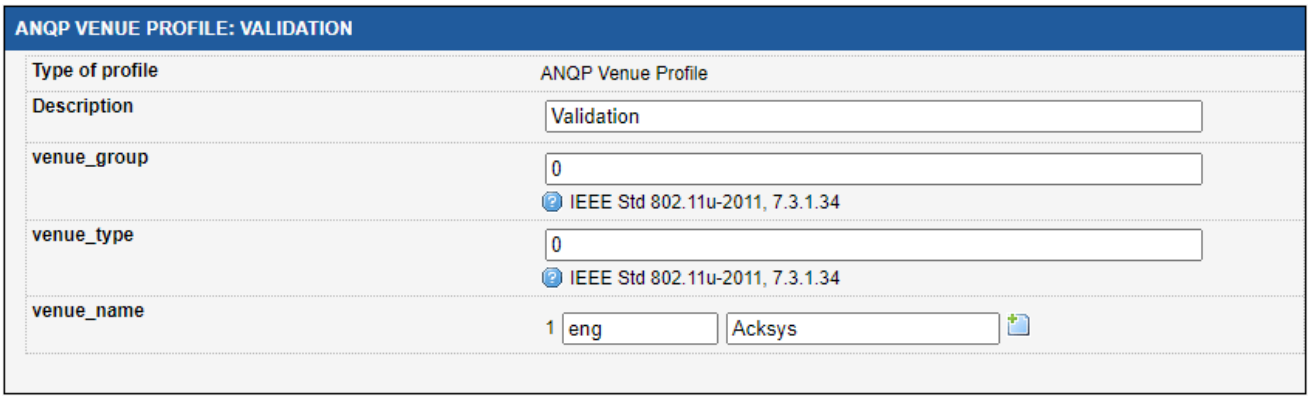
SOAP XML: OSU server support provisioning protocol SOAP XML (Simple Object Access Protocol XML) (Hotspot_2.0_Specification_v2.0: 8.4 Provisioning using SOAP XML)

OSU icon: displayed with OSU friendly name

OSU service desc: description of the service

Note: A Passpoint configuration can contain several OSU Provider profiles

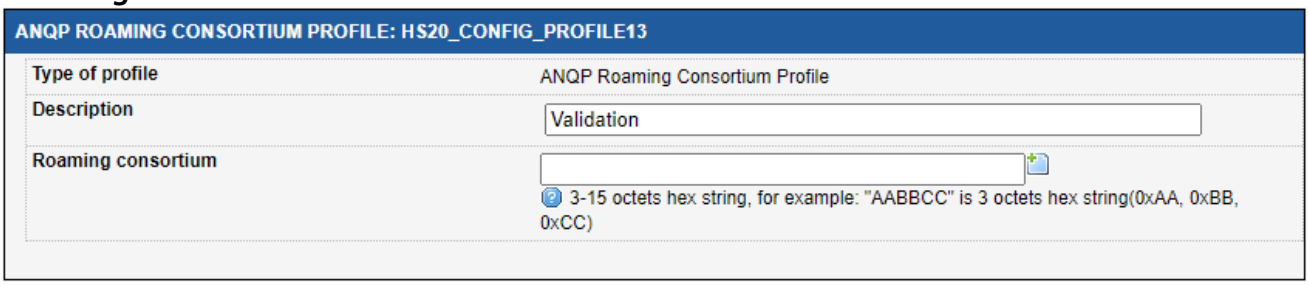
ANQP Venue



venue group and **venue type** specify the location of the AP

The values and their descriptions can be found in *IEEE std 802.11u-2011* section 7.3.1.34.

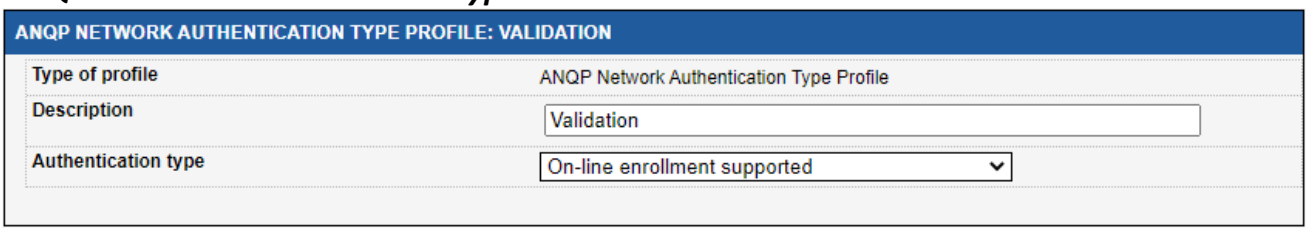
Roaming Consortium



Roaming consortium: The roaming consortium is a list of OI (Organization Identifier). Organization identifier is a 24-bit number assigned by the IEEE. This number uniquely identifies a manufacturer or organization in a MAC address. The first three bytes of the MAC address of a network interface is the OUI.

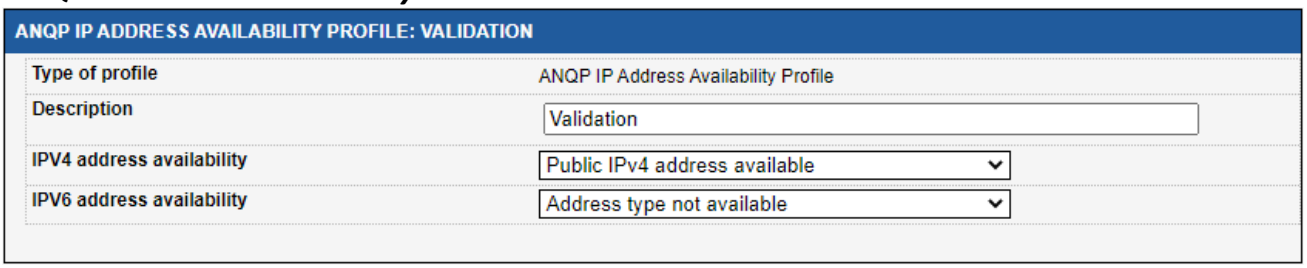
This field must be completed in hexdump format. For example 1000 in decimal, 0x3E8 in hexadecimal, hexdump is 03E8. For Acksys, OI is: 000990XXXXXXXXXXXXXXXXXXXXXXXX.

ANQP Network Authentication Type



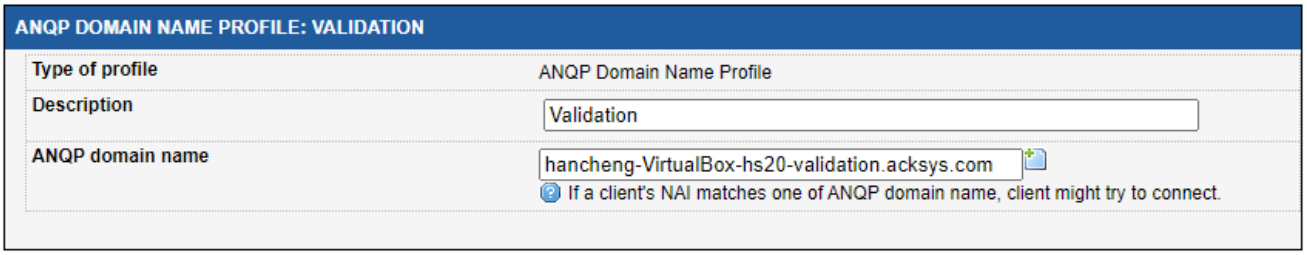
Authentication type: If a Passpoint is configured with ASRA (Additional Step Required for Access), an *ANQP network authentication type* profile is mandatory to apply to this configuration

ANQP IP Address Availability



Use this profile to specify the types of IPv4 and IPv6 addresses available in the access point network.

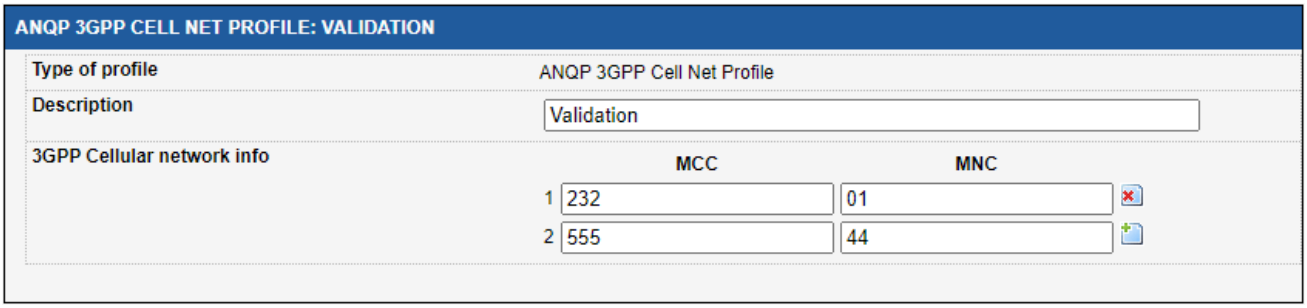
ANQP Domain name



The Domain Name list item provides a list of one or more domain names of the entity that operates the IEEE 802.11 access network.

Note that the client's NAI corresponds to one of the ANQP Domain name, the client will also try to connect to this AP.

ANQP 3GPP Cell Net

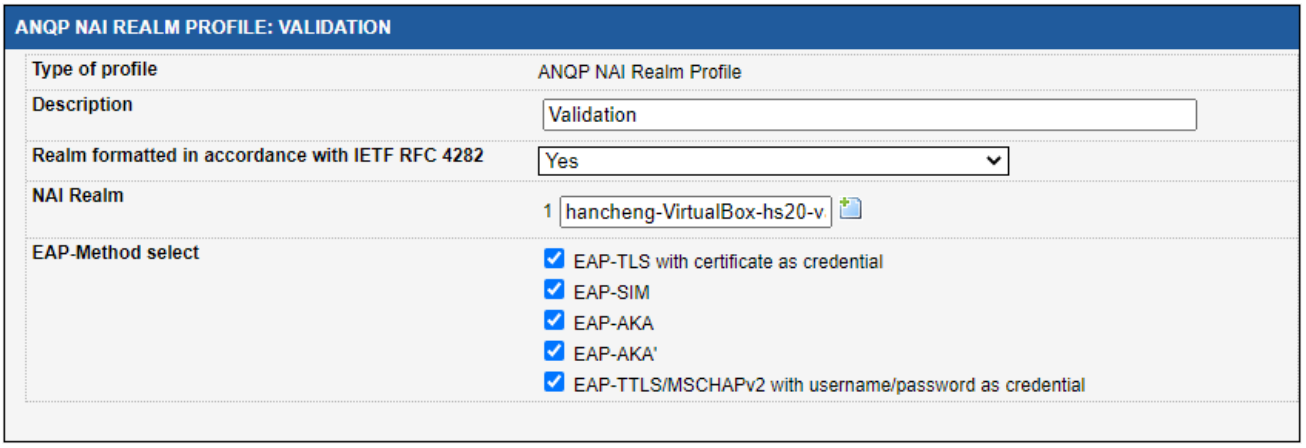


3GPP cellular network info is a duplicate list consisting of MMC and MNC, which is used to identify an operator.

MMC: Mobile country code, MCC is a three-digit country code, standardized by the International Telecommunication Union (ITU) in its recommendation E.212, for mobile telephone networks, more particularly in GSM and UMTS technologies. For example: MMC from France is 208.

MNC: Mobile network code, MNC is used in combination with the Mobile country code (MCC) for unambiguous identification of the network of a mobile network operator using the GSM, CDMA, TETRA, UMTS, LTE and certain mobile satellite networks . For example: 3gpp code from Orange is MCC = 208, MNC = 01

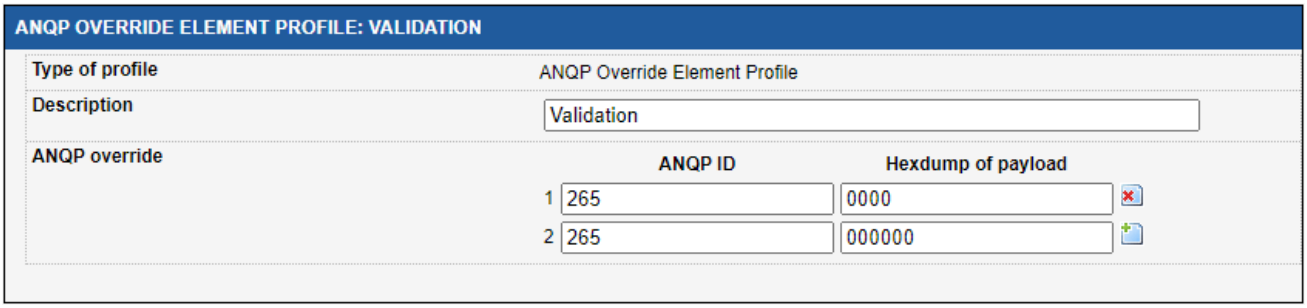
ANQP NAI Realm



Each **NAI Realm** can optionally be associated with a set of EAP methods. Each EAP method can optionally be associated with a set of authentication parameters. The NAI domain information provides a clue to the methods an STA can use to establish an association in an IEEE 802.1X RSN environment. If the STA recognizes the NAI domain, it can attempt authentication even if it thinks the EAP methods are incorrect.

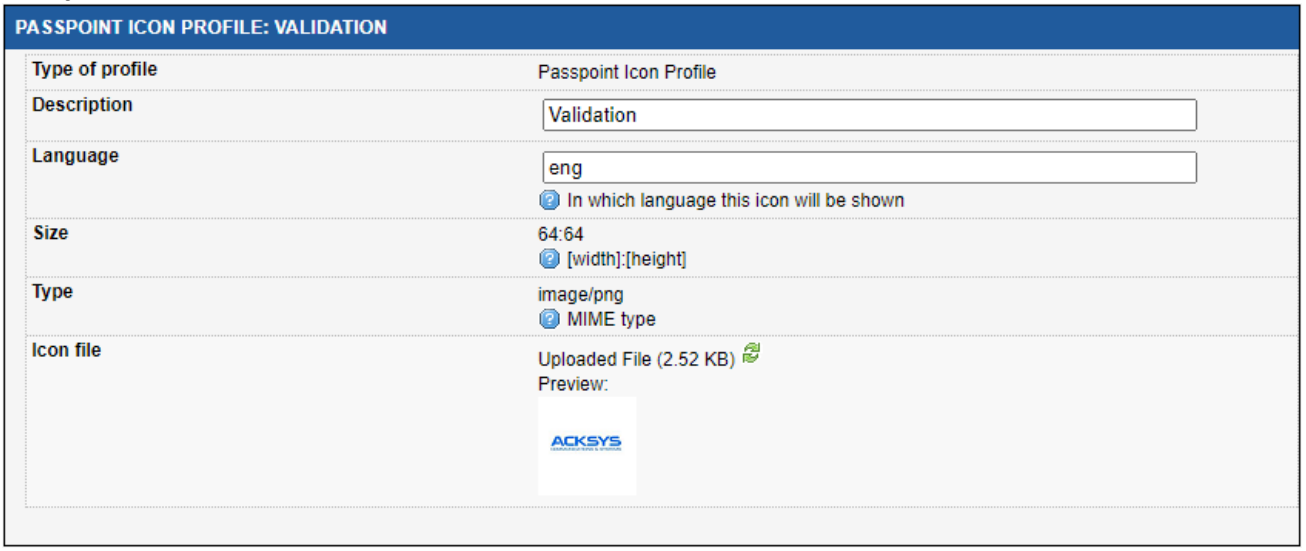
Note that a Passpoint config can have multiple ANQP NAI Realm profiles enabled.

ANQP Override Element



Additional ANQP elements with arbitrary values can be defined by specifying their content in Hexdump format. Note that these values will override the contents of ANQP elements that may have been specified in the higher layer configuration parameters.

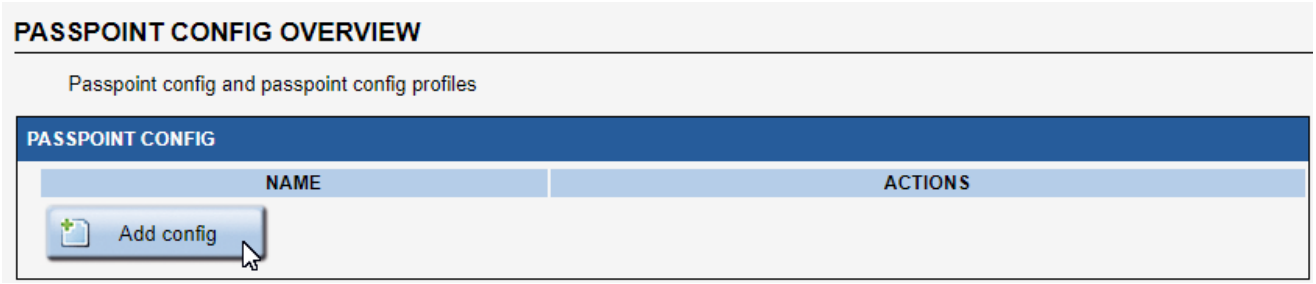
Passpoint icon

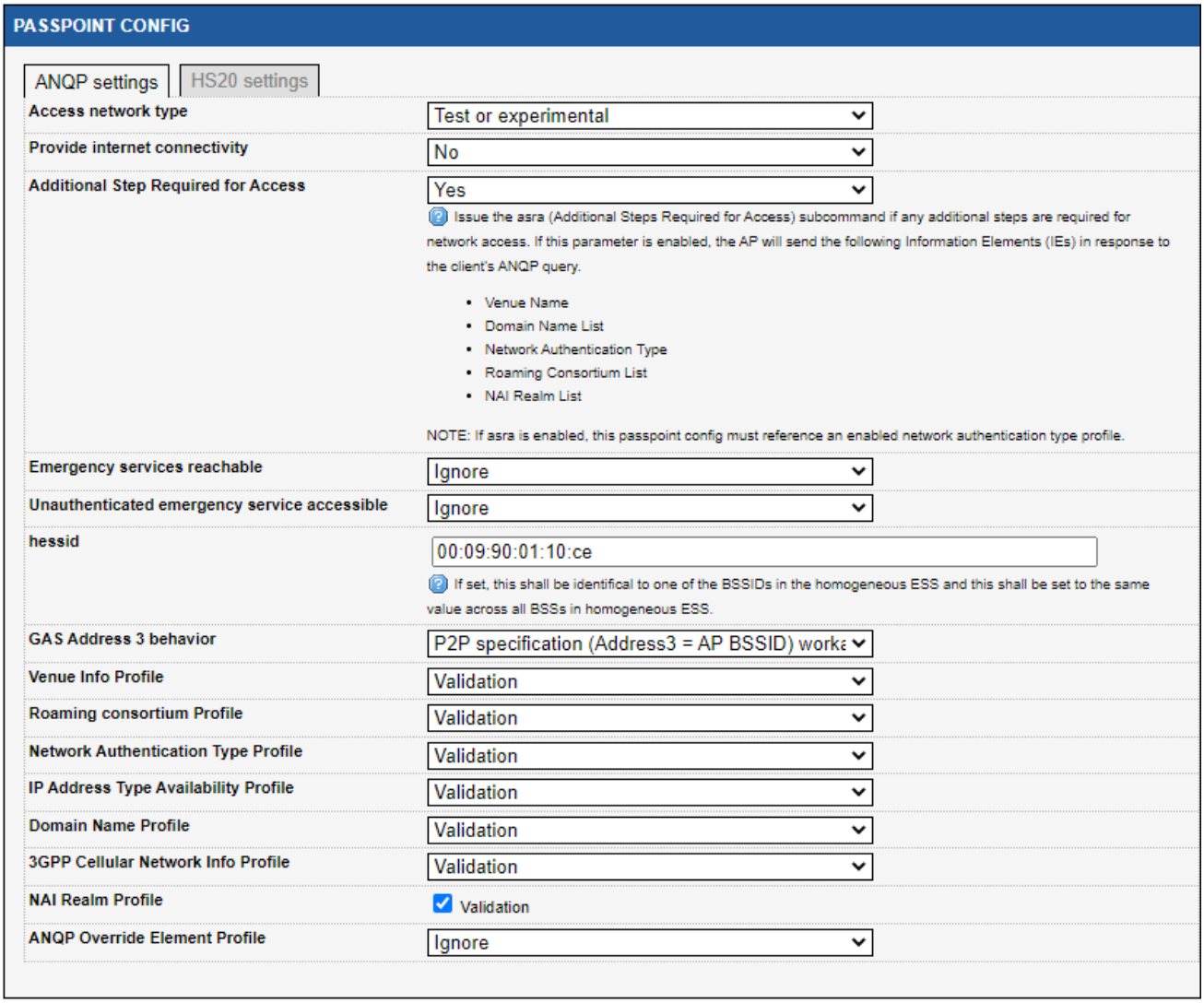


Download the icon file that will be referenced in another profile.

Passpoint Config

The passpoint configuration consists of several “passpoint config profiles”. A series of profiles must therefore be established before proceeding with the configuration of the passpoints.





Access network type: This option indicates the type of network that will be connected after the association. The available types are:

- Private network
- Private network with guest access
- Chargeable public network (paying public network)
- Free public network
- Personal device network
- Emergency services only network
- Test or experimental
- Wildcard (general network)

Provide internet connectivity: If the internet is available after pairing.

Additional Step Required for Access (ASRA): If additional measures are required for network access. Note: if this option is enabled, a valid “Network authentication type” profile must also be applied.

Emergency services reachable: Indicate if emergency services can be reached

Unauthenticated emergency service accessible: Indicate if Unauthenticated emergency services can be reached.

HESSID: Homogeneous ESS identify. If set, it must be the same as one of the BSSIDs in the HESS and must be set the same value in all SSEs in the homogeneous SSE.

GAS Address 3 behavior: The action to be taken regarding GAS frames for "address 3". Address 3 is the 3rd MAC address put in the 802.11 frame header. There are four address fields in the MAC frame format. These fields are used to indicate the basic service set identifier (BSSID), the source address (SA), the destination address (DA), the address of the sending STA (TA) and the address of the receiving STA (RA). Some frames may not contain some of the address fields.
The options are:

- P2P specification (Address3 = AP BSSID) workaround enabled by default based on GAS request Address3: Depending on the BSSID of the initial request from GAS which is a kind of 802.11 management frame (whose address 3 is BSSID), the address 3 of the response frame must be filled in with the BSSID of the access point or the wildcard (FF: FF: FF: FF: FF: FF).
    - If the BSSID of GAS inital request is broadcast, do IEEE 802.11 std
    - If not, we force address 3 of the response equals BSSID of the AP.
- IEEE 802.11 standard compliant regardless of GAS request Address3: Whatever the address 3 of the initial frame of GAS, always stick to the 802.11 standard
- Force non-compliant behavior: always ensure that address 3 of the initial response to the GAS request is the BSSID of the access point.

Venue info profile: Select a “Venue info” profile or select “ignore” to ignore this option.

Roaming consortium Profile: Select a “Roaming consortium” profile or select “ignore” to ignore this option.

Network Authentication Type Profile: Select a “Network Authentication Type” profile or select “ignore” to ignore this option.

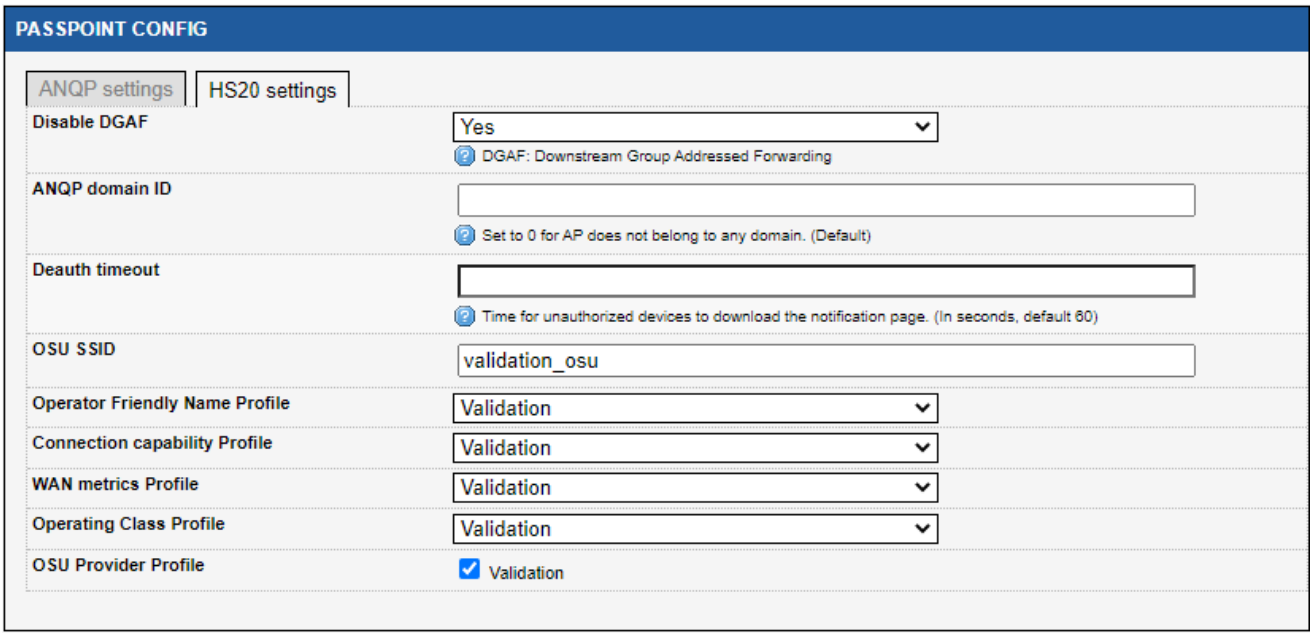
IP Address Type Availability Profile: Select an “IP Address Type Availability” profile or select “ignore” to ignore this option.

Domain Name Profile: Select a "Domain Name Profile" or select "ignore" to ignore this option.

3GPP Cellular Network Info Profile: Select a “3GPP Cellular Network Info” profile or select “ignore” to ignore this option.

NAI Realm Profile: Check one or more “NAI Realm” profiles or leave nothing to ignore this option.

ANQP Override Element Profile: Select an "ANQP Override Element" profile or select "ignore" to ignore this option.



Disable DGAF: Disable Downstream Group-Addressed Forwarding (DGAF). This can be used to configure a network where no frames addressed by a group are allowed. The access point does not transmit any group address frames to stations and random GTKs are issued for each station to prevent associated stations from forging such frames to other stations in the BSS.

ANQP domain ID: An identifier for a set of access points in an SSE that share the same common ANQP information (0 – 65535). The default is 0, which means that some of the ANQP information is unique to this access point (default).

Deauth timeout: If the RADIUS server indicates that the station is not authorized to connect to the BSS / ESS, the access point may allow the station some time to download a notification page (URL included in the message). This parameter defines this delay in seconds. The default is 60.

OSU SSID: This is the SSID used for all OSU connections to all OSU providers listed.

Operator Friendly Name Profile: Select an “Operator Friendly Name” profile or select “ignore” to ignore this option.

Connection capability Profile: Select a “Connection capability” profile or select “ignore” to ignore this option.

WAN metrics Profile: Select a “WAN metrics” profile or select “ignore” to ignore this option.

Operating Class Profile: Select an "Operating Class" profile or select "ignore" to ignore this option.

OSU Provider Profile: Check one or more “OSU Provider” profiles or leave nothing to ignore this option.

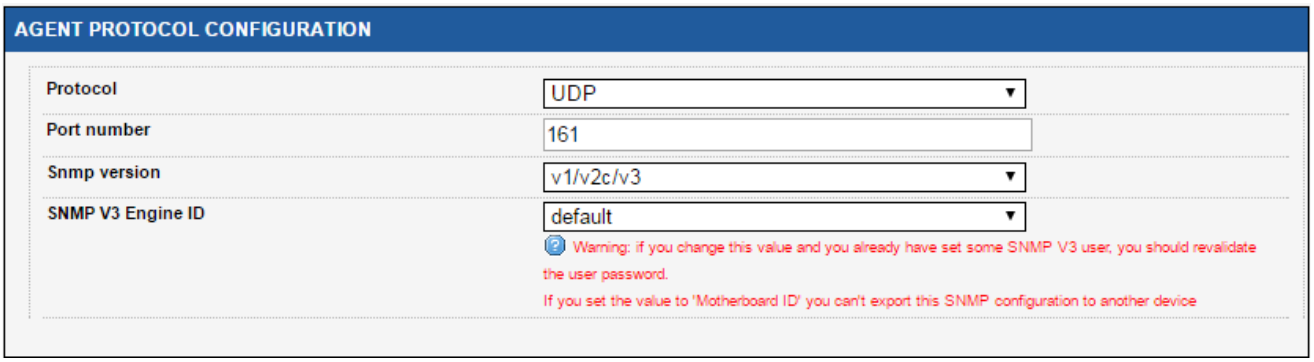
VI.1.10.7 SNMP Agent

The SNMP agent is enabled by default and allows read/write access, using the **public** community, to the MIB-II and ACKSYS MIB.

The ACKSYS MIB file is self-documented. To read the OIDs documentation please use a text file editor or MIB browser.

Please read the SNMP security chapter before configuring the SNMP users and access rights: V.6.1 SNMP security

AGENT PROTOCOL CONFIGURATION



In this section you can change:

Protocol:

The agent access method (UDP/TCP)

Port number:

The agent port number

SNMP version:

- **v1/v2c**: This will allow **security model v1**, **v2c** and **usm** (please see chapter)
- **v3**: This will allow only **usm security model**.

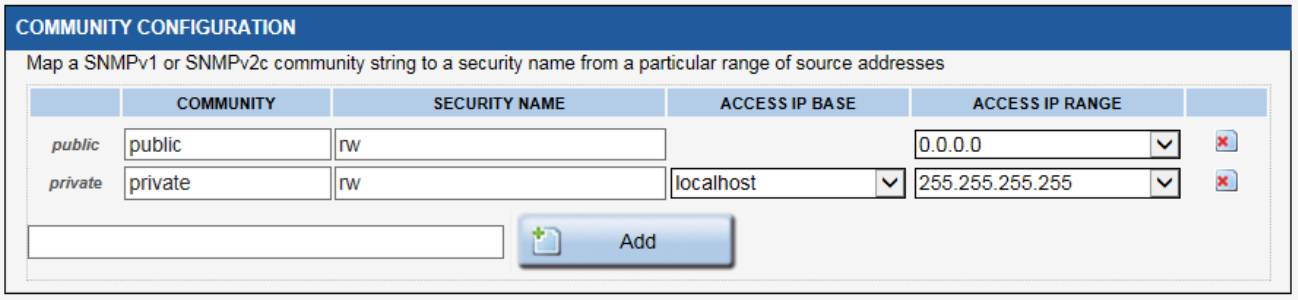
SNMP V3 Engine ID

- **Default:** The default Engine ID is the same for all devices. In this configuration, the SNMP settings can be shared between several devices. If you change this value while you already have SNMP V3 users, you must revalidate the user password on each device.
- **MotherboardID:** Use the Motherboard ID as EngineID. This ID is unique, so each device with this setting will have a different engine ID. In this setting, you cannot share the SNMP settings between several products. You should revalidate the user password on each device.

COMMUNITY CONFIGURATION

In this section, you can find the list of communities, their access rights and restrictions on who use them. It relies on the SNMP v1/v2c **community based security model**.

Warning: if you change the public community properties, you must ensure that any SNMP client is set up accordingly. For example, the *Acksys WaveManager* software has a menu to change communities on a per-device basis.



Access rights are defined in the “community configuration” subsection. To add an access rights specification, type in a nickname for the specification and click on the **Add** button. The nickname must be composed of letters, numbers and underscores. The nickname is **not** the community name, it is an **access rights specification** name.

By default, the **private** community is defined but unchangeable, for historical compatibility reasons. You can redefine the default communities at will.

Community:

The identification name that must be provided to the SNMP client in order for it to identify against the agent. You can use the same as the nickname, if you need to.

Security Name:

The Security Name that will be used to set the access right in the **VACM** section.

Access IP base:

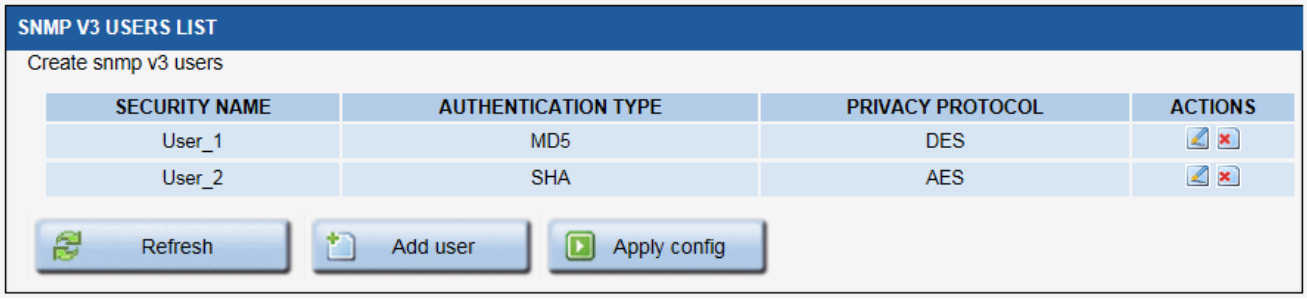
An IP address which is allowed to use this specification. If the DNS server is properly configured in the Setup/Network page, or obtained from a DHCP server, you can type a host name (a FQDN) instead.

Access IP range:

An IP mask which is applied to the IP base to determine the full range of allowed client IP addresses.

SNMP V3 USM user administration

In this section, you can create, delete or modify the security settings of a **SNMP v3** user based on the **USM** security model.



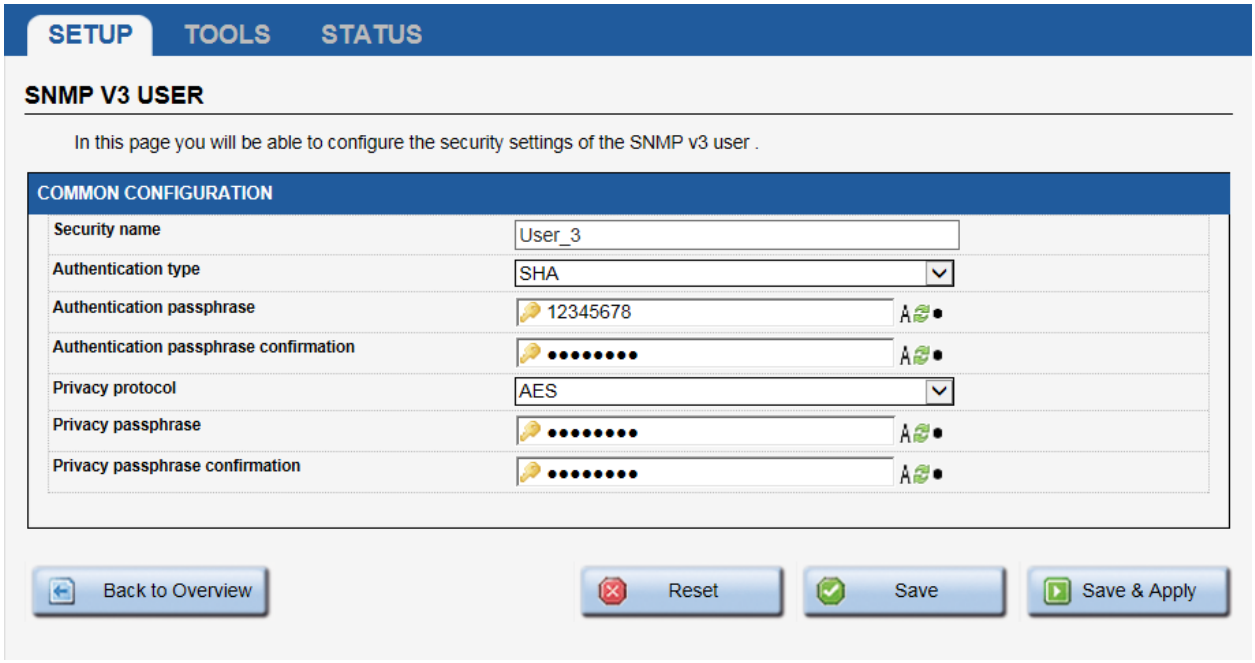
Refresh button:

Click on the refresh button, to synchronize with the user data base of the SNMP agent (since in SNMP v3, users can be created remotely with SNMP v3 commands).

This will also apply the saved changes on SNMP configuration.

Add user button:

Click on Add user button, to create a new SNMP v3 user.



In this section, you can set the user credentials.

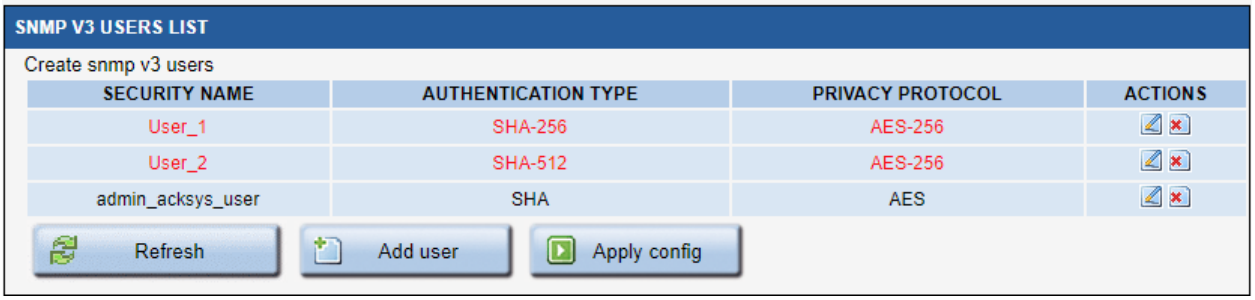
For security reasons, the stored passwords are encrypted and cannot be viewed later.

Authentication type:

Supported Authentication types are: SHA-512, SHA-384, SHA-256 and SHA-224
Supported Privacy protocols are AES-256, AES-192 and AES.
SHA1, MD5 and DES are also supported for compatibility, but marked as unsecure. They will certainly be removed in a future version, so we recommend not to use them.

Apply config button:

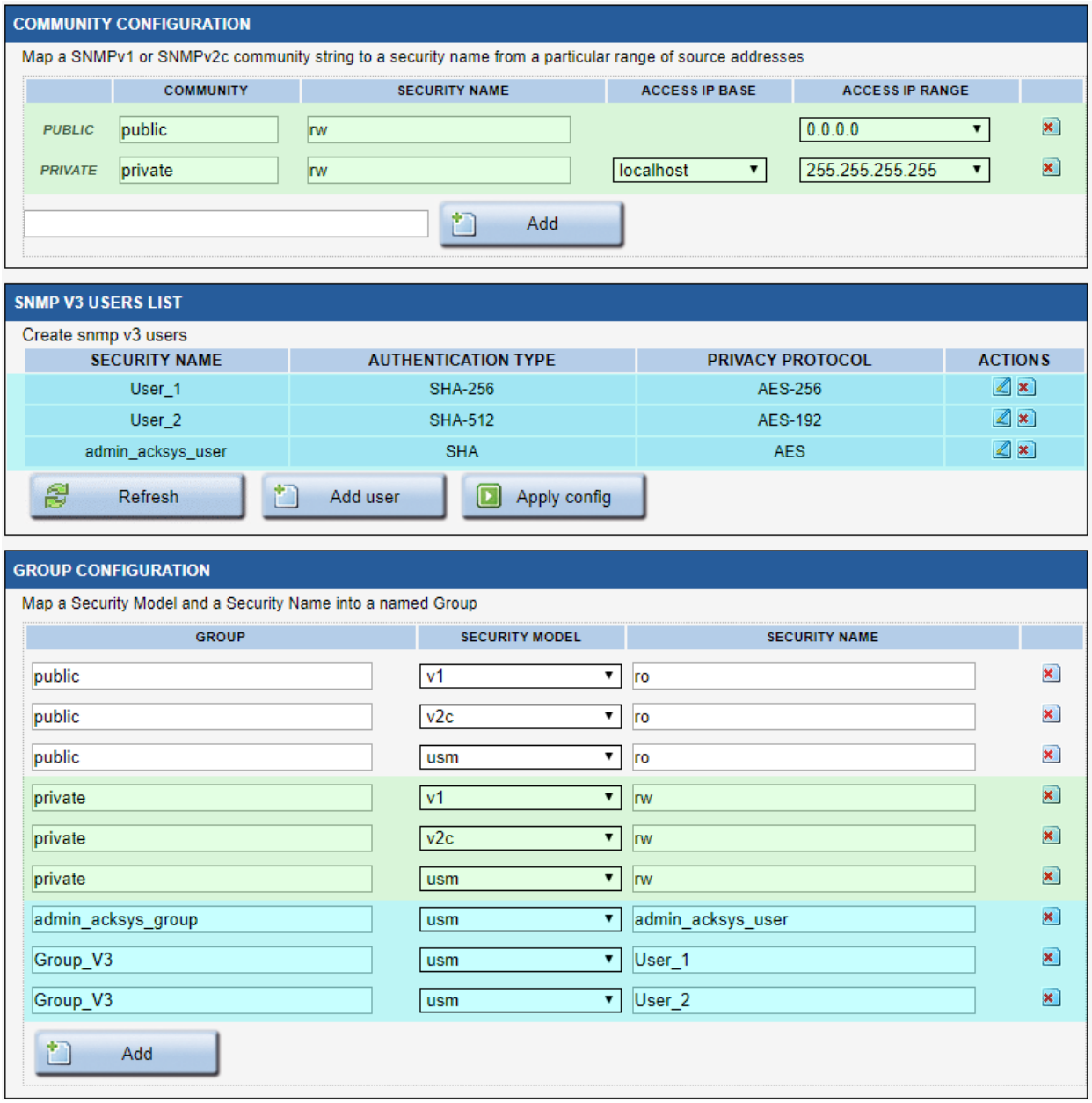
Click on this button to apply the saved changes. The saved changes that have not yet been applied for the SNMP v3 user list, are displayed in red:



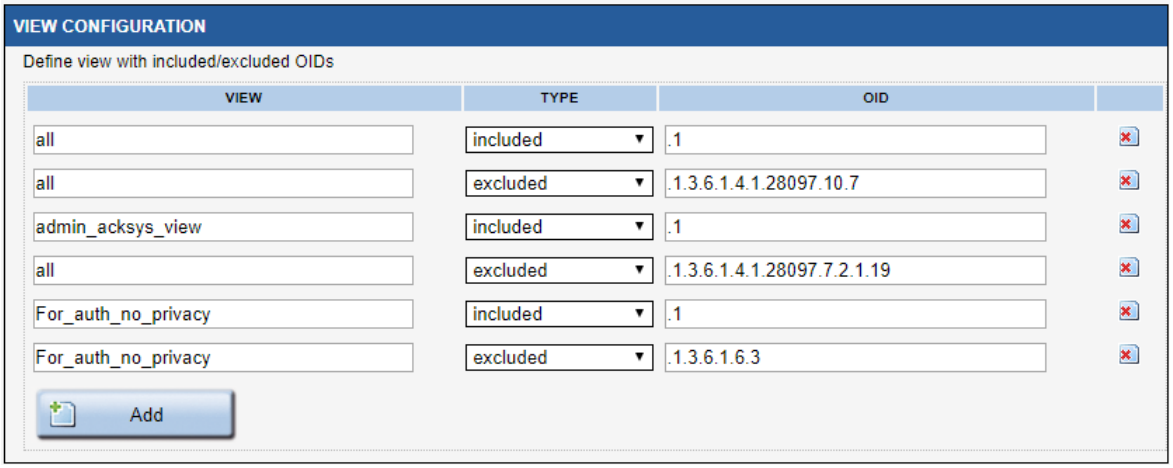
Access control administration (VACM)

In this section, you can manage the access rights of SNMP v3 users or SNMP v1/v2c communities.

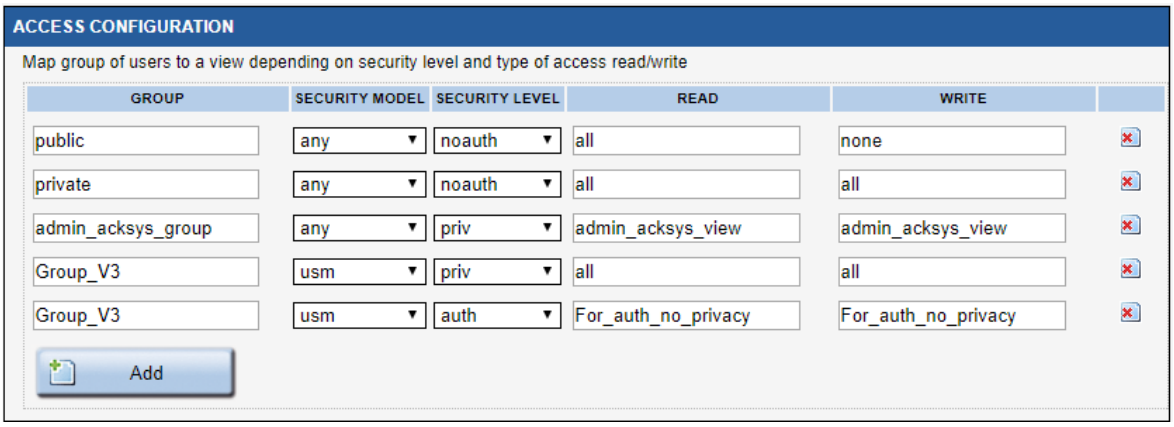
1) Add the user to a **Group** with its security model.



2) Create a View on the OIDs that you need the rights.

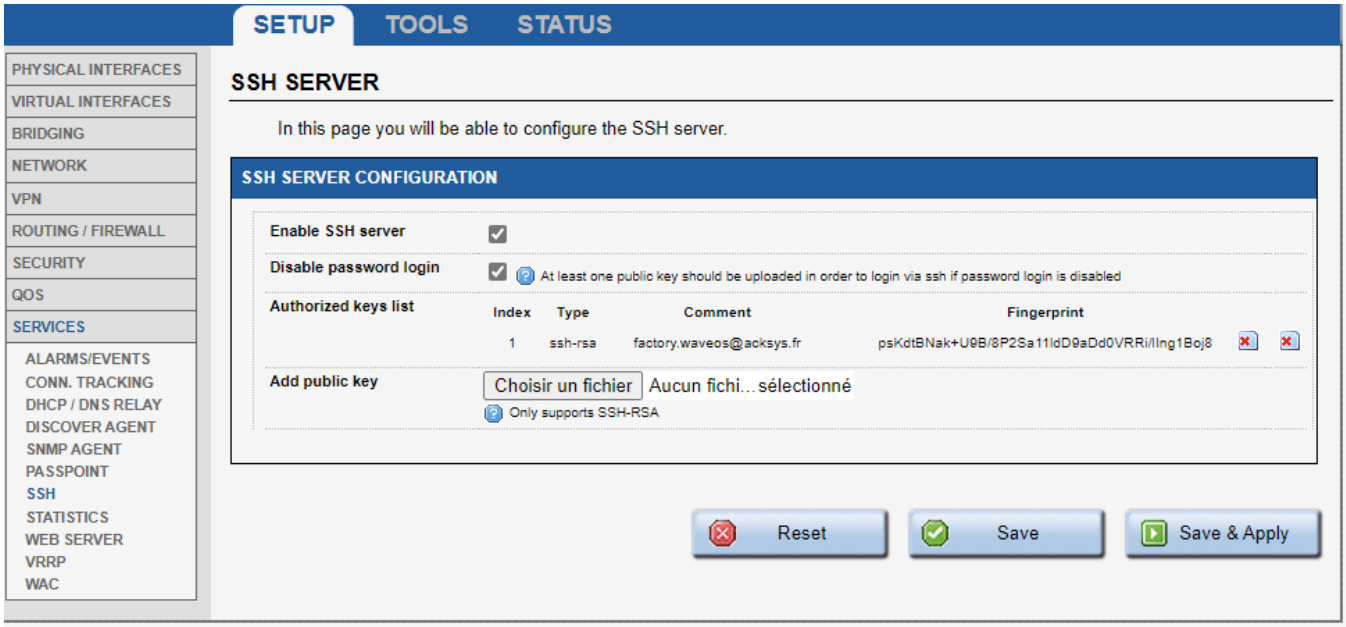


3) Set the access rights on the View for the Group depending on the user security model and security level.



VI.1.10.8 SSH Server

The embedded SSH server can be activated from this page. Warning, this feature is reserved for developers and can make your product vulnerable, only activate it if you have a perfect understanding of the subject.



Enable SSH server

The SSH server will be shut down if the case is not checked.

Disable password login

By check/uncheck the option, you can disable/enable password login. Attention: if the password login is disabled then SSH server can only be accessed by RSA key pairs.

Authorized keys list

Here lists all the authorized keys saved in the product.

Index: the index of a stored key, starting from 0.

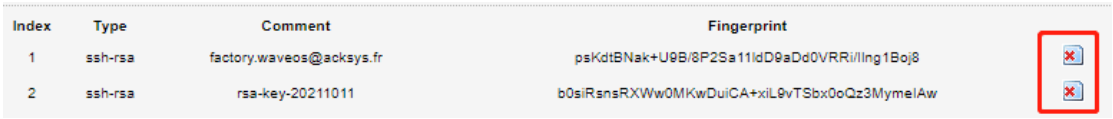
Type: the type of a stored key, for now only RSA key is supported.

Comment: the comment of a stored key.

NOTE: Do not take it as a key's identification, because the same two keys can have different comments and two different keys can have the same comment.

Fingerprint: the short identification of a stored key, one can compare if two keys are the same by comparing their fingerprints.

To delete a key: click the button with delete icon at the right of each row.



Index	Type	Comment	Fingerprint
1	ssh-rsa	factory.waveos@acksys.fr	psKdtBNak+U9B/8P2Sa11ldD9aDd0VRRi/Ing1Boj8
2	ssh-rsa	rsa-key-20211011	b0siRsnsRXWw0MKwDuiCA+xiL9vTSbx0oQz3MymeIAw

Add public key

You have to paste the generated key in plain-text file with the format:

ssh-rsa[space][AAAA….(key content)][space][key comment]

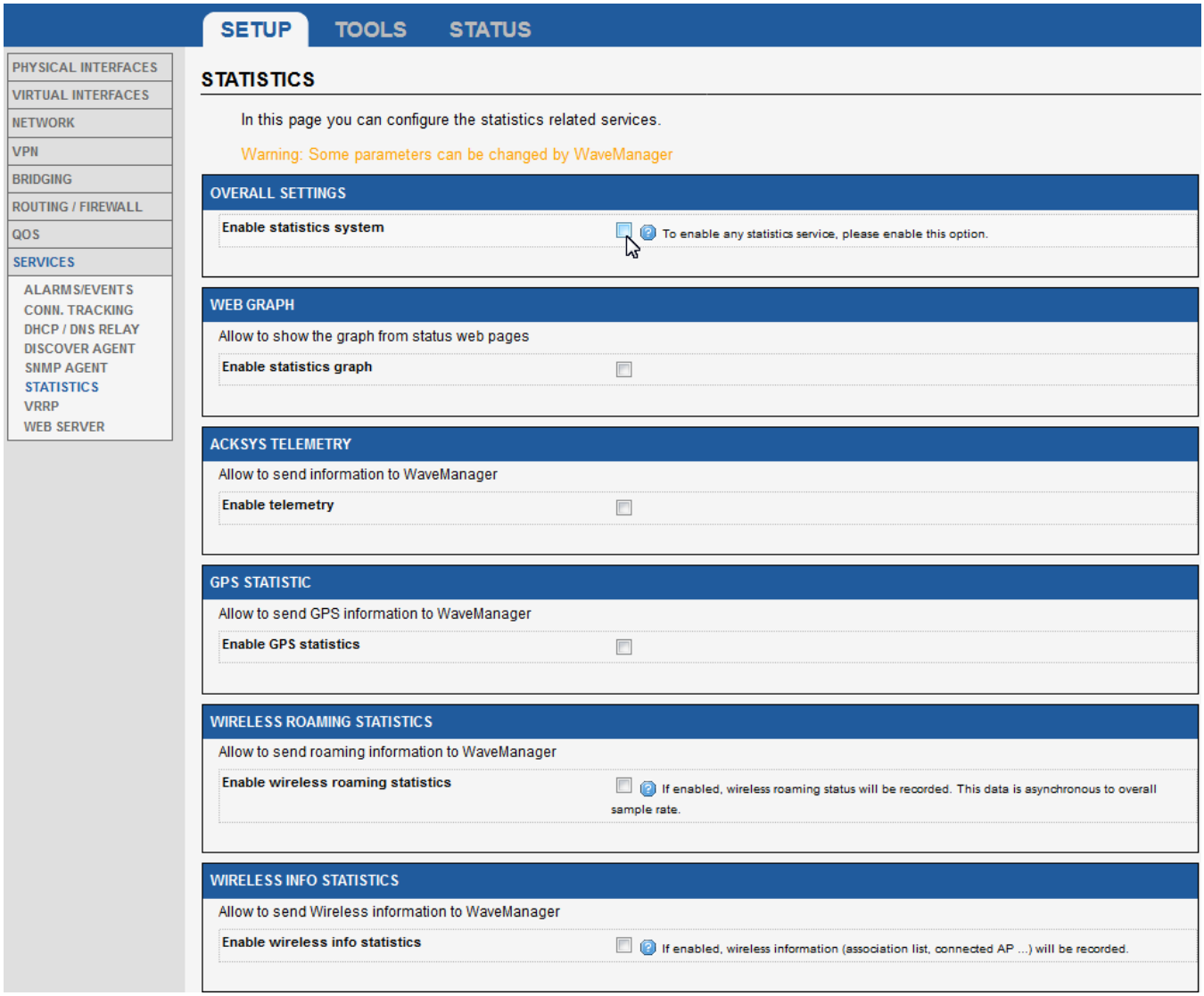
Here is an example (in one line):

ssh-rsa
AAAB3NzaC1yc2EAAAADAQABAAABAQCWOmRA3qIcY7lWjSg4psIaULpB7Usl6obkRveOxj8TCzcK9UsNzknGiSOIG2R
C0uZ2J5QR7B/ijLNLySkOpt/oVvM/30jWtpDNlX9n14AVmnNwwwT1xzNXzMt1qahg3TBpI6qGoEEuTZF24qu8Q8NL5y
f9N+tQS2HyYfSsJitf93PaRTH8hxYwmi41qCTVHXeqrI554YYzIkArYT7zXbUWsiQzrtz9QOk7s2lavF6gk+ZT1j1dbTqBjTfP
EfwknGpWdFTn257hJ6pEsK+Fx0KJhkzXIyMf1nLaTjRbtaZDmWD542r0eK7pHUGKfOpUem9dpFR9qrHupt9P1p2NBap
F rsa-key-20211011

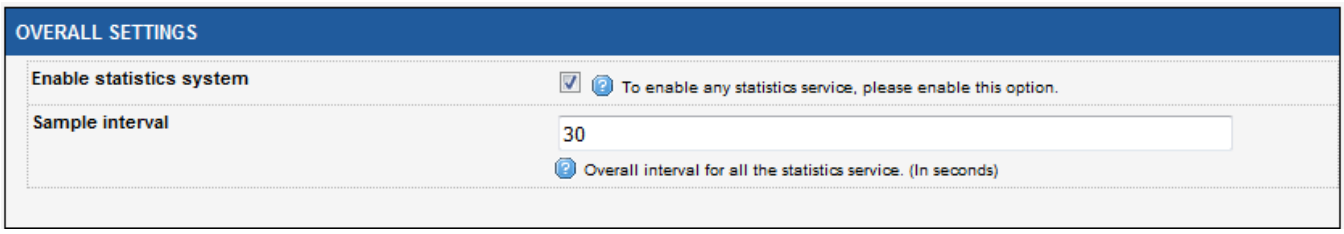
You can also add multiple keys at once by uploading a file containing one key per line. Files that do not match the format will be rejected.

VI.1.10.9 Statistics

The system counters graphs display the product performance as a timing diagram by collecting data periodically.

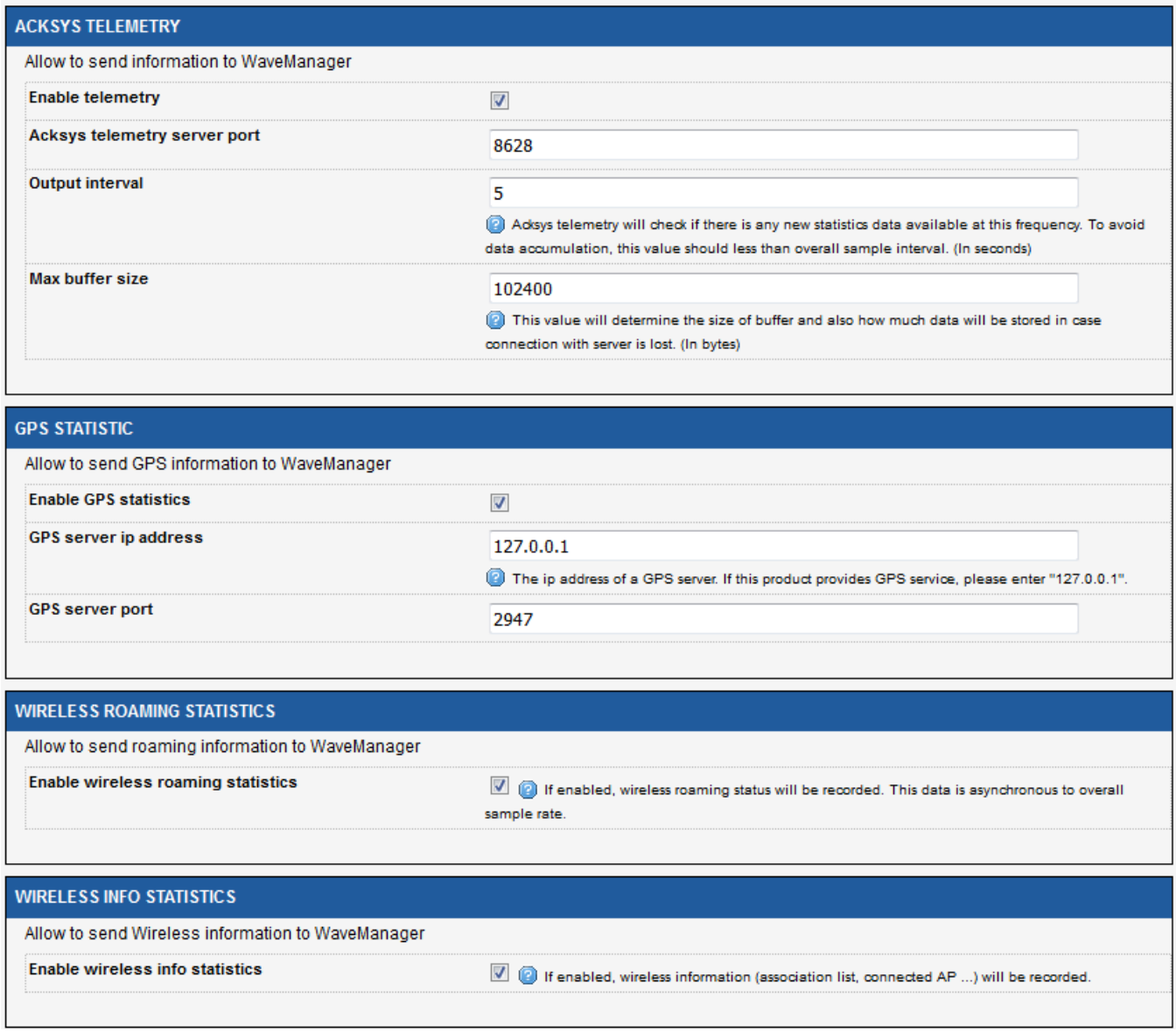


Statistic related services are disabled by default. Please check Enable statistics system in the OVERALL SETTINGS to activate these functions.



When statistical services are enabled, you can set the data collection interval (every 30 seconds by default).

When graphs are enabled, the product collects the wireless signal level received by its wireless client from the AP, and tx/rx traffic data of network interfaces in real time. In the STATUS page, you can display collected data in graphical format with various display durations (see sections VI.3.2 Network and section VI.3.6.1 Associated Stations)



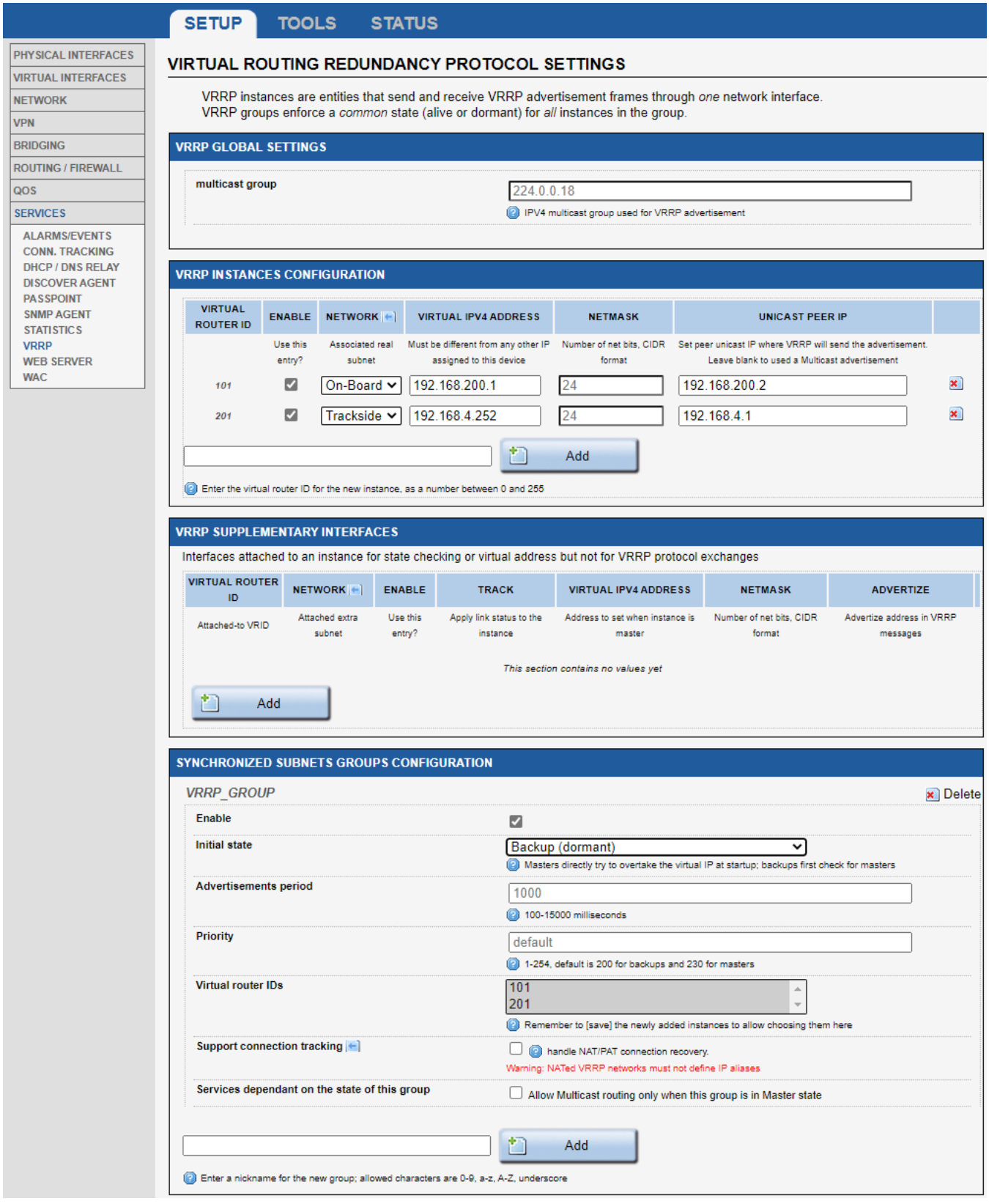
The collection of telemetry information, GPS statistics, roaming statistics and GPS statistics is activated and automatically configured by WaveManager when it is launched or when these services are activated. It’s possible to locally deactivate these services, but modification of the parameters is reserved for future functionalities not yet implemented.

VI.1.10.10 VRRP

In this page you will add the VRRP instances and their associated virtual IP address. Then you will create the VRRP groups, listing their instances and the properties common to all instances.

Before creating the instances, you must define all the needed subnets and their properties in the SETUP/NETWORK section.

If you are setting up a NAT or PAT router, you will need to enable the connection tracking service as well (see Connection tracking).



Subsection: VRRP global settings

Multicast group:

Set the multicast group that will be used by VRRP instance to send the advertisement. Leave blank to use the default group.

Subsection: VRRP INSTANCES CONFIGURATION

Each virtual IP address is identified by a number between 1 and 255. To create an instance, enter a valid, unused number in the box at the bottom of the first subsection, then click the **Add** button.

The instance is created and you can set its properties:

Enable:

you must enable the instance to use it. If you are testing various configurations you can disable instances you do not use.

Networks:

choose the network interface to associate with the virtual IP. The interface can be either a network device or a software bridge; however, broken links are not detected on software bridges.

Virtual IPV4 address:

choose the virtual IP address of your router for this subnet.

Netmask:

give the number of bits in the virtual address that hold the network part. (24 is the same as a 255.255.255.0 netmask, and so on).

Unicast peer IP:

VRRP can use unicast advertisement in place of multicast. The unicast IP address must be enabled during the master send the advertisement. Leave blank to use multicast advertisement.

Red cross:

with the red cross icon  you can delete an instance.

Subsection: SYNCHRONIZED SUBNETS GROUPS CONFIGURATION

Each instances group is given a name formed of letters, numbers and underscore sign. To create a group, enter a valid, unused name in the box at the bottom of the second subsection, then click the “Add” button. A group is created and you can set its properties:

Red cross:

with the red cross icon  you can delete a group.

Enable:

you must enable the group to use it. Disable it for tests.

Initial state:

this should reflect the intended role of the product for the group.

Advertisements period:

interval between two messages sent to the backup. A small value accelerates failure detection but increases network load.

Priority:

used for negotiation when several backups are set up. The default values assign a sensible value depending on the initial role.

Virtual router IDs:

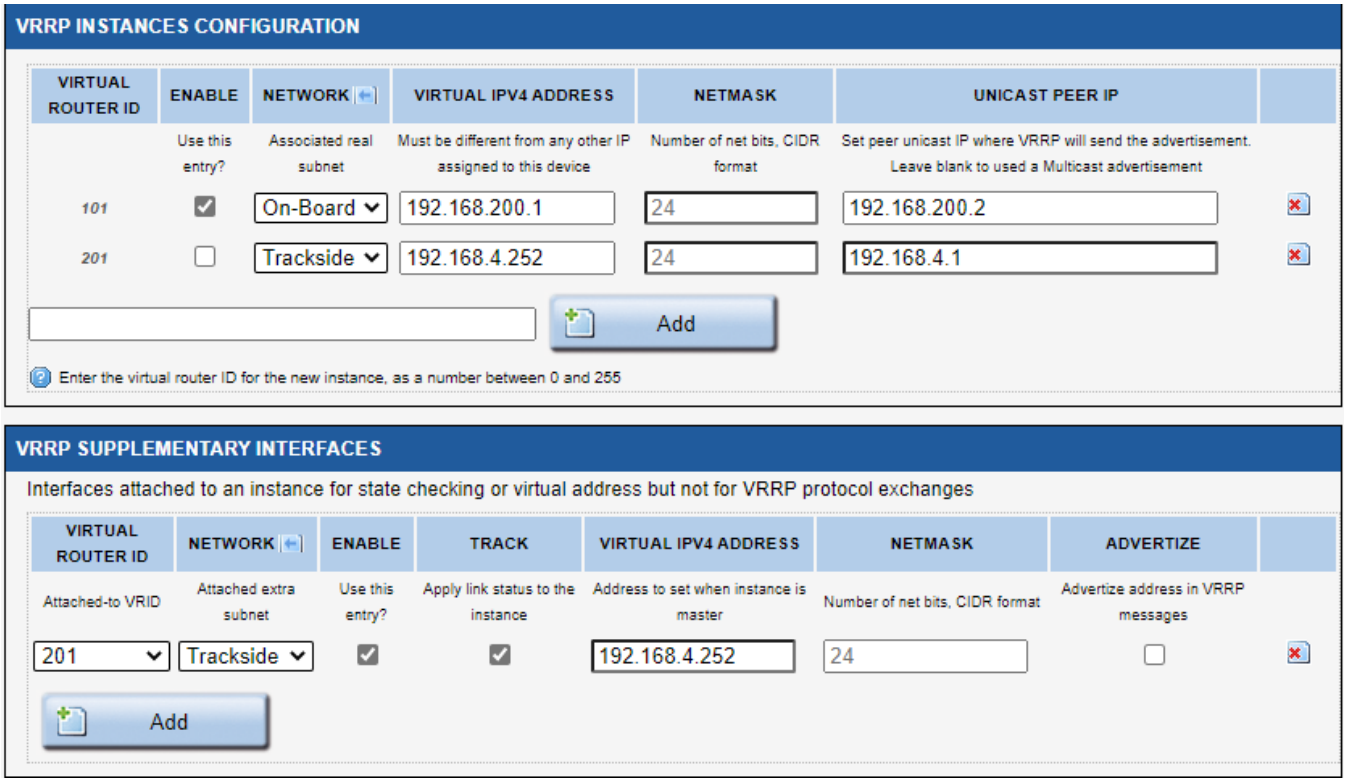
a multi-selection box to select instances in the group.

Support connection tracking:

check to transfer connection information from the active router to the inactive one.

Subsection: SYNCHRONIZED SUBNETS GROUPS CONFIGURATION

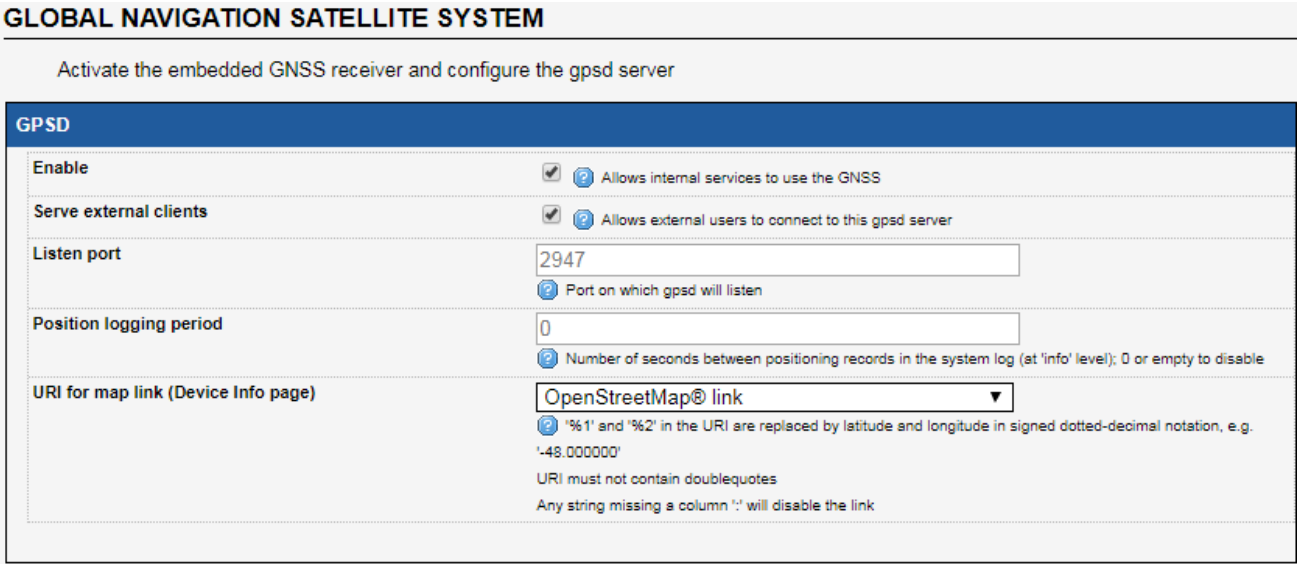
This section allows to define additional interfaces attached to an instance, for state checking or virtual address, but which will not be used for protocol exchanges. This will in particular prevent to send advertisements on certain interfaces: for example here, we will send advertisement only to the *On-Board* interface, the *Trackside* interface will no longer be used for this purpose.



Note that after creating the additional interface without advertisement on the model of ID 201, it could be removed from the configuration section. However, it may be useful to simply disable it (*ENABLE* checkbox), at least during the test phase, and in this case only select ID 101 in the *Virtual router IDs* of the group (in the *Synchronized subnets group configuration* section).

VI.1.10.11 GNSS Agent (on some models)

This page configures the GNSS agent.



Enable

Allow use of the location service.

Serve external clients

Allow devices outside of the product to query its position using the gpsd protocol. If disabled, the position can still be queried with SNMP, displayed on the Status→Device Information page, or logged to an external log server.

Listen port

Change TCP server port for external clients.

Position logging period

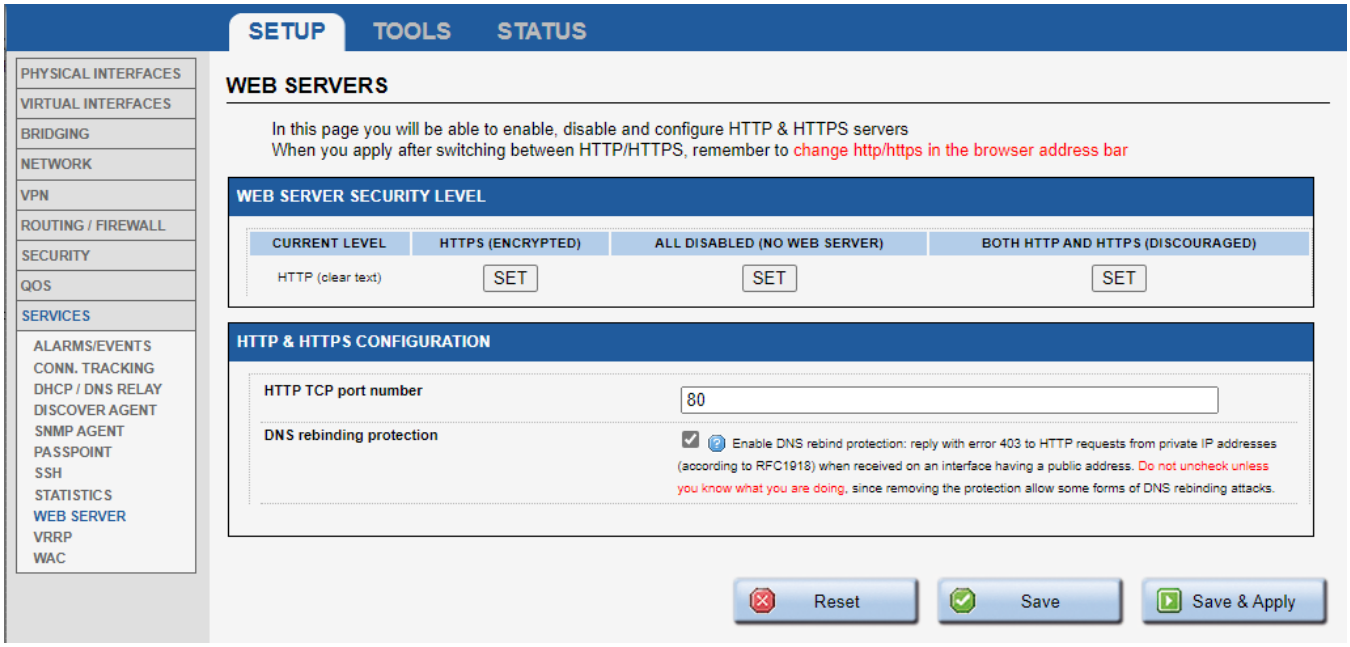
Periodically add an entry in the system log indicating current position.

URI for map link

The current position that appears on the Status→Device Information page is embedded in a web link, allowing for example to display a map using external services. Here you can choose among renown public services, or set up a link to your preferred web server. To disable the link entirely, choose **custom** and enter a dash or a hash mark (anything but a column). If the string **%1** appears in the link, it will be replaced with the latitude, and **%2** will be replaced with the longitude.

VI.1.10.12 Web Server

This menu allows to select and configure HTTP and HTTPS servers. Default is **HTTP**:



HTTP TCP port number

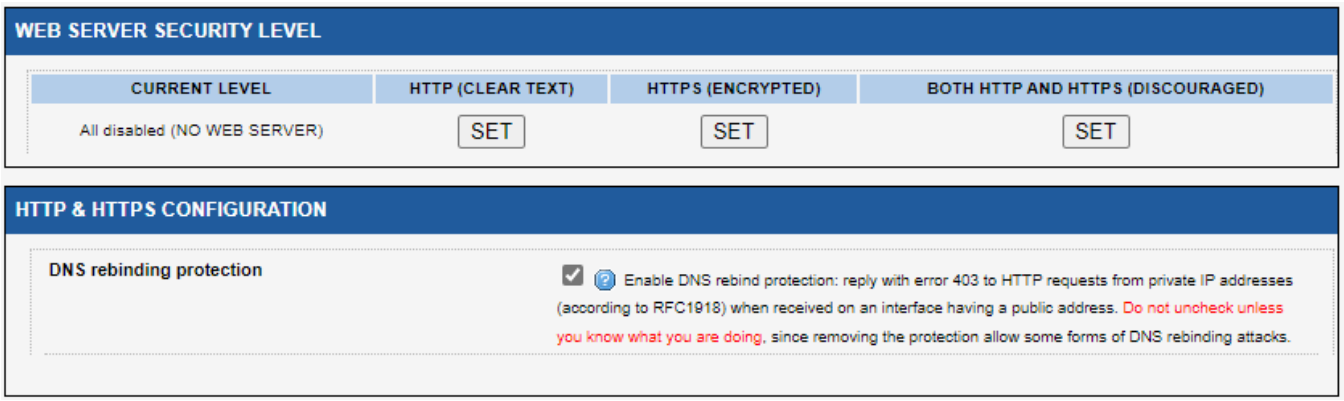
If you want to use a port different from the default port 80, you can specify it here

DNS rebinding protection

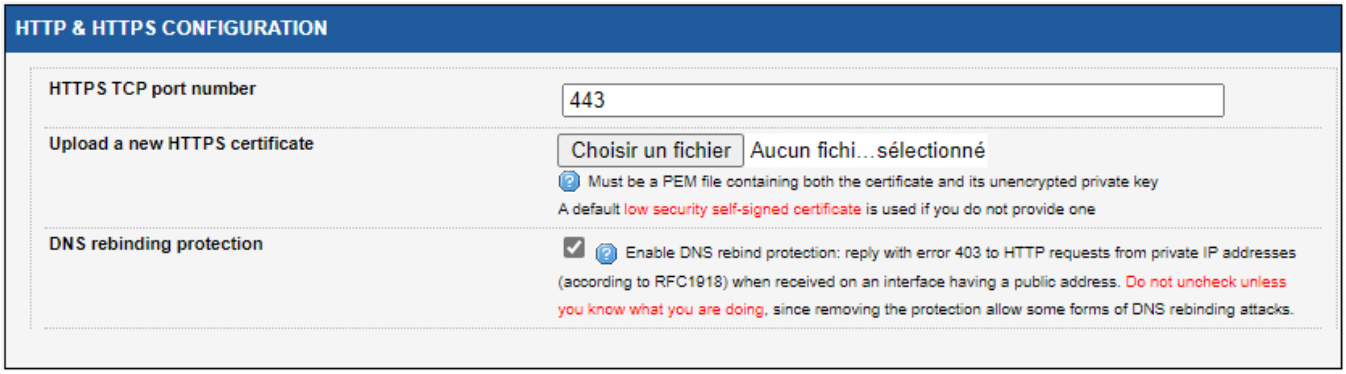
When checked, the DNS rebinding protection option allows to comply with the recommendations of RFC1918, which prohibits access from a private address to a WEB server configured on a public address. For example, if the product is configured at the public address 82.128.0.30, it will not be possible to open the WEB pages of this product from the private address 192.168.1.40: a 403 error will be issued in response to the request.

To choose another available option, just click the corresponding SET buttons:

All disabled (NO WEB SERVER)



HTTPS (ENCRYPTED)



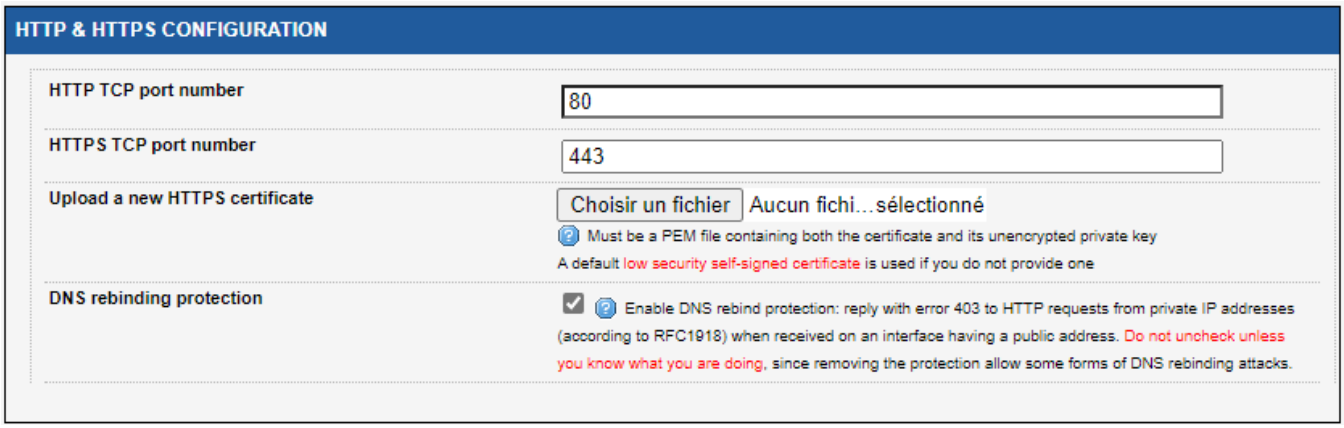
HTTPS TCP port number

If you want to use a port different from the default port 443, you can specify it here
Upload a new HTTPS certificate

Upload a new HTTPS certificate

For the HTTPS server, you can upload a web certificate file (PEM format). The certificate file is verified and uploaded when you Save or Save & Apply

Both HTTP and HTTPS (discouraged)



HTTP TCP port number

If you want to use a port different from the default port 80, you can specify it here

HTTPS TCP port number

If you want to use a port different from the default port 443, you can specify it here
Upload a new HTTPS certificate

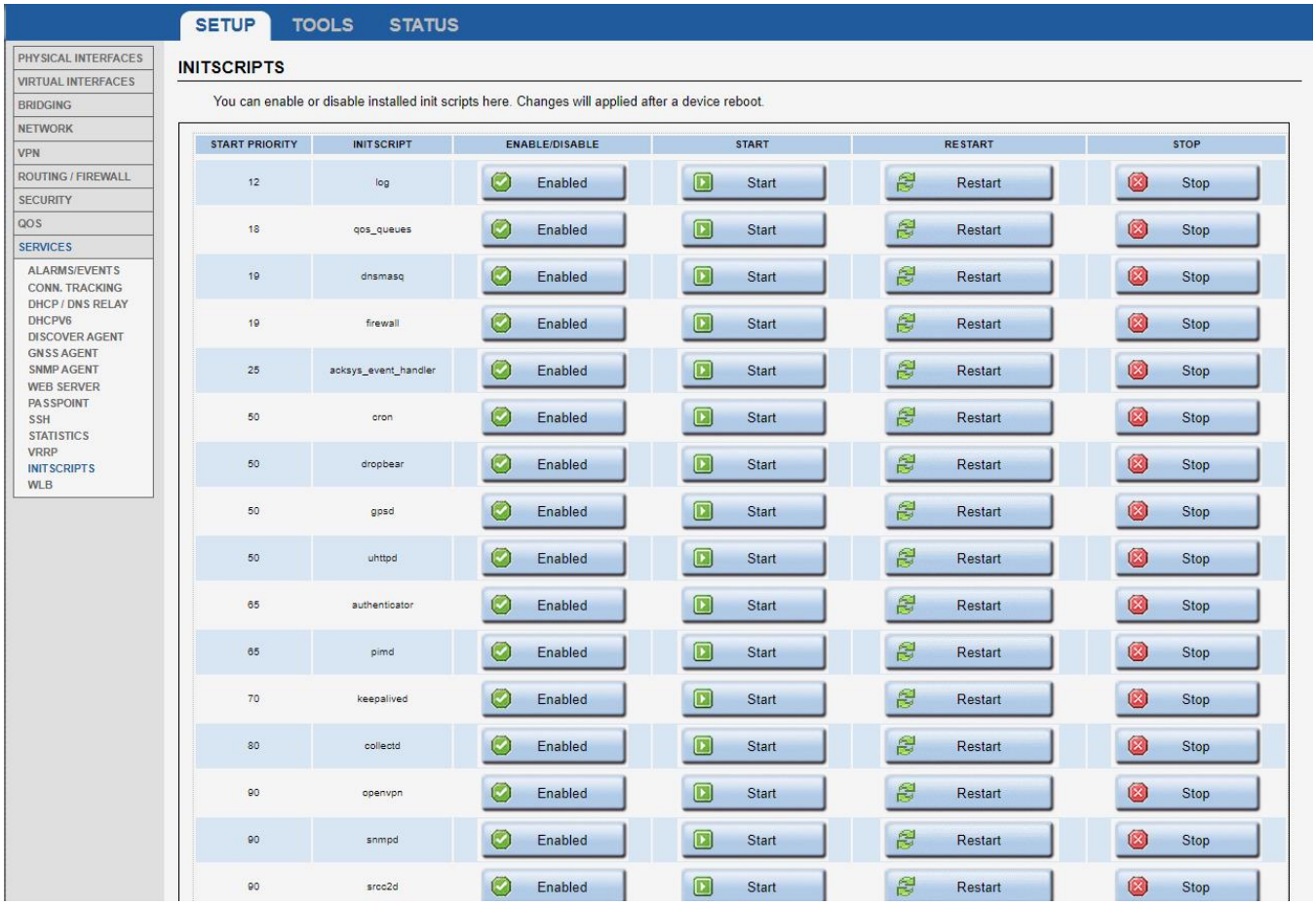
Upload a new HTTPS certificate

For the HTTPS server, you can upload a web certificate file (PEM format). The certificate file is verified and uploaded when you Save or Save & Apply

VI.1.10.13 INIT SCRIPTS

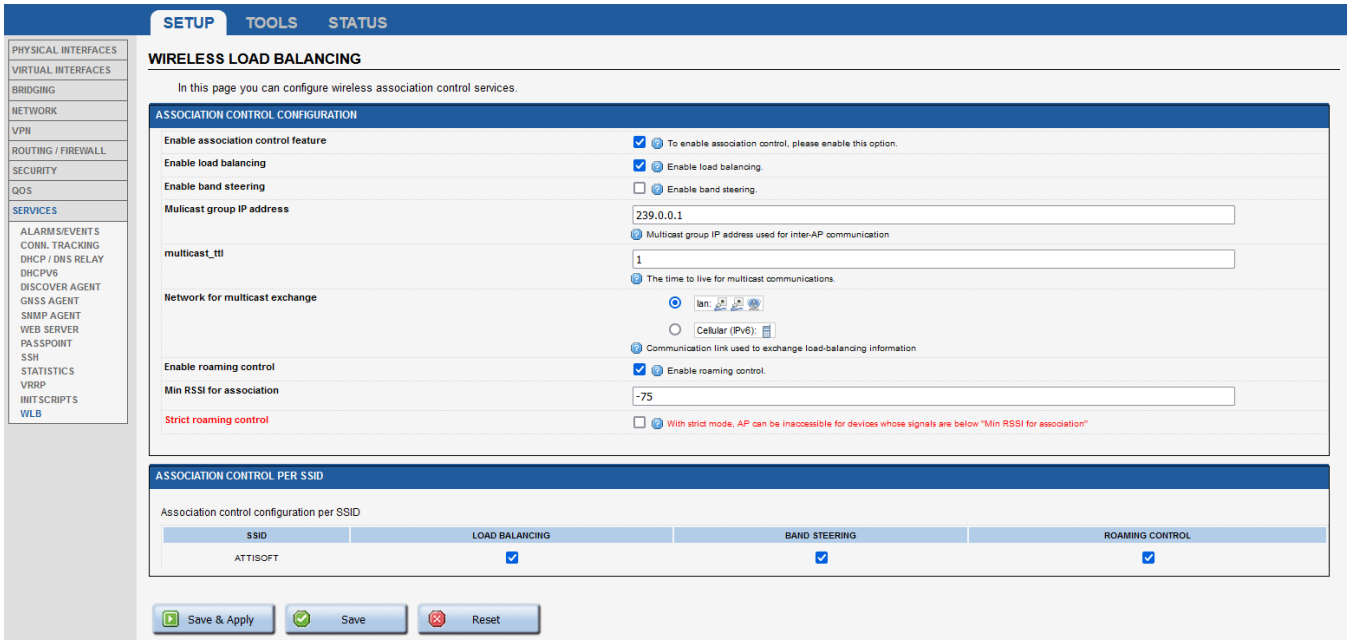
SERVICES/INIT SCRIPTS menu allows to manage and monitor some essential scripts installed such as:

- View on the service priority
- View of the service name
- Enable /disable a service
- Start / Restart /Stop a service



VI.1.10.1 WLB

SERVICES/WLB menu allows to configure the WLAN Association control system



ASSOCIATION CONTROL CONFIGURATION

Enable association control feature

You must check this box to display the different WLB options.

Enable load balancing

You must check this box to enable load balancing and display the following parameters:

Multicast group IP address

APs send ***probe announcements*** to other APs belonging to the same multicast group. The user can personalize the multicast-group IP address (239.0.0.1 by default).

Multicast_TTL

By default, ***probe announcements*** are sent in multicast to APs of the same LAN (TTL=1 by default). However, the user can configure TTL to make ***probe announcements*** traverse routers, i.e., APs belonging to different LANs.

Network for multicast exchange

Select here the networks on which the ***probe announcements*** will be advertised.

Attention! When the load balancing is enabled, you **must** define the **Maximum simultaneous associations** parameters in General Setup, Access Point Mode page.

Enable band-steering

Check this box to enable band-steering. This will allow dual-band capable STAs to move to a less congested band.

Enable roaming control

Check this box to enable roaming control and display the following parameter:

Min RSSI for association

When roaming control is enabled, the user must specify a RSSI threshold below which associated STAs are disassociated. Association requests are accepted only if the RSSI is above this threshold.

Strict roaming control

Strict mode impacts the behavior of the roaming control:

Association with Strict mode enabled:

Devices with signals that are LOWER than ***Min RSSI for association*** cannot connect.

Association with Strict mode disabled:

The AP will refuse the first connection attempts whose signals are LOWER than "Min RSSI for association". If a device tries to connect to the same AP for the second time, after the first failure, the AP will accept unconditionally (ignoring the client's current signal level). Devices of this type are called *insisted devices*

De-association with Strict mode enabled:

After 5 consecutive signal samples that are LESS than "Min RSSI for association", the AP will disconnect this device immediately.

De-association with Strict mode disabled:

- The AP will maintain the connection of the *insisted device* unconditionally as long as at least one of the last 5 consecutive signal samples is below ***Min RSSI for association***
- When the last 5 signal samples are higher than ***Min RSSI for association***, the *insisted* role of the *insisted devices* is removed.
- For *non-insisted* devices, i.e. normal devices, the AP will cut the connection when: last 5 signal samples are all below ***Min RSSI for association***

Please note that the sample interval is 3 seconds

ASSOCIATION CONTROL PER SSID

Load balancing, band-steering, and roaming control are applied per SSID. Thus, they can be enabled/disabled for each SSID in the system.

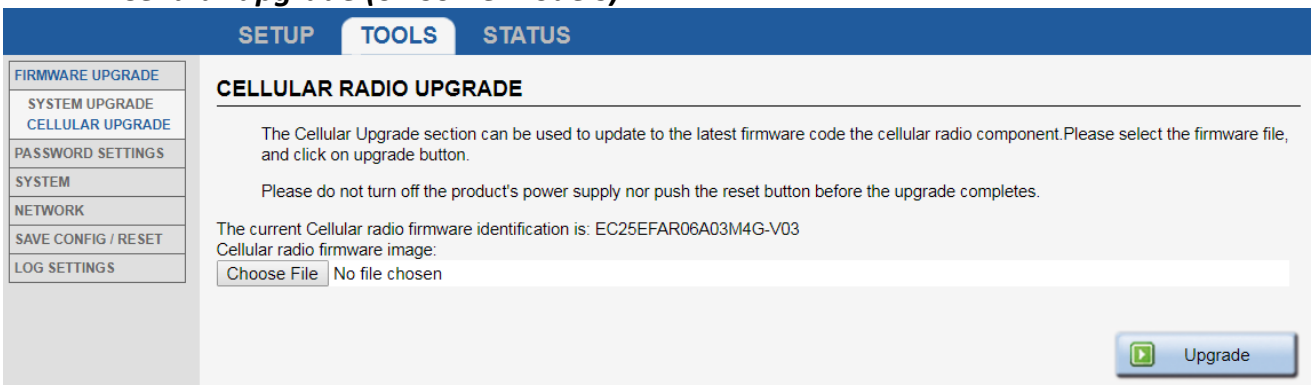
VI.2 Tools Menu

This menu allows you to administrate your product. A set of menu is provided and offers simplified the following possibilities:

VI.2.1 Firmware upgrade

Firmware upgrade has its own section in this user manual: *Firmware Upgrade*.

VI.2.1.1 Cellular upgrade (on some models)



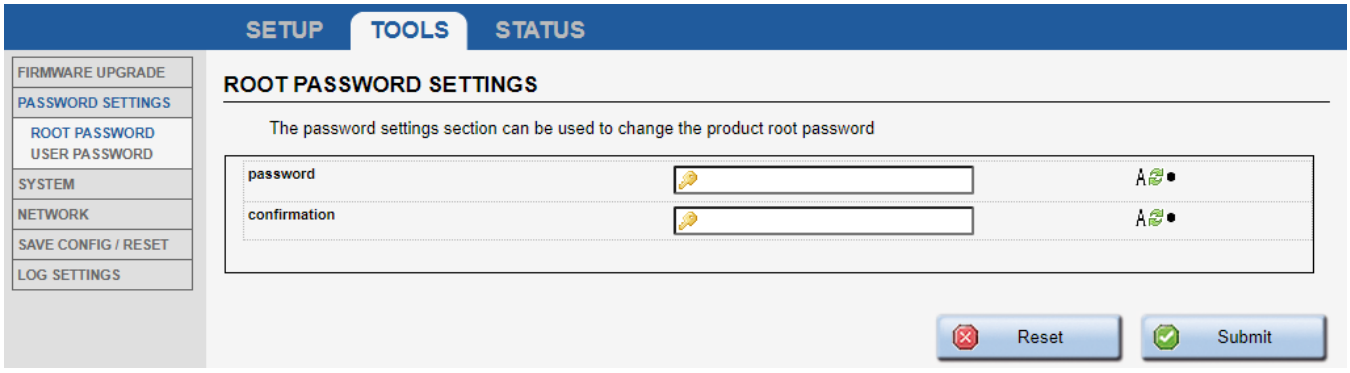
Products equipped with a cellular radio provide this function to upgrade the firmware of the embedded radio card.

Do not attempt to upgrade the cellular firmware unless the Support service provides you an adequate firmware file and related instructions.

Check the current cellular firmware identification before upgrading, as all upgrades do not apply to all versions.

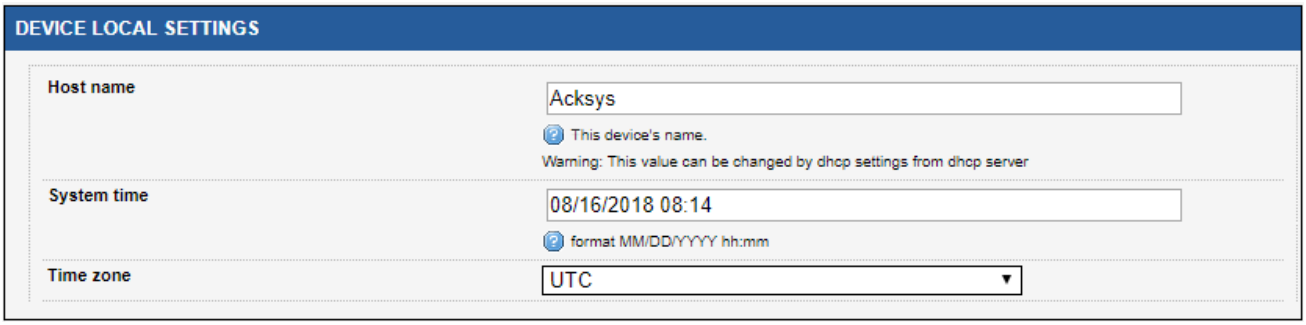
VI.2.2 Password Settings

In this menu, you can modify the product's passwords. USER has restricted access to STATUS pages. ROOT has access to all configuration pages (STATUS, TOOL and SETUP)



VI.2.3 System

VI.2.3.1 Device Local settings



Host Name:

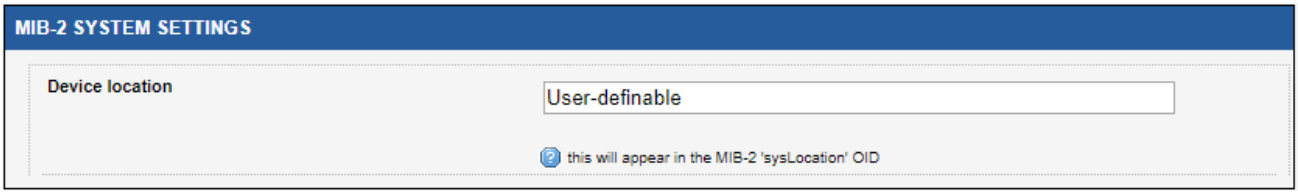
This is the name of the device. It can be changed the DHCP setting when the unit is configured as DHCP client. This text will be shown in the Device Info STATUS page.

System time and Time Zone:

Allows to set the current time and select your time zone.

ATTENTION: local time setting is lost at each reboot. No battery is provided to keep time accuracy during power off. Use a time server if needed.

VI.2.3.2 MIB-2 System Settings



Device Location:

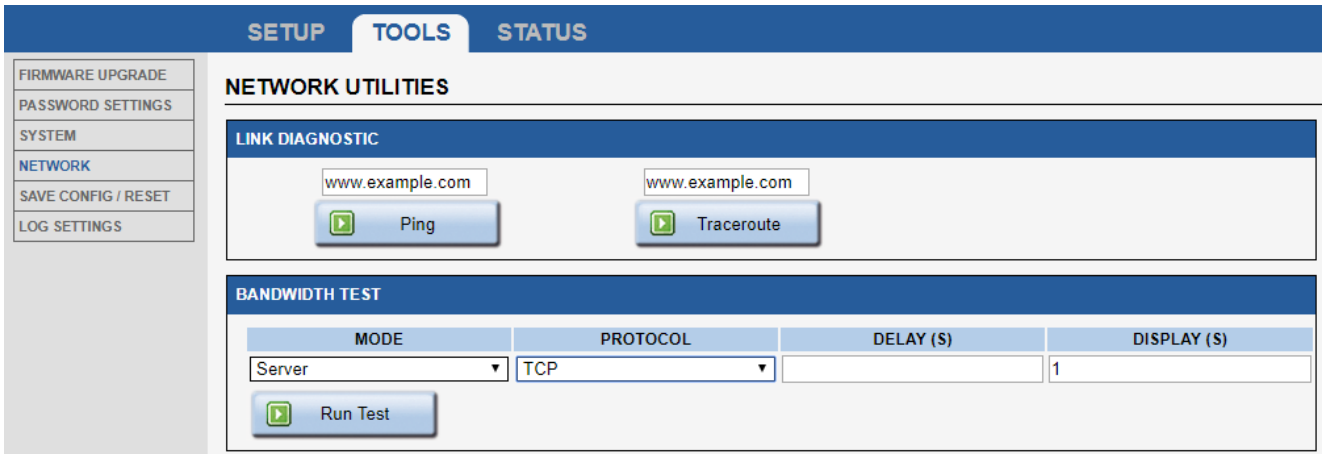
This text will be shown in the WaveManager **Location** column, in the SNMP **sysLocation** value and in the browser caption.

VI.2.3.3 Network Timer Server

If the NTP server is reachable on the network, the product can use it to configure its local time.

One can use either IP address or domain name but the use of domain name requires configuring one or more DNS server addresses in the Network configuration section.

VI.2.4 Network Utilities



LINK DIAGNOSTIC:

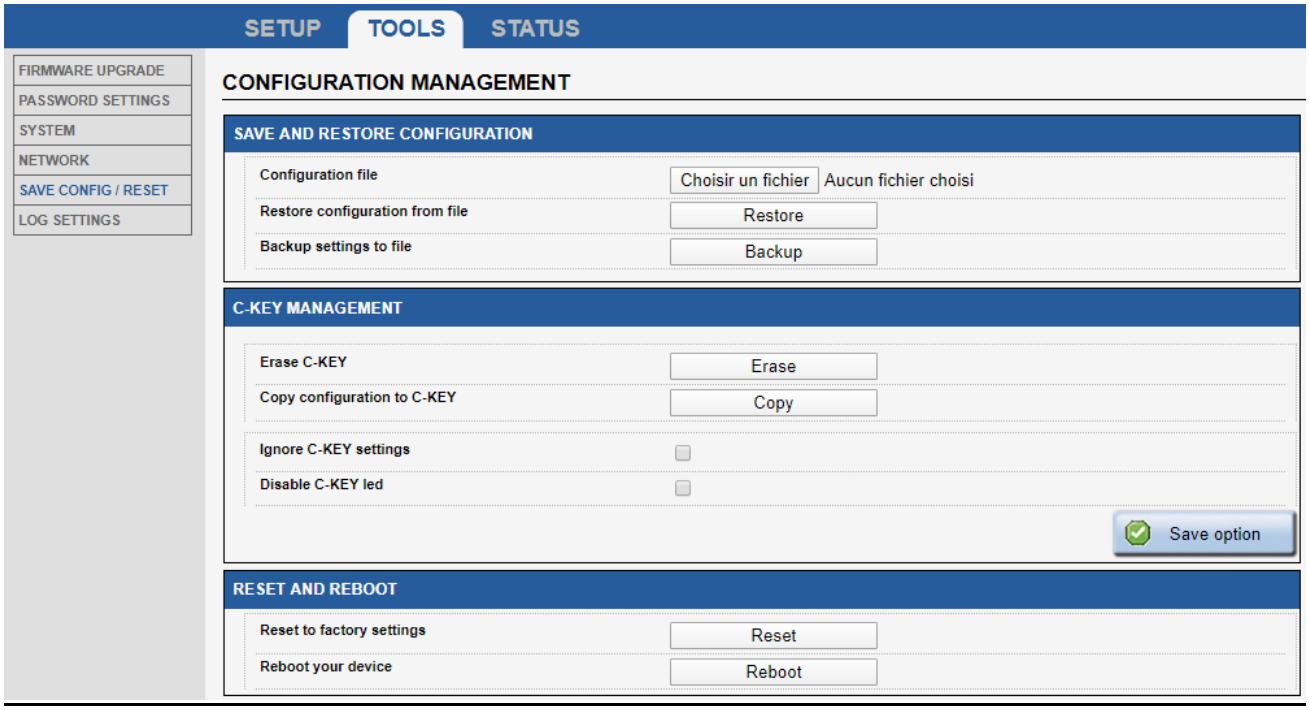
This panel provides two standard UNIX tools: ping and traceroute. Place the argument in the text field above the corresponding button and then click the button. The results will be displayed in a frame below.

You can use either an IP address or a domain name but the use of domain name requires to configure one or more DNS server addresses in the Network configuration section.

BANDWIDTH TEST:

Here you can perform an iPERF test, either in Server or Client mode, using TCP or UDP protocol. **DELAY** defines the duration of the test in seconds, while **DISPLAY** defines the status lines display interval in seconds.

VI.2.5 Save Config / Reset



Save And Restore Configuration:

With this panel, you can download the product configuration as file using the **backup settings to file**. The **Restore configuration from file** will ask for a previously saved configuration file and then restore it.

C-KEY Management:

Erase C-KEY:

This option will erase all the C-KEY contents. This has to be done before the first time you will copy configuration to the C-KEY.

Copy configuration to C-KEY:

This option will save your current configuration into the C-KEY. The configuration previously stored in the C-Key is kept in the C-Key as a backup; if the new configuration becomes damaged the backup will be loaded instead at boot time.

WARNING: the WPA keys and the various certificates (802.1x, HTTPS) will be copied as well. Anyone coming into possession of the C-Key can extract this information if no administration password has been defined.

Ignore C-KEY setting:

This option, if checked, will prevent the product from loading the C-KEY configuration at start-up. Otherwise the C-Key contents will overwrite the internal configuration files at boot time (default behavior).

Disable C-KEY led:

This option, if checked, will turn off the C-KEY status led permanently. This is useful if you don’t have any C-KEY and do not want to see the permanently red C-KEY status LED. This can also be used to slightly reduce power consumption in case of embedded system.

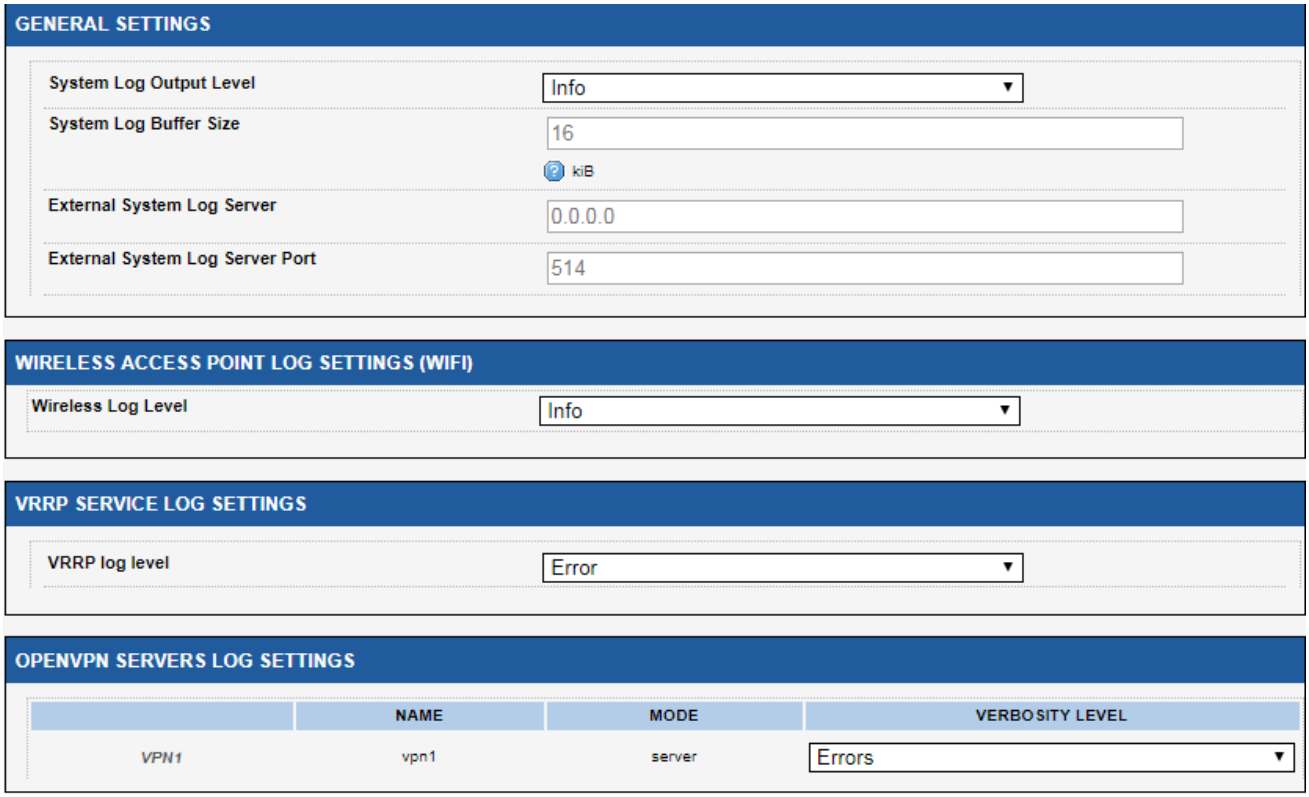
Reset And Reboot:

Reset to factory settings:
This option will restore the default product settings.

Reboot your device:
As its name suggests, a click on this button will reboot the device.

VI.2.6 Log Settings

You can configure the log parameters on this page.



General settings:

This section is about configuring the system log.

System Log Output Level:

Sets the minimum seriousness of a message to allow its insertion in the system log.

External System Log Server and Port:

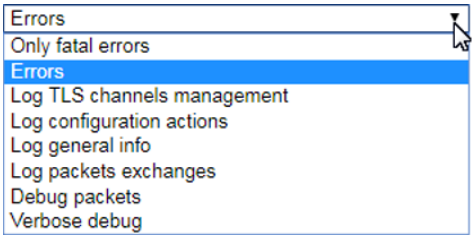
Optional remote log server configuration. IP address and UDP port where the log messages will be sent using the syslog protocol. Leave empty to disable.

Log settings:

These sections are used to configure logging for various services. The messages are sent to the system log if their seriousness is above the configured level.
So, the log messages go through two rounds of filtering: one in the specific service and one in the syslog service. Please make sure the system log output level is high enough to display all required messages.

Verbosity Level:

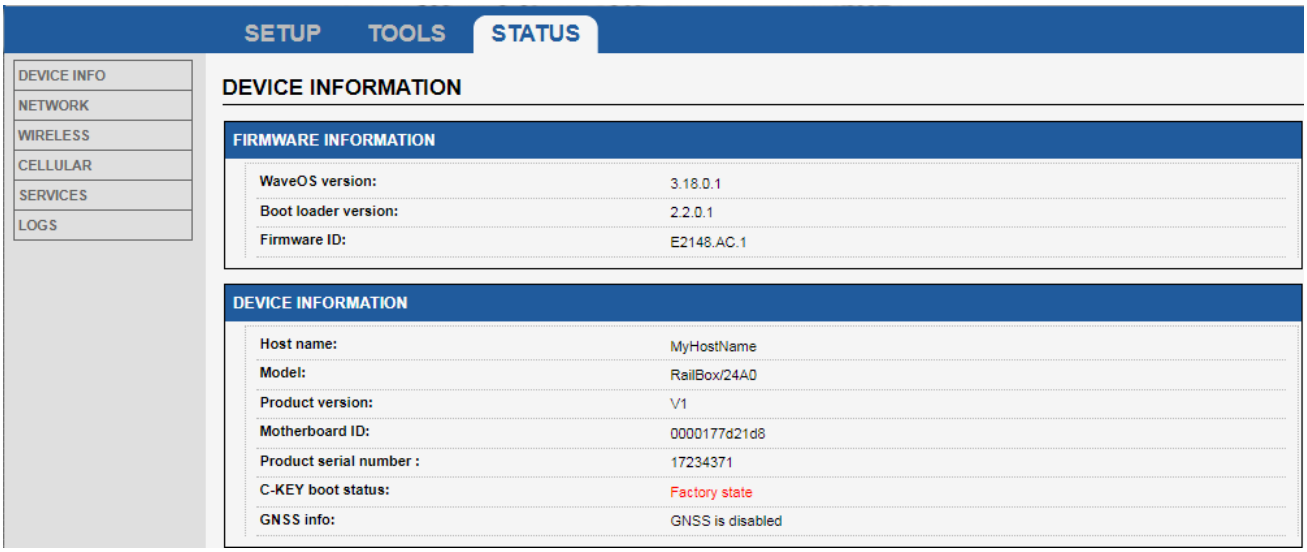
Sets the minimum seriousness of a message relating to the OpenVPN server to allow its insertion in the system log.



VI.3 STATUS Menu

VI.3.1 Device Info

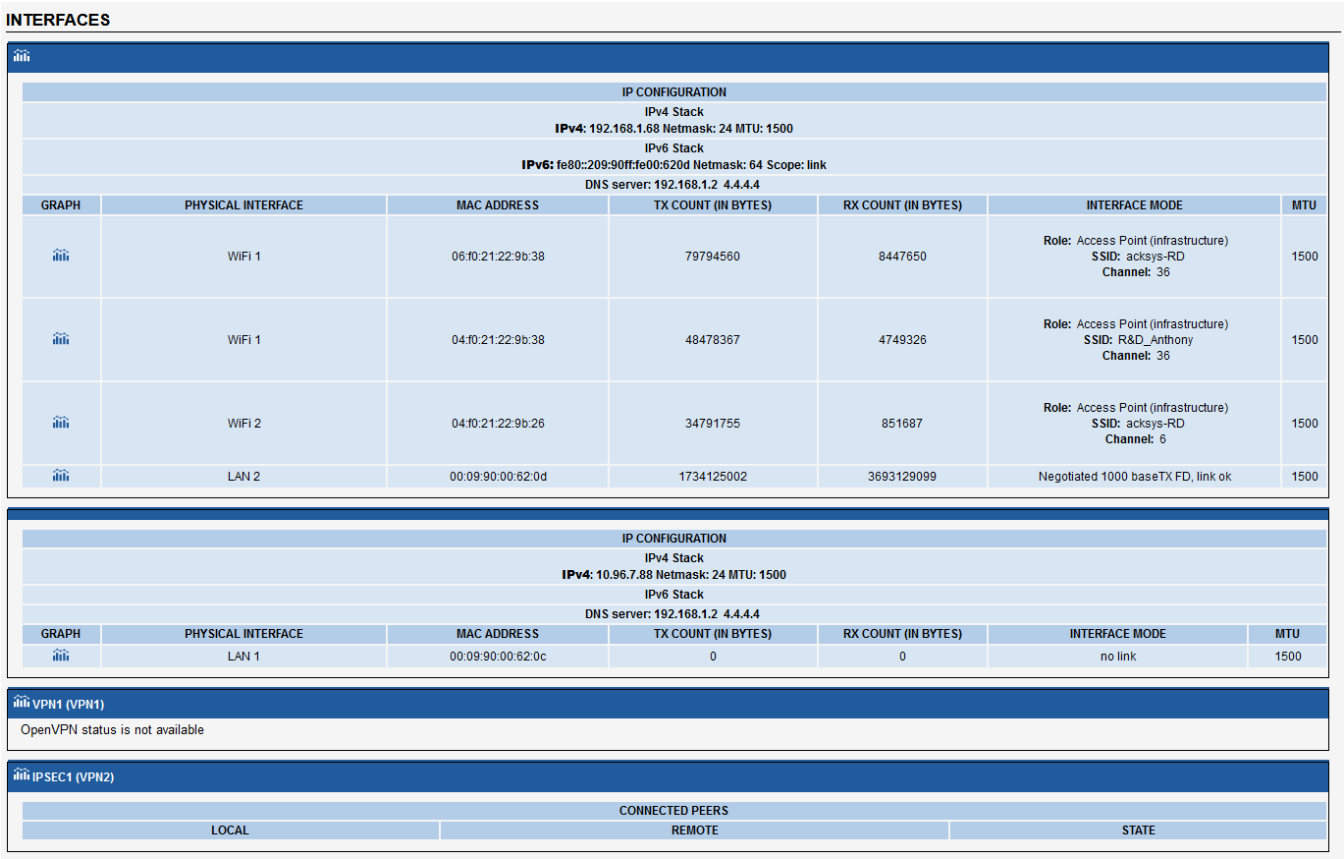
This page displays some useful information about the device. Providing the content of this page to the ACKSYS support team will speed up the technical support process.



To change the target of the link appearing with valid GNSS info, please refer to GNSS Agent configuration

VI.3.2 Network

This page summarizes the network interfaces configuration and displays transmitted and received packets counts.

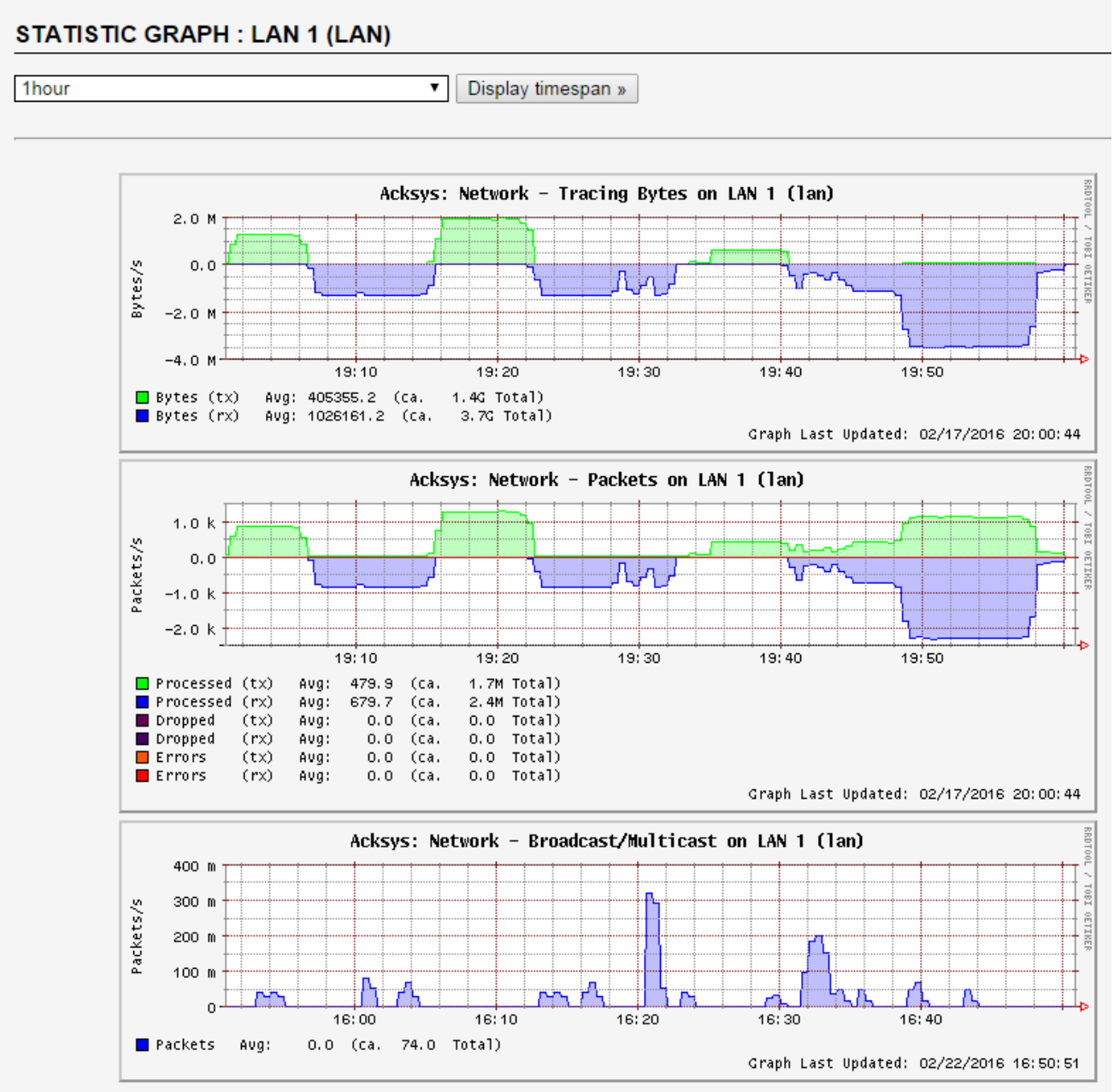


Graph: graph availability

: The history graph of the interface is unavailable because the function is disabled in the SETUP menu (SERVICES/COUNTER GRAPHS).

: The history graph of the interface is available, click the icon to display the graph.

: The history graph of the bridged network is available, click to display the graph.



This page displays the history graphs of the interface LAN 1:

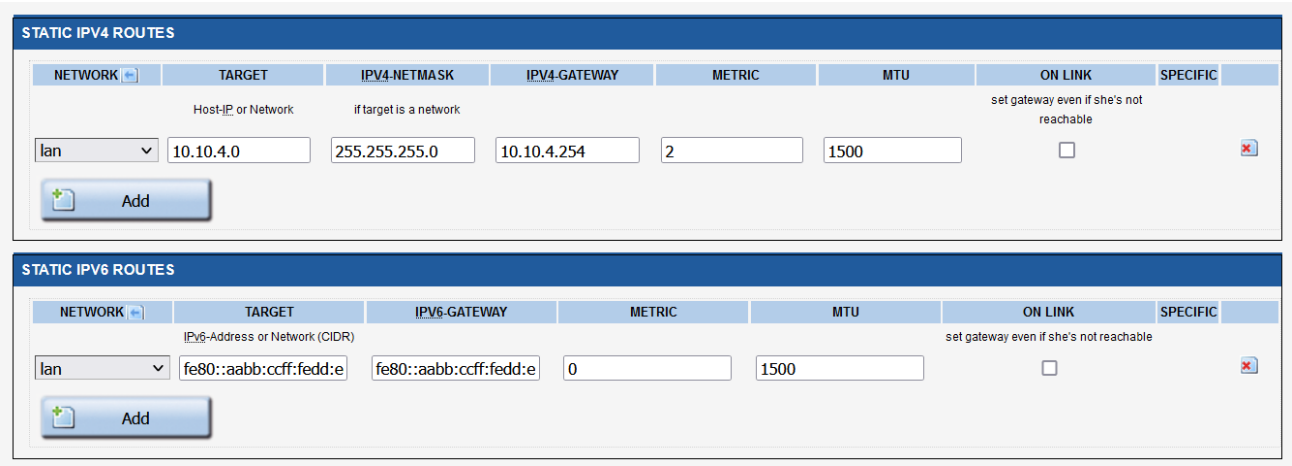
Tracing bytes graph: displays the number of bytes sent (tx) and received (rx) on this interface.

Packets graph: displays the number of processed, dropped and error packets sent (tx) and received (rx) on this interface.

Broadcast/Multicast graph: displays the number of broadcast/multicast packets on this interface.

You can also configure the display duration to 10 minutes, 1 hours, 1 day, 1 week or 1 month.

VI.3.3 Routes

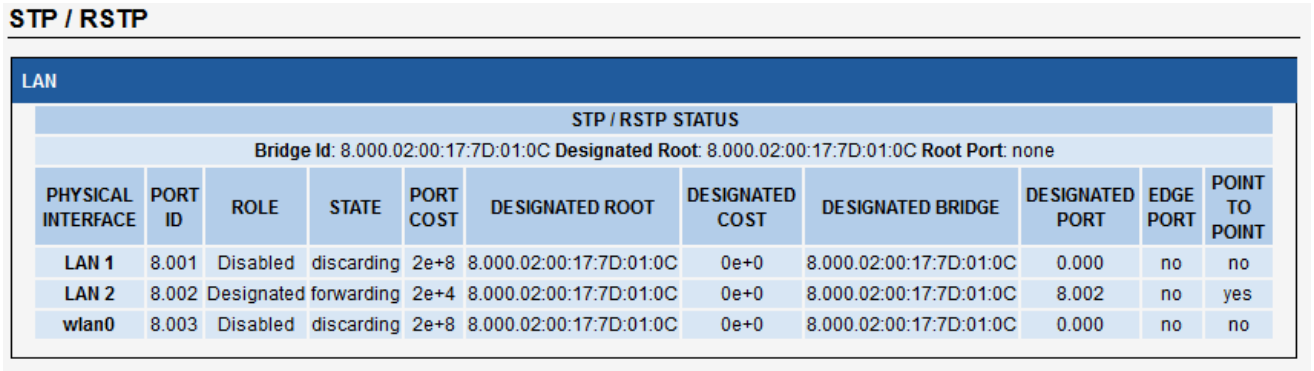


This page displays the active IPV4 routes and IPV6 route active on the product.

	Field Name	Sample Value	Explanation
1.	Network	loopback	**Network interface used**
2.	Target	0:0:0:0:0:0:0:0/0	**Indicates where a TCP/IP packet, with a specific IP address, should be directed**
3.	IPv6-Gateway	0:0:0:0:0:0:0:0/0	**Indicates through which gateway a TCP/IP packet should be directed**
4.	**Metric**	**FFFFFFFF**	**Metric number indicating interface priority of usage**

VI.3.4 Bridges

This page displays the port statuses of the STP/RSTP bridges, if there are bridges with STP/RSTP enabled in the product.



Physical interface: Port in the bridge

Port Id: Port identifier for the specified port, it is made up from the port priority and the interface number of the port.

Role: The Rapid Spanning Tree Algorithm assigns one of the following Port Roles to each Bridge Port: Root Port, Designated Port, Alternate Port, Backup Port, or Disabled Port.

The Disabled Port role is assigned if the port is not operational or is excluded from the active topology by management.

State: The port forwarding state:

For RSTP: it can be discarding, learning or forwarding.

For STP: it can be disabled, blocking, listening, learning or forwarding.

Port Cost: By default, it depends on the port speed, but it can be configured in the STP/RSTP settings.

Designated Root: Root Bridge for the Spanning tree. It is made up using the priority and base MAC address of the root bridge.

Designated Bridge: Bridge which contains the *Designated port*. It is made up from the priority and base MAC address of that bridge.

Designated port: Port that got the designated role among all bridge ports connected to this LAN (this includes the current port and the ports on the adjacent bridges). It is made up from the port priority and the interface number of the port.

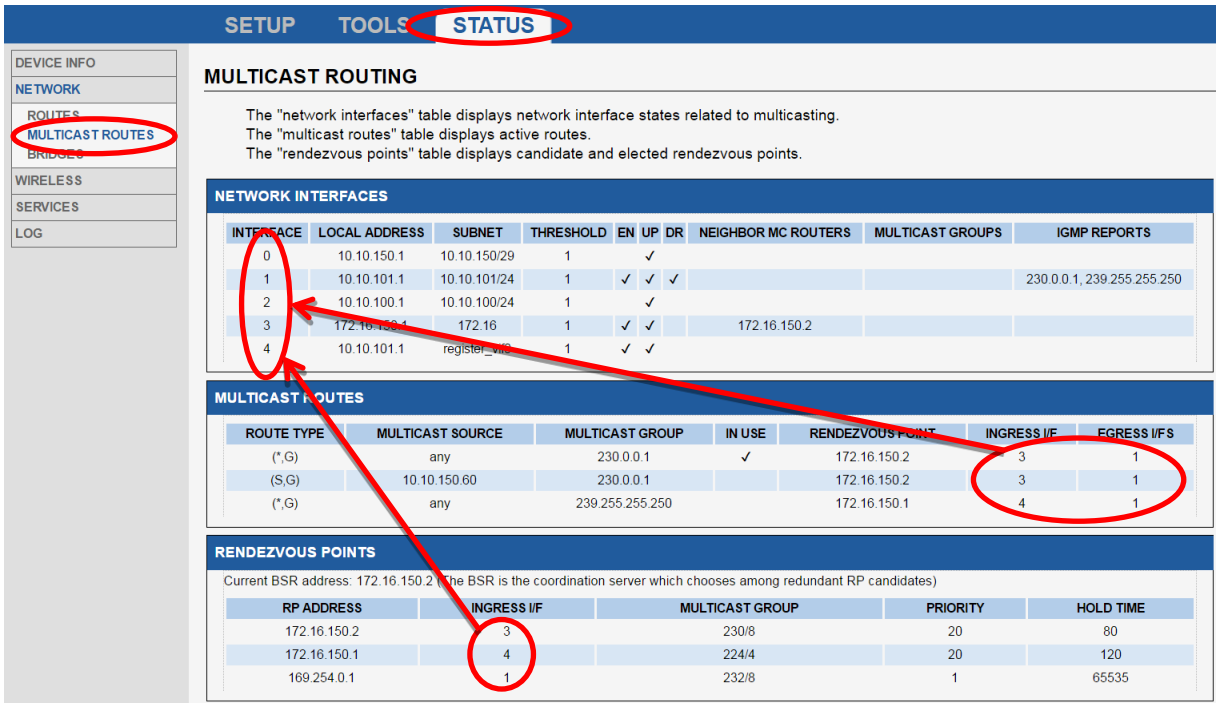
Designated Cost: Path cost to Root Bridge via the *Designated port* (Sum of ports costs of each root port on each bridge between the designated port and the Root Bridge)

Edge port: Set to true if the port is at the edge of the topology (connected to an end station), otherwise set to false.

Point to Point: Set to true if the port is connected to a point to point media (connected directly to another switch with a cable), otherwise set to false.

VI.3.5 Multicast routes

This page displays all available information about the running instance of the PIM multicast router.



a. <u>Network interfaces section</u>

Interface: network number referred to in ingress/egress columns.

Local address: Unicast IP address assigned to the network in Setup/Network page.

Subnet: the subnet this interface connects to, and the number of subnet bits. The **register_vif0** subnet is the special interface where senders send encapsulated data to their rendezvous point.

Threshold: Minimum TTL required to forward data to this interface.

EN: multicasting is enabled on this interface.

UP: this interface is available (e.g. the RJ45 connector is plugged in…).

DR: this router is Designated for this network.

Neighbor MC routers: other PIM routers directly connected to this network.

Multicast groups: PIM-SSM groups handled on this interface.

IGMP reports: list of groups for which receivers send join requests on this local network.

b. Multicast routes section

Route type: (*,G) for any source to group, (S,G) for specific source to group.

Multicast source: source requested by the receiver: any or a specific IP address.

Muticast group: the group concerned by the route entry.

In use: this entry is actively used to forward data.

Rendezvous point: the IP address that was computed for the group.

Ingress I/F: interface where the multicast data is expected to arrive.

Egress I/F: interface list where the multicast data must be forwarded.

c. Rendezvous points section

RP address: the IP address of the rendezvous point for this block of groups

Ingress I/F: interface toward the RP, hence, where data comes in.

Multicast group: the block of groups associated to this RP.

Priority: Priority of the RP for elections. Locally (statically) configured groups have a priority of 1.

Hold time: the delay after which this entry will become invalid if not refreshed in the meantime.

- Note that there is always an entry for the IP address 169.254.0.1 which is used internally to manage SSM routing.

VI.3.6 Wireless

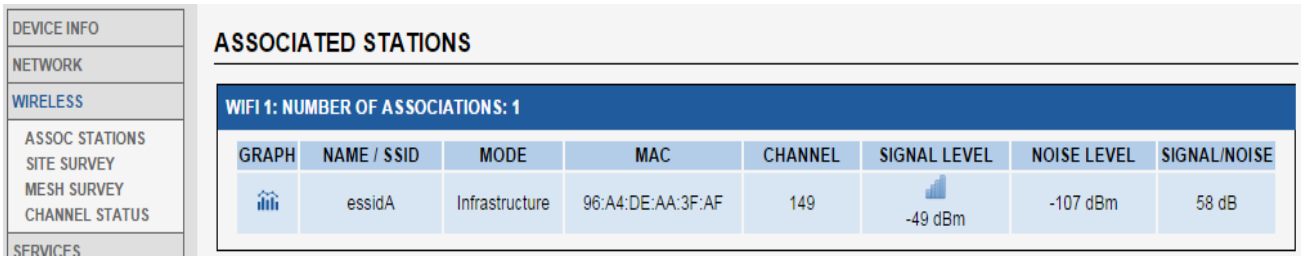
VI.3.6.1 Associated Stations

If the radio card is in **access point mode**, this panel will list the clients connected to it and display RF signal properties.

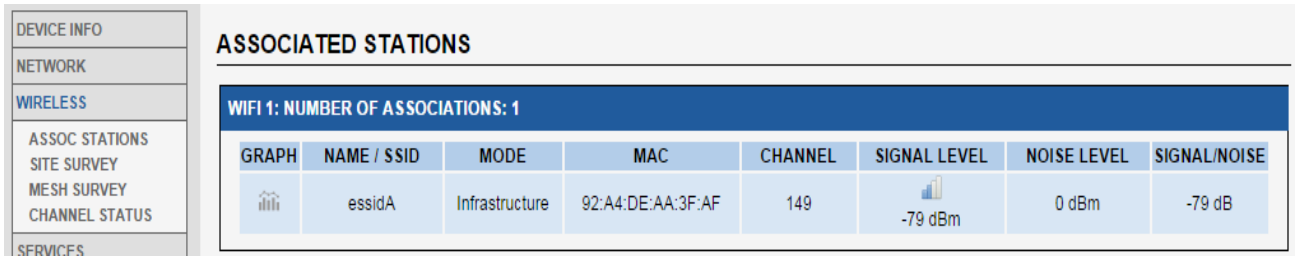
If the radio card is in **client mode**, when it's associated with an access point, its RF details will be listed on this panel.

The signal level displayed is the one obtained from the **last frame received**, whatever its type (data or management) or modulation kind. So, **it is not comparable to the values appearing in the site survey**, which concern only probe and beacon frames.

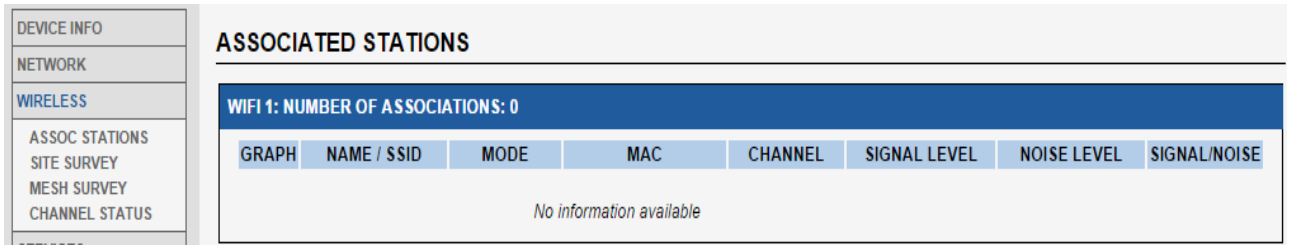
Also, the signal level can vary a lot depending on the traffic. When data is received with a high MCS value, the signal can be low because typical transmitters are less powerful at high speeds; when no data is received the signal may raise because it is taken from low-rate beacons.



In client mode, the radio card associates with an access point

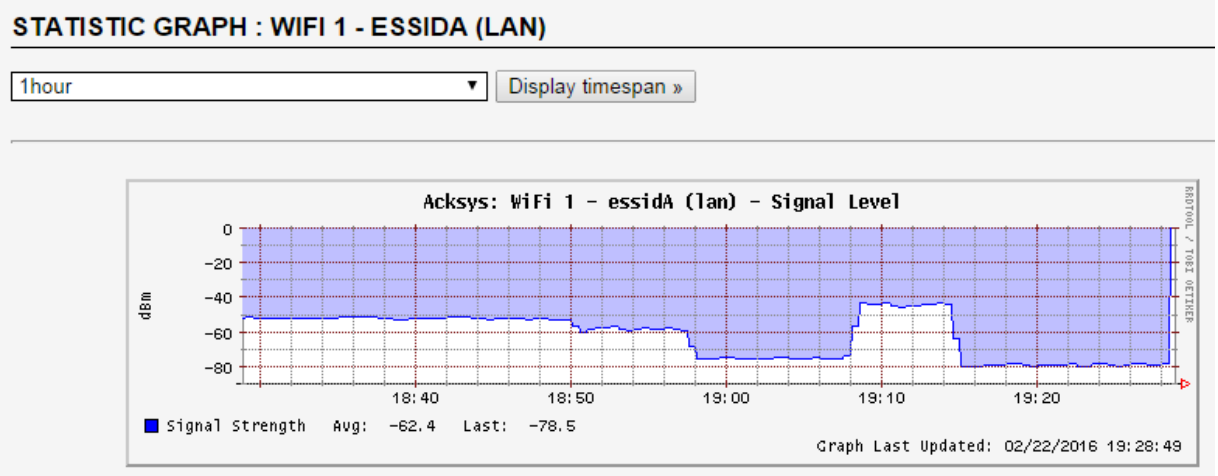


In access point mode, one associated station.



No associated station

You can display the statistic graph about signal strength by pressing the statistic graph icon . The statistic graph is only available for **client mode**. If the radio card is in **access point mode**, the statistic graph icon will be disabled.



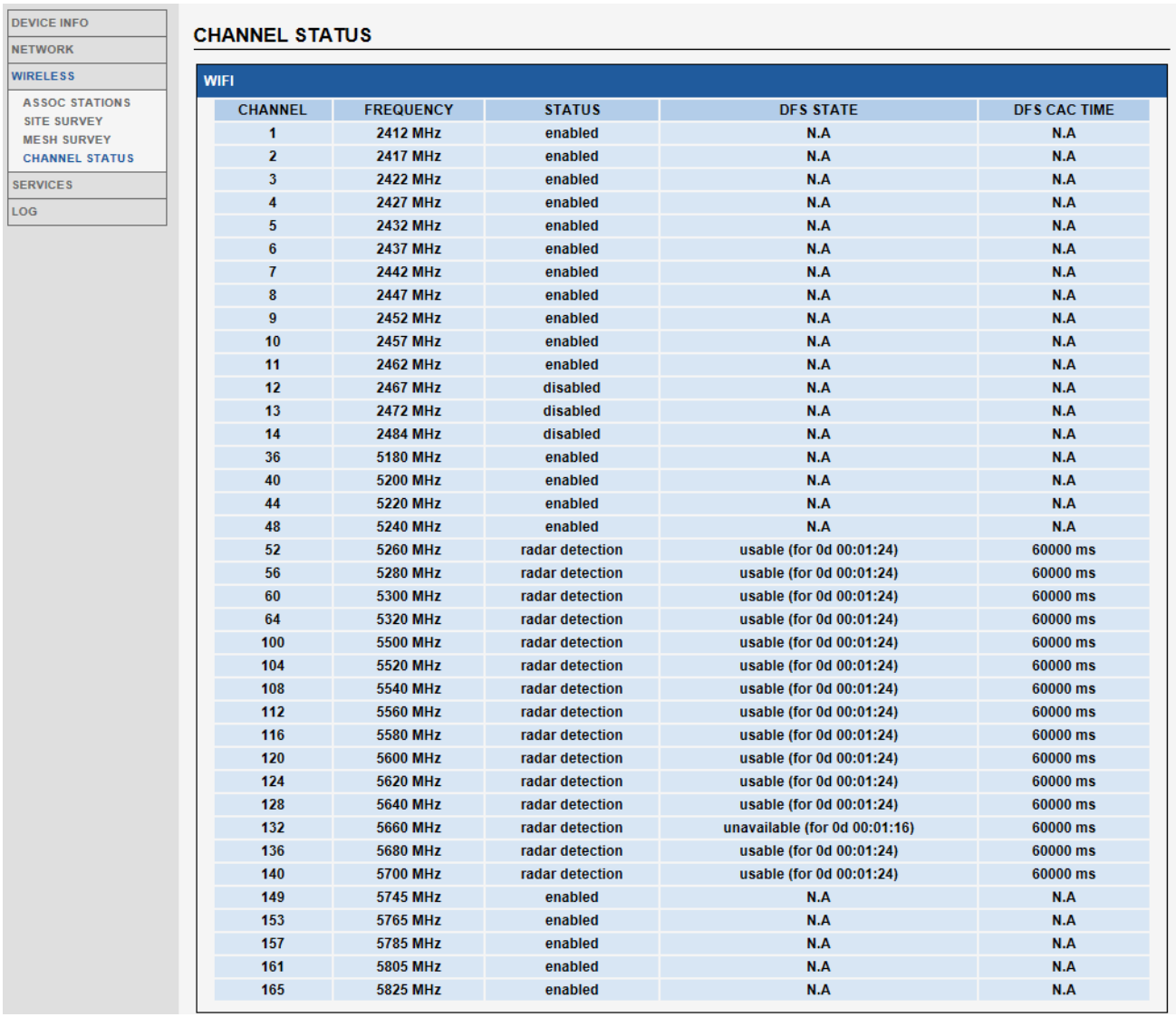
This page displays the statistic graph of the wireless interface:

Signal Level graph: It displays signal level in dBm for wireless interface in real time.

You can also configure the display duration to 10 minutes, 1 hours, 1 day, 1 week or 1 month.

VI.3.6.2 Channel Status

This panel displays the availability of all wireless channels on each radio device.



CHANNEL	FREQUENCY	STATUS	DFS STATE	DFS CAC TIME
1	2412 MHz	enabled	N.A	N.A
2	2417 MHz	enabled	N.A	N.A
3	2422 MHz	enabled	N.A	N.A
4	2427 MHz	enabled	N.A	N.A
5	2432 MHz	enabled	N.A	N.A
6	2437 MHz	enabled	N.A	N.A
7	2442 MHz	enabled	N.A	N.A
8	2447 MHz	enabled	N.A	N.A
9	2452 MHz	enabled	N.A	N.A
10	2457 MHz	enabled	N.A	N.A
11	2462 MHz	enabled	N.A	N.A
12	2467 MHz	disabled	N.A	N.A
13	2472 MHz	disabled	N.A	N.A
14	2484 MHz	disabled	N.A	N.A
36	5180 MHz	enabled	N.A	N.A
40	5200 MHz	enabled	N.A	N.A
44	5220 MHz	enabled	N.A	N.A
48	5240 MHz	enabled	N.A	N.A
52	5260 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
56	5280 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
60	5300 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
64	5320 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
100	5500 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
104	5520 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
108	5540 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
112	5560 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
116	5580 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
120	5600 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
124	5620 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
128	5640 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
132	5660 MHz	radar detection	unavailable (for 0d 00:01:16)	60000 ms
136	5680 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
140	5700 MHz	radar detection	usable (for 0d 00:01:24)	60000 ms
149	5745 MHz	enabled	N.A	N.A
153	5765 MHz	enabled	N.A	N.A
157	5785 MHz	enabled	N.A	N.A
161	5805 MHz	enabled	N.A	N.A
165	5825 MHz	enabled	N.A	N.A

Status: channel constraints against the current Radio Regulation Area.

- Enabled: this channel is part of the current Regulation Area.
- Disabled: this channel is not part of the current Regulation Area.
- Radar detection: this channel is part of the current Regulation Area and Radar presence must be monitored.

DFS state: Dynamic Frequency Selection states for channels.

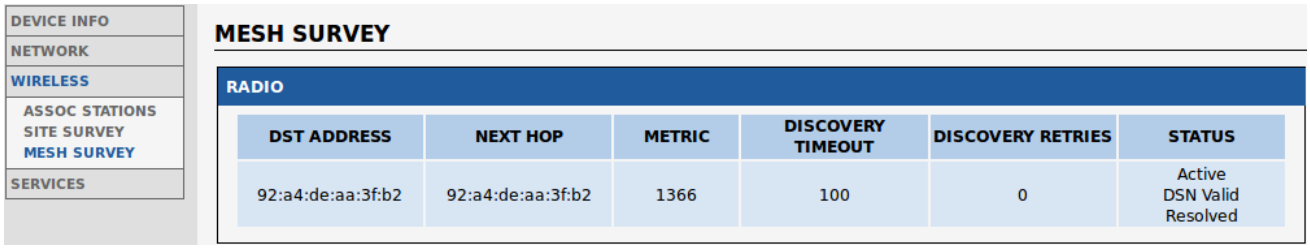
- Usable: The channel can be used, but channel availability check (CAC) must be performed before using it (Not in client mode, as it is the AP which manages the connection).
- Unavailable: A radar was detected on the channel, it cannot be used for the regulation-defined non-occupancy period (NOP).
- Available: The channel has been CAC checked and is available.

DFS CAC time:

The duration of the check for the presence of radar, before considering the channel as Available.

VI.3.6.3 MESH Survey

This panel summarizes properties for all 802.11s Mesh Points currently available.



DST Address:
MAC address of the final destination.

Next Hop:
MAC address of the next mesh node in order to reach “DST Address”.

Metric:
Represents the total cost of this mesh path (less is better).

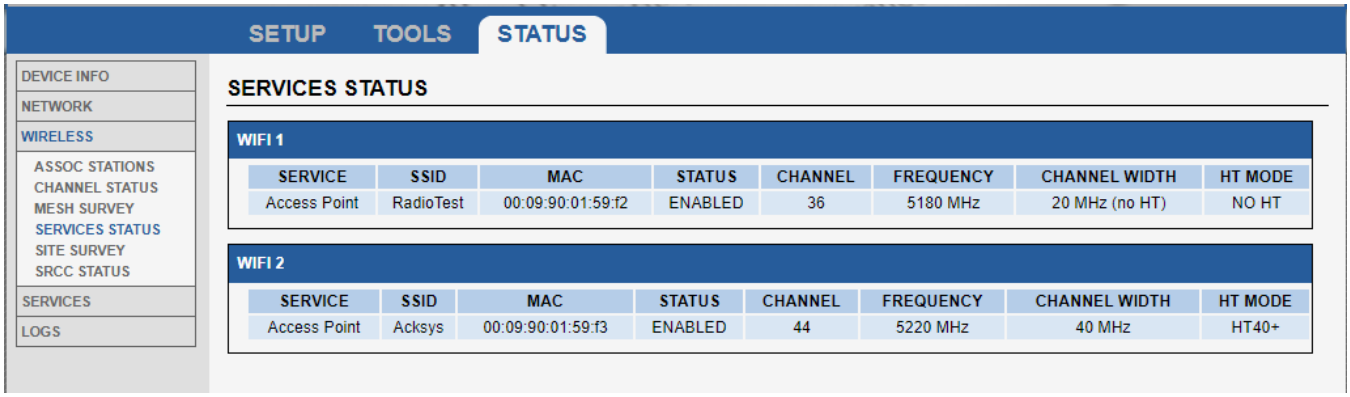
Discovery Timeout:
Displays the current discovery timeout for this mesh path (in milliseconds)

Discovery retries:
As its name implies, displays the number of discovery retries.

Status:
Displays the mesh path current state.
Must be one of the following:

- Active : this mesh path can be used for forwarding
- Resolving : the discovery process for this mesh path is running
- Resolved : the discovery process ends successfully
- DSN Valid : the mesh path contains a valid destination sequence number

VI.3.6.4 Service status



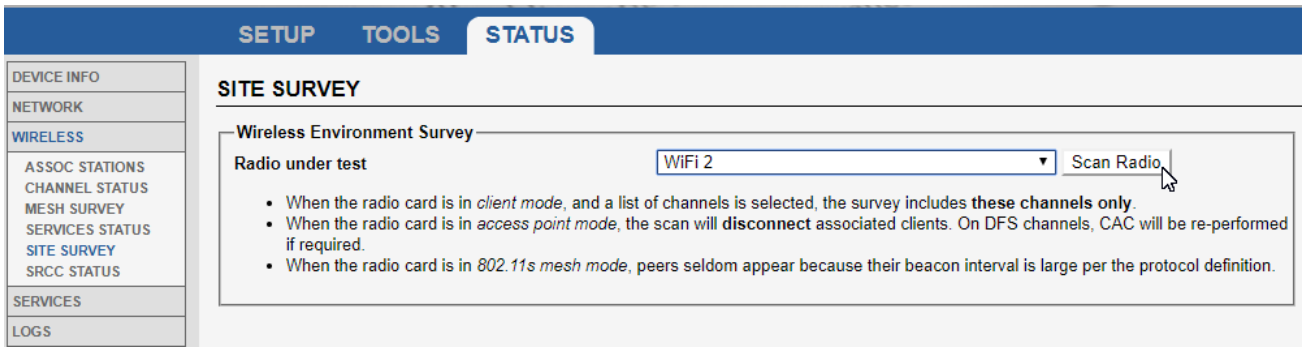
Service status gives complementary information about the current state of the wireless interfaces. The STATUS field gives in particular useful information on the state of DFS channels.

VI.3.6.5 Site Survey

This feature allows to detect all access points within range. The results may depend on the mode the radio card is set to:

- When the radio card is in **client mode**, and a list of candidate channels is selected in the **Roaming** tab of the wireless setup, the survey will only include access points using the selected channels.
- When the radio card is in **access point mode**, the scan will disconnect associated clients.
- When the radio card is in **802.11s mesh mode**, some peers seem to appear and disappear at random because their beacon interval is large per the protocol definition, but the scan period is short.

On dual radio products, you can select the radio card with which you want to perform the site survey. Click on **Scan Radio** to start the survey. This operation may take a few minutes.

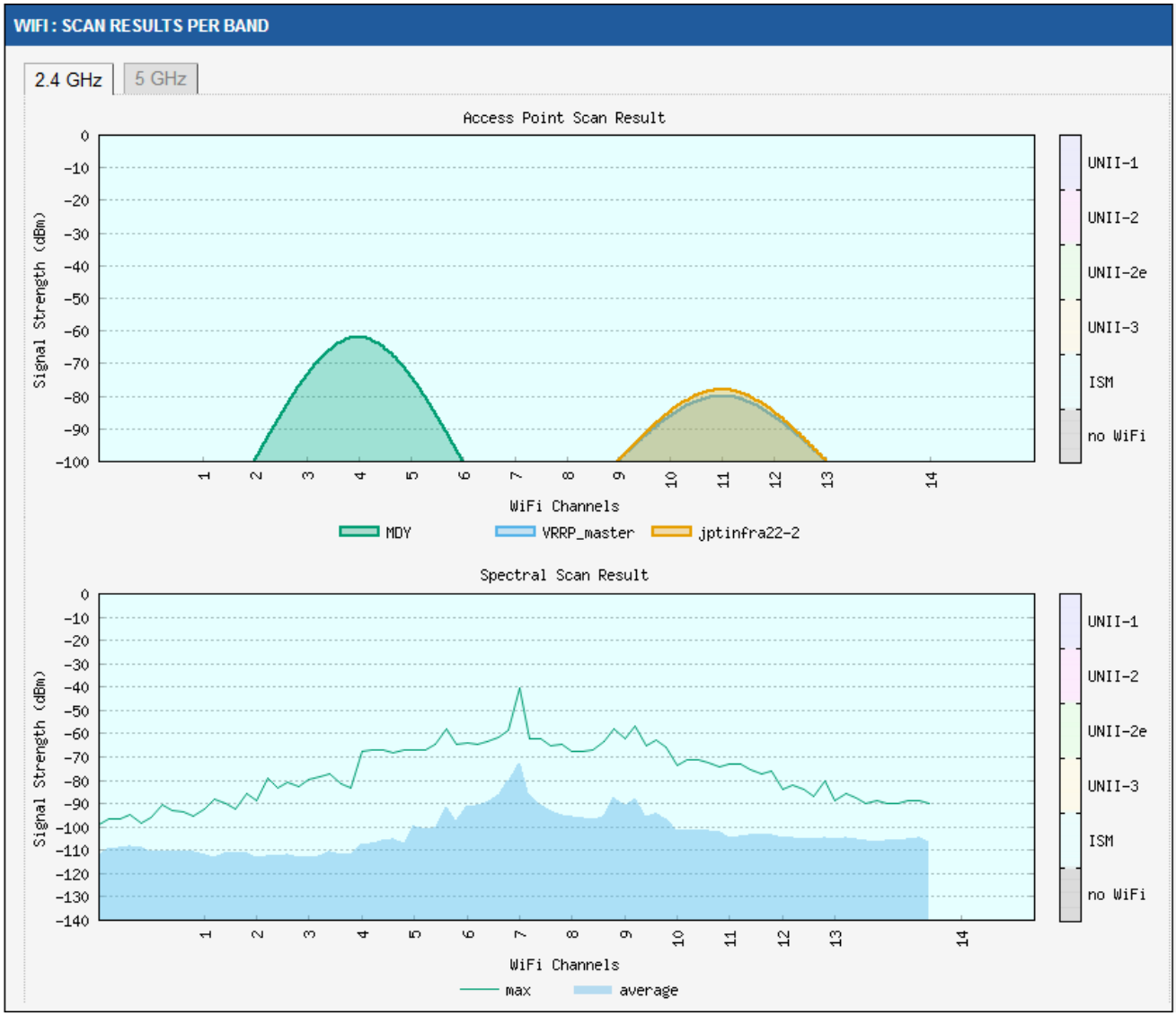


Please note that during the scan period, the radio card can no longer perform the function for which it is programmed. If, for example, it is configured as an Access Point, all associated clients will be temporarily disconnected. Also note that the site survey can work even when the radio card is not activated.

Attention, a disturbed environment can prevent the detection of certain Access Points, so it is not abnormal to have significantly different results between two successive site survey.

The first panel displays a radar view of the detected access points, and below the measured electromagnetic noise level. You can display the 2.4GHz band or the 5GHz band by clicking on the respective tabs.

We can see in the example below the presence of an electromagnetic noise around the frequency of channel 7. This noise is of non-Wi-Fi, because there is no access point on this frequency.



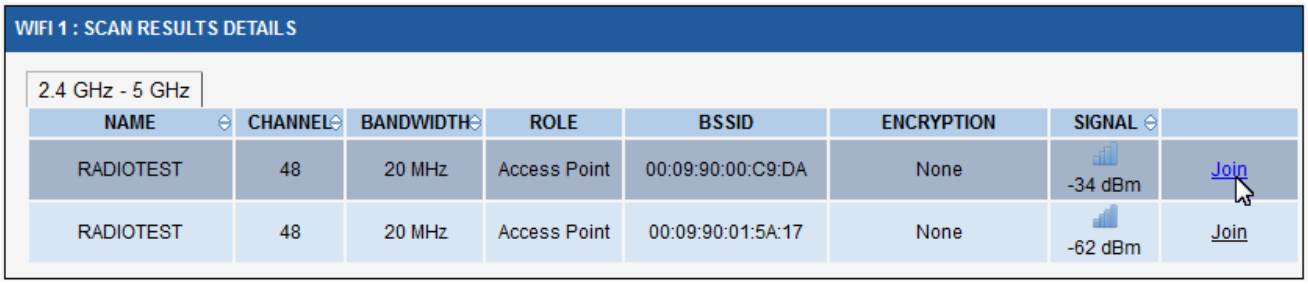
The lower table lists all the access points that could be detected.

WIFI 1 : SCAN RESULTS DETAILS

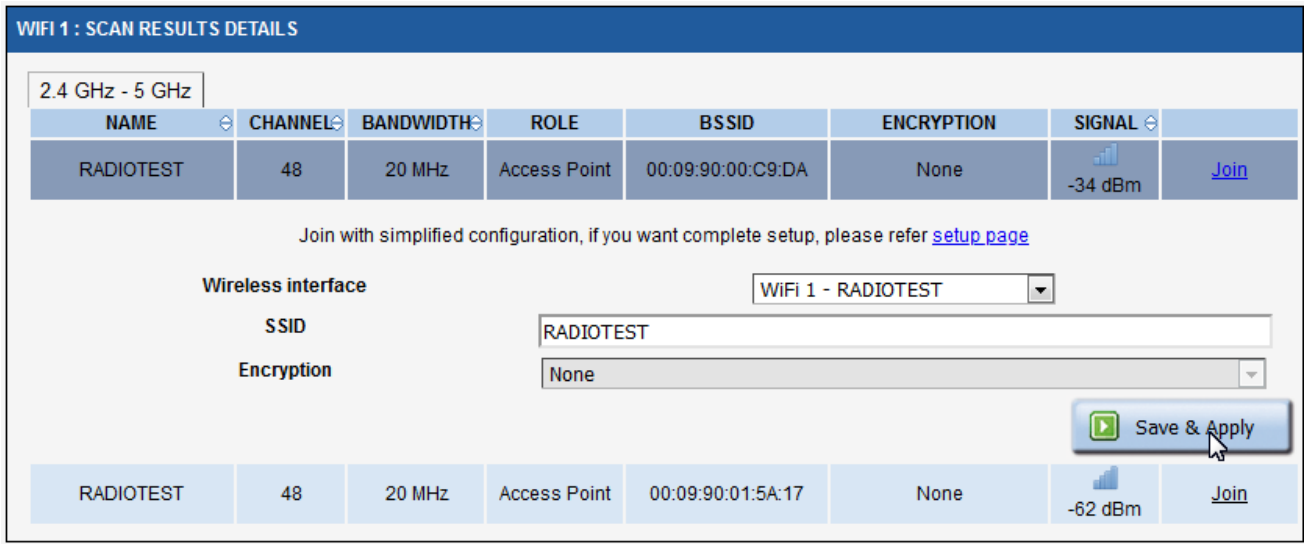
2.4 GHz - 5 GHz

NAME	CHANNEL	BANDWIDTH	ROLE	BSSID	ENCRYPTION	SIGNAL	
MDY	4	20 MHz	Access Point	00:1C:F0:08:CF:10	WPA2 PSK	-34 dBm	Join
VRRP_master	48	20 MHz	Access Point	04:F0:21:2C:6C:E3	None	-62 dBm	Join
jptinfra22-2	11	20 MHz	Access Point	04:F0:21:19:EB:95	WPA2 PSK	-75 dBm	Join
RADIOTEST	48	20 MHz	Access Point	00:09:90:00:C9:DA	None	-74 dBm	Join
RADIOTEST	48	20 MHz	Access Point	00:09:90:01:5A:17	None	-80 dBm	Join

Please note that the signal level of each detected Access Point is taken from probe and beacon frames only, which are sent at the lowest available rate. In general, the signal level found for these frames is better than the one from data frames.



The **Join** button in the right column of the result line does not appear if the SSID is hidden. You can click on this button to connect to this Access Point



Wireless interface allows to choose whether you want to replace the existing configuration or create a new instance on the radio card. This last option is not possible if the current configuration is already in the client (you cannot have more than one client role on a radio)

VI.3.6.6 SRCC Status

This page provides information on the status of the SRCC interface.

Here are some examples illustrating different stages of SRCC initialization:

Coach topology discovery

SRCC STATUS
STATE: COACH TOPOLOGY DISCOVERY

SRCC DISCOVER RESULT		
COACH SWITCH NODE LIST		
	MAC ADDRESS	SRCC TYPE

Wi-Fi neighbor discovery

SRCC STATUS
STATE: WIFI NEIGHBOR DISCOVERY

SRCC DISCOVER RESULT		
COACH SWITCH NODE LIST		
	MAC ADDRESS	SRCC TYPE
WIFI NEIGHBOR LIST		
	MAC ADDRESS	SIGNAL

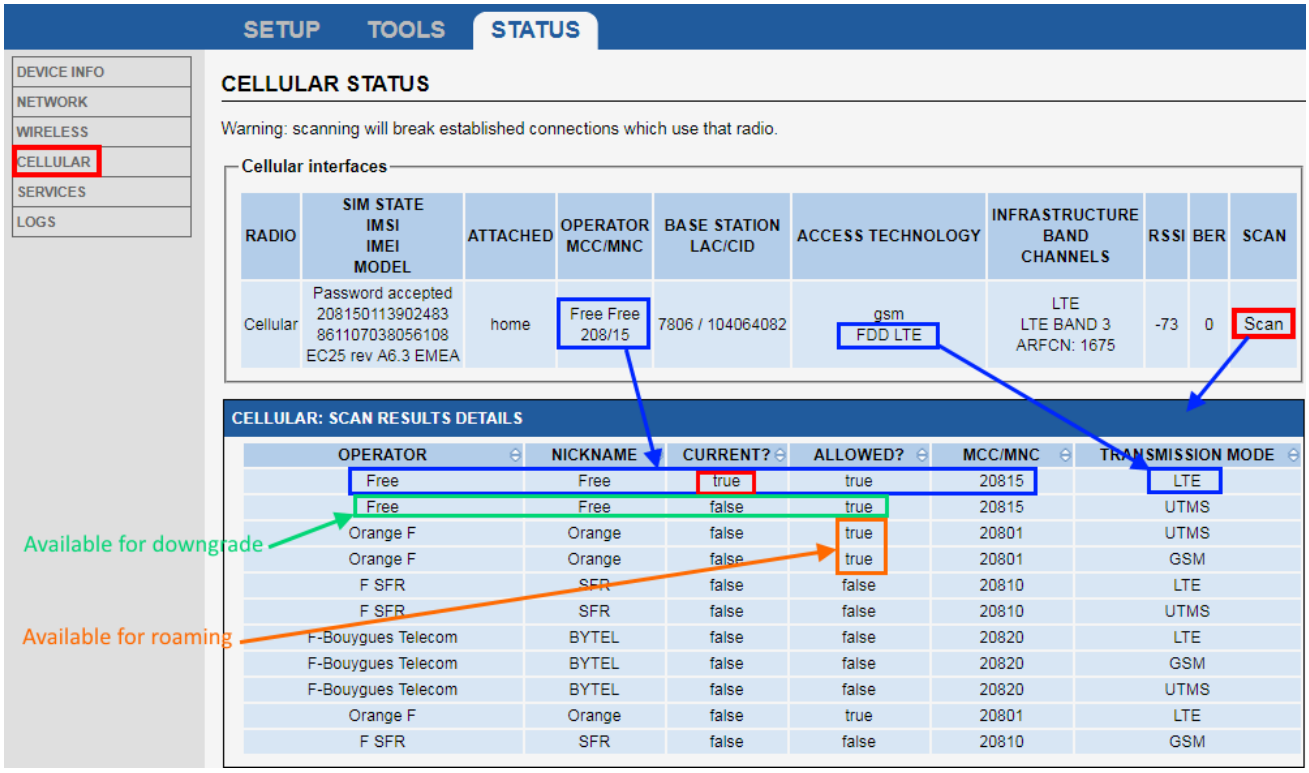
Configuration complete

SRCC STATUS		
STATE: LINK CONFIGURED		
COACH CONFIGURATION		
POSITION IN COACH	MAC ADDRESS	SRCC TYPE
Local switch node	00:09:90:00:5a:f7	a

LINK CONFIGURATION	
MAC ADDRESS	ROLE
00:09:90:00:5a:db	AP
00:09:90:00:5a:f7	CLIENT

VI.3.7 Cellular

This page summarizes information about the cellular radio operation.



Cellular interfaces

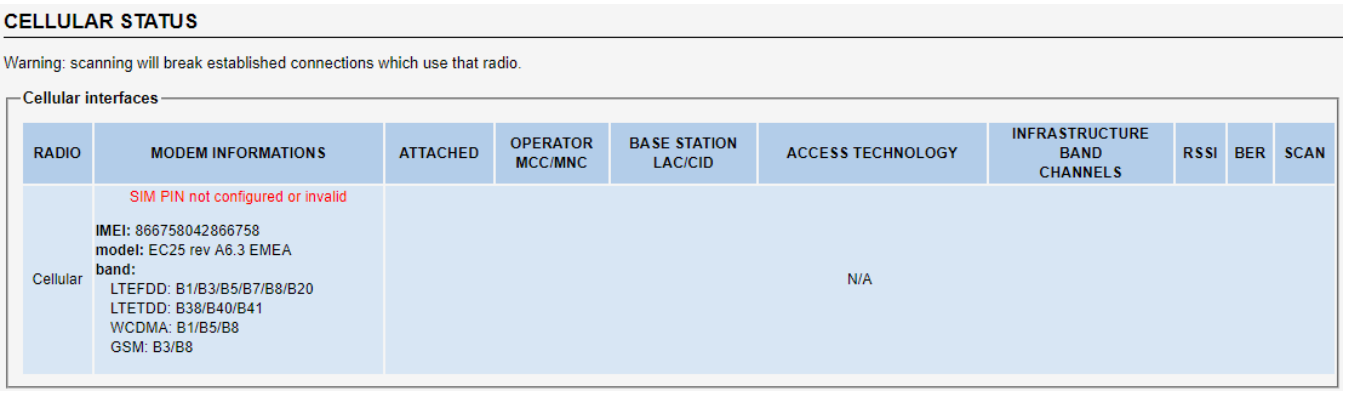
- Radio — Network interface name
- SIM state — Presence, PIN code state…
- IMSI — Unique identifier of the SIM77777
- IMEI — Unique identifier of the radio client
- Model — Radio card model, version, geographic region
- Attached — “home” uses the SIM native operator, “roaming” uses an allowed operator
- Operator — Operator name, MCC and MNC
- LAC/CID — Base station location and ID (operator specific)
- Access technology – GSM or CDMA
- RSSI — Signal quality estimator
- BER — Bit Error Rate estimator; estimated number of errors per 10000 bits (see 3GPP TS 45.008)
- Scan — Starts a scan to detect available operators around

Scan results details

- Current? — Operator and mode the radio is currently attached to
- Allowed? — The operators the radio is allowed to roam to

Other information is self-explanatory.

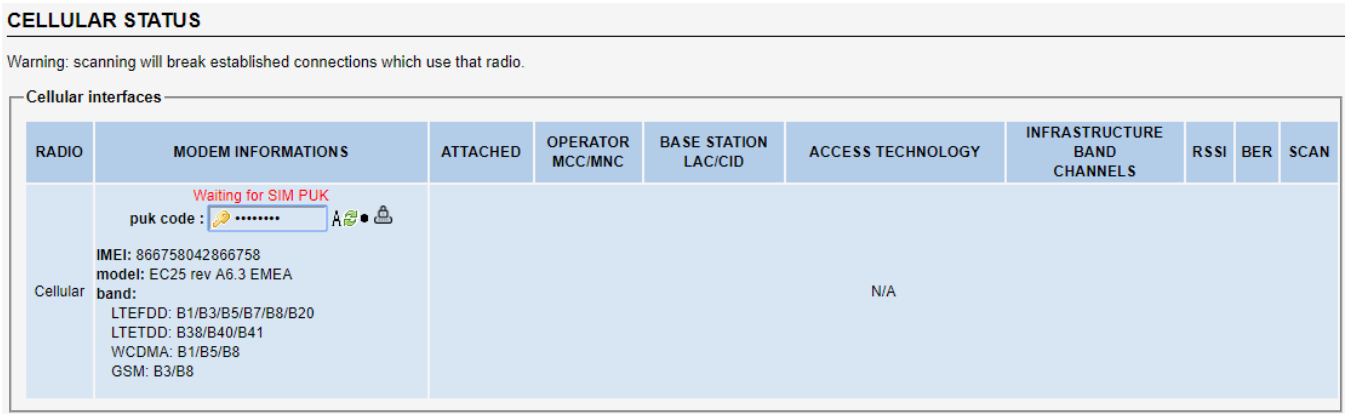
SIM PIN not configured or invalid



When this message appears in the status page, it means that the PIN code has not been entered or is incorrect. Please note, after three attempts to start in these circumstances, the SIM card may be locked

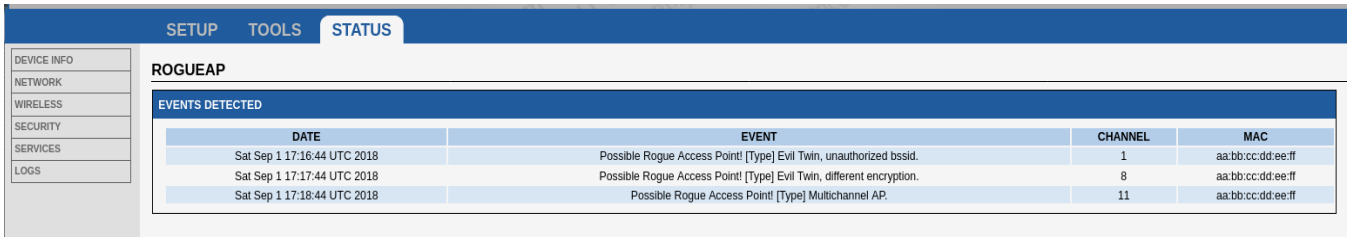
Unlocking the SIM card with the PUK code

When the LTE interface requests a PUK code (after 3 incorrect pin codes, for example) an input field is displayed to allow the PUK code to be entered.
As you have to give a pin code when you change the PUK code, we put the pin code which is configured for the SIM card slot. In this way, we are sure that next time the pin code will be correct.



VI.3.8 Security

This panel displays the list of security alerts.



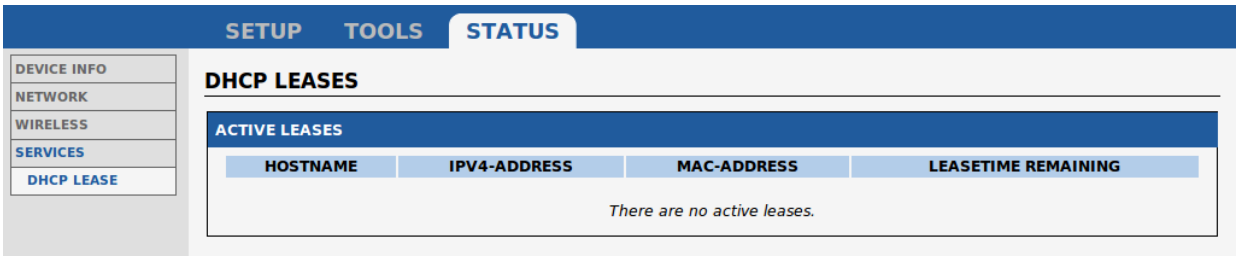
The events are:

- *RogueAP detector service started on Wi-Fi interface wlan xx* (This is an information only).
- Evil Twin, different encryption.
  The wireless security level is different from the expected value.
- Multichannel AP.
  The SSID is detected on a different channel from the configured channel for this instance.
- Evil Twin, unauthorized BSSID.
  The BSSID emitting the SSID is not defined in the allowed BSSID list.
- Strange RSSI.
  The RSSI value is out of the RSSI range expected for this SSID.

VI.3.9 Services

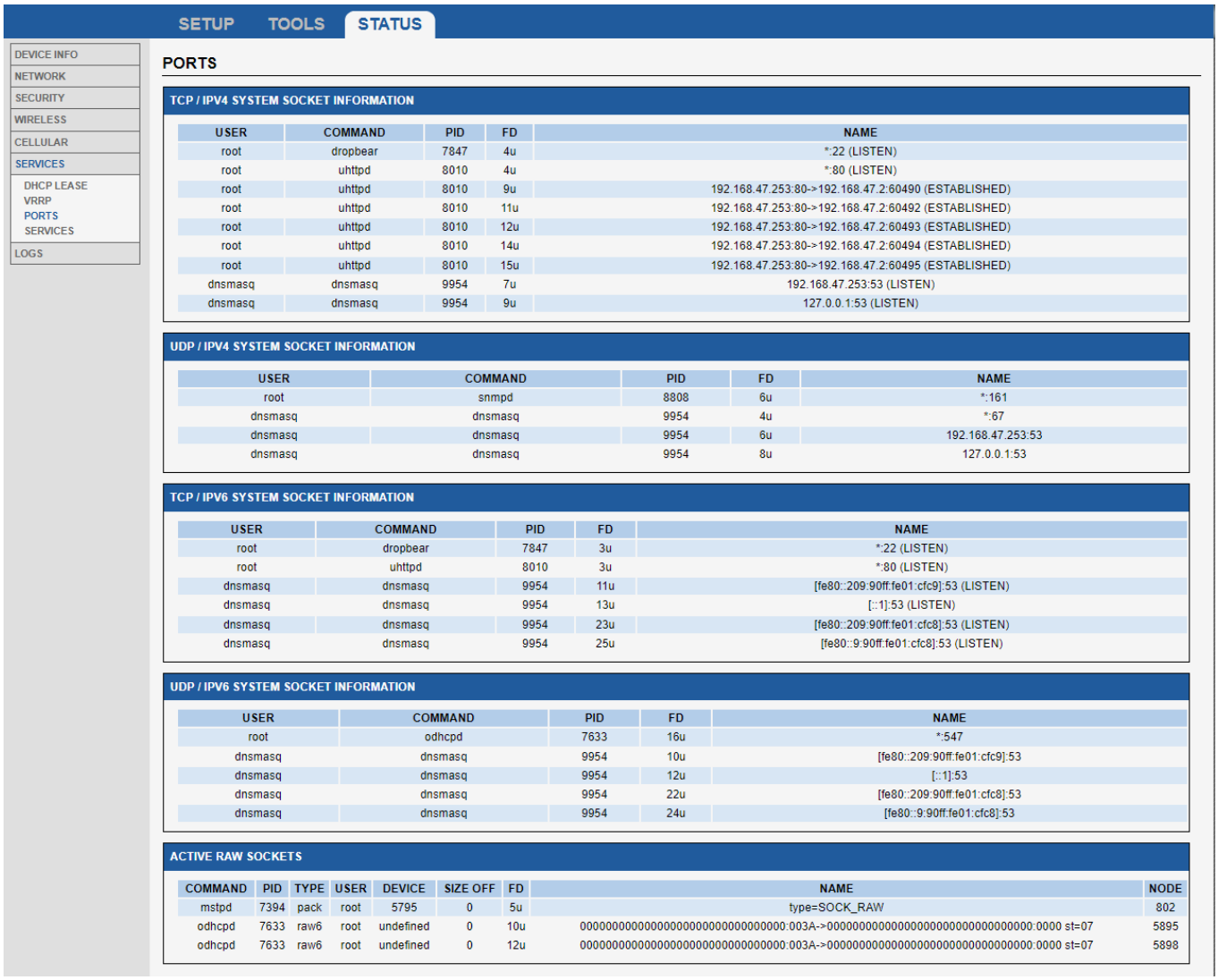
VI.3.9.1 DHCP Lease

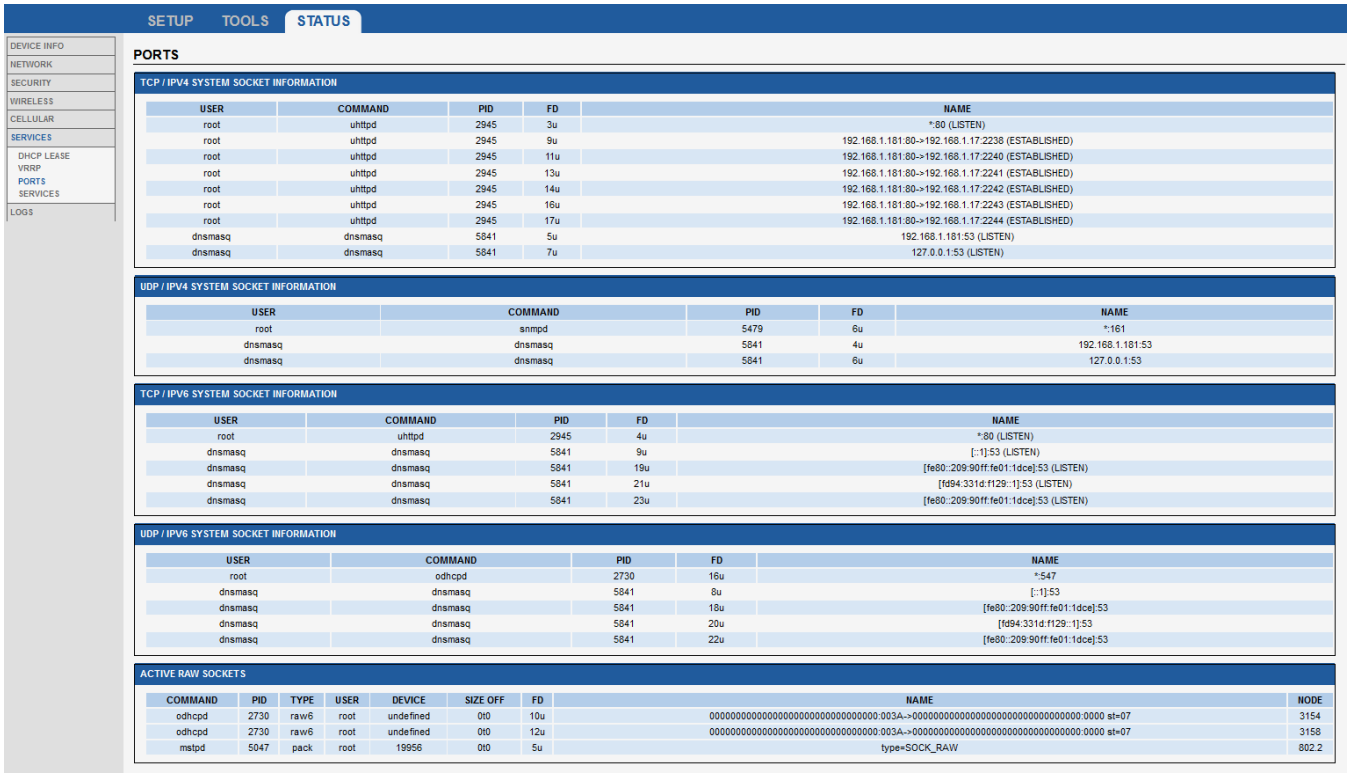
This panel summarizes the properties of all the current DHCP leases.



VI.3.9.2 PORT

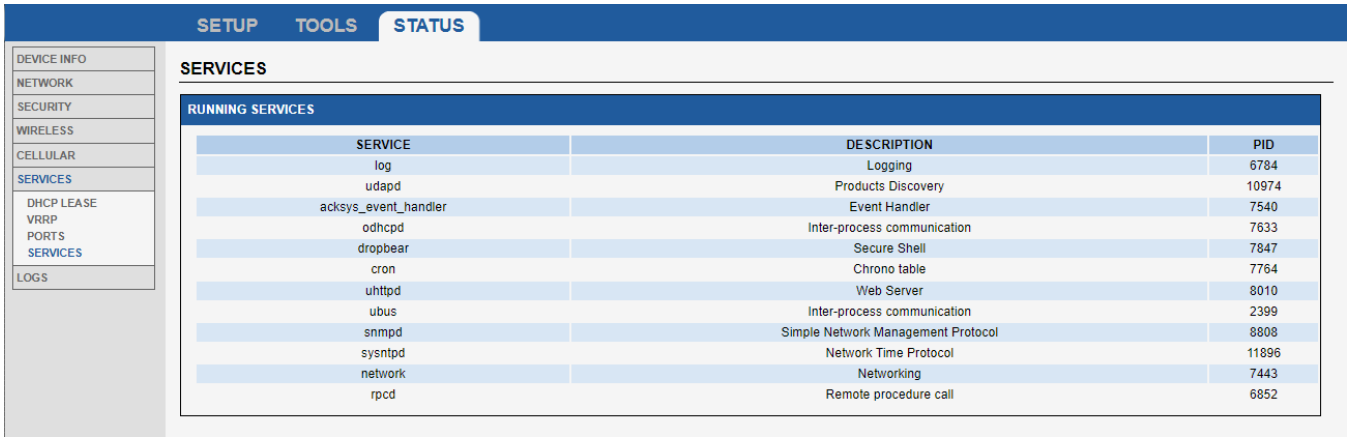
This panel displays the current opened port per service in order to monitor TCP port for instance for actives clients.





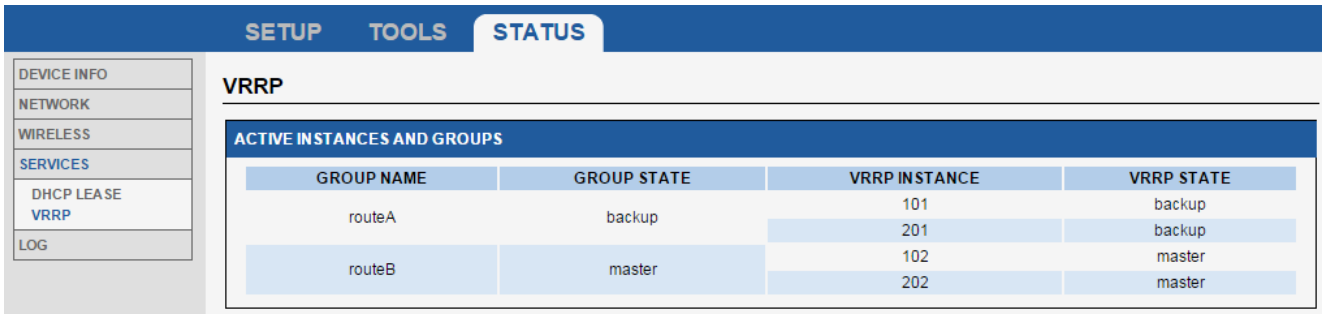
VI.3.9.3 SERVICES

This panel displays the list of services to allow the IT Teams to know the running services and stop it in case of security breach detected.



VI.3.9.4 VRRP

This panel displays the current state for the VRRP instances and groups configured in the product.



Here you can see that two virtual gateways are set up in this product. The first one is named “routeA” and groups virtual interfaces 101 and 201. It is currently inactive, because a master is detected on both interfaces.

The virtual gateway “routeB” is currently actively routing packets between virtual interfaces 102 and 202.

VI.3.10 Logs

This panel allows visualizing the product logs.

The **Config log** displays a summary of the unit configuration, to verify that there are no inconsistencies in the configuration.

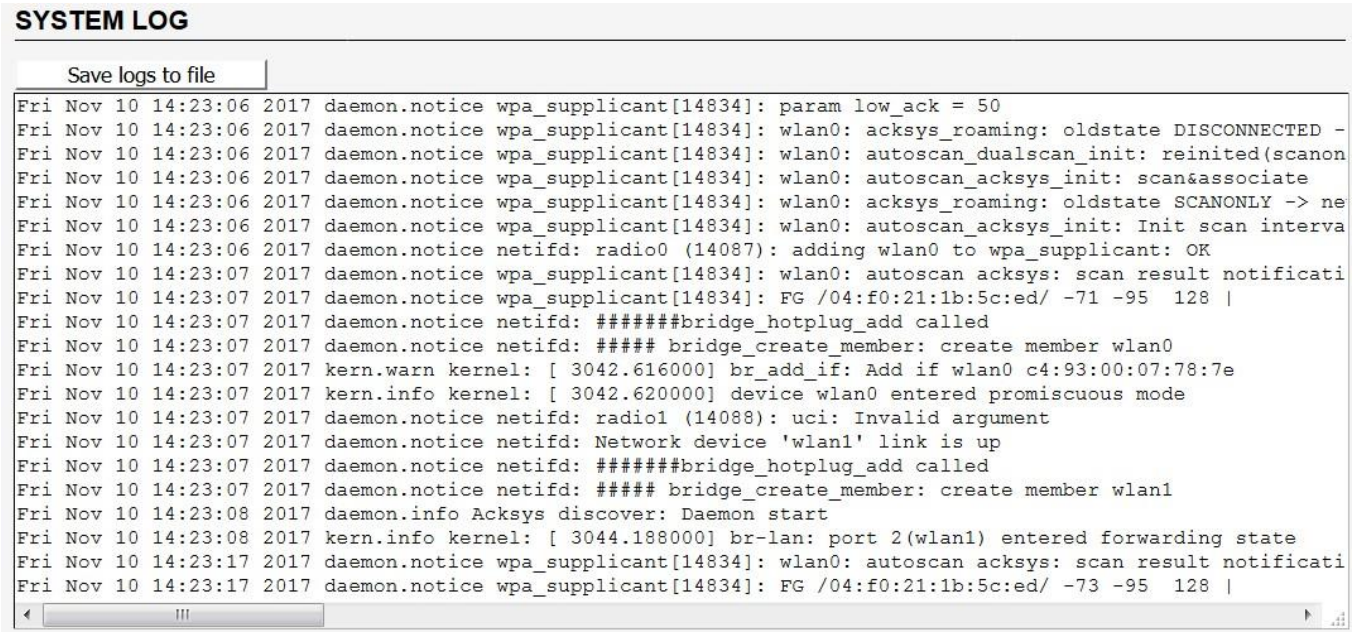
The **kernel log** displays log messages from the Linux kernel only. It is not filtered, i.e. it includes all recent messages sent by the kernel.

The **system log** displays log messages from both the kernel log and from the running services. The messages in this log are limited to the importance levels configured in the Setup/Tools/Log setting page.

In client mode, you can optionally display, in the system log, messages relating to the roaming process (see section VI.1.1.1 Advanced roaming tab). Please refer to the following table for the signification of the symbols surrounding the BSSID's (MAC addresses) displayed in these messages:

[B1:B2:B3:B4:B5:B6**]**	*BSSID of the current AP*
B1:B2:B3:B4:B5:B6	*BSSID of the AP selected for the next roaming*
/B1:B2:B3:B4:B5:B6**/**	*AP discarded by the 'matching SSID' test*
tB1:B2:B3:B4:B5:B6**t**	*AP discarded by the 'no return' test*
mB1:B2:B3:B4:B5:B6**m**	*AP laid aside by the 'minimum signal level' test*
MB1:B2:B3:B4:B5:B6**M**	*AP laid aside by the 'maximum signal level' test*

Note : An AP 'laid aside' can still be used if there is no other choice.



KERNEL LOG

Save logs to file

```
[     0.000000] Linux version 3.18.9 (cv@devRD) (gcc version 4.8.3 (OpenWrt/Linaro GCC 4.8-2014.04 r43290) )
[     0.000000] bootconsole [early0] enabled
[     0.000000] CPU0 revision is: 00019750 (MIPS 74Kc)
[     0.000000] SoC: Qualcomm Atheros QCA9558 ver 1 rev 0
[     0.000000] Determined physical RAM map:
[     0.000000]  memory: 08000000 @ 00000000 (usable)
[     0.000000] User-defined physical RAM map:
[     0.000000]  memory: 08000000 @ 00000000 (usable)
[     0.000000] Initrd not found or empty - disabling initrd
[     0.000000] Zone ranges:
[     0.000000]   Normal   [mem 0x00000000-0x07ffffff]
[     0.000000] Movable zone start for each node
[     0.000000] Early memory node ranges
[     0.000000]   node   0: [mem 0x00000000-0x07ffffff]
[     0.000000] Initmem setup node 0 [mem 0x00000000-0x07ffffff]
[     0.000000] On node 0 totalpages: 32768
[     0.000000] free_area_init_node: node 0, pgdat 8039e250, node_mem_map 81000000
[     0.000000]   Normal zone: 256 pages used for memmap
[     0.000000]   Normal zone: 0 pages reserved
[     0.000000]   Normal zone: 32768 pages, LIFO batch:7
[     0.000000] Primary instruction cache 64kB, VIPT, 4-way, linesize 32 bytes.
[     0.000000] Primary data cache 32kB, 4-way, VIPT, cache aliases, linesize 32 bytes
[     0.000000] pcpu-alloc: s0 r0 d32768 u32768 alloc=1*32768
[     0.000000] pcpu-alloc: [0] 0
[     0.000000] Built 1 zonelists in Zone order, mobility grouping on.  Total pages: 32512
[     0.000000] Kernel command line:  board=42 console=ttyS0,115200 mtdparts=ar934x-nfc:3M(uboot),2M(uboot-en
[     0.000000] ack_ethaddr_setup: ethaddr 00:09:90:00:8b:5f,c4:93:00:07:78:80
[     0.000000] eth0 => mac 00:09:90:00:8b:5f
[     0.000000] eth1 => mac c4:93:00:07:78:80
[     0.000000] eth2 => mac 00:00:00:00:00:00
[     0.000000] eth3 => mac 00:00:00:00:00:00
[     0.000000] eth4 => mac 00:00:00:00:00:00
[     0.000000] PID hash table entries: 512 (order: -1, 2048 bytes)
[     0.000000] Dentry cache hash table entries: 16384 (order: 4, 65536 bytes)
[     0.000000] Inode-cache hash table entries: 8192 (order: 3, 32768 bytes)
[     0.000000] Writing ErrCtl register=00000000
[     0.000000] Readback ErrCtl register=00000000
[     0.000000] Memory: 125748K/131072K available (2870K kernel code, 127K rwdata, 412K rodata, 164K init, 18
[     0.000000] SLUB: HWalign=32, Order=0-3, MinObjects=0, CPUs=1, Nodes=1
[     0.000000] NR_IRQS:51
[     0.000000] Clocks: CPU:720.000MHz, DDR:600.000MHz, AHB:200.000MHz, Ref:40.000MHz
[     0.000000] Calibrating delay loop... 359.42 BogoMIPS (lpj=718848)
[     0.028000] pid_max: default: 32768 minimum: 301
[     0.028000] Mount-cache hash table entries: 1024 (order: 0, 4096 bytes)
[     0.028000] Mountpoint-cache hash table entries: 1024 (order: 0, 4096 bytes)
[     0.028000] NET: Registered protocol family 16
[     0.028000] MIPS: machine is Acksys EmbedAir1000
[     0.032000] registering PCI controller with io_map_base unset
[     0.032000] ar724x-pci ar724x-pci.1: PCIe link is down
[     0.032000] registering PCI controller with io_map_base unset
[     0.032000] ath79_device_reset_set: SGMII dbg register is good (07560710)=> skip reset
[     0.136000] ath79_device_reset_clear: SGMII_DEBUG value 0756070f
[     0.240000] usbcore: registered new interface driver usbfs
```

CONFIG LOG

Save logs to file

```
####################################        DEVICE LIST         ####################################
Device_label  Device_name  Interface_name
------------  -----------  --------------
LAN 1         eth0         eth0
LAN 2         eth1         eth1
WiFi 1        phy0         radio0
WiFi 2        phy1         radio1


####################################          WIFI LIST         ####################################
Interface_label                Interface_name       Network_included_in
---------------                --------------       -------------------
WiFi 1.RADIOTEST               radio0w0             bond1
WiFi 2.RADIOTEST               radio1w0             bond1


####################################       Check VLAN LIST      ####################################
Nothing to report
####################################          VLAN LIST         ####################################
vlan_description     vlan_name  Interface_attached_to  vid   Network_included_in  interface_name
----------------     ---------  ----------------------  ---   -------------------  --------------


####################################   Check GRE/NETWORK LIST   ####################################
Nothing to report
####################################          GRE LIST          ####################################
gre_description      gre_name   gre_network  local_endpoint_type  tunlink
---------------      --------   -----------  -------------------  -------


####################################        NETWORK LIST        ####################################
network_description  network_name  network_proto network_type         network_ifname
-------------------  ------------  ------------- ------------         --------------
loopback             loopback      static                             lo
lan                  lan           static        bridge               eth0 eth1
bond1                bond1                       bond                 ***N/A***
```

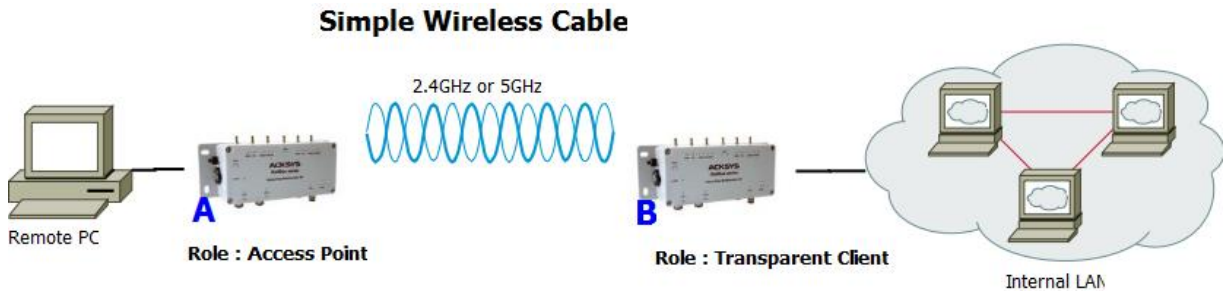
VII WIRELESS TOPOLOGIES EXAMPLES

This products line has highly configurable devices allowing multiple wireless topologies. The followings sections describe the most used ones.

For every topology, the characteristic parameters for this topology are written in RED.

VII.1 Simple “Wireless cable”

In this mode, an access point and an infrastructure bridge pair just replaces an existing Ethernet cable.



Configuration summary:

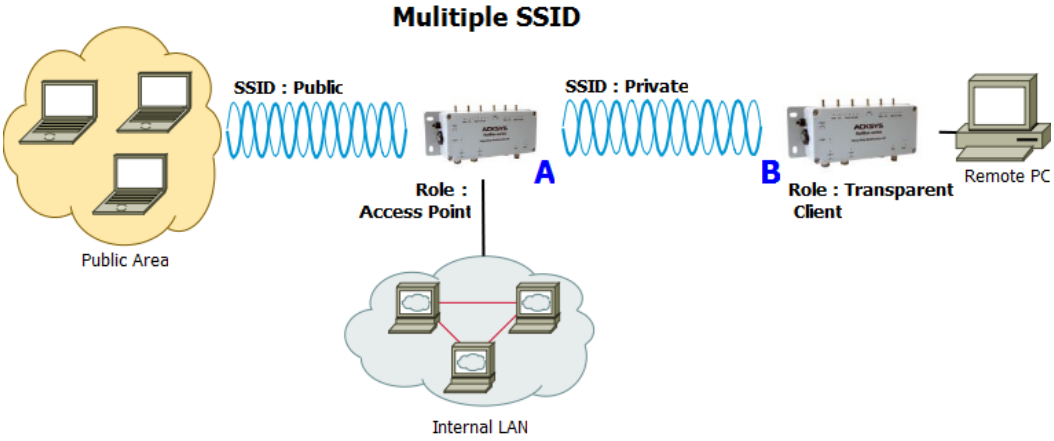
In this example, we are using 802.11a with 20MHz HT mode, channel 36, country code FR and ACKSYS as ESSID. You can obviously change any of these parameters as long as your choice makes sense.

Product A	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	802.11a
HT mode	20MHz
Channel	36
Country code	FR
Interface Configuration 1	
Parameter	***Value***
Role	Access Point
ESSID	ACKSYS

Product B	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	same as product A
HT mode	same as product A
Channel	same as product A
Country code	any
Interface Configuration 1	
Parameter	***Value***
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A

VII.2 Multiple SSID

In this mode, a single access point provides multiple SSID at the same time in order to allow different specific security schemes for each SSID.



Configuration summary:

In this example, we are using 802.11na with 40MHz above HT mode, channel 36, country code FR, ACKSYS as private ESSID and SYSKCA as public ESSID. You can obviously change any of these parameters as long as your choice makes sense.

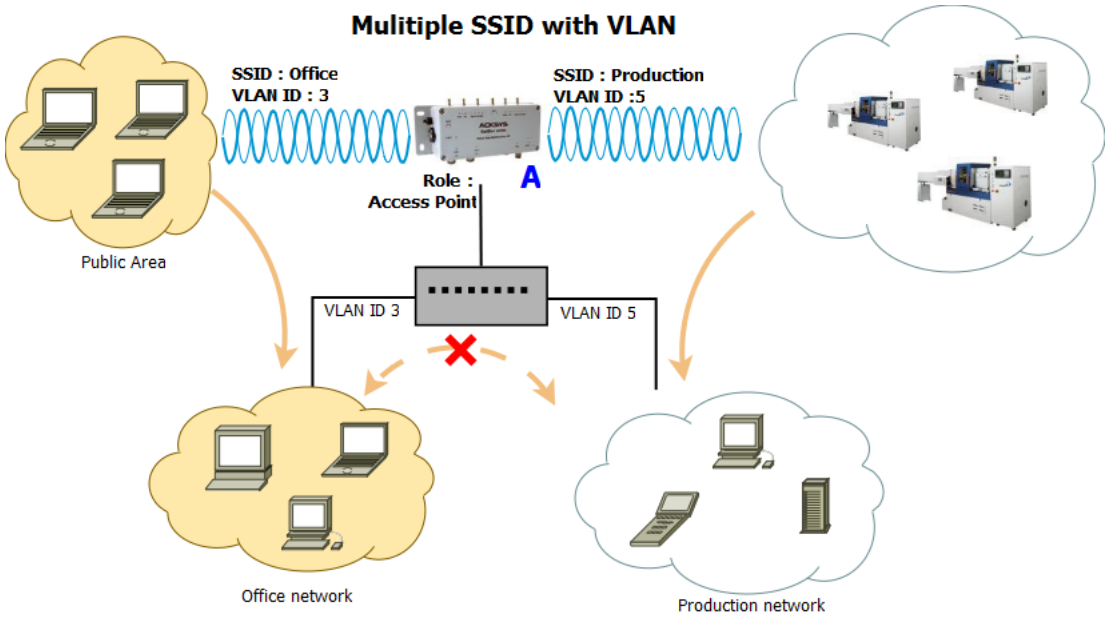
Product A	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	802.11na
HT mode	40 MHz above
Channel	36
Country code	FR
Interface Configuration 1 (Public)	
Parameter	***Value***
Role	Access point
ESSID	SYSKCA
Interface Configuration 2 (Private)	
Parameter	***Value***
Role	Access point
ESSID	ACKSYS

Product B	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	same as product A
HT mode	same as product A
Channel	same as product A
Country code	any
Interface Configuration 1	
Parameter	***Value***
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A private ESSID

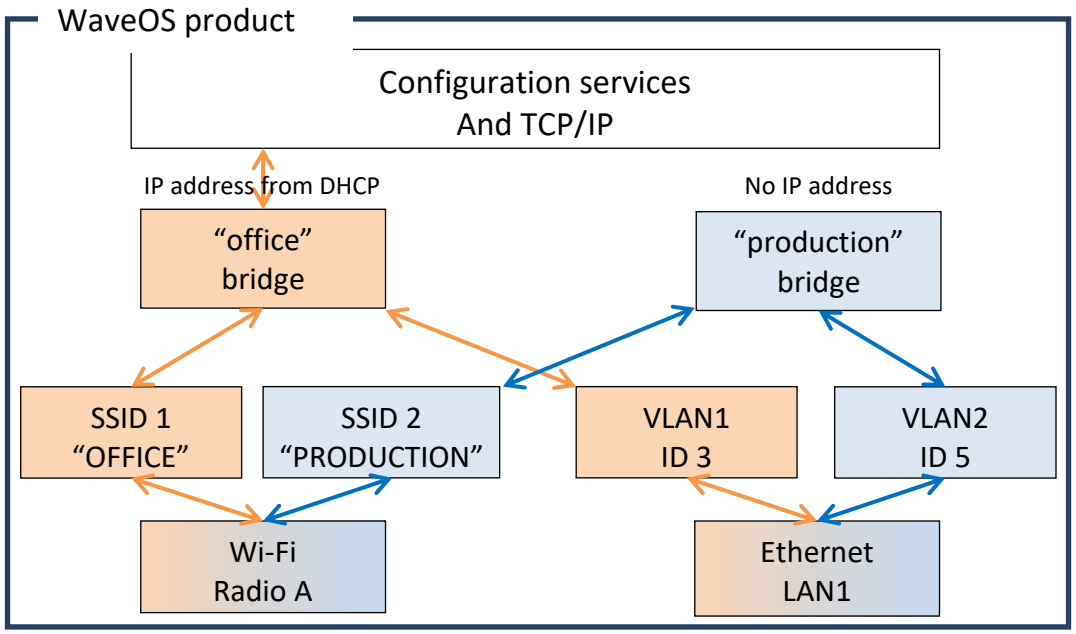
VII.3 Multiple SSID with VLAN

In this configuration, a single access point provides multiple SSID at the same time in order to allow different security schemes for each SSID. All SSID traffics share the same LAN interface. You can isolate SSID traffics from each other on the LAN using VLANs.

This mode adds a 802.1q tag in the frames sent to the LAN, and uses the tag in incoming LAN frames to forward data to the associated SSID. The tag itself is not transmitted over the Wi-Fi link.



The internal architecture of product “A” supporting this setting is:



Configuration summary:

Product A	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	802.11na
HT mode	40 MHz above
Channel	36
Country code	FR
Interface Configuration 1 (Office)	
Parameter	***Value***
Role	Access point
ESSID	OFFICE
Interface Configuration 2 (Production)	
Parameter	***Value***
Role	Access point
ESSID	PRODUCTION

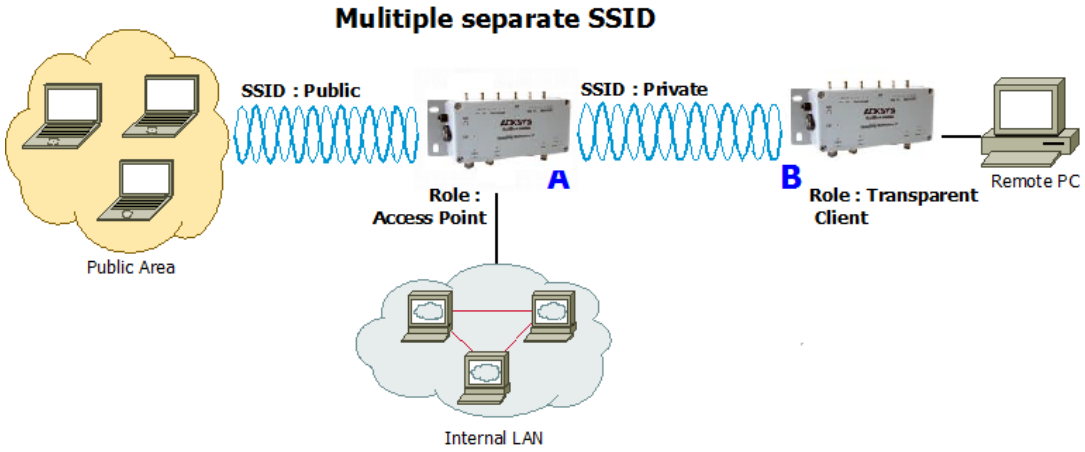
Virtual interface (VLAN 3)	
Parameter	***Value***
VLAN ID	3
Interface	LAN
Virtual interface (VLAN 5)	
VLAN ID	5
Interface	LAN
Network (office)	
Protocol	DHCP
Bridge interfaces	Checked
Interfaces	LAN.3 and “office” Wi-Fi adapter
Network (Production)	
Protocol	None
Bridge interface	Checked
Interfaces	LAN.5 and “production” Wi-Fi adapter

In order to achieve this configuration using the browser interface, you must change things in order:

- In the “virtual interfaces” menu, create the VLAN interfaces above the Ethernet LAN
- In the “physical interfaces” menu, set wireless radio settings and create one “access point” interface per needed SSID
- In the “network” menu, create one network per virtual network and use it to associate the VLAN from the Ethernet, with the SSID from the wireless radio.

VII.4 Multiple separate SSID

In this mode, a single product uses its two radios to provide AP service simultaneously on two different channels or even radio bands, for better separation of functions (e.g. one channel for public access and one channel for SCADA).



Configuration summary:
In this example, we have two different configurations (one per radio card).

For Radio A (Public side):
Mode: 802.11na, HT mode: 40MHz above, channel: 36, country code: FR, ESSID: ACKSYS. You can obviously change any of these parameters as long as your choice makes sense.

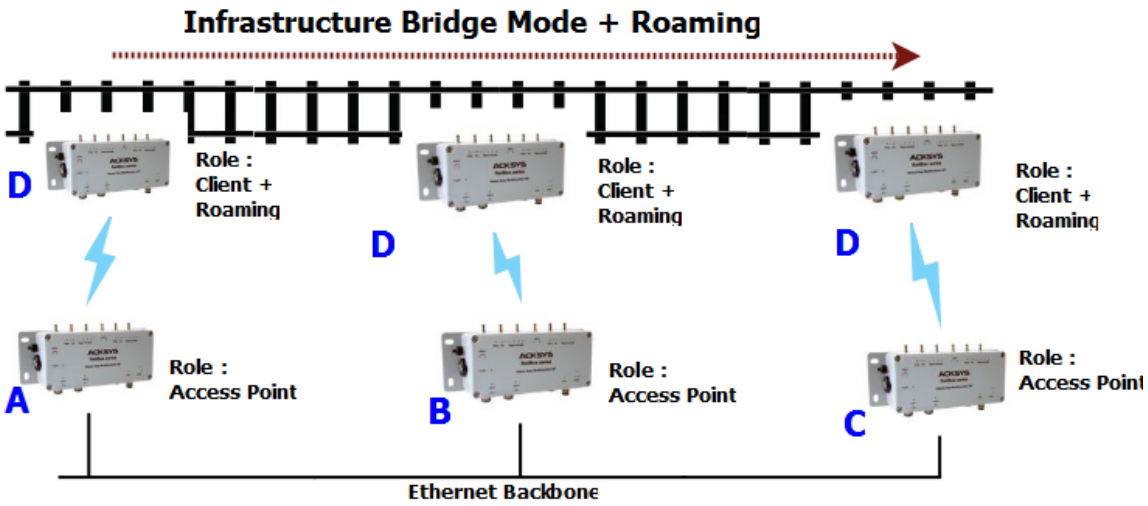
For Radio B (Private side):
Mode: 802.11na, HT mode: 40MHz above, channel: 44, country code: FR, ESSID: SYSKCA. You can obviously change any of these parameters as long as your choice makes sense.

Product A	
Device Configuration 1 (Radio A)	
Parameter	***Value***
Enable device	on
802.11 mode	802.11na
HT mode	40 MHz above
Channel	36
Country code	FR
Interface Configuration 1 (Radio A)	
Parameter	***Value***
Role	Access point
ESSID	Private
Device Configuration 2(Radio B)	
Parameter	***Value***
Enable device	on
802.11 mode	802.11na
HT mode	40 MHz above
Channel	44
Country code	FR
Interface Configuration 2 (Radio B)	
Parameter	***Value***
Role	Access point
ESSID	Public

Product B	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	802.11na
HT mode	40 MHz above
Channel	44
Country code	FR
Interface Configuration 1	
Parameter	***Value***
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A private ESSID

VII.5 Infrastructure bridge + Roaming

In this mode an infrastructure bridge can switch from an access point to another without breaking connectivity.



Configuration summary:

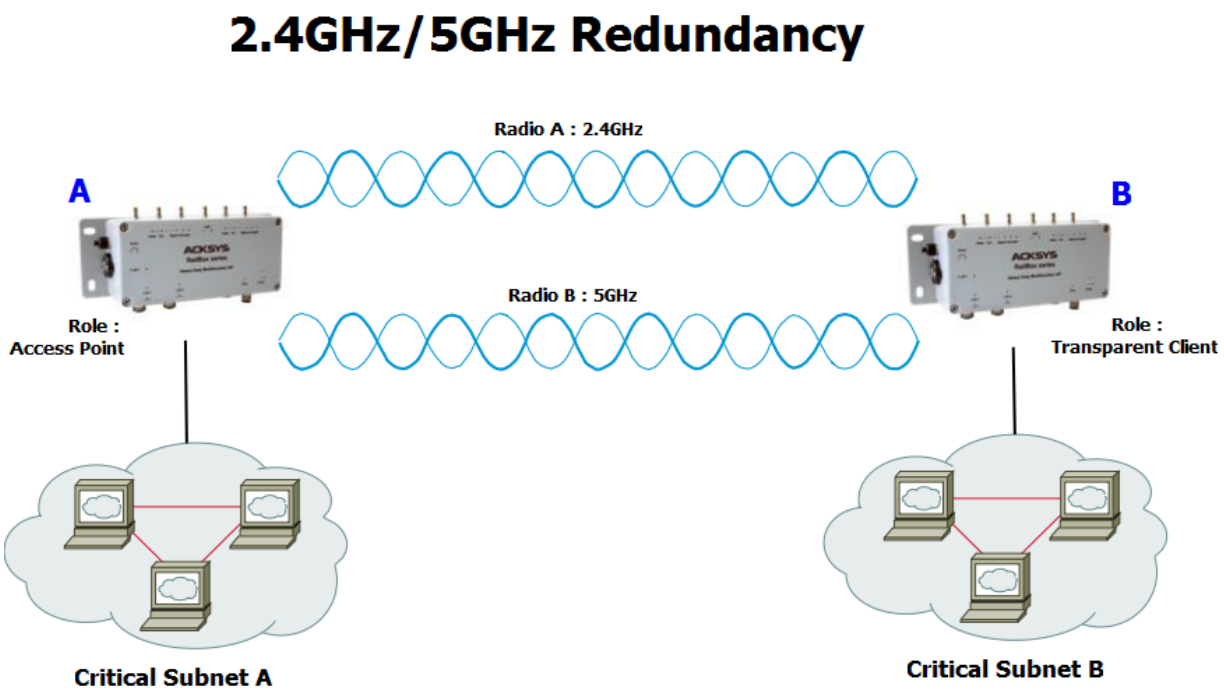
In this example, we are using the same parameters than previously with a roaming threshold set to -60dBm and a 5s scan cycle period.

Products A, B, C	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	802.11na
HT mode	40MHz above
Channel	36
Country code	FR
Interface Configuration 1	
Parameter	***Value***
Role	Access point
ESSID	ACKSYS

Product D	
Device Configuration	
Parameter	***Value***
Enable device	on
802.11 mode	same as product A
HT mode	same as product A
Channel	same as product A
Country code	any
Interface Configuration 1	
Parameter	***Value***
Role	Client
ESSID	same as product A
Roaming	
Parameter	***Value***
Enable proactive roaming	on
Channel	same as product A
Current AP minimum level	-60
Delay between 2 successive scan cycle	5000

VII.6 Point-to-point redundancy with dual band

In this mode, two dual radio products form a redundancy link by creating two wireless links on different channels. Only one link transfers data at a time. If one of the two links breaks down, the second one will replace it.



Configuration summary:

In this example, we have two different configurations (one per radio card). You can obviously change any of these parameters as long as your choice makes sense.

For Radio A:

Mode: 802.11ng, HT mode: 20MHz, channel: 11, country code: FR, ESSID: ACKSYS1.

For Radio B:

Mode: 802.11na, HT mode: 20MHz, channel: 36, country code: FR, ESSID: ACKSYS2.

ATTENTION: This topology creates a network loop. You must provide a way to cut one of the two Wi-Fi links. This is usually done by using STP or RSTP inside the products. The product series provides STP since firmware 1.4.0 . STP must be activated in both Product A and Product B. See section “Spanning Tree Protocols (STP, RSTP)” for more details.

Product A

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	802.11ng
HT mode	20MHz
Channel	11
Country code	FR

Interface Configuration 1(Radio A)

Parameter	*Value*
Role	Access point
ESSID	ACKSYS1

Device Configuration (Radio B)

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1(Radio B)

Parameter	*Value*
Role	Access point
ESSID	ACKSYS2

Product B

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	same as product A
HT mode	same as product A
Channel	same as product A
Country code	any

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A

Device Configuration (Radio B)

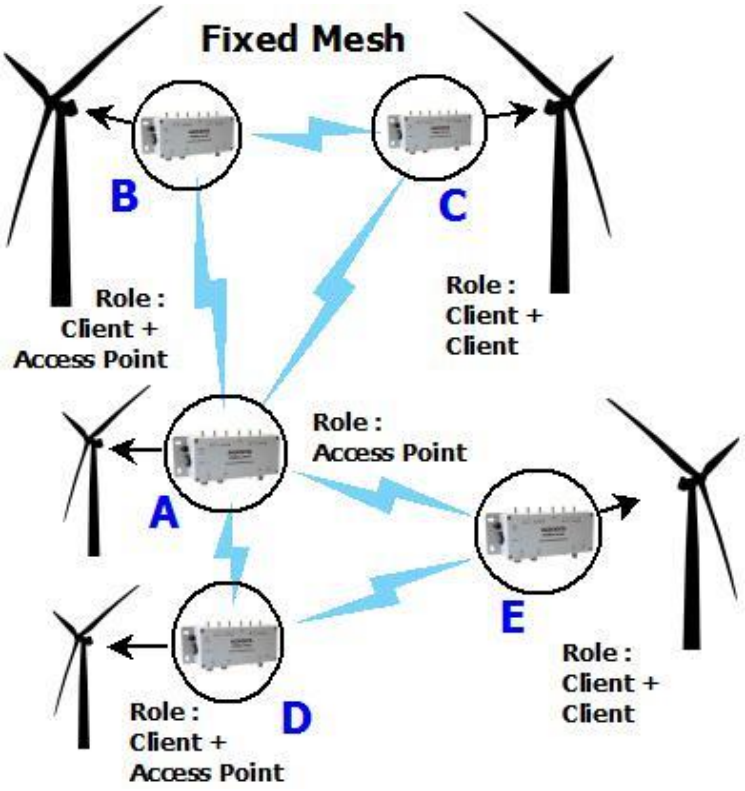
Parameter	*Value*
Enable device	on
802.11 mode	same as product A
HT mode	same as product A
Channel	same as product A
Country code	any

Interface Configuration 1 (Radio B)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A

VII.7 Fixed Mesh

This topology provides a convenient way to handle loop/redundancy on your network.



Configuration summary:
You can obviously change any of these parameters as long as your choice makes sense.

Mode (Product **A** and Radio A for Products **B**, **C**, **D**, **E**,): 802.11na, HT mode: 20MHz , channel: 36, country code: FR, ESSID: ACKSYS.

Mode (Radio B for Products **B**, **C**): 802.11na, HT mode: 20MHz , channel: 40, country code: FR, ESSID: ACKSYS2.

Mode (Radio B for Products **D**, **E**): 802.11na, HT mode: 20MHz , channel: 60, country code: FR, ESSID: ACKSYS3.

ATTENTION: This topology may create one or more network loop. You must provide a way to cut them. This is usually done by using STP or RSTP inside the products. This products series provides STP since firmware 1.4.0. STP needs to activated in each product. See section VI.1.4.1 Network configuration for more details.

Product A

Device Configuration

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration

Parameter	*Value*
Role	Access point
ESSID	ACKSYS

Product B

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	Same as product A
HT mode	Same as product A
Channel	Same as product A
Country code	any

Interface Configuration (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 address format
ESSID	ACKSYS

Device Configuration (Radio B)

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	40
Country code	FR

Interface Configuration (Radio B)

Parameter	*Value*
Role	Access Point
ESSID	ACKSYS2

Product C

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	Same as product A
HT mode	Same as product A
Channel	Same as product A
Country code	any

Interface Configuration (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 address format
ESSID	ACKSYS

Device Configuration (Radio B)

Parameter	*Value*
Enable device	on
802.11 mode	Same as product B (Radio B)
HT mode	Same as product B (Radio B)
Channel	Same as product B (Radio B)
Country code	any

Interface Configuration (Radio B)

Parameter	*Value*
Role	Client
Bridging mode	4 address format
ESSID	Same as product B (Radio B)

Product D

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	Same as product A
HT mode	Same as product A
Channel	Same as product A
Country code	any

Interface Configuration (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	ACKSYS

Device Configuration (Radio B)

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	60
Country code	FR

Interface Configuration (Radio B)

Parameter	*Value*
Role	Access Point
ESSID	ACKSYS3

Product E

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	Same as product A
HT mode	Same as product A
Channel	Same as product A
Country code	any

Interface Configuration (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	ACKSYS

Device Configuration (Radio B)

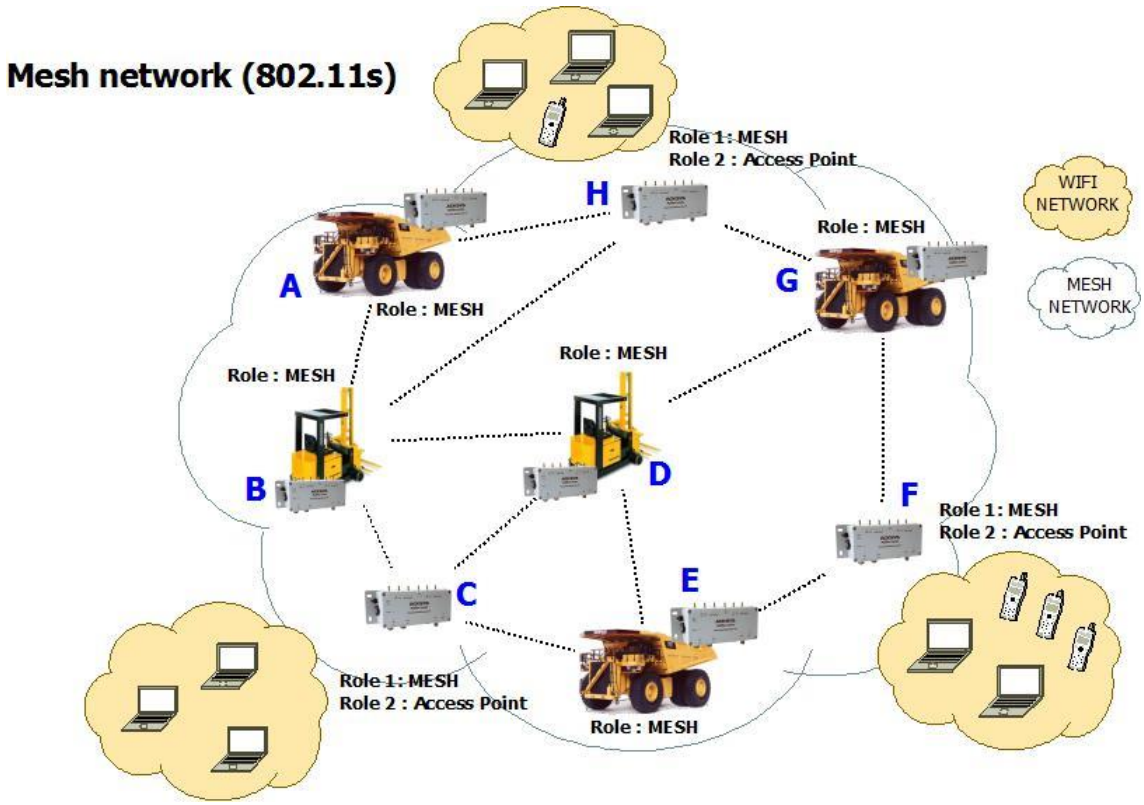
Parameter	*Value*
Enable device	on
802.11 mode	Same as product D (Radio B)
HT mode	Same as product D (Radio B)
Channel	Same as product D (Radio B)
Country code	any

Interface Configuration (Radio B)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	Same as product D (Radio B)

VII.8 802.11s Mesh

This topology uses the IEEE 802.11s standard. There is an overview of 802.11s in the section V.2.1.3 Mesh (802.11s) Mode



Configuration summary:

You can obviously change any of these parameters as long as your choice makes sense.

Mode (Products **A**, **B**, **E**, **D**, **G** and Radio A for Products **C**, **F**, **H**): 802.11na, HT mode: 20MHz , channel: 36, country code: FR, MESHID: ACKSYS.

Mode (Radio B for Products **C**): 802.11na, HT mode: 20MHz , channel: 40, country code: FR, ESSID: ACKSYS1.

Mode (Radio B for Products **F**): 802.11na, HT mode: 20MHz , channel: 44, country code: FR, ESSID: ACKSYS2.

Mode (Radio B for Products **H**): 802.11na, HT mode: 20MHz , channel: 48, country code: FR, ESSID: ACKSYS3.

Product A, B, E, D, G

Device Configuration

Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration

Parameter	Value
Role	Mesh (802.11s)
MESHID	ACKSYS

Product C

Device Configuration (Radio A)

Parameter	Value
Enable device	on
802.11 mode	Same as Product A
HT mode	Same as Product A
Channel	Same as Product A
Country code	any

Interface Configuration (Radio A)

Parameter	Value
Role	Mesh (802.11s)
MESHID	ACKSYS

Device Configuration (Radio B)

Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	40
Country code	FR

Interface Configuration (Radio B)

Parameter	Value
Role	Access Point
ESSID	ACKSYS1

Product F

Device Configuration (Radio A)

Parameter	Value
Enable device	on
802.11 mode	Same as Product A
HT mode	Same as Product A
Channel	Same as Product A
Country code	any

Interface Configuration (Radio A)

Parameter	Value
Role	Mesh (802.11s)
MESHID	ACKSYS

Device Configuration (Radio B)

Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	44
Country code	FR

Product H

Device Configuration (Radio A)

Parameter	Value
Enable device	on
802.11 mode	Same as Product A
HT mode	Same as Product A
Channel	Same as Product A
Country code	any

Interface Configuration (Radio A)

Parameter	Value
Role	Mesh (802.11s)
MESHID	ACKSYS

Device Configuration (Radio B)

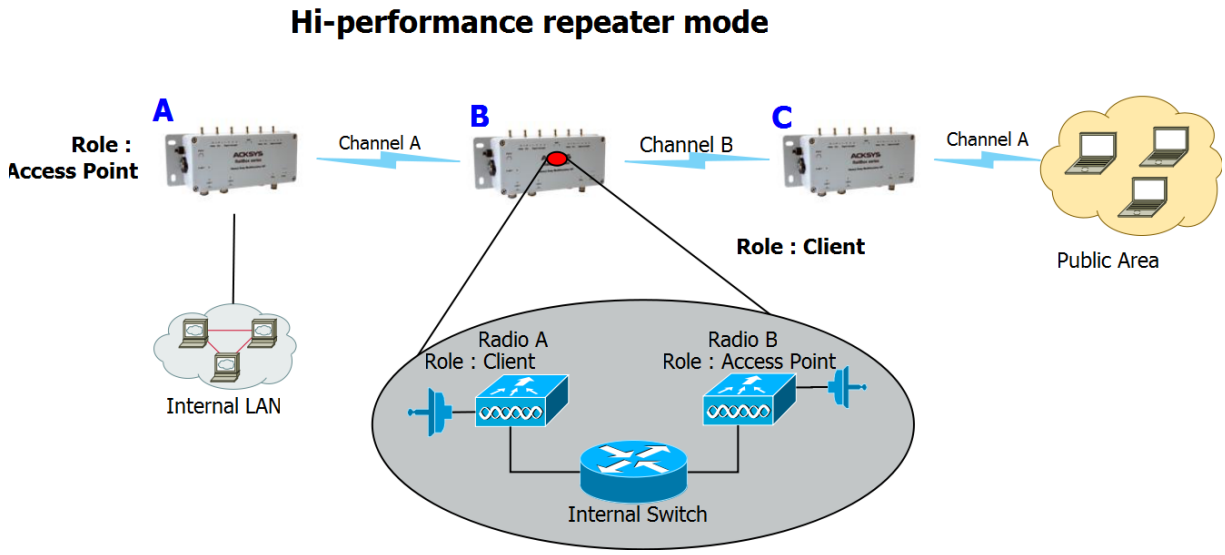
Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	48
Country code	FR

Interface Configuration (Radio B)	
Parameter	***Value***
Role	Access Point
ESSID	ACKSYS2

Interface Configuration (Radio B)	
Parameter	***Value***
Role	Access Point
ESSID	ACKSYS3

VII.9 High performance repeater

This mode takes advantage of the dual radio card device to implement a high-performance repeater.



Configuration summary:

Mode (Product **A** to Product **B**): 802.11na, HT mode: 20MHz , channel: 36, country code: FR, ESSID: ACKSYS1. You can obviously change any of these parameters as long as your choice makes sense.

Mode (Product **B** to Product **C**): 802.11na, HT mode: 20MHz , channel: 44, country code: FR, ESSID: ACKSYS2. You can obviously change any of these parameters as long as your choice makes sense.

This configuration allows to not share the Wi-Fi channel. In this example, Radio A of Product **B** only communicates with Product **A** while Radio B of Product **B** only communicates with Product **C**.

Attention: You must choose different channels for Radio A and Radio B.

Product A

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	40MHz above
Channel	36
Country code	FR

Interface Configuration 1(Radio A)

Parameter	*Value*
Role	Access point
ESSID	ACKSYS1

Product B

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	40MHz above
Channel	36
Country code	FR

Interface Configuration 1(Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	ACKSYS1

Device Configuration (Radio B)

Parameter	*Value*
Enable device	on
802.11 mode	802.11ng
HT mode	40MHz above
Channel	44
Country code	FR

Interface Configuration 1(Radio B)

Parameter	*Value*
Role	Access point
ESSID	ACKSYS2

Product C

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	40MHz above
Channel	44
Country code	FR

Interface Configuration 1(Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	ACKSYS2

Device Configuration (Radio B)

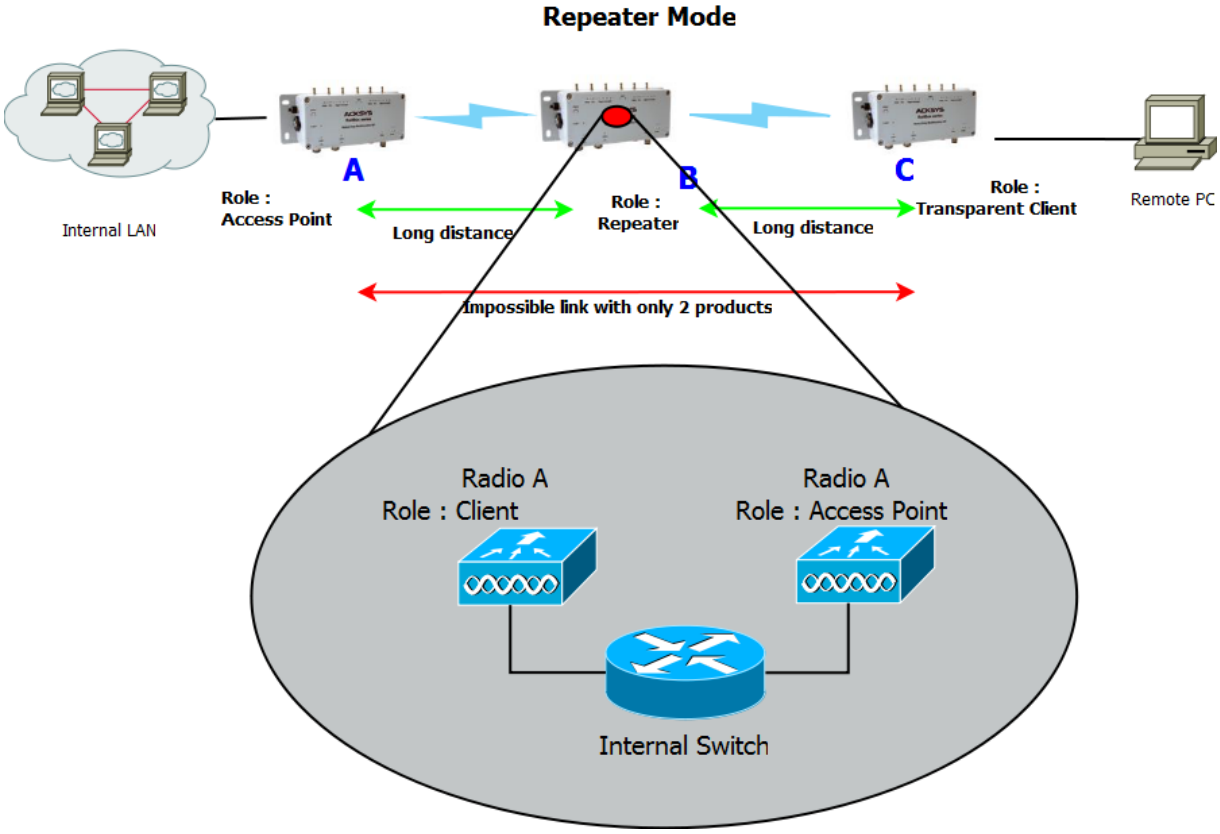
Parameter	*Value*
Enable device	on
802.11 mode	802.11ng
HT mode	40MHz above
Channel	36
Country code	FR

Interface Configuration 1(Radio B)

Parameter	*Value*
Role	Access point
ESSID	ACKSYS1

VII.10 Line topology repeater (single radio card)

Using this mode, you can extend the link distance by adding one or more intermediate repeater devices (see section *0* for supporting products).



Configuration summary:

Mode: 802.11na, HT mode: 20MHz, channel: 36, country code: FR, ESSID: ACKSYS. You can obviously change any of these parameters as long as your choice makes sense.

The repeater role is equivalent to one access point and one bridge infrastructure in the same radio card. In the example above, product **B** acts as a client of product A and as an access point with product **C**.

Both products **A** and **B** have the same SSID; in order to avoid associating with itself, the repeater needs to know the BSSID of the access point with whom it must associate with (product **A** in this example).

Product **C** is set to 4-addresses bridging mode. This is the best way to achieve transparent communication. Other modes (like ARPNAT) would also work, but with caveats; see section V.2.6 Wired to wireless bridging in infrastructure mode for more information.

Product A

Device Configuration (Radio A)

Value	*Parameter*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1(Radio A)

Value	*Parameter*
Role	Access point
ESSID	ACKSYS

Product C

Device Configuration (Radio A)

Value	*Parameter*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A

Product B

Device Configuration (Radio A)

Parameter	*Value*
Enable device	on
802.11 mode	same as product A
HT mode	same as product A
Channel	same as product A
Country code	any

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
Multiple ESSIDs	on
Wireless Network Nicknames	SSID_ACKSYS

ESSID Configuration (SSID_ACKSYS)

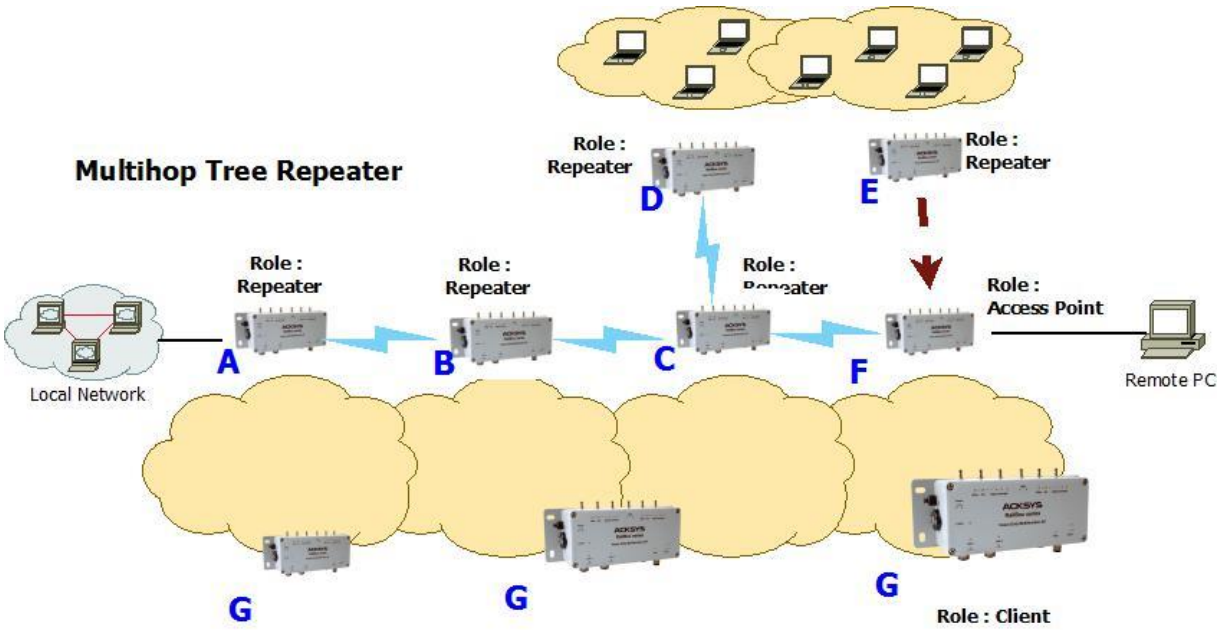
Parameter	*Value*
WLAN description	SSID_ACKSYS
ESSID	same as product A
Priority group	7
BSSID	Product A radio card MAC address

Interface Configuration 2 (Radio A)

Parameter	*Value*
Role	Access point
ESSID	same as product A

VII.11 Multihop tree repeater

You can also extend the coverage area in several directions and still get full connectivity by adding one or more intermediate repeater devices.



Configuration summary:

Mode: 802.11na, HT mode: 20MHz, channel: 36, country code: FR, ESSID: ACKSYS. You can obviously change any of these parameters as long as your choice makes sense.

This topology shows that repeaters interconnection is not limited to a line. Nevertheless, the repeaters interconnections are limited to a tree structure. However, this does not limit data exchange, which can take place between any two devices in the tree.

Product **F** (the last product in the tree) must be set to access point mode. Theoretically, product **F** could be configured in repeater mode but the client portion of the repeater would consume radio bandwidth trying to associate.

Product A

Device Configuration

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
Mutiple ESSIDs	on
Wireless Network Nicknames	SSID_ACKSYS

ESSID Configuration (SSID_ACKSYS)

Parameter	*Value*
WLAN description	SSID_ACKSYS
ESSID	ACKSYS
Priority group	7
BSSID	Product B radio card MAC address

Interface Configuration 2 (Radio A)

Parameter	*Value*
Role	Access point
ESSID	ACKSYS

Product B

Device Configuration

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
Mutiple ESSIDs	on
Wireless Network Nicknames	SSID_ACKSYS

ESSID Configuration (SSID_ACKSYS)

Parameter	*Value*
WLAN description	SSID_ACKSYS
ESSID	same as product A
Priority group	7
BSSID	Product C radio card MAC address

Interface Configuration 2 (Radio A)

Parameter	*Value*
Role	Access point
ESSID	same as product A

Product C

Device Configuration

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
Mutiple ESSIDs	on
Wireless Network Nicknames	SSID_ACKSYS

ESSID Configuration (SSID_ACKSYS)

Product D

Device Configuration

Parameter	*Value*
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1 (Radio A)

Parameter	*Value*
Role	Client
Bridging mode	4 addresses format (WDS)
Mutiple ESSIDs	on
Wireless Network Nicknames	SSID_ACKSYS

ESSID Configuration (SSID_ACKSYS)

Parameter	Value
WLAN description	SSID_ACKSYS
ESSID	same as product A
Priority group	7
BSSID	Product F radio card MAC

Interface Configuration 2 (Radio A)

Parameter	Value
Role	Access point
ESSID	same as product A

Parameter	Value
WLAN description	SSID_ACKSYS
ESSID	same as product A
Priority group	7
BSSID	Product C radio card MAC

Interface Configuration 2 (Radio A)

Parameter	Value
Role	Access point
ESSID	same as product A

Product E

Device Configuration

Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration 1 (Radio A)

Parameter	Value
Role	Client
Bridging mode	4 addresses format (WDS)
Mutiple ESSIDs	on
Wireless Network Nicknames	SSID_ACKSYS

ESSID Configuration (SSID_ACKSYS)

Parameter	Value
WLAN description	SSID_ACKSYS
ESSID	same as product A
Priority group	7
BSSID	Product F radio card MAC

Interface Configuration 2 (Radio A)

Parameter	Value
Role	Access point
ESSID	same as product A

Product F

Device Configuration

Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration

Parameter	Value
Role	Access Point
ESSID	same as product A

Product G

Device Configuration

Parameter	Value
Enable device	on
802.11 mode	802.11na
HT mode	20MHz
Channel	36
Country code	FR

Interface Configuration	
Parameter	***Value***
Role	Client
Bridging mode	4 addresses format (WDS)
ESSID	same as product A

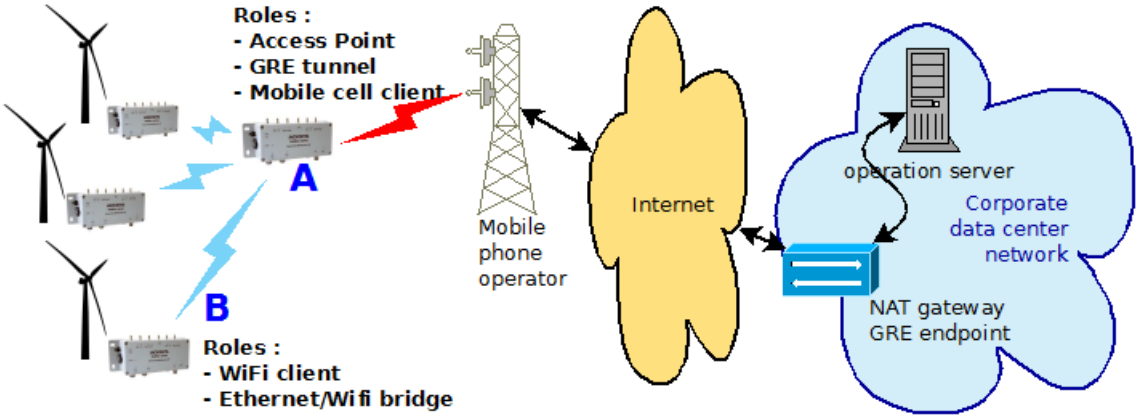
Roaming	
Parameter	***Value***
Enable proactive roaming	on
Channel	same as product A
Current AP minimum level	-60
Delay between 2 successive scan cycle	5000

VII.12 Cellular communication

VII.12.1.1 Simple connection from product to Internet

In this setup, only the product itself can access to Internet servers. The devices on the product LAN or WLAN cannot use the connection, nor can a remote computer request access to the product.

This is a very basic case, allowing for example the product to join a publicly accessible log server or GRE tunnel endpoint. It is not very useful *per se*, but gives the gist of the techniques involved.



Only the configuration of product ‘A’ (the plant gateway) is given below. Product ‘B’ and the operation server share a virtual LAN in the same IP range (192.168.0.0/24), products ‘B’ being fed their address through DHCP in the range 192.168.0.100… 192.168.0.249. The operation server should have an address such as 192.168.0.1.

The ‘B’ products are given product ‘A’ as their default gateway, but this is not useable for two reasons: (a) zones forwarding is not set in the configuration below, and (b) the NAT in the phone operator network does not know how to route back to individual ‘B’ products.

In the picture, the GRE endpoint is installed in the NAT gateway, but it could be installed in some other device, provided the NAT has a forwarding rule to that device.

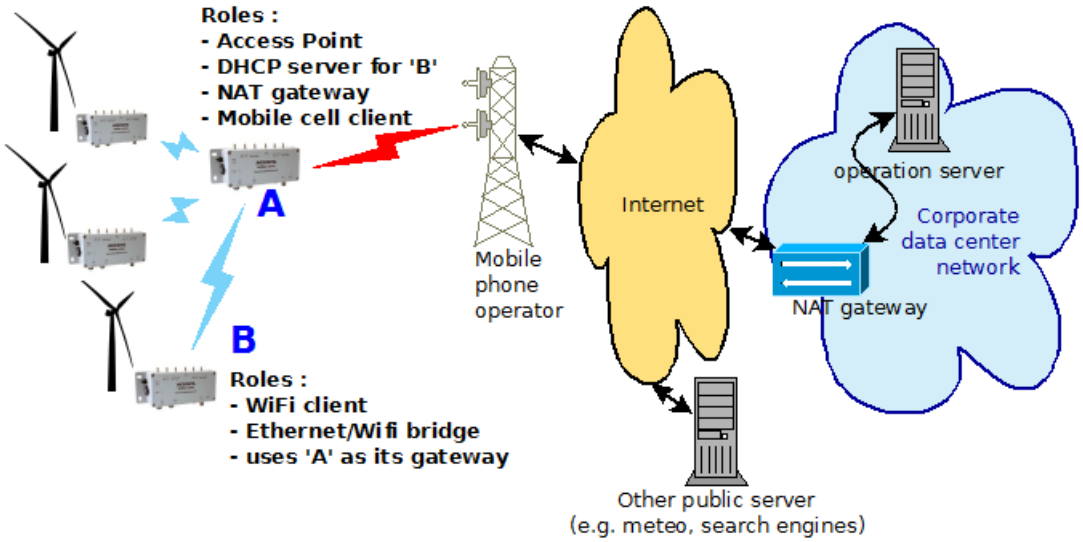
Product A	
Device Configuration (WiFi)	
Parameter	***Value***
Enable device	on
802.11 mode	802.11ac+n
HT mode	20 MHz
Channel	36
Country code	FR
Interface Configuration (WiFi)	
Parameter	***Value***
Role	Access point
ESSID	MySsid
Network Configuration (Cellular)	
Parameter	***Value***
Enable interface	on
Replace default route	on
Use peer DNS	on
SIM1 (or SIM2) pin code	Operator provided value
Country code	FR

Product A (continued)	
Network Configuration (LAN)	
Parameter	***Value***
Enable interface	on
IPv4 address	192.168.0.1
IPv4 Netmask	255.255.255.0
DHCP Service	
Parameter	***Value***
Ignore interface	off
Virtual interfaces/L2 tunnels	
Remote IP v4	Public address of data center NAT gateway
Network	LAN
Local Endpoint network	Cellular
Static route to remote	on
Corporate NAT gateway/GRE endpoint	
NAT	Redirect GRE to private GRE endpoint
Important note:	configuration of the data center gateway cannot be shown here since it depends on its manufacturer and model.

Client

VII.12.2 NAT/PAT gateway between LAN and Internet

In this setup, all devices on the LAN gain access to the Internet provided they use the product as their gateway.



The big picture looks like the previous one, but the cellular interface on product ‘A’ must be set up as a NAT/PAT. Since access to the entire Internet is granted, the GRE tunnel is left out:

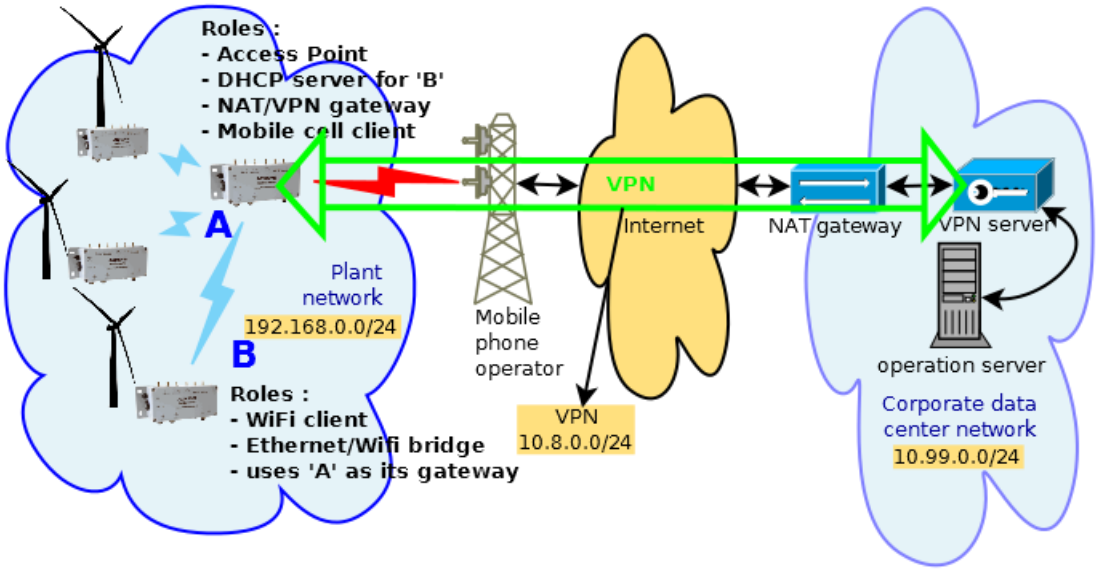
Product A	
Device Configuration (WiFi)	
Parameter	***Value***
Enable device	on
802.11 mode	802.11ac+n
HT mode	20 MHz
Channel	36
Country code	FR
Interface Configuration (WiFi)	
Parameter	***Value***
Role	Access point
ESSID	MySsid
Network Configuration (LAN)	
Parameter	***Value***
Enable interface	on
IPv4 address	192.168.0.1
IPv4 Netmask	255.255.255.0
Network Configuration (Cellular)	
Parameter	***Value***
Enable interface	on
Replace default route	on
Use peer DNS	on
SIM1 (or SIM2) pin code	Operator provided value
Country code	FR
DHCP Service	
Parameter	***Value***
Ignore interface	off
Firewall – public zone	
Name	Public
Enable NAT/PAT	on
Default acceptance policy	All disabled
Covered networks	Cellular
Traffic forward	As required by application
Firewall – private zone	
Name	Private
Enable NAT/PAT	off
Default acceptance policy	All enabled
Covered networks	lan
Inter-zone forwarding	Allow to “public”

Products B	
Device Configuration (WiFi)	
Parameter	***Value***
Enable device	on
802.11 mode	802.11ac+n
HT mode	20 MHz
Channel	36
Country code	FR
Interface Configuration (WiFi)	
Parameter	***Value***
Role	Client
ESSID	MySsid
Network Configuration (LAN)	
Parameter	***Value***
Enable interface	on
Protocol	DHCP
Interfaces settings tab:	
Bridge interfaces	on
Interface	Wifi, LAN 1, LAN 2
Corporate NAT gateway	
Important note: the data center gateway may require extra configuration, e.g. NAT/PAT forwarding rules. It cannot be shown here since it depends on the gateway’s manufacturer and application specifics.	

Client

VII.12.3 Secure gateway LAN-to-private data center through Internet

In this setup, all devices on the product LAN gain access to the remote corporate datacenter through a VPN over Internet.



'B' devices can only access the IP addresses allowed by the routing tables in both the gateway product 'A' and the VPN server at the data center. The gateway product 'A' is usually set to forward all traffic to the VPN server. However it may include exceptions to allow access to specific Internet places outside the VPN. The VPN server (at the data center) usually restricts forwarding to a selected group of operation servers, forbidding the remote device to access unauthorized computers and vice-versa.

Authentication mode

For the sake of clarity, the configuration below uses PSK authentication. A real installation should use certificates. Certificates are more secure and allow the server to accept several clients simultaneously. Also, they allow extra routing configuration to be pushed from the server to its clients at connection time. The PSK can be produced on a Linux computer with the following command:

```
openvpn --genkey --secret static.key
```

Corporate OpenVPN server configuration

Complete configuration depends on the corporate infrastructure. Only guidelines can be given here.

Configuration of ‘B’ products is the same as in the previous example.

Product A

Device Configuration (WiFi)

Parameter	Value
Enable device	on
802.11 mode	802.11ac+n
HT mode	20 MHz
Channel	36
Country code	FR

Interface Configuration (WiFi)

Parameter	Value
Role	Access point
ESSID	MySsid

Network Configuration (LAN)

Parameter	Value
Enable interface	on
IPv4 address	192.168.0.1
IPv4 Netmask	255.255.255.0

Network Configuration (Cellular)

Parameter	Value
Enable interface	on
Replace default route	on
Use peer DNS	on
SIM1 (SIM2) pin code	Operator provided value
SIM1 (SIM2) APN	Operator provided value

DHCP Service (LAN)

Parameter	Value
Ignore interface	off

Firewall – public zone

Name	Public
Enable NAT/PAT	on
Default acceptance policy	All disabled
Covered networks	Cellular
Traffic forward / Firewall	As required by application

Firewall – private zone

Name	Private
Enable NAT/PAT	off
Default acceptance policy	All enabled
Covered networks	lan
Inter-zone forwarding	Allow to “vpn2corp”
Firewall	As required by application

Product A (continued)

Firewall – vpn2corp zone

Parameter	Value
Name	vpn2corp
Enable NAT	on
Default acceptance policy	All enabled
Covered networks	vpn1
Traffic forward / Firewall	As required by application

VPN (vpn1)

Parameter	Value
Enable virtual network	on
Listener port	1194 Set to port redirected by corporate NAT to the VPN server
VPN local address	10.8.0.2 VPN server’s local address plus 1
Local routes	
Target net	10.99.0.0
Netmask	255.255.255.0
Gateway	10.8.0.1
Auth/Crypto key type	Pre-shared key
Auth/Crypto key	Upload a PEM key
Client settings/Remote OpenVPN server address	IP of corporate gateway

Client

Corporate NAT gateway / VPN server

Important note: the data center gateway may require extra configuration, e.g. NAT forwarding rules. It cannot be shown here since it depends on the gateway’s manufacturer and application specifics.

Sample OpenVPN server configuration file

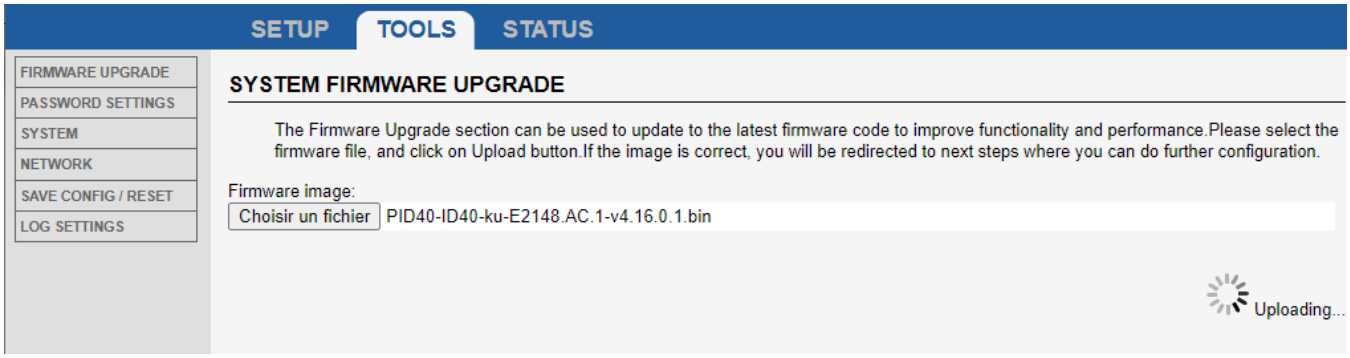
```
secret /etc/openvpn/certificates/vpn1/secret
mode p2p
auth SHA1
cipher AES-256-CBC
comp-lzo no
dev tun
ifconfig 10.8.0.1 255.255.255.0
keepalive 10 30
port 1194
proto udp
route-gateway 10.8.0.2
route 192.168.0.0 255.255.255.0
topology subnet
```

VIII FIRMWARE UPGRADE

VIII.1 Standard upgrade

VIII.1.1 Firmware file upload

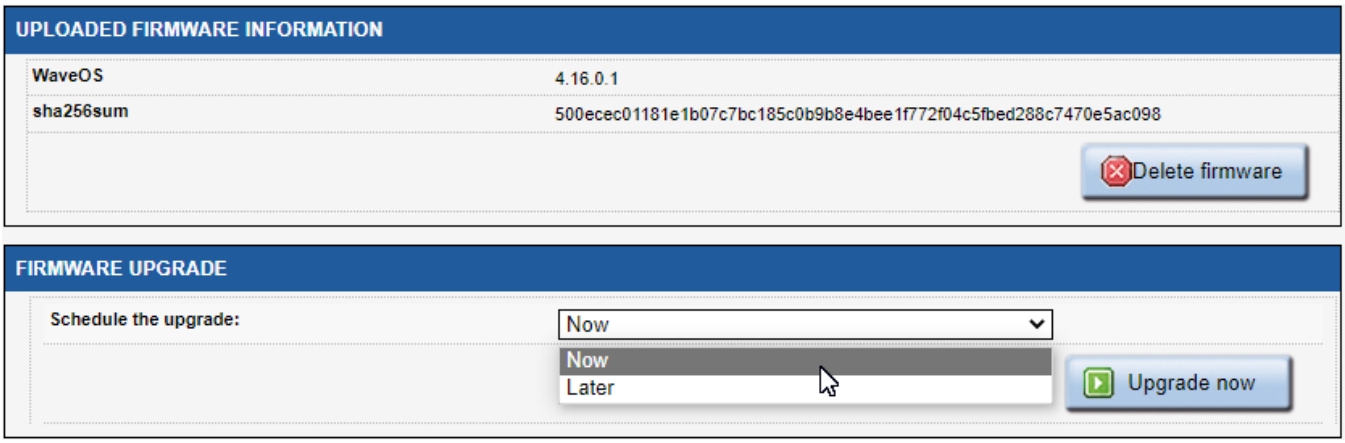
Uploading a new version of the firmware is easily done from the web interface page **TOOLS→FIMWARE UPGRADE→SYSTEM UPGRADE**



Once the upload is performed the Upgrade menu is displayed.

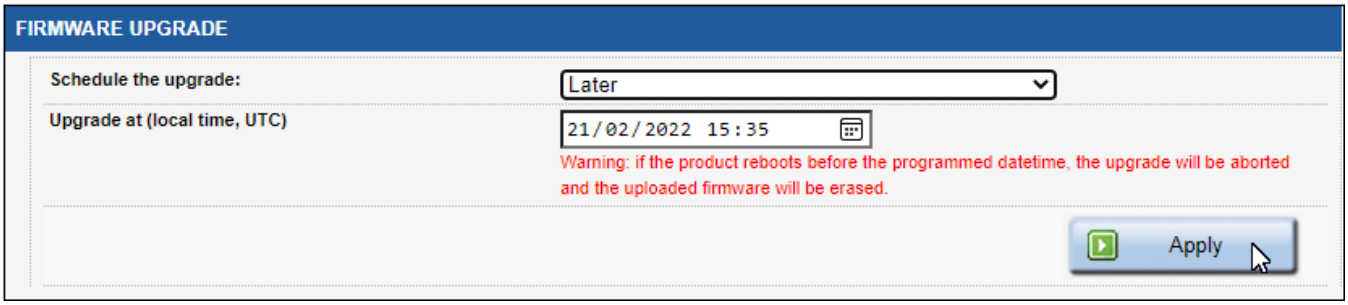
VIII.1.2 Firmware immediate upgrade

You can upgrade the firmware immediately by selecting Now and clicking on Upgrade now. The upgrade will start immediately and the router will reboot.



VIII.1.3 Firmware scheduled upgrade

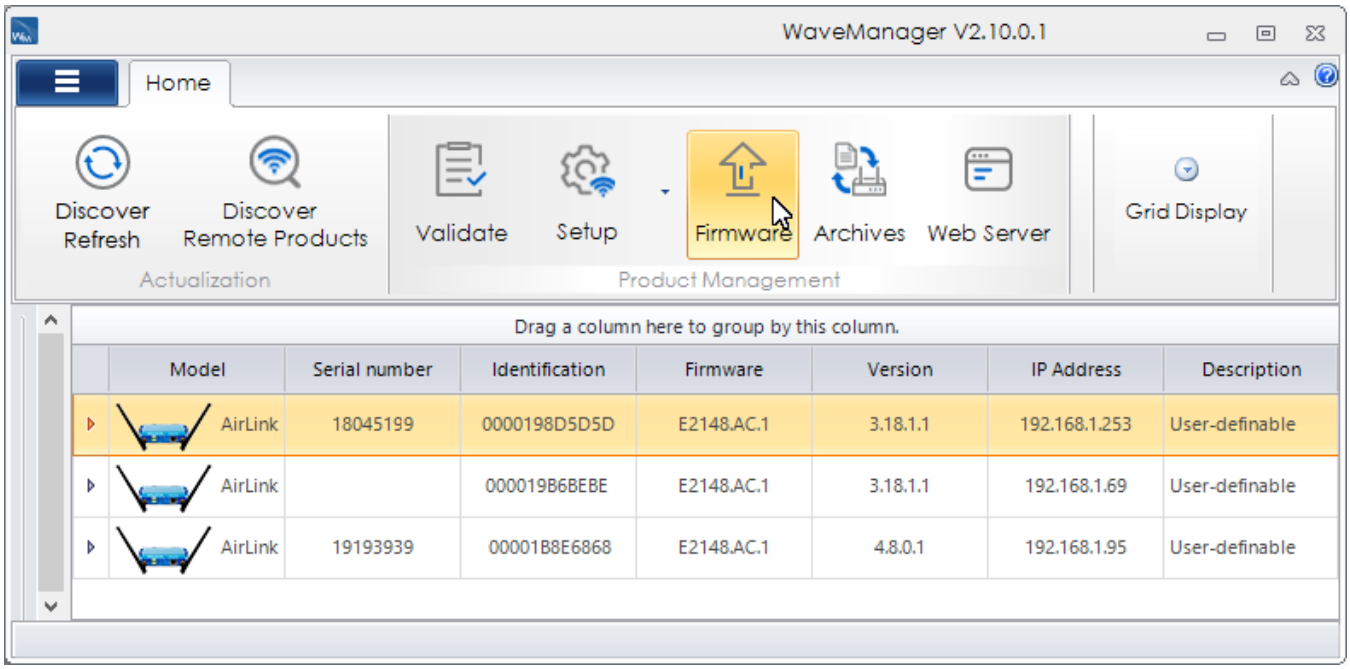
You can also schedule a date and time to start the upgrade. By default, the router date and time is displayed in the agenda. If you define a date or time in the past a message error will warn that date and time must be equal or later to current date.



Note: whatever the Firmware upgrade mode, all previous configuration changes will be left unchanged.

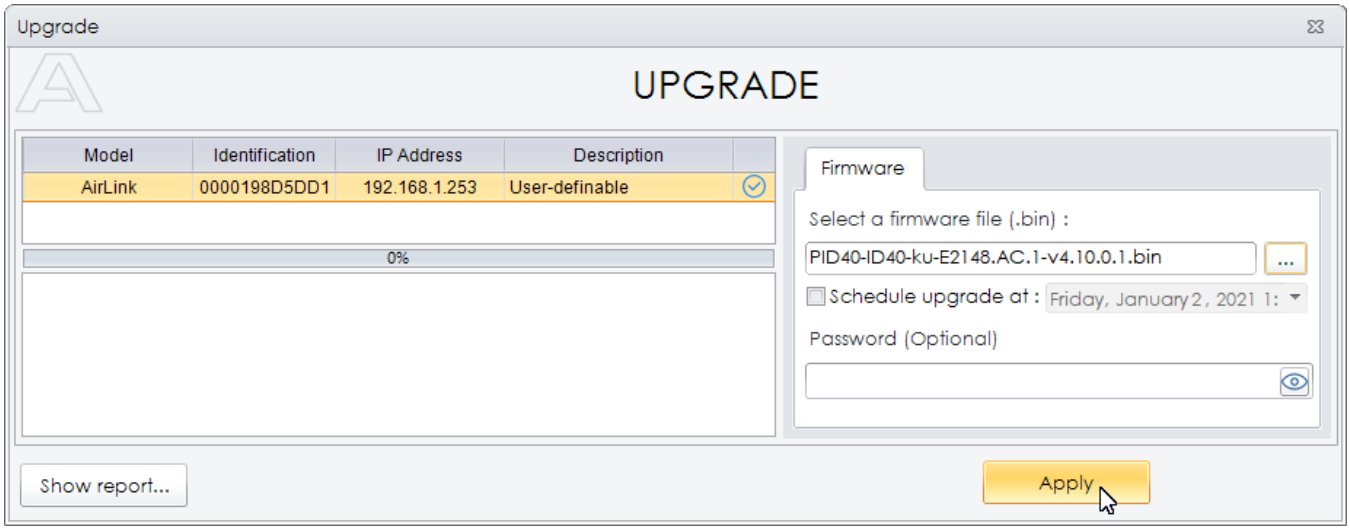
VIII.2 Upgrade in WaveManager

WaveManager is also a convenient way to upgrade your Acksys product. It's particularly interesting for batch updates**.** In the product list, select the unit you want to upgrade and click **Firmware**

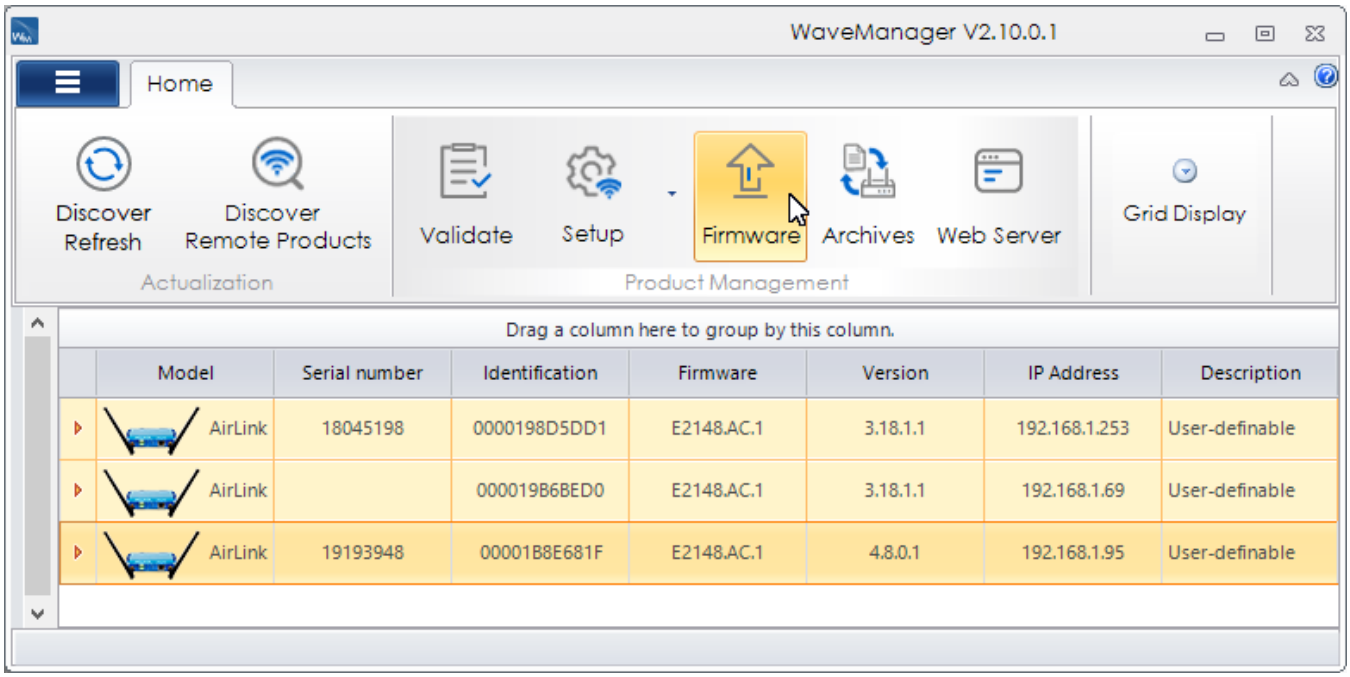


If the subnet of the product doesn't match the subnet of your computer, you can change its IP address before upgrading from this page.

Then, find the firmware binary file on your disk, enter the admin password if needed, and click **Apply**



If you want to upgrade several units (same model), you just need to make a multi-selection in the main window:



For more information, please refer to the WaveManager user's guide.

VIII.3 Bootloader upgrade

The bootloader is a separate module which handles product bootup and emergency upgrade. Since it is so essential, this is a critical upgrade and the product might be damaged if a power failure happens during this upgrade. So, you should upgrade the bootloader only if requested by ACKSYS in order to avoid a product return.
Please respect the following recommendations:

- be sure to use a robust power supply
- choose a quiet desk instead of production line
- wait until the complete product reboot before trying to refresh the web page
- do not hesitate to contact the ACKSYS support team (support@acksys.fr) if you have any question

Please contact Acksys technical support to obtain the bootloader package corresponding to your product. The bootloader upgrade may be applied using the TOOLS/FIRMWARE UPGRADE page in the internal web interface. The procedure uses the same upgrade process than the regular firmware upgrade:

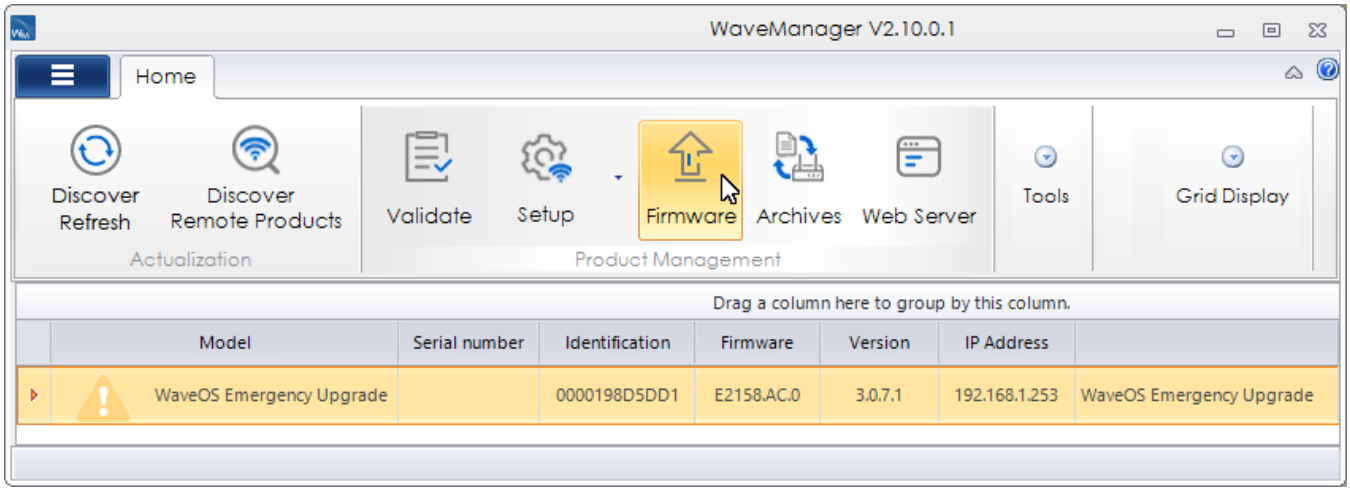
- click the **Browse** button in order to select the upgrade file
- click the **Execute** button in order to perform the upgrade

VIII.4 Fallback after an interrupted upgrade operation

If the upgrade process fails due (for example) to an unexpected power supply failure during Flash EPROM programming, the product will automatically switch to failover mode.

At its next reboot the product will find out that the firmware is incomplete and the **Emergency upgrade** mode will start automatically. You can recognize that the product is in this failover mode because its **DIAG LED** will blink quickly (remind that this LED is green or OFF in normal working mode). The product will then execute a restricted service allowing only firmware uploads from the ACKSYS WaveManager software.

If a simple reset is not enough to exit Emergency Upgrade mode, it will be necessary to update the firmware from Wavemanager. Products in Emergency upgrade mode are clearly identifiable in WaveManager. Select the unit in the list, then click **Firmware** and upgrade the unit as indicated chapter *VIII.1* above.



While the product is in **Emergency upgrade** mode it still allows to restore factory settings by pressing the reset button more than two seconds.

You can voluntarily enter Emergency Upgrade mode: press and hold the reset button during product start-up, until the **Diag** led starts to blink

IX TROUBLESHOOTING

This section gives indications on the checks to perform when things do not work as expected after configuration.

A network sniffer may prove very helpful when debugging network connections. We recommend WireShark, a free sniffer working on Windows and Linux.

IX.1 Basic checks

Check power supply LED(s)

If the power supply LED is OFF, check that the power supply is correctly plugged at both ends; check that the delivered current and voltage is in the acceptable range. Products with dual power supply can work with only one source provided.

Check Diag LED

The Diag LED should go OFF (or green, on some models) 30 to 45 seconds after power up (depending on product model and configuration complexity). If it remains permanently fixed, the product is out of order. If it is blinking quickly, the device is in Emergency upgrade mode.

Check State LEDs

The State LED is OFF when the corresponding radio is disabled; it is blinking when the product tries to associate (or waits for association); it is steadily ON when associated.

If the product is set for infrastructure station mode, it will try to connect to an access point with corresponding configuration (channel, protocol, keys and SSID). During the search the Wlan status LED is blinking (red) and WLAN (blue) LED is off.

- Insure that the access point is in range
- Insure that the access point Wi-Fi and security parameters match the product Wi-Fi and security parameters.

Check WLAN LEDs

- The WLAN LED blinks whenever frames are sent or received. Even when no data transfers take place, management frames may make this LED blink.

IX.2 Network configuration checks

Check IP address

Check IP addresses: the following assumes that all network devices are in the same LAN (the computer used for the tests, the product, the remote device):

- All network devices must be in the same IP subnet (**see RFC 950**). For example, 192.168.1.253 and 192.168.1.10 are in the same subnet, but 192.168.1.253 and 128.1.1.10 are not (assuming a netmask of 255.255.255.0)
- All network devices must have the same netmask
- When changing the IP address of one device, the others keep the old address for several minutes in the ARP cache: clear it with “arp –d” (Windows O.S.) or by powering off the caching devices
- Windows (or other) firewalls may prevent communication.
- The web interface (in the Tools/Network menu) provides a “ping” feature which executes the ping command in background and then display the result on the web page. A traceroute tool is also available on the same page.

Check security parameters

Check security parameters: when installing, always disable all security parameters until everything else works correctly. Add security parameters at the end, when you are sure about the whole configuration parameters.

Check Wi-Fi parameters

Check Wi-Fi parameters: all the communicating devices must have matching Wi-Fi parameters. Check the SSID, the channel, the 802.11 mode (a, g, na, ng), the topology (infrastructure, mesh, repeater or ad-hoc). If in doubt, set the same given fixed channel on all communicating devices, and do not use the 4-addresses bridging mode, for this format is not compatible with some AP providers.

IX.3 Cellular configuration checks

Check Status LED

If it stays off, you did not enable the device (Status/Network/Cellular)
If it is blinking, something is wrong with the SIM card or the antenna.

Check SIM

Check that you entered the correct PIN code. Check that the SIM selected matches the slot where the SIM is inserted.

Set the system log and the cellular service to “info” level and check for “PIN code event” messages in the system log.

Check antenna(s)

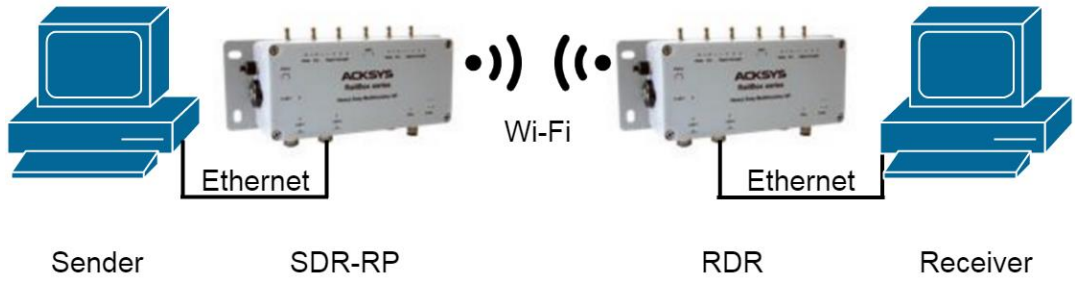
Check that the main antenna is plugged in and any intervening SMA connector is firmly screwed in. Check that you use SMA connectors, not RPSMA. Check that you use an adequate antenna, Wi-Fi antennas won’t work.

Check Operator subscription

Is it ready to use? Is it paid? Try inserting the SIM in a regular mobile phone to confirm the availability of the subscription and the presence of radio signal in your area.

IX.4 Multicast router checks

The following Reference configuration is used in this section:



Sender sends multicast traffic.

SDRRP is a multicast router, designated (sole) router on the right-side Ethernet and rendezvous point for the multicast group (Sender side Designated Router and Rendezvous Point).

RDR is a multicast router, designated (sole) router on the left-side Ethernet (Receive side Designated Router).

Receiver runs software that reads multicast traffic sent by ***sender***.

Check unicast configuration

- From Receiver, can you ping each of RDR, SDRRP, Sender?
- From Sender, can you ping each of SDRRP, RDR, Receiver?
- From RDR, can you ping each of Receiver, SDRRP, Sender?
- From SDRRP, can you ping each of Receiver, RDR, Sender?

Run software

Run the sender and the receiver software now.

Check multicast configuration in SDRRP

- Are the “Enable multicast”, “Enable bootstrap” and “Rendezvous point candidate” checkboxes all checked?
- Does “local rendezvous point configuration” contain the proper group prefix?
- Are the two network interfaces reaching Ethernet and Wi-Fi enabled to handle multicast? Leave defaults for other parameters for now.

Now, if the multicast log level is set to Debug in ***SDRRP***, you can see the following message every 10 seconds:

```
daemon.debug pimd[nnn]: move_kernel_cache: SG
```

Also, the “Status/network/multicast routes” may show, briefly from time to time, the ***Sender*** address in the multicast routes section. This indicates that join requests from ***Receiver*** do not reach ***SDRRP*** yet.

If the ***Sender*** address is steady and “in use” in the multicast routes section, see below the ***Sender*** checks.

- Look at the “Status/network/multicast routes” on ***SDRRP***.
  - In the “network interfaces” section, does it show the IP address of ***RDR*** in the column “Neighbor MC routers” on the expected line? Else either ***RDR*** is not enabled for the Wi-Fi link, or the link is not established or flickers.
  - In the “Rendezvous points” section, do you see your group? Is it associated with the address of ***SDRRP***? Is the BSR address one of ***RDR*** or ***SDRRP***?

Check multicast configuration in RDR

- Look at the “Status/network/multicast routes” on ***RDR***.
  - In the “network interfaces” section, is the “DR” checkbox marked for the receiver side Ethernet network interface? Else there is another PIM router on this network.
  - In the “network interfaces” section, does it show the IP address of ***SDRRP*** in the column “Neighbor MC routers” on the expected line?
  - In the “network interfaces” section, does it show the multicast group in the column “IGMP reports” on the expected line? Else there is a problem with ***Receiver***. Maybe it uses a unicast address instead of multicast, or a multicast in the range 224.0.0.x/24, or it uses IGMPv3 and you configured IGMPv2.
  - In the “multicast routes” section, does it show a route for the group? Is the “RP address” the one of ***SDRRP***? Is the ingress interface the one where ***Receiver*** is attached?
  - In the “Rendezvous points” section, do you see your group? Is it associated with the address of ***SDRRP***? Is the BSR address one of ***RDR*** or ***SDRRP***? Else there is no BSR, and the rendezvous points and incorrectly configured.

Check IP options in Sender

These checks depend on the software you use, we can only give broad indications.

- Double check the TTL used by ***Sender***. If possible, dump the Ethernet traffic with “tcpdump” (Linux) or “Wireshark” (Windows and Linux). Display the TTL of outgoing frames.
- Double check the size of the frames. If possible, reduce it for a first try. 1000 bytes should pass quite anywhere. You can use “iperf” or “jperf” to generate multicast traffic with a known frame size.

Check UDP options in Sender and Receiver

- Do they use the same UDP port? The same data format?

X FREQUENTLY ASKED QUESTIONS

This section answers questions to various aspects of the operation of the products.

X.1 How to reset the device to factory settings?

You can reset to factory settings via the WEB interface (VI.2.5 Save Config / Reset), but in some cases, you will need to use the reset button for this purpose. Please refer to the product documentation to find the location of the reset button. Here is the procedure to restore the factory settings:

Push and hold the reset button steadily for at least 3 seconds, until the DIAG LED turns red, then release the button; Wait until the DIAG LED turns back green, then check with WaveManager that the IP address of the device has been reset to the factory default 192.168.1.253.

X.2 I Can't find the Transparent Client mode

The old **Transparent Client** role is now a subset of the generic **Client (infrastructure)** role, and must be configured in the **Advanced settings** tab of the **Interface configuration** section (Bridging mode **4-addresses format (WDS)**).

X.3 How is the Wi-Fi bit rate chosen?

The bit rate used to send a frame depends on several considerations and may have a large effect on both the throughput between two devices, and the bandwidth left for other devices.

Some frames are always sent at the lowest available bit rate: broadcasts and multicasts aim all stations hence they must reach the farthest possible distance; management frames are important and reception must be ensured as much as possible.

The lowest configured bit rate is supposed to always succeed. This bit rate will be used as a starting value after association. Then a dynamic adaptative algorithm named MINSTREL is used, quickly converging to the optimum rate while periodically checking for better throughput at other rates. The MINSTREL algorithm is described in:
http://linuxwireless.org/en/developers/Documentation/mac80211/RateControl/minstrel/

X.4 What is the difference between WMM, WME, IEEE802.11e?

These are various names for the QoS function. IEEE802.11e is an extension of WME QoS, it adds APSD (automatic power save delivery) and HCCA, a rarely used protocol (QoS Wi-Fi usually uses EDCA). The products support WME, which consists of the mandatory features of IEEE802.11e. WMM is another name for WME.
The WME capability consists in having 4 priority classes (best-effort, background, video, voice). Each transmitted frame belongs to one class and the parameters for contention/collision resolution in the air media can be fine-tuned depending on the class.

X.5 Multicast

X.5.1 Multicast route is unstable in the Web interface?

After configuring a multicast group and starting the corresponding multicast sender, you may experiment that the route comes and goes in the Web interface, page Status/Network/Multicast routes list.

One frequent cause is that the router receives the multicast flow but ignores it because no outgoing interface is configured.

Check the relevant interfaces in the “local networks configuration” section of the Setup/Routing/Multicast routing page.

Check that the IGMP reports from the receiver include the expected multicast group (see next FAQ below).

X.5.2 Receiver device does not send its multicast group in its IGMP reports?

In Linux devices, IGMP messages are sent only on the interface defined by the routing table, which must include an appropriate routing entry such as

```
$ route –n
Destination  Gateway   Genmask     Flags Metric Ref    Use Iface
(…)
224.0.0.0    0.0.0.0   240.0.0.0   U     0      0      0 eth0
```

X.6 My CISCO access point rejects my client bridge?

We assume that SSID, channel and security are correctly set up. To allow bridging a LAN to a CISCO AP, the “passive mode” must be used on the CISCO AP, so that the proxy ARP server is disabled. See section *V.2.6.2a Masquerading (ARPNAT).*

X.7 Fast roaming features

Figures given below are accurate for the firmware version 2.2.0 and will be updated as needed in future releases of this document.

X.7.1 What is the scan period when proactive roaming is enabled?

When the client is connected, proactive roaming cycles through the activated channels. Each channel is scanned for a duration of around 56ms, during which the radio is deemed “off-channel” and no data can flow; then a 200ms pause is inserted between each channel scan to allow data transfers, and an extra delay can be configured between cycles in order to improve throughput by lowering CPU usage and off-channel time.

The 200 ms pause does not take place when the channel to scan is the one currently in use.

For example, for a 4-channels scan with a configured delay of 3000 ms, the scan period will be 56ms + 0ms + 56ms + 200ms + 56ms + 200ms + 56ms + 3000ms = 3464ms. The radio cannot communicate while it is off-channel, in this case this is (3x56)/3464 = 4,8% of the time. The throughput decreases accordingly.

This figure is only an approximation and may vary under very heavy loads.

X.7.2 What is the roaming delay when the current access point disappears suddenly?

This can occur when a big obstacle suddenly gets in the way of the radio waves: for example, turning around the corner of a tunnel. This can also happen if the AP is powered off or fails for whatever reason. The client product has several ways to find out:

- If the client is sending data to the AP and the AP no longer acknowledges it, the client will drop the association after 50 unacknowledged frames. Each frame is retried using the relevant retry procedures and appropriate (configurable) supported rates.
- If the client does not send data, it will rely on the beacons received from the AP. The client will detect when several consecutive beacons are missing; after which it will send two extra control frames (each retried 10 times) to further probe the AP. If the AP still does not respond, the client will drop the association. The number of missing beacons is configurable.
  The total duration of this procedure depends on the configured number, the beacon interval duration set in the AP configuration, and the lowest configured basic rate (for the probe involving the control frames)

X.8 The GRE tunnel does not forward data?

Provided that the GRE endpoints IP addresses are correct at both end of the tunnel, and each side can ping each other, this can happen in a corner case when

- The GRE tunnel local endpoint uses a wireless Access Point interface,
- The AP is configured in such a way that it cannot initialize quickly because of ACS or DFS delays,

In this case, at startup, the GRE tunnel searches for an outgoing route to the remote endpoint but cannot find it because it does not exist yet. It reverts to some default route potentially pointing in the wrong direction.

The solution is to either change the AP settings, or to include the AP network interface into a bridge. A software bridge has no startup delay and the GRE tunnel will always find it.

X.9 How to configure LAN in SLAAC to get IPv6 address from RA server

WaveOS in release 4.18.0.1 support RA server and not DHCPv6 to address host in infrastructure mode. This chapter is an overview of IPv6 and RA server section.

X.10 FTP through a NAT router

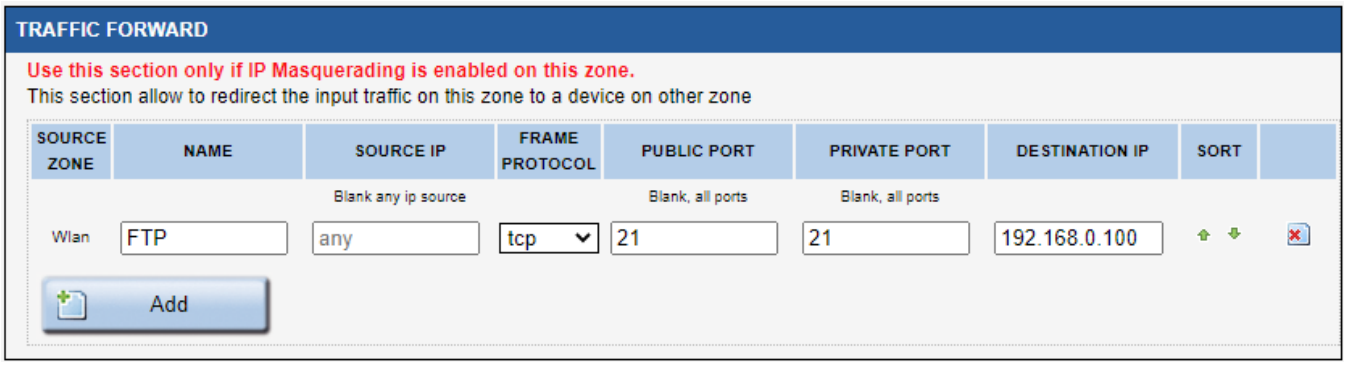
FTP transfers usually involve two TCP connections: the first control connection goes from the FTP client to port 21 on the FTP server. This connection is used for logon and to send commands and responses between the endpoints. Data transfers (including the output of “ls” and “dir” commands) requires a second data connection.

The FTP client can operate in 2 modes:

Passive Mode: The client issues a PASV command. Upon receipt of this command, the server listens on a dynamically-allocated port then sends a PASV reply to the client. The PASV reply gives the IP address and port number that the server is listening on. The client then opens a second connection to that IP address and port number.

Active Mode: The client listens on a dynamically-allocated port then sends a PORT command to the server. The PORT command gives the IP address and port number that the client is listening on. The server then opens a connection to that IP address and port number.

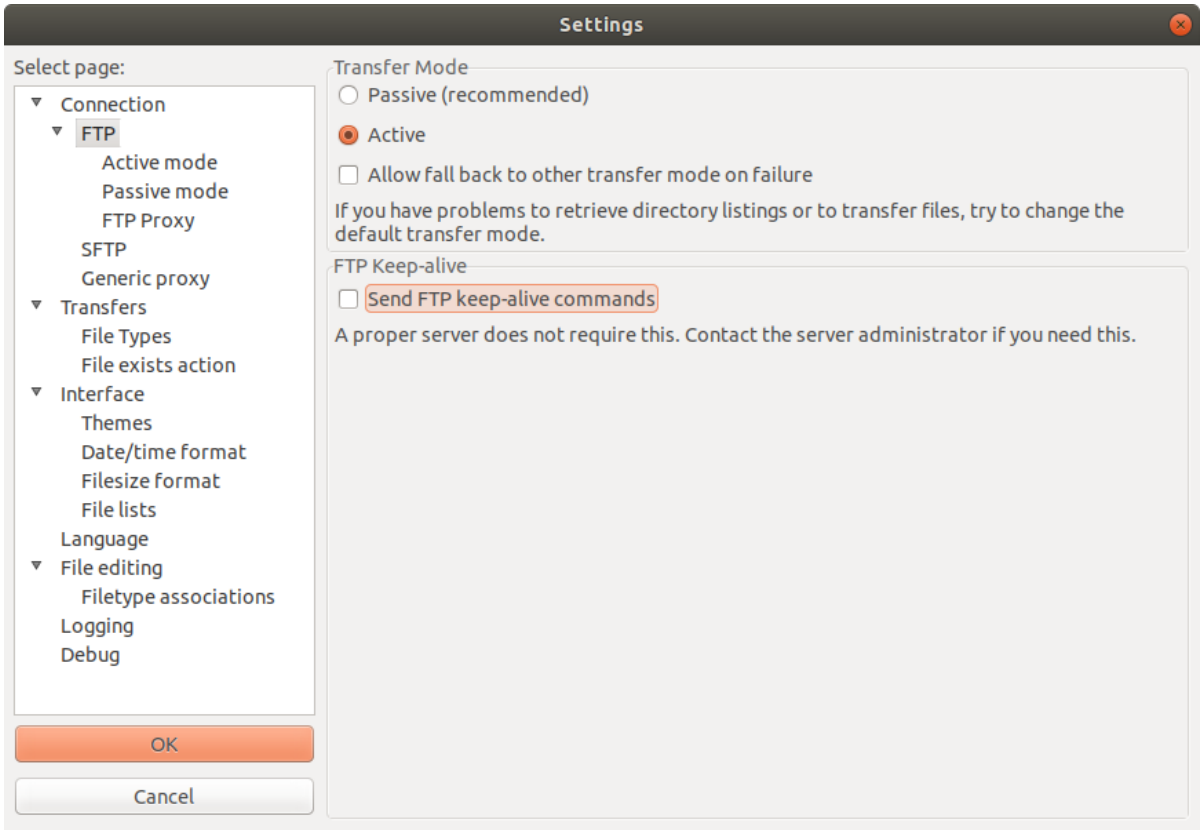
In the case where the data transfer must pass through a NAT router, it will be necessary to enter the forward traffic table of the NAT zone so as to ensure the redirection of the FTP flows from the public zone to the local destination IP, port 21:

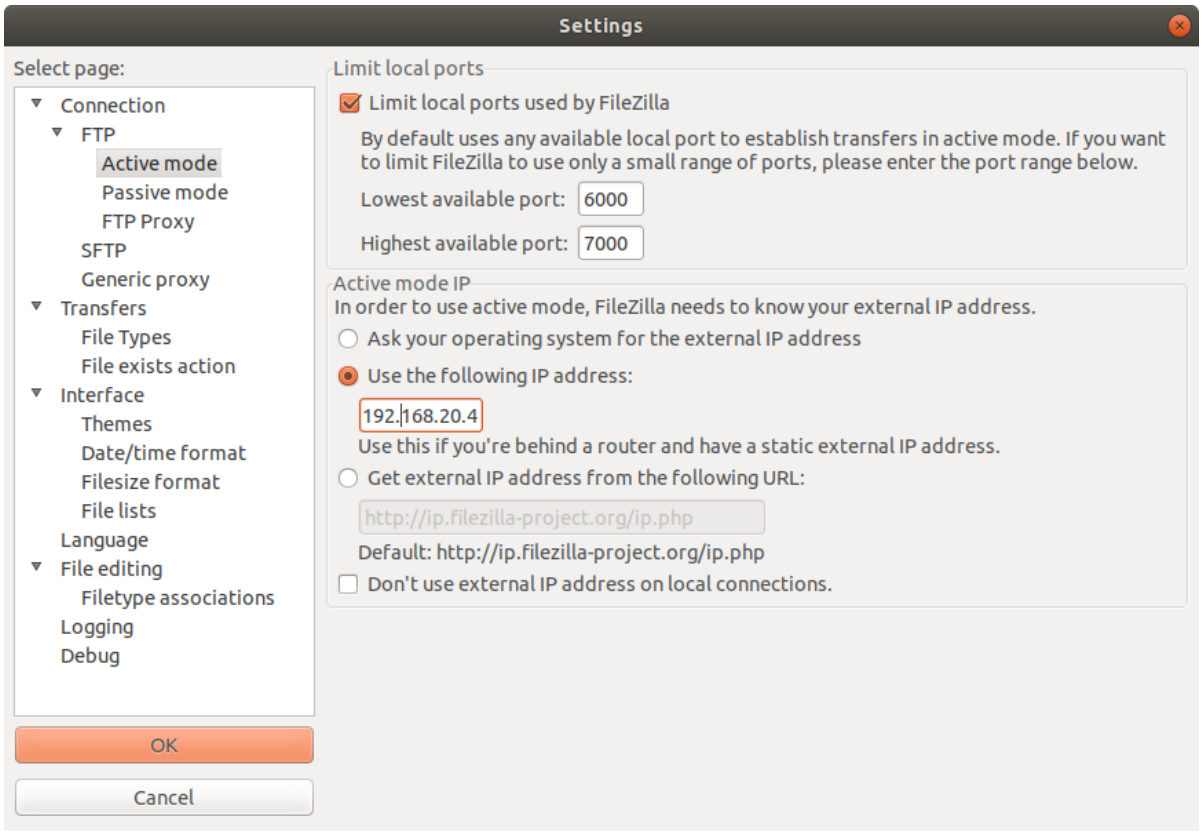


If the FTP server is located in the public area, the FTP client will be configured in passive mode, so that it is the source of the FTP DATA connection. (This is the default mode with FileZilla)

If the server is located in a private zone, the FTP client must be configured in active mode, so that it is the source of the FTP DATA connection. Here is how to configure FileZilla FTP client in active mode:

- In the client settings section, FTP page, select the Active mode
- In the Active mode page, check the **Limit local ports used by FileZilla** box. You can leave the default range if it is free, or define your own range.
- Check **Use the following IP address** and enter the public IP address of the router


Settings
Select page:
Connection
FTP
Active mode
Passive mode
FTP Proxy
SFTP
Generic proxy
Transfers
File Types
File exists action
Interface
Themes
Date/time format
Filesize format
File lists
Language
File editing
Filetype associations
Logging
Debug
OK
Cancel
Transfer Mode
Passive (recommended)
Active
Allow fall back to other transfer mode on failure
If you have problems to retrieve directory listings or to transfer files, try to change the default transfer mode.
FTP Keep-alive
Send FTP keep-alive commands
A proper server does not require this. Contact the server administrator if you need this.


Settings
Select page:
Connection
FTP
Active mode
Passive mode
FTP Proxy
SFTP
Generic proxy
Transfers
File Types
File exists action
Interface
Themes
Date/time format
Filesize format
File lists
Language
File editing
Filetype associations
Logging
Debug
OK
Cancel
Limit local ports
Limit local ports used by FileZilla
By default uses any available local port to establish transfers in active mode. If you want to limit FileZilla to use only a small range of ports, please enter the port range below.
Lowest available port: 6000
Highest available port: 7000
Active mode IP
In order to use active mode, FileZilla needs to know your external IP address.
Ask your operating system for the external IP address
Use the following IP address:
192.168.20.4
Use this if you're behind a router and have a static external IP address.
Get external IP address from the following URL:
http://ip.filezilla-project.org/ip.php
Default: http://ip.filezilla-project.org/ip.php
Don't use external IP address on local connections.

XI APPENDIX – GLOSSARY AND ACRONYMS

802.11	An IEEE standard describing several variations of network layers 1 and 2 of a radio LAN.
802.11s	The part of the IEEE 802.11 standard that describes wireless mesh networks.
AP	Access point.
A-MPDU	Aggregated MAC protocol data unit. Several MAC frames concatenated in one big frame and handed to the Physical Layer for transmission in one chunk.
BSR	The Bootstrap Router is the multicast router responsible for dynamic selection and distribution of the mapping between RP's and multicast groups.
BSS	Basic Service Set, the network formed by one AP and its clients.
Bridge	In the context of wireless applications, a bridge is a network component that transfers LAN (Ethernet) frames to the WLAN (Wi-Fi) media and vice-versa. When the WLAN is in infrastructure mode, the term "bridge" is used for the client of the AP, though, technically, the AP is also a bridge. In the broader context of networking, a bridge transfers layer 2 frames from one physical interface to another, without resorting to level 3 routing. For example, an Ethernet switch is a hardware bridge, and the products include a software bridge between their various interfaces such as Ethernet, multiple WLAN clients or APs, mesh, and so on.
BSSID	BSS identifier, usually the MAC address of the AP or a derivation thereof.
GNSS	Global Navigation Satellite System, one of GPS (US), GLONASS (russian), Galileo (European) or BeiDou (Chinese).
IPv4	Internet Protocol version 4, a network layer in the TCP/IP protocol stack which is responsible for the delivery of packets to the correct target computer. IPv4 uses 32 bits sized addresses like "192.168.1.1".
IPv6	Internet Protocol version 6 (IPv6) is the second-generation network layer protocol. Designed by the Internet Engineering Task Force (IETF), IPv6 is an upgraded version of Internet Protocol version 4 (IPv4).
LAN	Local Area Network, a part of a network where devices can directly use MAC (OSI layer 2) addresses to communicate with each other.
MCC	Mobile Country Code, unique country identifier for cellular networks.
MCS	Modulation and Coding Scheme, the way the bits are encoded in radio waves in 802.11n.
MNC	Mobile Network Code, operator identifier for cellular networks in the designated country
OSI	Open Systems Interconnection, an ISO standard reference model to organize networking systems into specialized layers.
PSK	Pre-shared key, a symmetric crypto system where the same key is used at both ends of the link. This implies that the key must be previously transferred by a

	separate way from one end to the other (and this way could be a target for an attack).
Repeater	A combined client+AP on the same radio, linked together in a software bridge. Data received either by the AP or by the Ethernet LAN can be forwarded through the client to a remote AP, allowing setting up a chain.
RP	The Rendezvous Point is the multicast router responsible for distribution of a given multicast group.
RTS/CTS	An optional MAC protocol, that requires sending a small RTS frame that reserves the air medium for a long enough duration to send the next data frame. The receiver replies by sending a CTS frame that makes the same reservation. Therefore, all wireless stations in radio range of both the transmitter and the receiver, are informed of the data transmission that will take place.
SSID	Service Set Identifier, a string identifying the wireless network formed by a group of APs and their clients.
SSM	Source Specific Multicast is a variant of multicast routing where the receiver knows the address of the sender, so that there is no need to go through the RP.
USM	User-based Security Model, a way to define SNMP access permissions on a per-user basis.
VLAN	Virtual LAN, a LAN tunneled in another LAN by adding a VLAN tag to each frame in the VLAN.
Wi-Fi™	“Wireless Fidelity”. In this documentation, this term is used as a synonym for 802.11.
WLAN	Wireless LAN, a group of Wi-Fi stations sharing a common network name (SSID or Mesh ID), and a common authentication method, in order to exchange information with each other.
RA	Router advertisements contain a list of subnet prefixes that is used to determine if a host is on the same link (on-link) as the router.

XII APPENDIX – 802.11 RADIO CHANNELS

XII.1 11b/g (2.4GHz)

These networks use the ISM (Industrial Scientific and Medical) radio band on the [2.3995-2.4965] spectrum.

Channel (25 MHz)	Central frequency (GHz)	Allowed by
1	2,412	Asia MKK, Europe ETSI, US FCC
2	2,417	Asia MKK, Europe ETSI, US FCC
3	2,422	Asia MKK, Europe ETSI, US FCC
4	2,427	Asia MKK, Europe ETSI, US FCC
5	2,432	Asia MKK, Europe ETSI, US FCC
6	2,437	Asia MKK, Europe ETSI, US FCC
7	2,442	Asia MKK, Europe ETSI, US FCC
8	2,447	Asia MKK, Europe ETSI, US FCC
9	2,452	Asia MKK, Europe ETSI, US FCC
10	2,457	Asia MKK, Europe ETSI, US FCC
11	2,462	Asia MKK, Europe ETSI, US FCC
12	2,467	Asia MKK, Europe ETSI
13	2,472	Asia MKK, Europe ETSI
14	2,484	Asia MKK

Besides specifying the center frequency of each channel, 802.11 also specifies (in Clause 17) a spectral mask defining the permitted distribution of power across each channel. The mask requires that the signal be attenuated by at least 30 dB from its peak energy at ± 11 MHz from the center frequency, so that the channels are effectively 22 MHz wide. One consequence is that stations can only use every fifth channel without overlap, typically 1, 6 and 11 in the Americas, 1-13 in Europe, etc. Another is that channels 1-13 effectively require the band 2401-2483 MHz, the actual allocations being for example 2400-2483.5 in the UK, 2402-2483.5 in the US, etc.

Since the spectral mask only defines power output restrictions up to ± 22 MHz from the center frequency to be attenuated by 50 dB, it is often assumed that the energy of the channel extends no further than these limits. It is more correct to say that, given the separation between channels 1, 6, and 11, the signal on any channel should be sufficiently attenuated to minimally interfere with a transmitter on any other channel. Due to the near-far problem, a transmitter can impact a receiver on a “non-overlapping” channel, but only if it is close to the victim receiver (within a meter) or operating above allowed power levels.

XII.2 802.11a/h (5 GHz)

These networks use the 5 GHz radio band UN-II (Unlicensed-National Information Infrastructure).
UN-II uses four separate sub-bands: UN-II-1, 2, 2e and 3.

Band	Channel (20 MHz)	Central frequency (GHz)	Allowed by
U N II 1	34	5,170	Japan TELEC
	36	5,180	Europe ETSI, US FCC
	38	5,190	Japan TELEC
	40	5,200	Europe ETSI, US FCC
	42	5,210	Japan TELEC
	44	5,220	Europe ETSI, US FCC
	46	5,230	Japan TELEC
	48	5,240	Europe ETSI, US FCC
U N II 2	52	5,260	Europe ETSI, US FCC
	56	5,280	Europe ETSI, US FCC
	60	5,300	Europe ETSI, US FCC
	64	5,320	Europe ETSI, US FCC
U N II 2e	100	5,500	Europe ETSI, US FCC
	104	5,520	Europe ETSI, US FCC
	108	5,540	Europe ETSI, US FCC
	112	5,560	Europe ETSI, US FCC
	116	5,580	Europe ETSI, US FCC
	120	5,600	Europe ETSI, US FCC
	124	5,620	Europe ETSI, US FCC
	128	5,640	Europe ETSI, US FCC
	132	5,660	Europe ETSI, US FCC
	136	5,680	Europe ETSI, US FCC
	140	5,700	Europe ETSI, US FCC
	144	5,720	Europe ETSI, US FCC
U N II 3	149	5,745	US FCC
	153	5,765	US FCC
	157	5,785	US FCC
	161	5,805	US FCC
	165	5,825	US FCC

Summary:

Europe (ETSI): 19 channels

- UN-II 1 : 4 channels 36, 40, 44, 48
- UN-II-2 : 4 channels 52, 56, 60, 64
- UN-II-2e : 11 channels : 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140

US and Canada (FCC): 23 channels

- UN-II 1 : 4 channels 36, 40, 44, 48
- UN-II-2 : 4 channels 52, 56, 60, 64
- UN-II-2e : 11 channels : 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140
- UN-II-3 : 4 channels : 149, 153, 157, 161, 165

Japan (TELEC): 4 channels

- UN-II-1 : 4 channels : 34, 38, 42, 46