ACKSYS
COMMUNICATIONS & SYSTEMS

APPLICATION NOTE

How to configure CBB Roaming

July 2025

Content

1. Introduction

The purpose of this document is to explain the concept of the ACKSYS *Connect Before Break* (CBB) functionality and guide you in configuring your ACKSYS product in client mode with CBB.

Roaming occurs when a wireless client device moves out of the usable range of one wireless access point (AP) and connects to another AP typically one with a stronger signal.
Roaming happens in three main steps:

Scanning

The Wi-Fi client sends a probe request for a specific SSID, and nearby access points respond with probe replies. The client builds a list of APs along with their signal strengths. The selection of the best AP is based on:

- SSID match
- Security compatibility
- Signal strength

The AP with the highest signal strength that meets SSID and security criteria is selected.

Authentication & Association

The client sends an authentication request to the selected AP and waits for a response. Upon successful authentication, it sends an association request. Once associated, the new AP informs the old AP with a disassociation packet to update routing tables.

Convergence

The client finalizes the handoff by re-associating with the new AP. The network updates are triggered, completing the handover process.

Note: Even with two radio cards, conventional roaming causes a brief disconnection while switching APs. This can result in packet loss, especially during high-throughput data transfers.
To address this, ACKSYS developed a proprietary roaming mode, **Connect Before Break** that minimizes packet loss, even in high-speed environments.

2. Requirements

To illustrate CBB we will take the example of train-to-ground communication, but it can be used in many other environments (cable car, shuttle, AGV…).
Requirements for this use case:

- RailBox dual radio cards or any ACKSYS Dual Radio
- 2 antennas pointing to the same direction (1 antenna per radio card)
- The TX signal power must be the same for each antenna and radio-frequency cable
- No discontinuity in Wi-Fi coverage on ground, and the minimum power must be sufficient to transfer data

To ensure 0.1% packet loss error ratio, you must also verify:

- No ACI (adjacent channel interference)
- No CCI (co-channel interference)

All APs on the trackside must be bridged (Layer 2) together.

3. Roaming Limitation

There are different types of roaming:

- Reactive roaming,
- Proactive roaming in mono radio mode,
- Proactive roaming in dual radio mode.

Reactive roaming is the default roaming in WiFi, as per the standard. It starts scanning only upon the current AP is lost.
Limitation: This is not efficient and causes high packet loss.
Application: WiFI clients roaming rarely from AP to AP

Proactive roaming in mono radio mode allows channel scanning while the client is associated to an AP. It's not waiting for the AP loss to start the scanning process. So, this is an improvement in comparison to the standard.
Limitation: the data flow is still regularly interrupted by the scan process and the change of AP.
Application: This roaming type is suited for not critical mobility applications and low packets loss for urban mobility.

Proactive roaming in dual radio mode allows to start the scan process on a separate WiFi radio. This will free up the first WiFi radio which only processes user data. Scanning card collects information in regards to the best surrounding AP's. Data card switches to the elected AP when suited.
Limitation: the data flow is still regularly interrupted by the change of AP.
Application: This roaming type is suited for not critical mobility applications with very low packets loss ratio.

None of these roaming types is suitable for high speed mobility and critical applications.

Objective: establish a reliable train to ground communication, with a bandwidth of 500Mb/s at 350km/h

4. Connect Before Break Concept

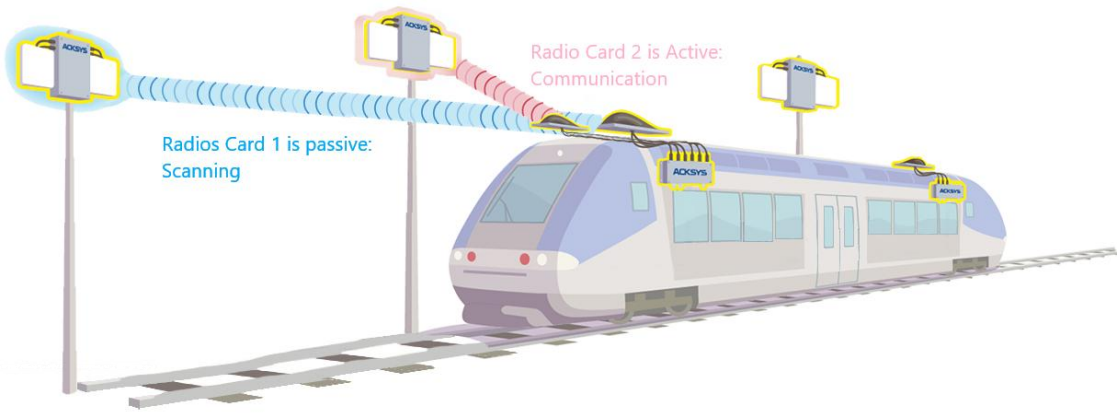
Proprietary type of roaming developed by ACKSYS:

- Requires 2 radios, one radio scans while the other one transfers data
- The 2 Wi-Fi clients alternatively transfer data and scan (switches role from 'scan' to 'data transfer').

To reach 0 packet loss, we ensure there is always 1 radio connected to the new AP, while the other card is disconnecting from the old AP.

The card transferring data is called "active radio" and is connected to the best AP. The other card is scanning and is called "passive" radio and is connected to the next best AP.

1. On the active radio, the signal level of the current AP drops below the roaming threshold, and enter in 'need roam' status
2. If the passive radio has a better signal level meeting the roaming criteria,
   - ⇨ The passive radio moves to active
   - ⇨ The active card
     - moves to passive mode
     - is still associated to the old AP
     - keeps sending and receiving packets from the ground until convergence of the network to the new AP
3. The new active card sends Gratuitous ARP (GARP) frames to converge the network
4. Then the active card leaves the current AP and starts scanning (as passive card)



5. Connect Before Break Details

5.1 Improvements

Connect Before Break (CBB) is an improved dual client proactive roaming. The 2 clients execute alternatively data communication or scan.

Those 2 clients can be either on the same radio or on 2 separate radios. In case of 2 separate radios, multi-channel roaming can be supported.

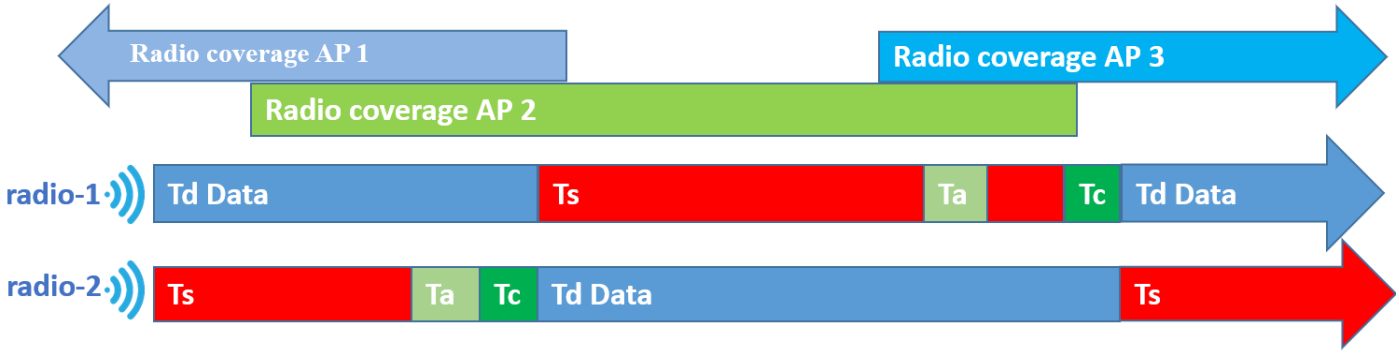
The AP change has minimal impact on data flow (and packet loss) as it is not anymore handled by the client owning the data session but by the one doing the scanning.

When thresholds are met, the scanning client stops scanning and associates to the newly elected AP. Data flow is switched between the 2 clients: scanning client becomes data handling client and data handling client starts scanning and associating to the next best AP.

This roaming type is suited for high to very high mobility use-cases.

5.2 Time Chart

Alternatively, Client 1 and Client 2 are sending data or are scanning:



Where:

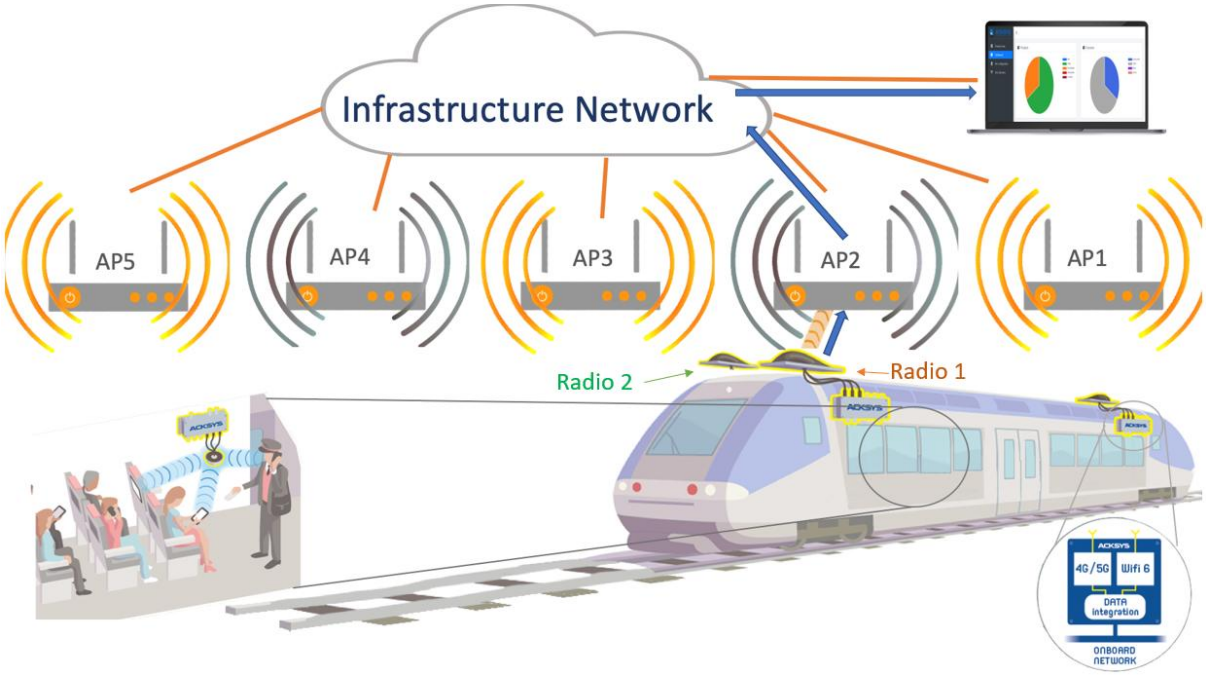
- **Td**: sending data period
- **Ts**: scanning period
- **Ta**: association period (depends on security algorithms used)
- **Tc**: convergence time (depends on ground network)
- **Th**: handover duration = **Tc**

Roaming (and convergence) is triggered by the gratuitous ARP sent from the device to the new AP (and underlying switch).
In case of CBB, association and roaming (convergence) are not following each other, unlike in previous roaming types. This allows to remove Ta time from Th, and is the improvement brought by the Connect Before Break solution.

5.3 Connect Before Break Process

5.3.1 Initial state

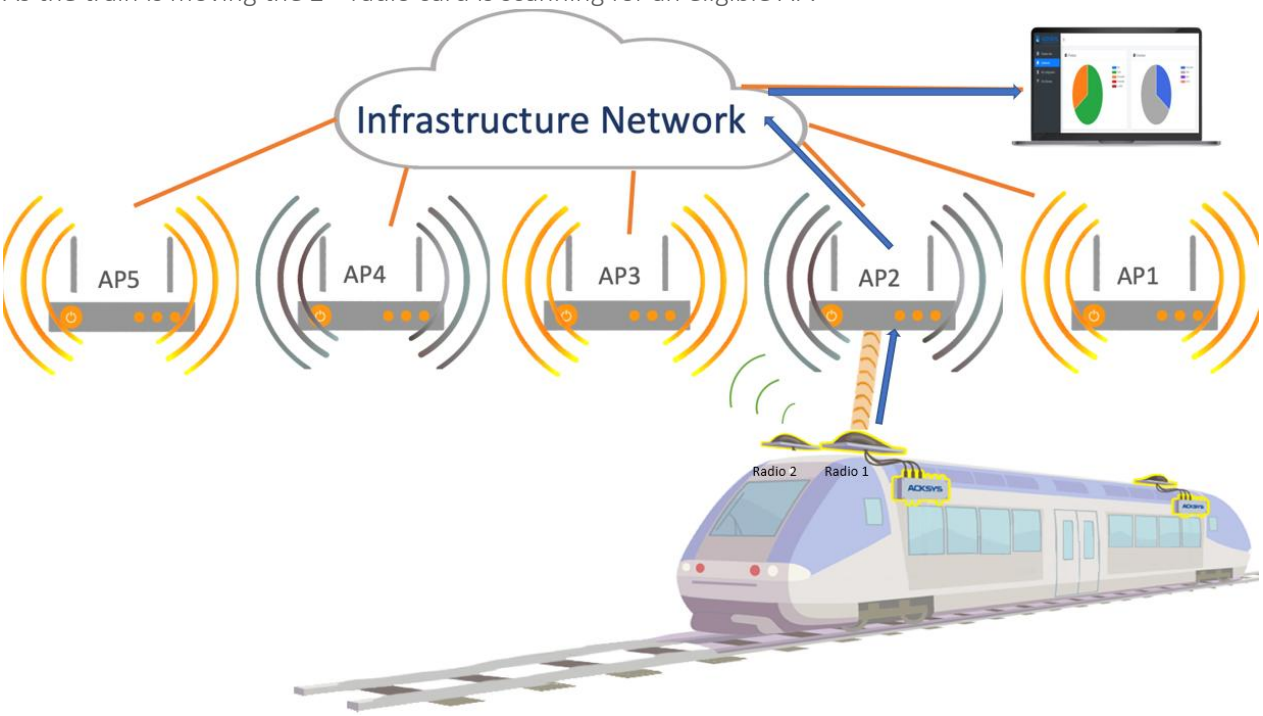
All the data are sent by the first radio card.



Represents data flow

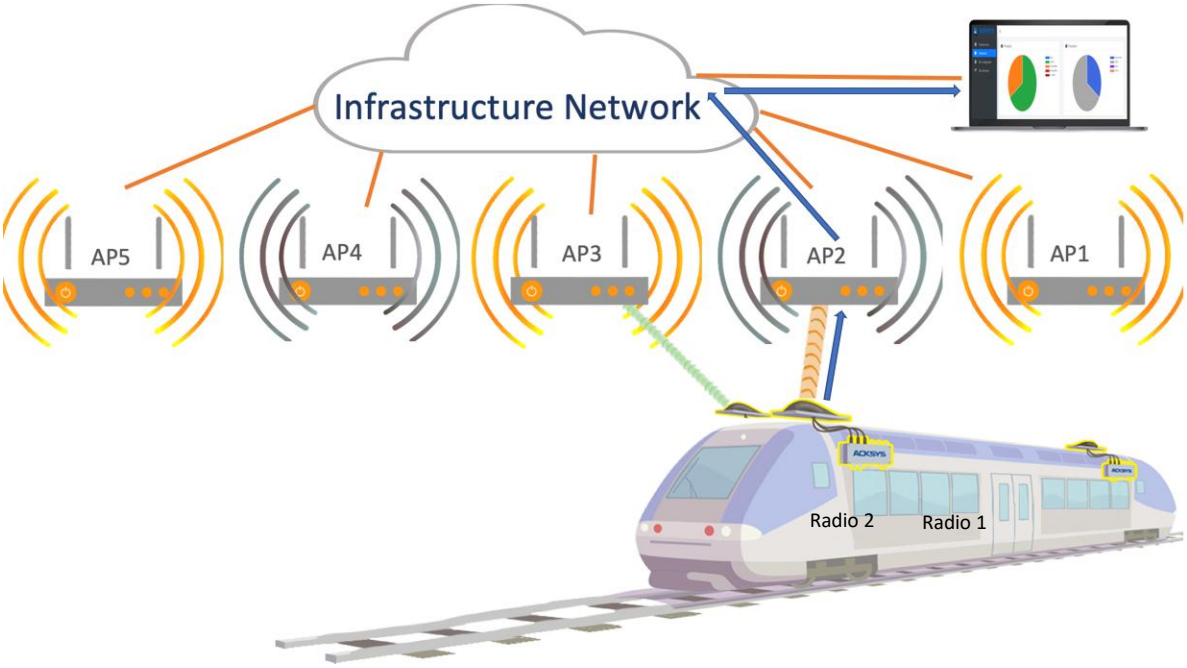
5.3.2 Scanning

As the train is moving the 2nd radio card is scanning for an eligible AP.



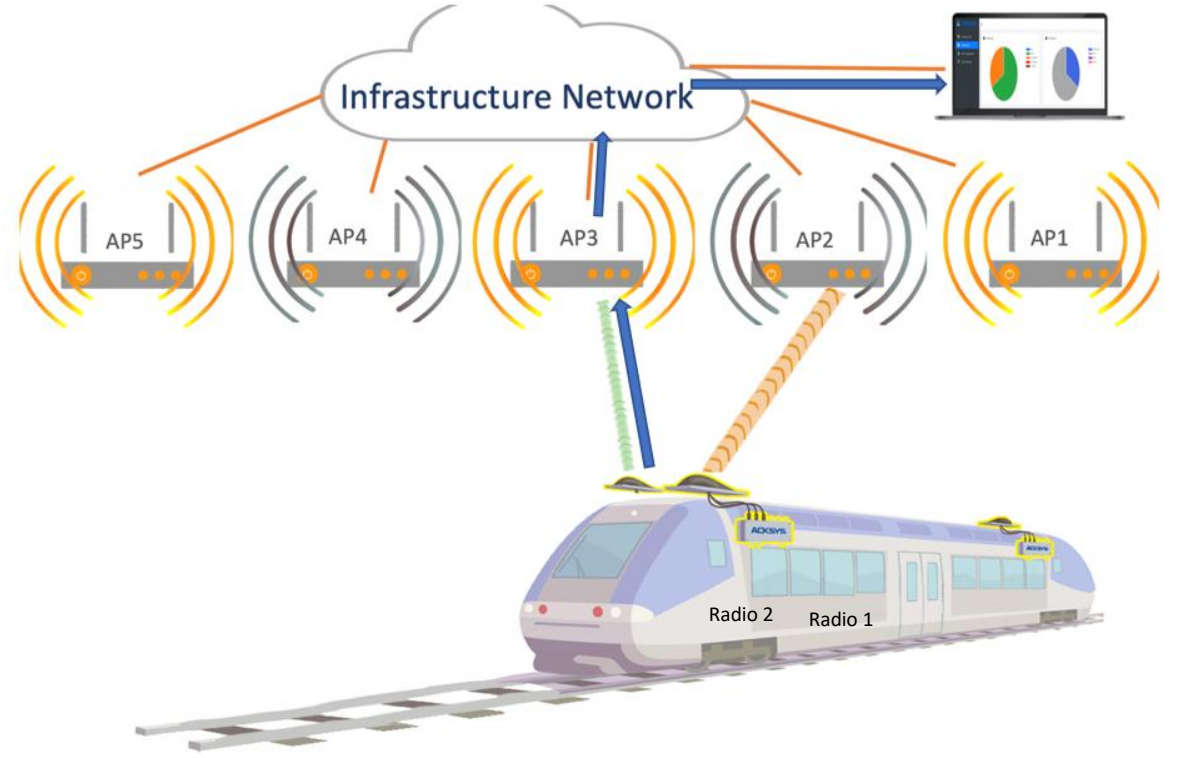
5.3.3 Association of client 2

The 2nd radio card associates to the next available AP. Scanning on radio 2 results in election of AP3, and association to AP3.
Data flow on radio 1 is not interrupted.

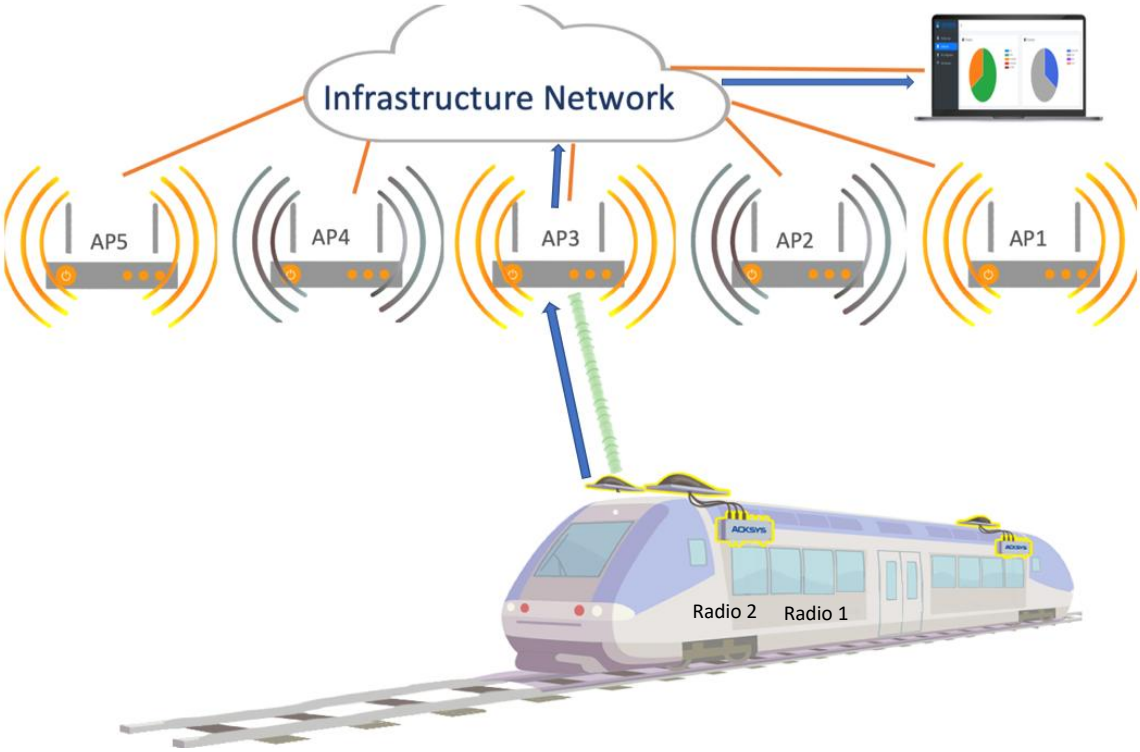


5.3.4 Switch between radio cards

Data are sent via the radio 2.

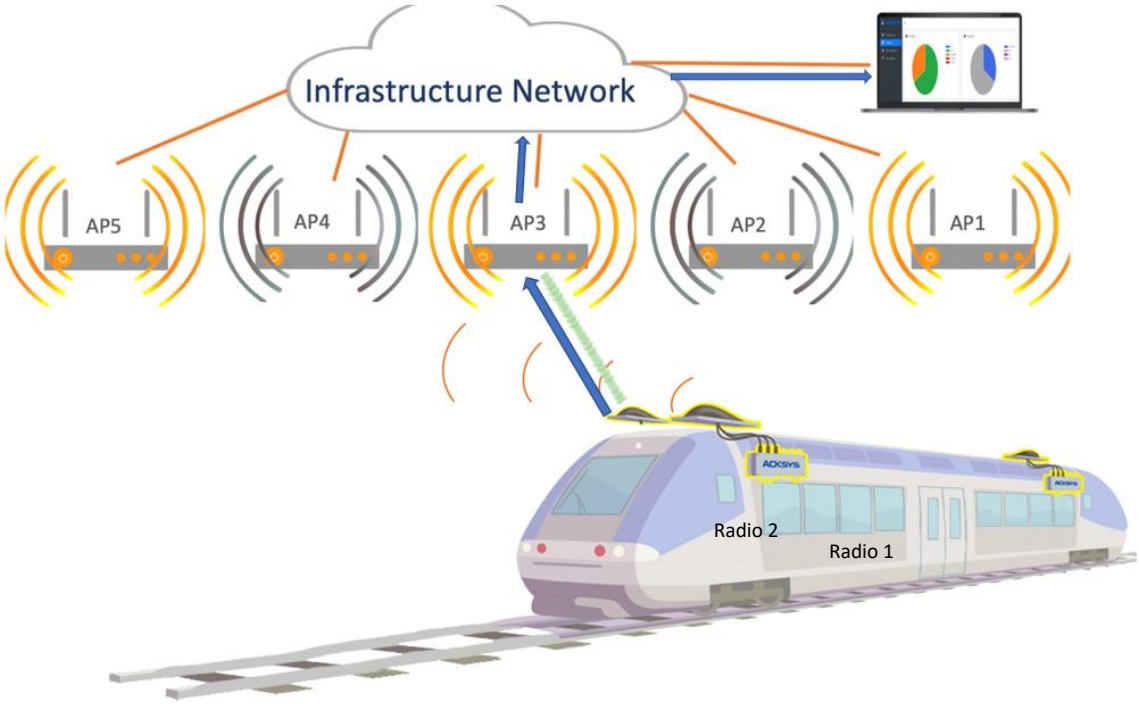


5.3.5 Network convergence



Convergence is terminated. Gratuitous ARP are sent to infrastructure network to update the MAC tables.

5.3.6 Final state



Scanning is done now by Radio 1 with no impact on radio 2 data flow.

6. Roaming basic parameters

Scan parameters:

- List of channels to scan,
- Time between two scans (parameter C),
- Level of current AP above which no scanning needed.

Conditions to select the candidate AP:

- Minimum: minimum signal level to analyze candidate,
- Boost: signal improvement to be brought by candidate AP.

Conditions to leave current AP for candidate AP:

- Leave threshold: signal below which current AP will be left.

7. Roaming advanced parameters

Stability parameter:

- Hysteresis: threshold measurement tolerance.

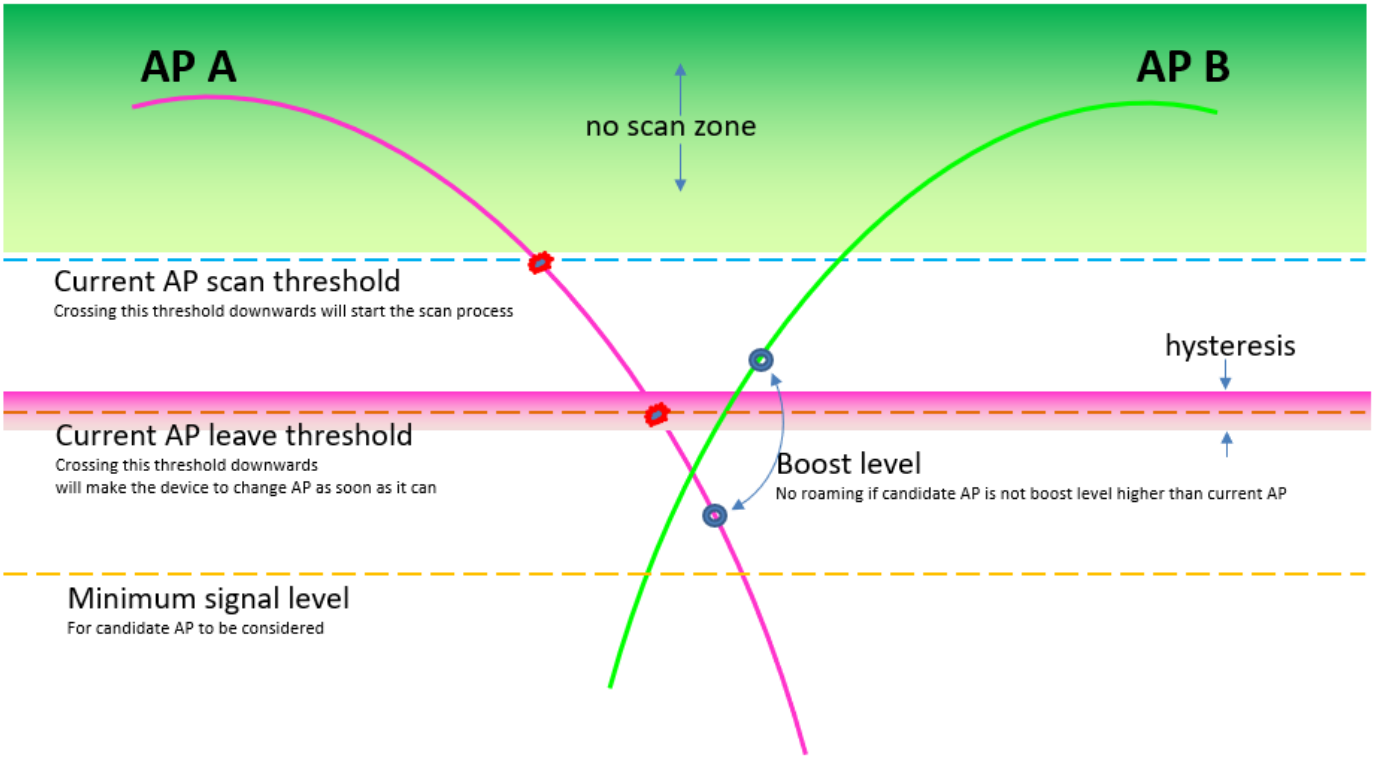
Candidate AP parameters:

- Maximum: maximum signal level to analyze candidate AP,
- No-return delay: minimum delay before returning to an already used AP.

Conditions to leave current AP for the candidate AP:

- Minimum delay between two roamings,
- Signal thresholds,
- RSSI smoothing factor (weighing importance of latest beacons vs older ones),
- Number of lost beacons.

Roaming sequence:



⇨ **Performances achieved:**

- Packet loss magnitude order: < 0,1% at 350km/h
- not dependent of speed
- not dependent of throughput

8. Wi-Fi Client settings

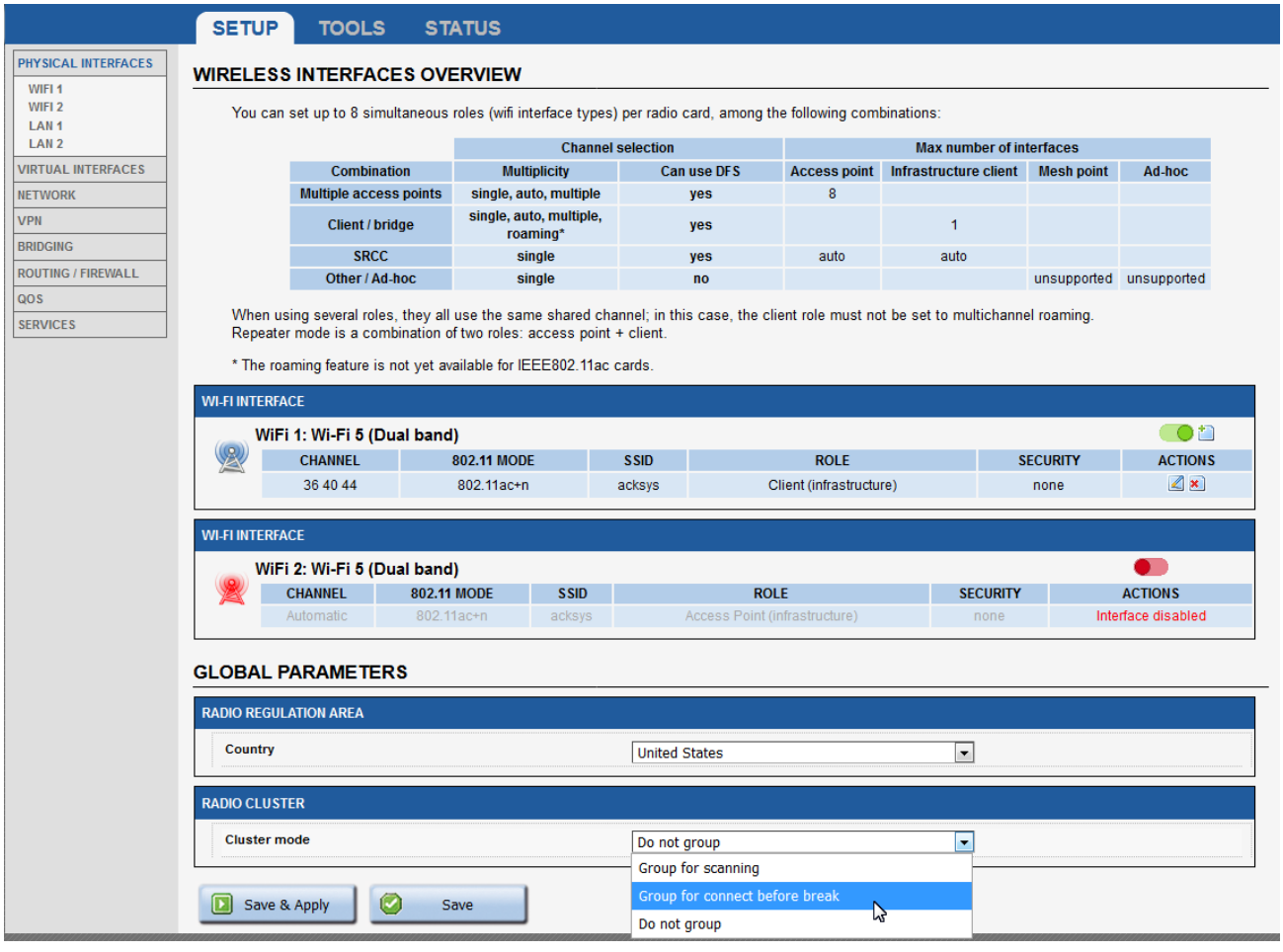
For this example, we will use the following parameters:

- Bridge client mode (no routing)
- 802.11ac using channels 36, 40 & 44
- SSID: AcksysRBB
- No security
- Roaming delay between scans = 2 seconds
- Roaming leave threshold = -75 dB
- Interface Wi-Fi 1 used for data

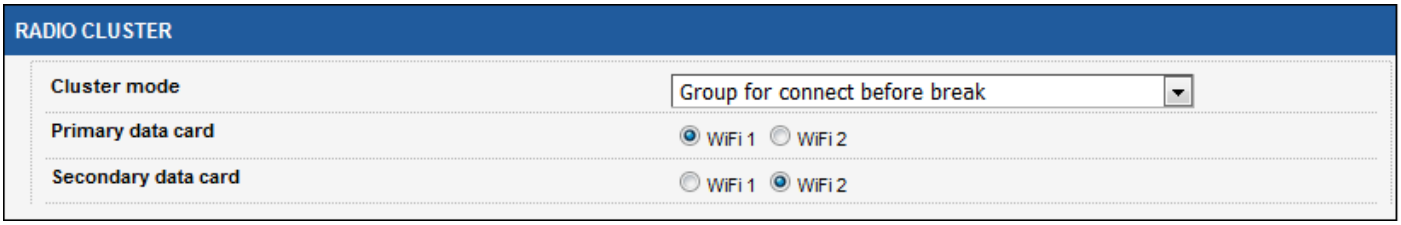
NOTE: Please note that when the Wi-Fi client is in bridge mode, the **Connect Before Break** can be used only with Acksys WaveOS products as Access points. To use Access Points from other brands, your client must be configured as a NAT router.

9. Connect Before Break configuration

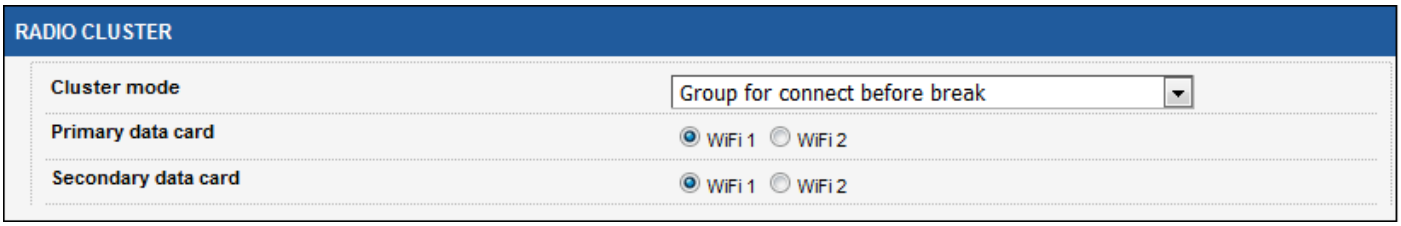
In SETUP/PHYSICAL INTERFACES, set the RADIO CLUSTER to *Group for connect before break* and press Save



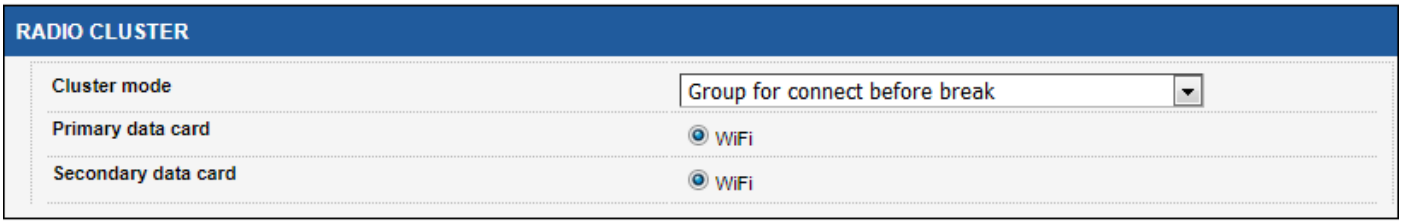
The choice of the initial primary interface has, in most cases, no effect on the operation since it's a temporary state. The WiFi 1 interface is selected by default as the primary card. This is the configuration we will use for this example.



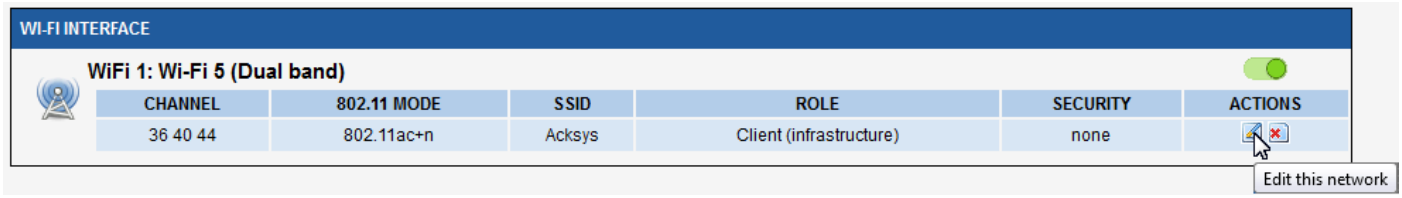
For your information, please note that you can also choose to use only one radio card for both functions. In the following example, the Connect before break client is defined only on WiFi1, and WiFi2 can be used for another purpose. Beware: this implies that you can use only one radio channel!



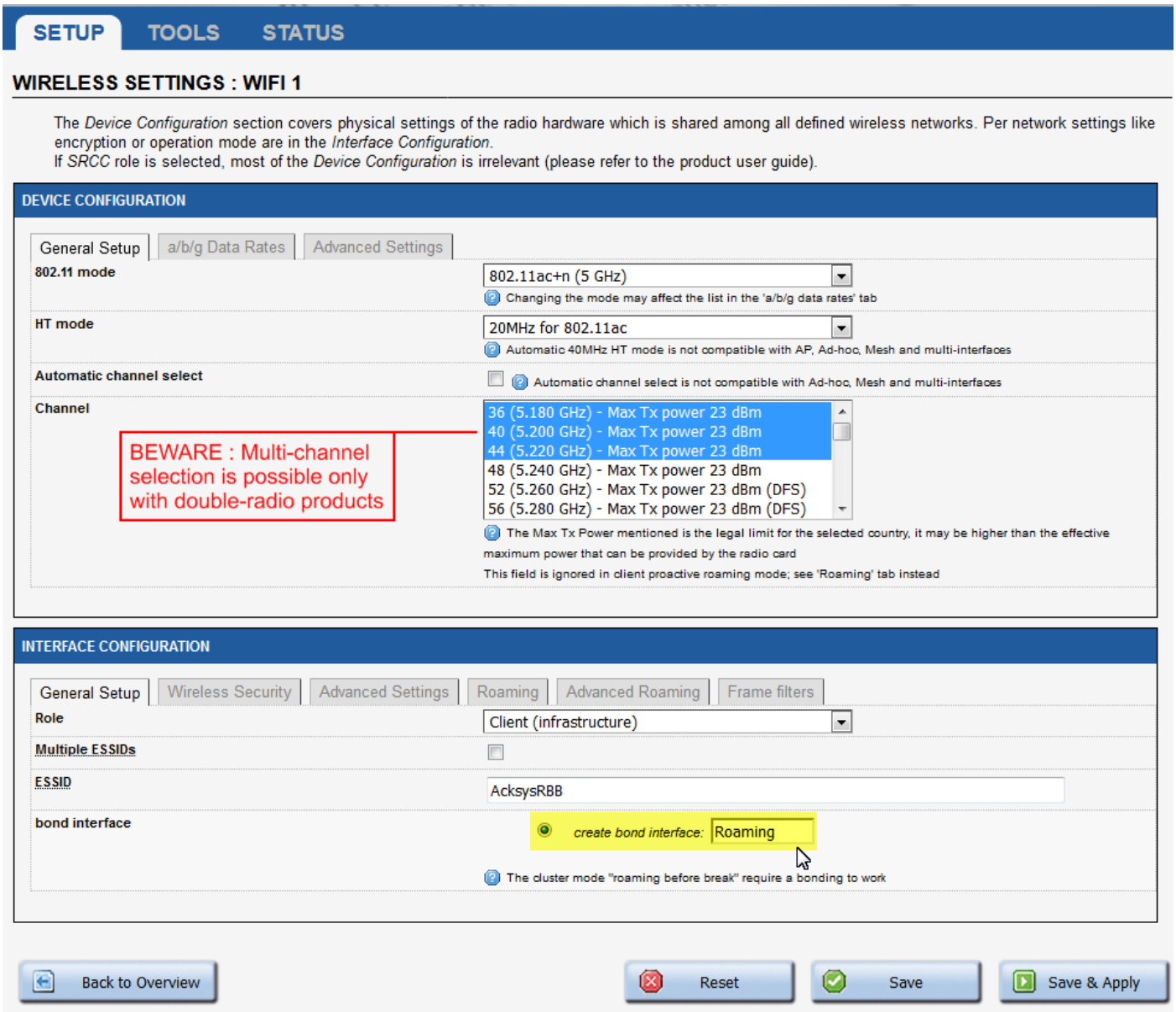
If your product only has one radio card, of course you have no choice: both functions, scanning and data exchange, are handled by the same radio interface, and you can scan only one channel



After saving this page, edit the Wi-Fi interface

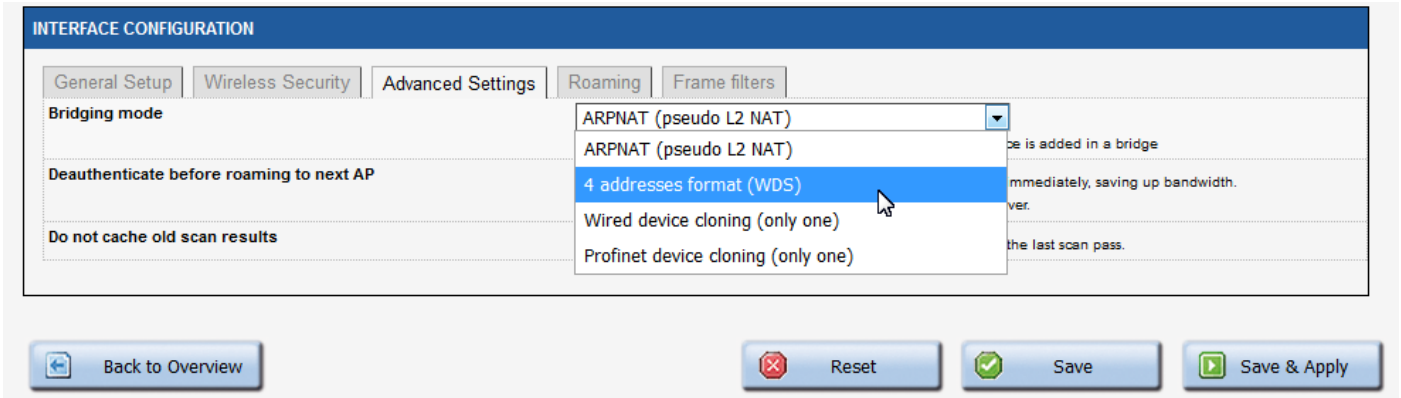


Give a name to the *bond interface* (here we choose *Roaming*), and change the Wi-Fi settings according to your needs.

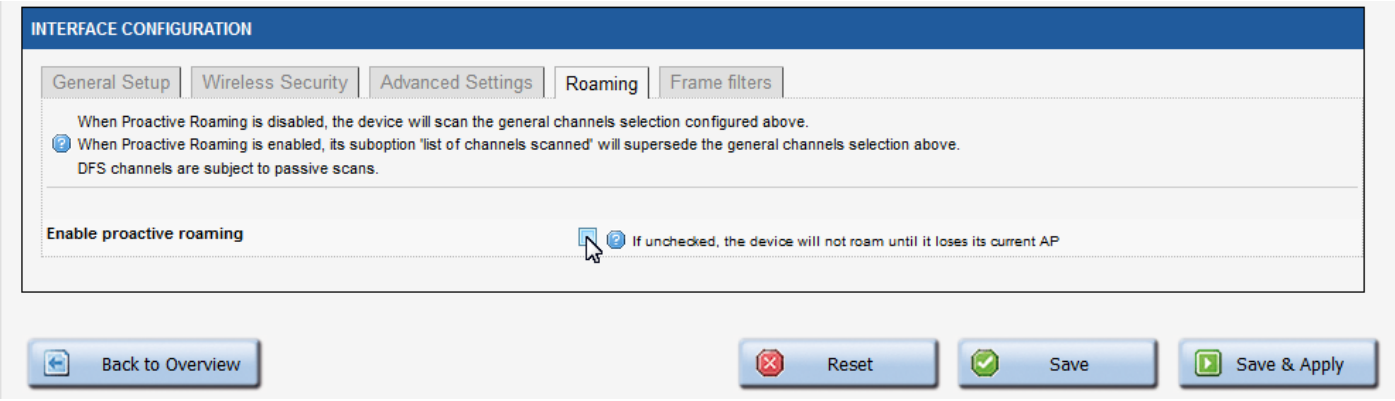


9.1 CBB in Bridged Mode

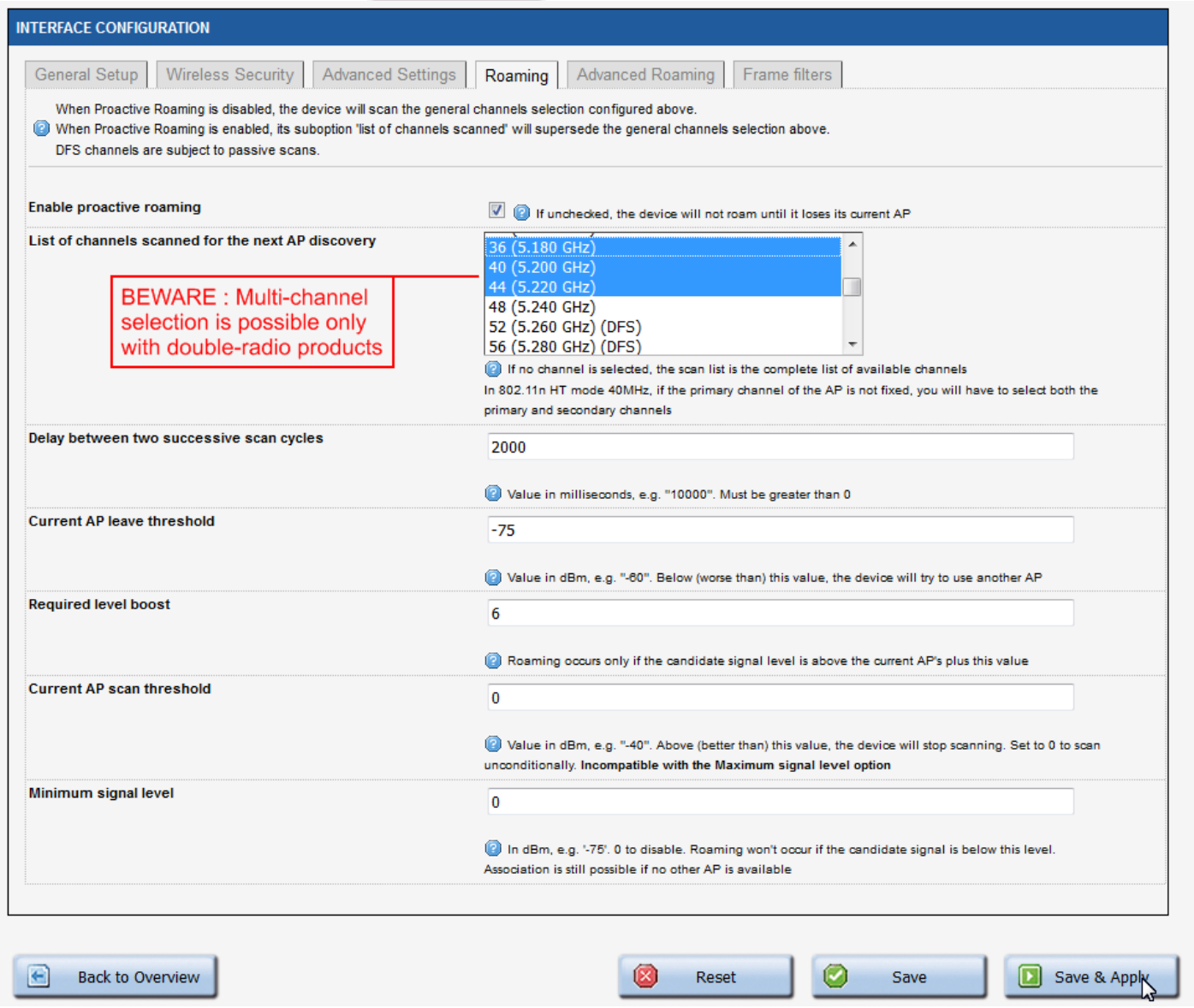
In the advanced settings, select *4 addresses format (WDS)*. Caution: this implies the exclusive use of WaveOS Acksys access points.



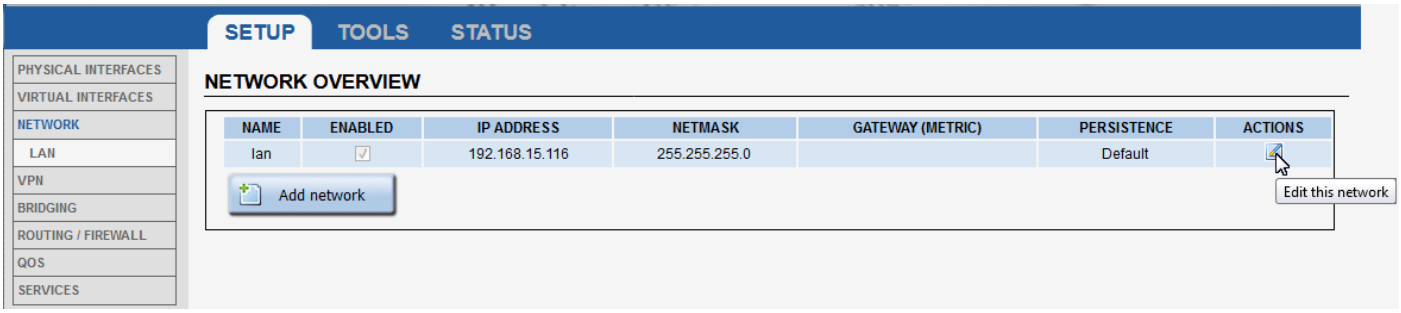
In the Roaming tab, select *Enable proactive roaming*



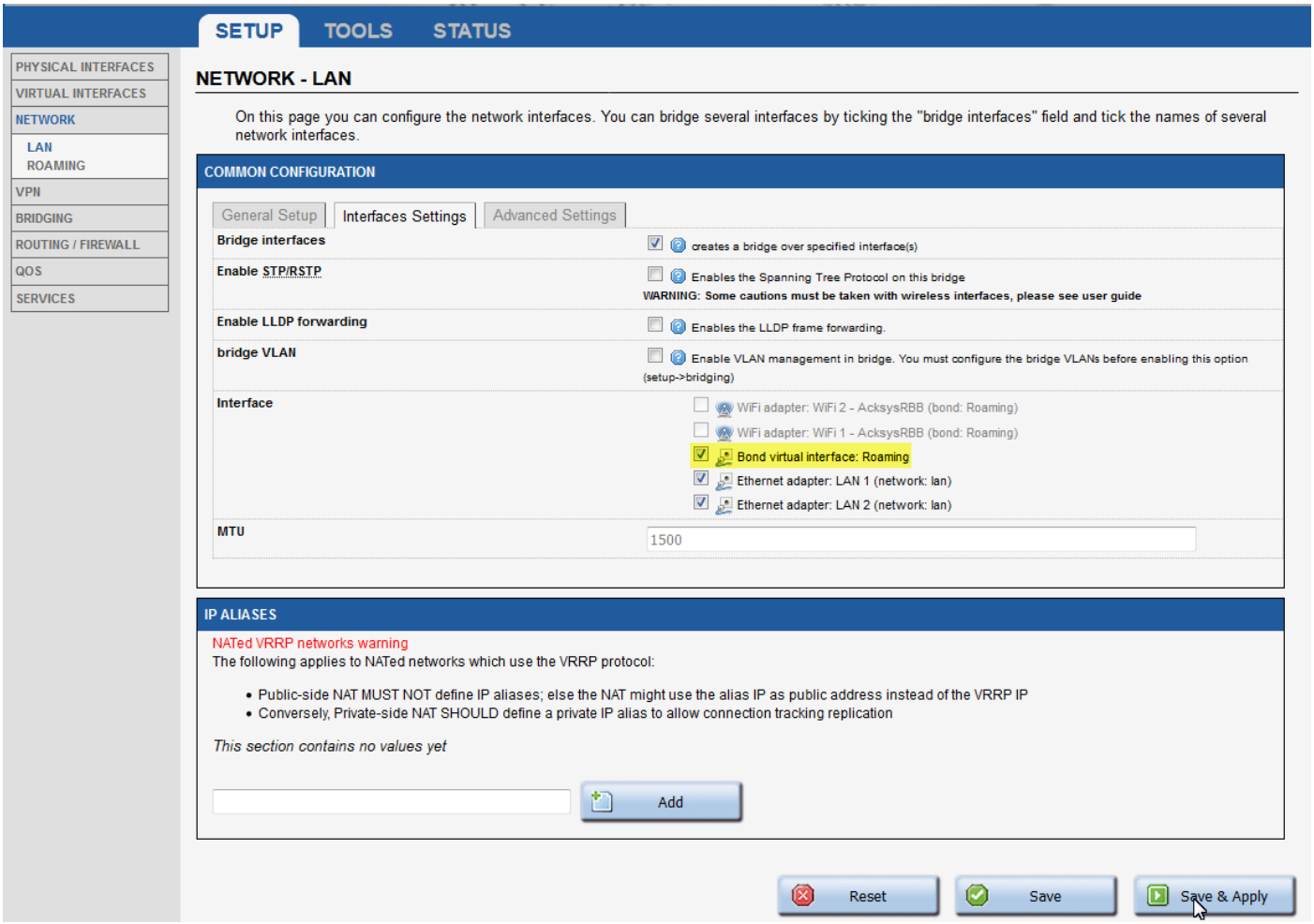
Set your roaming parameters, then Save & Apply



Edit your main Network (default name is *LAN*)



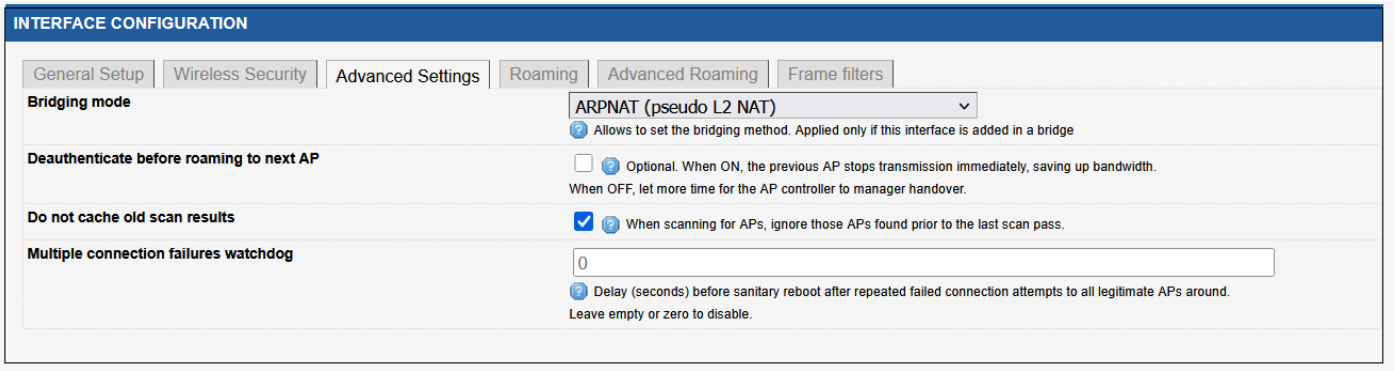
Include the *Roaming* bond interface into the bridge, then 



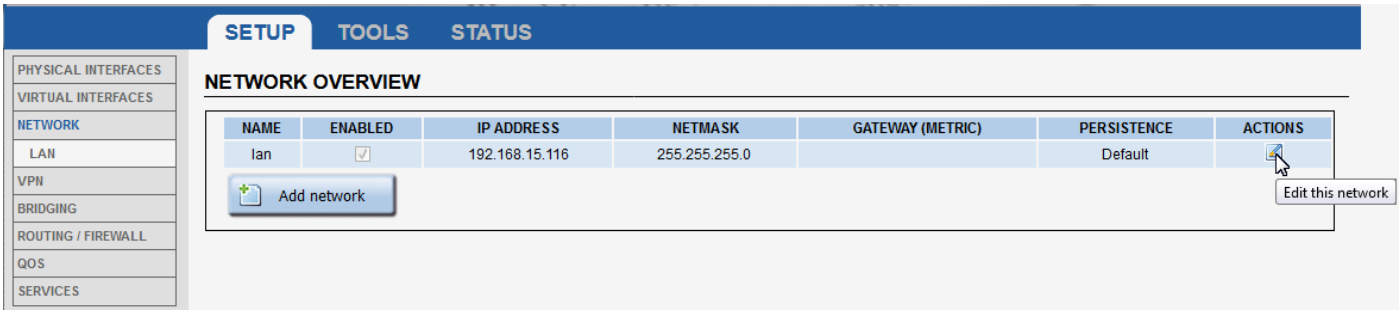
9.2 CBB in Router Mode

In router mode, we will configure two distinct network zones, one dedicated to the LAN interface and another for the WiFi interface.

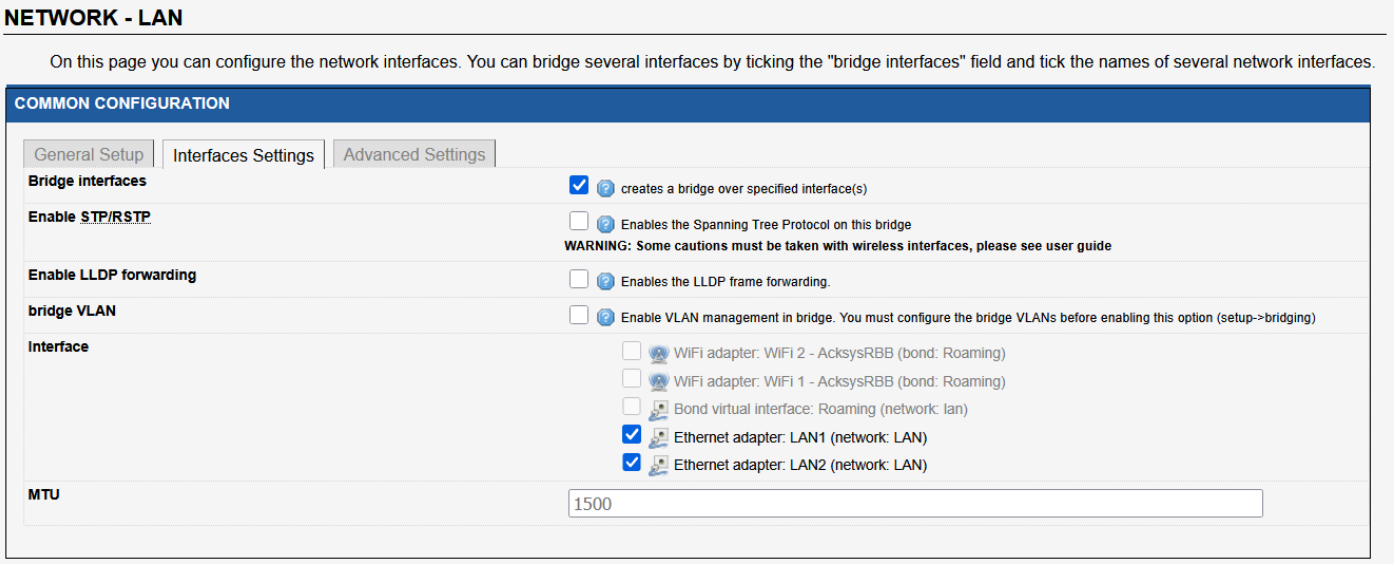
In the advanced settings, select *4 addresses format (WDS) in case of AP are ACKSYS or ArpNat for any other AP Vendor*.



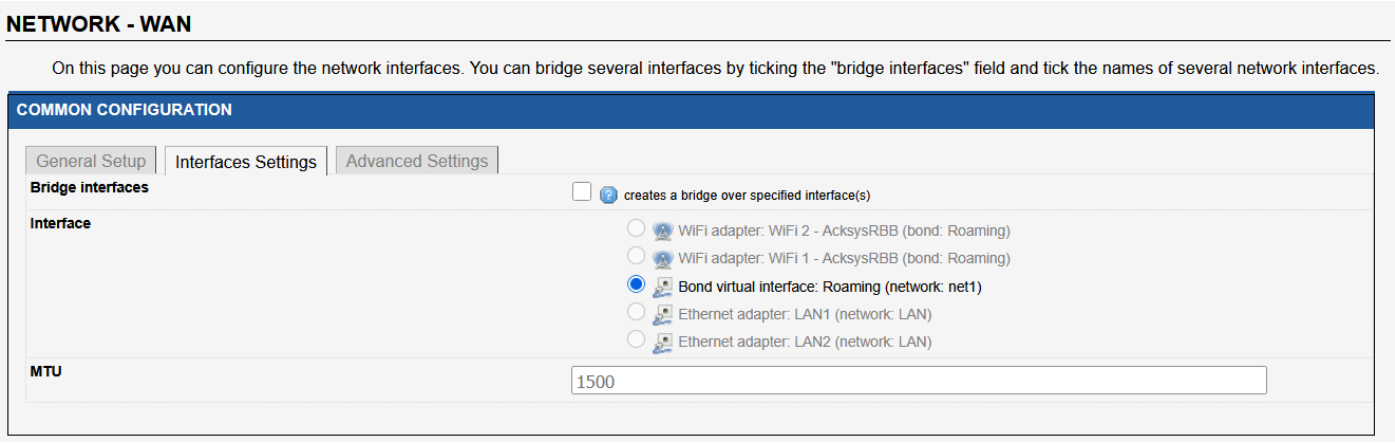
Edit your main Network (default name is *LAN*)



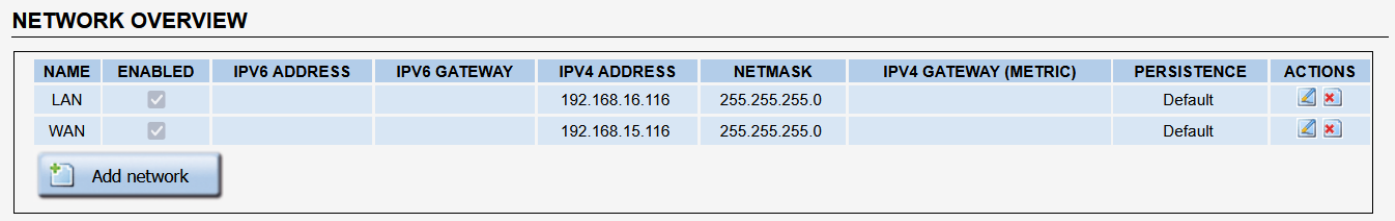
Exclude the *Roaming* bond interface into the bridge, then save



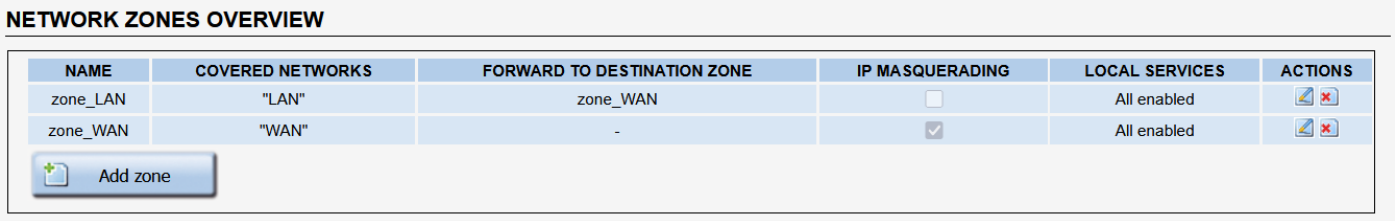
We will create another Network, WAN and associate its to the Bond Interface not in the Bridge



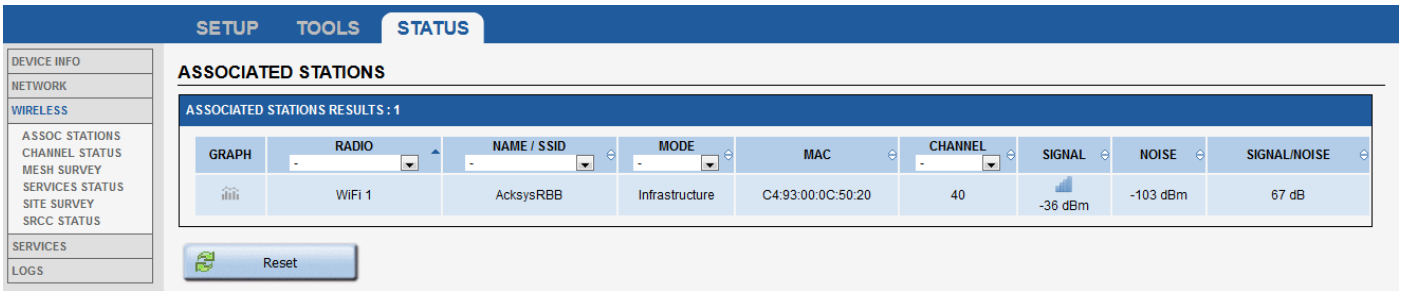
2 Network OverView



2 Network Zones OverView



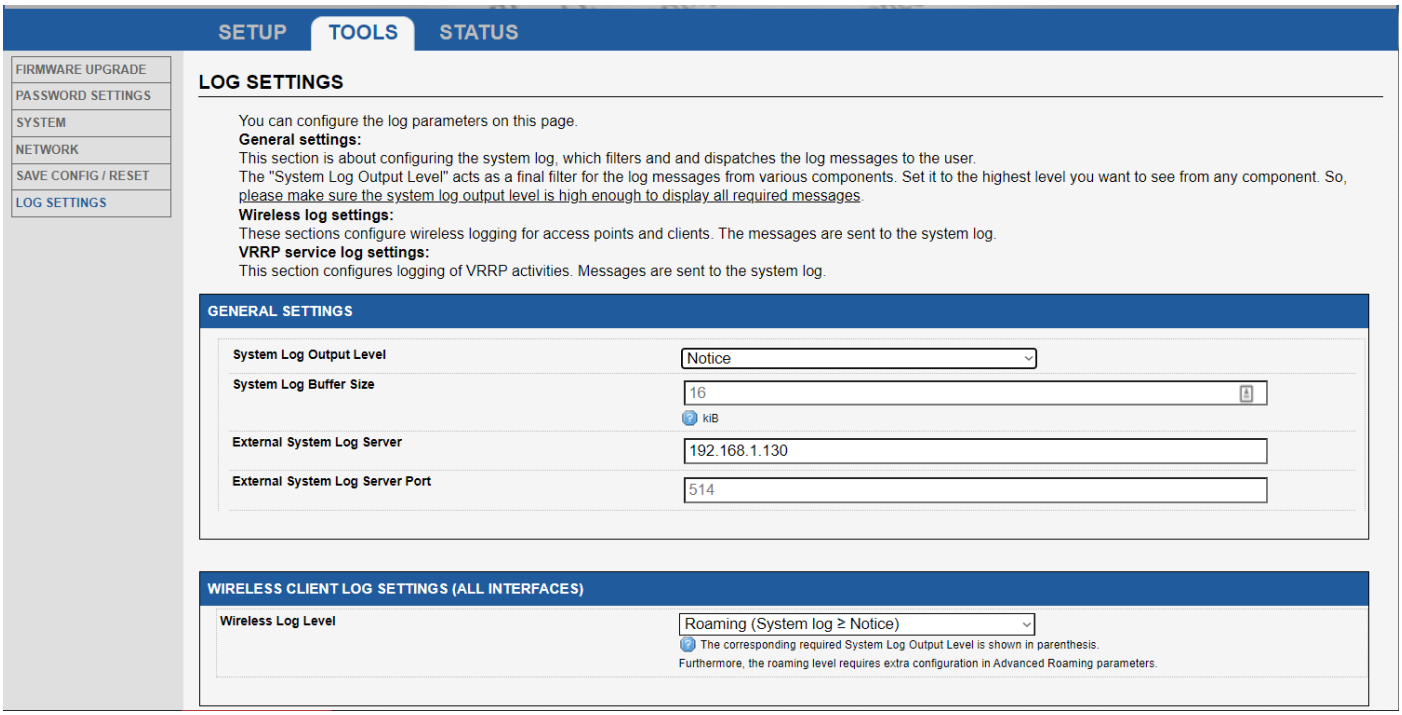
Your product is now ready for a fast and efficient roaming, without loss of packets during the handover



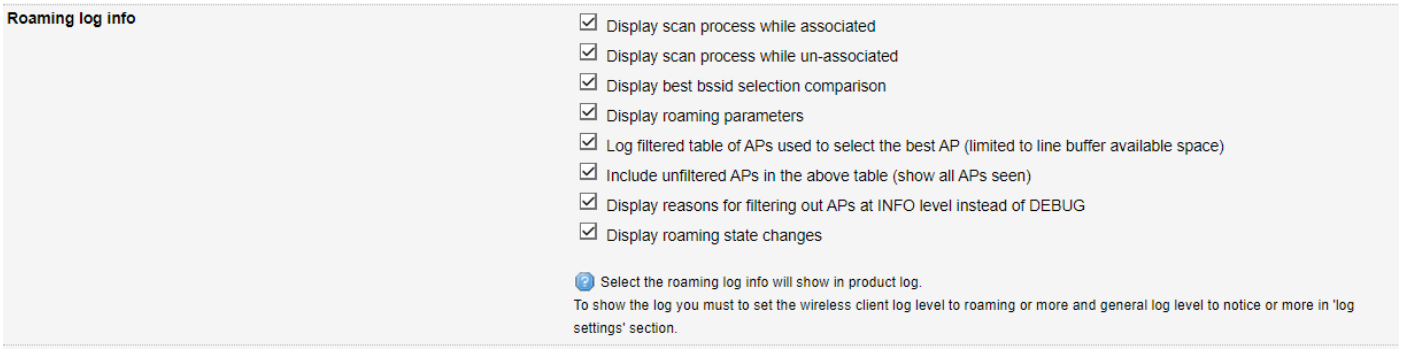
10. Logs

Specific logs are raised during the roaming process.

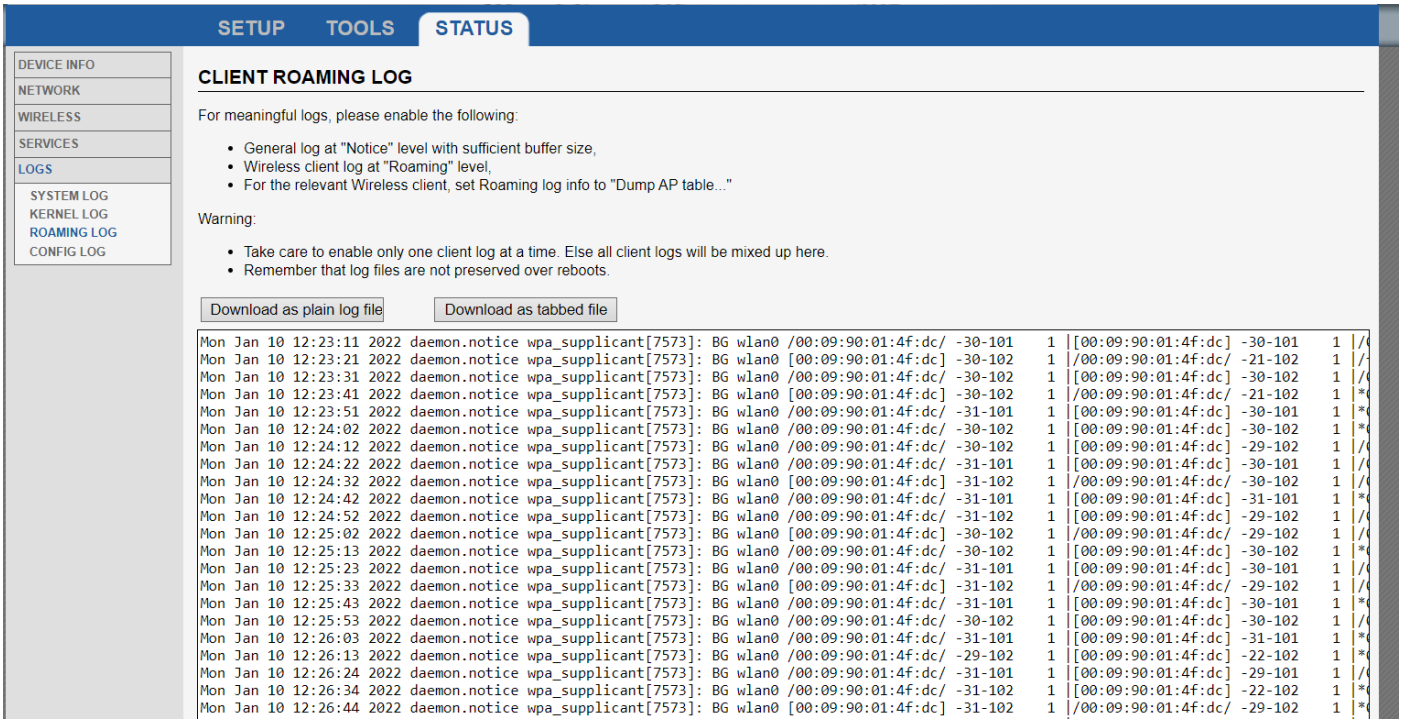
First enable these logs in TOOLS / LOGS SETTINGS, and in WIRELESS CLIENT LOG SETTINGS, select Roaming level:



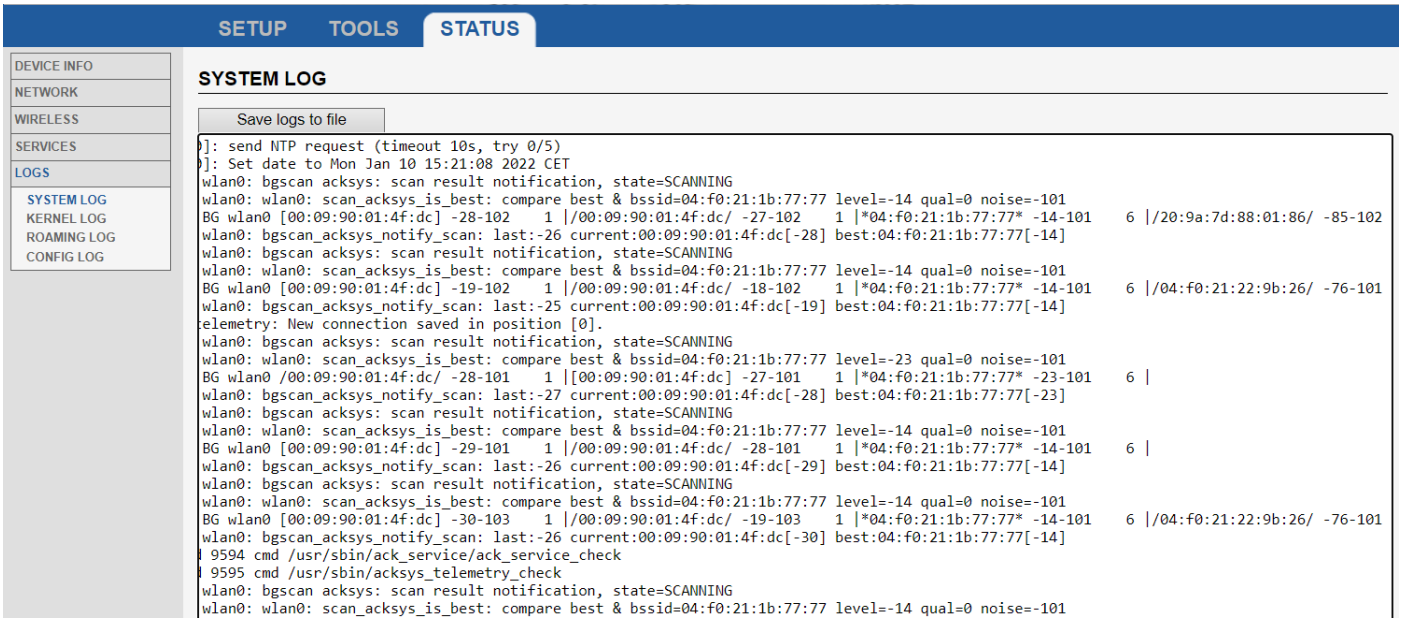
Then in SETUP / PHYSICAL INTERFACE / WIFI / Advanced Roaming, select which information you want to log:



When a wireless client transitions (roams) from one access point (AP) to another within the same network, the system automatically records this event in the roaming logs. Each roaming instance generates corresponding log entries that capture relevant details such as the timestamp, source and destination APs, client MAC address, and signal strength metrics.



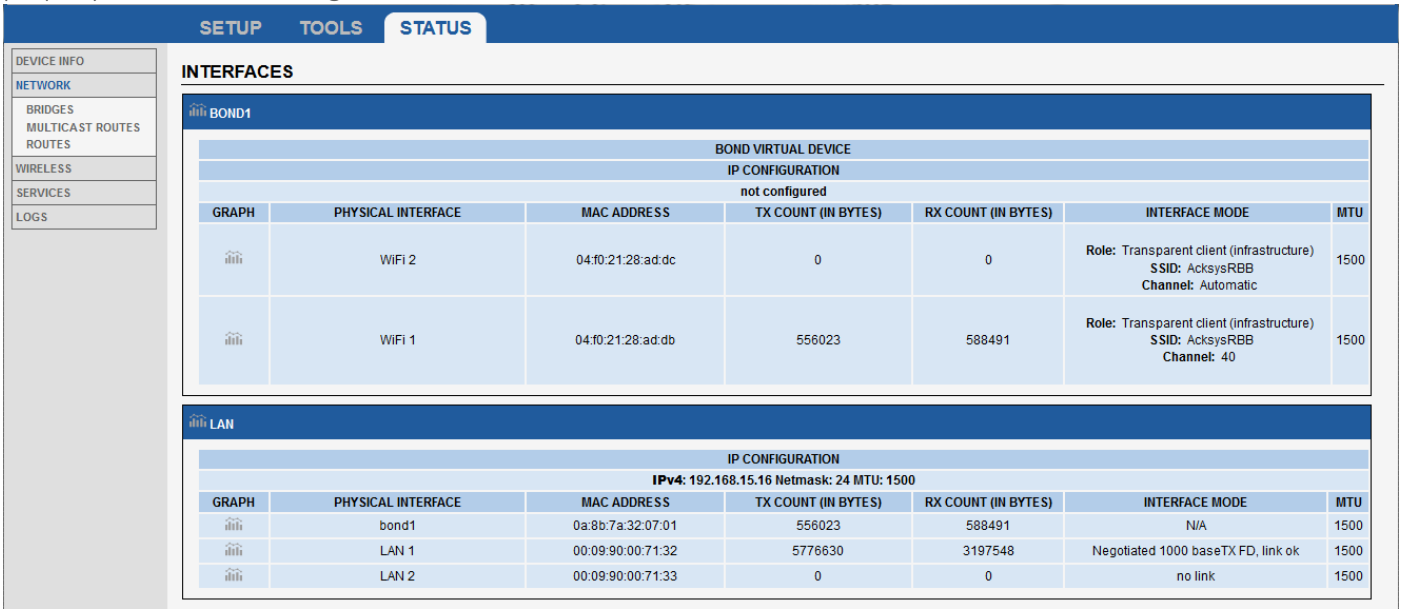
These logs are useful for monitoring client mobility, troubleshooting connectivity issues, and optimizing wireless coverage in System Logs:



11. CBB Connectivity Troubleshooting

Verify Interface Status

In the event of a malfunction, begin by checking the *STATUS / Network* page to ensure that all network interfaces are properly mounted and recognized.



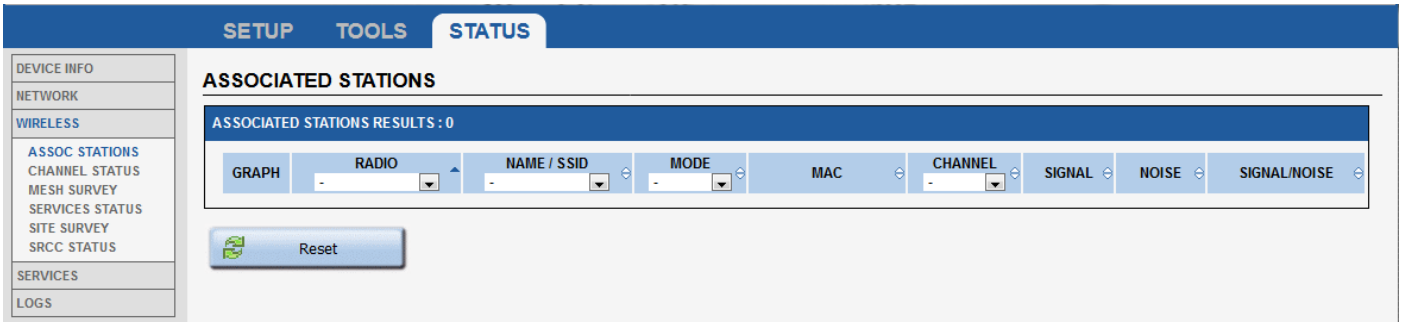
Analyze Wireless Activity

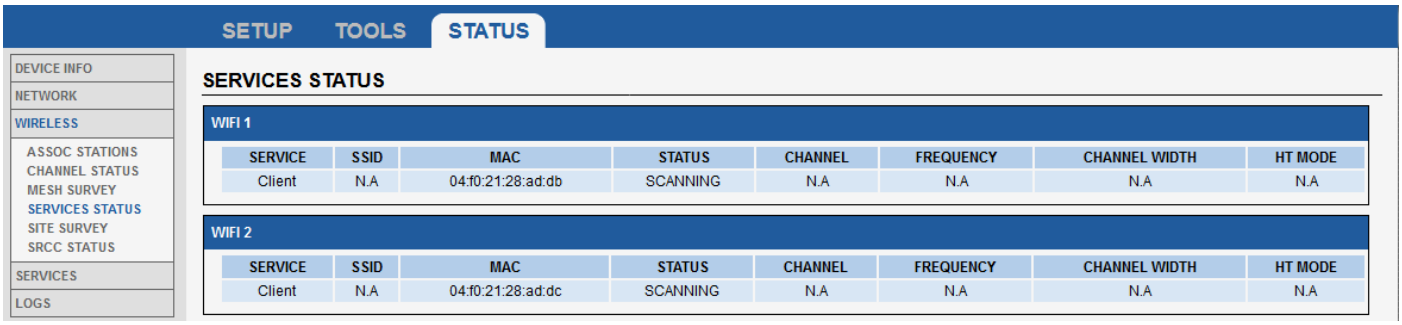
In the event of a malfunction, begin by checking the *STATUS / Network* page to ensure that all network interfaces are properly mounted and recognized.

The STATUS / WIRELESS / ASSOCIATED STATIONS and the STATUS / WIRELESS / SERVICES STATUS pages provide valuable insights, particularly an instant overview of the radio interfaces' status, allowing you to determine which interface is active and which is passive.

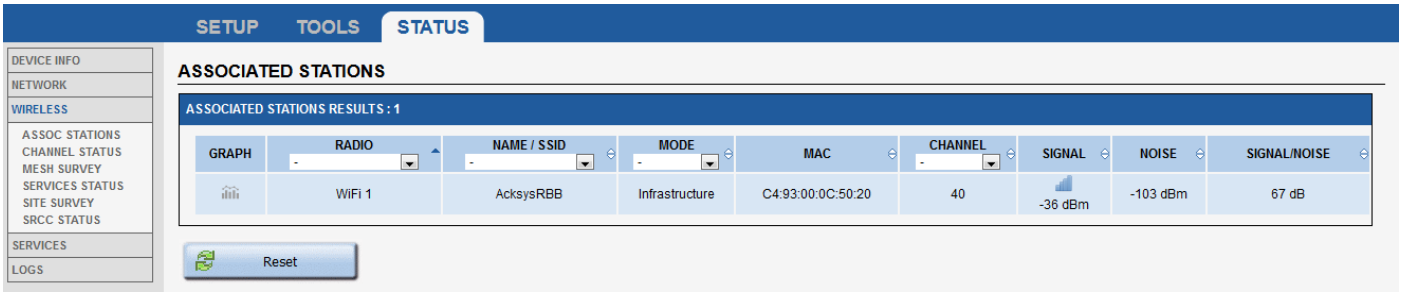
For example:

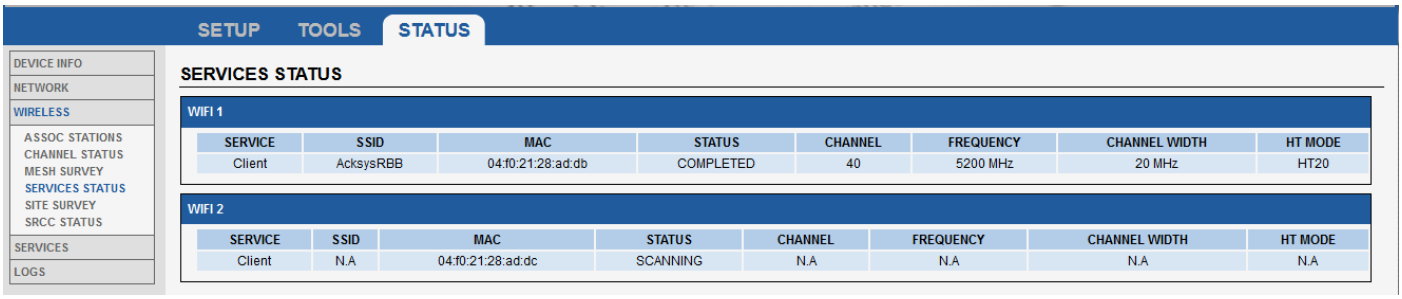
- If **no station is associated** and both radio interfaces are in **scanning** mode, it indicates that the client has not yet discovered any access point. In such cases, we recommend performing a **site survey** to verify the presence of access points configured with the expected parameters (SSID, radio channel, security mode, etc.).



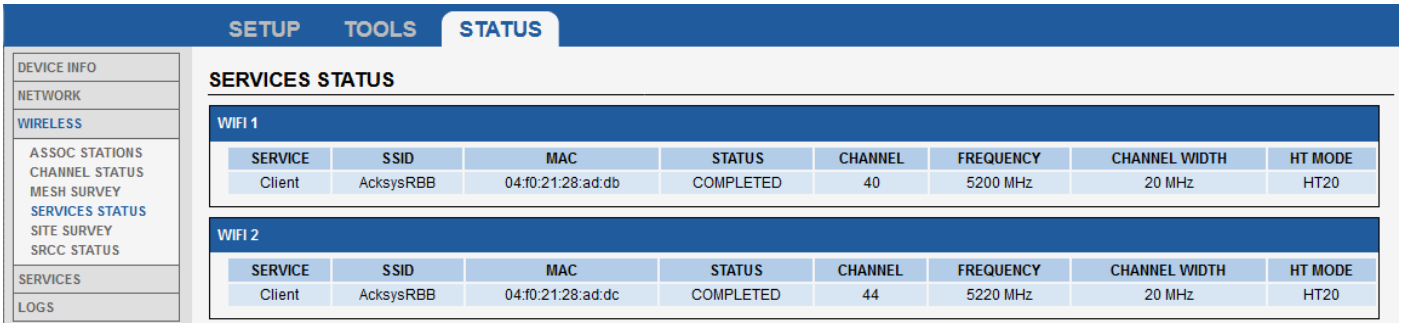


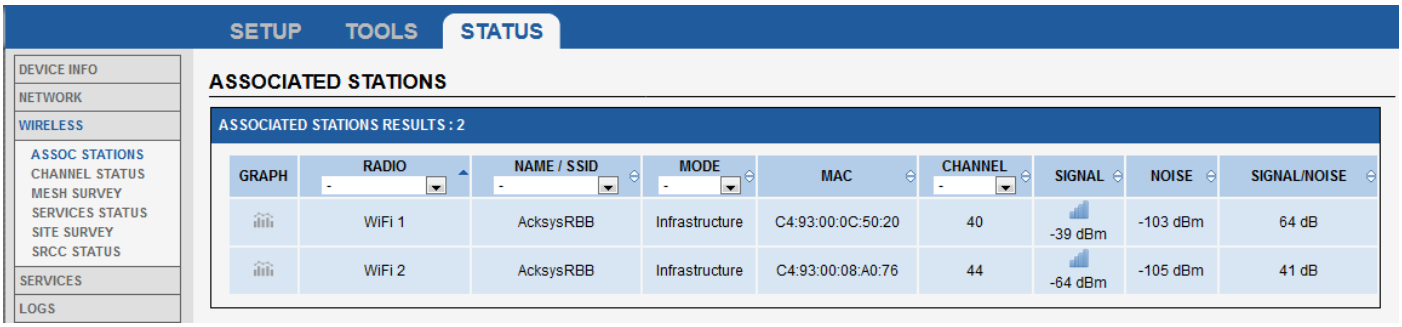
- If **WiFi1 is connected** while **WiFi2 is still scanning**, it means the first interface has established a connection, while the second is still searching for a secondary access point.





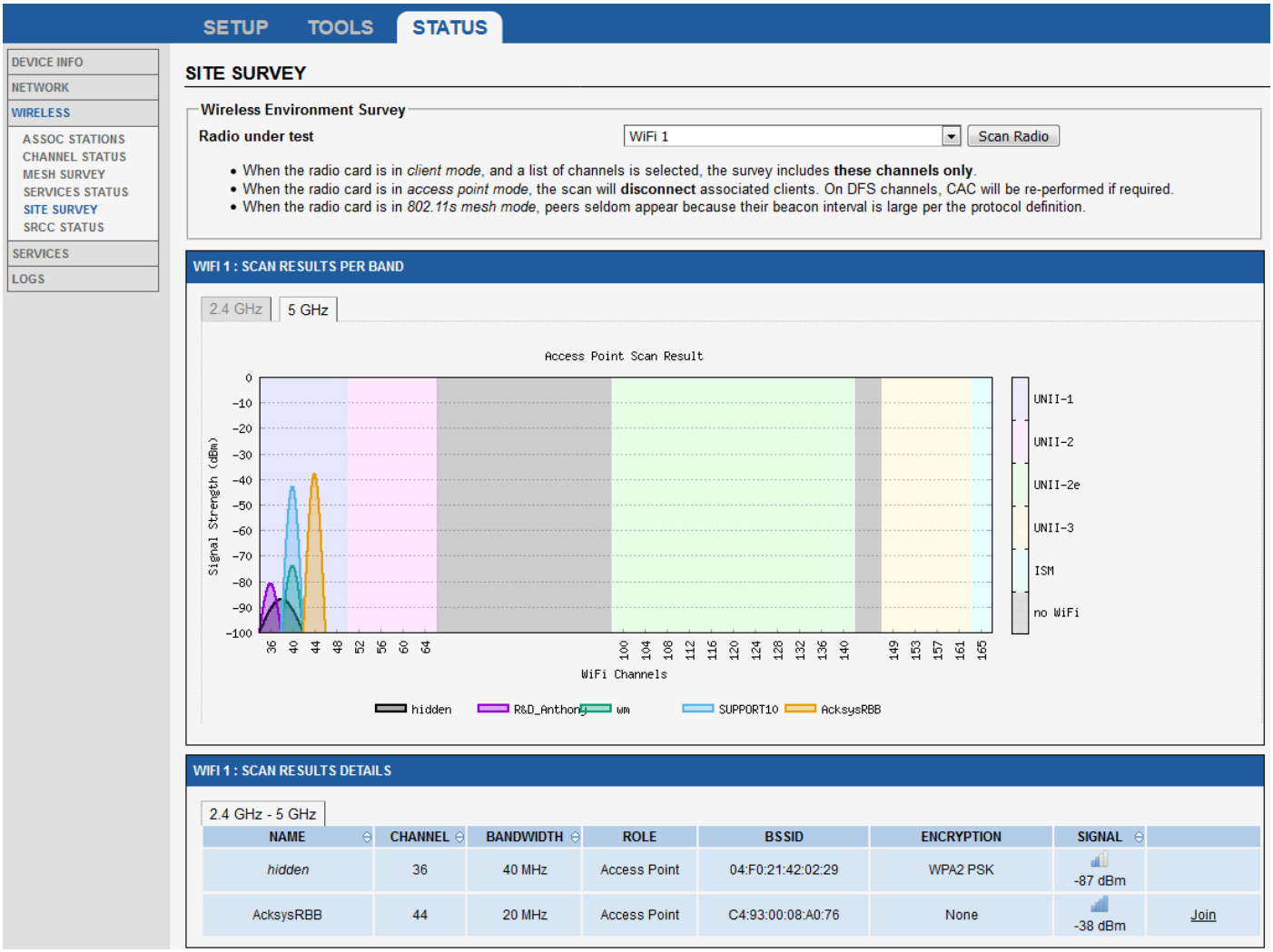
- When **WiFi2 successfully connects**, both interfaces are associated, ensuring optimal redundancy or load balancing.





Run a Site Survey

If the product fails to detect any access point, you can initiate a **site survey** to identify which APs are visible to the device. If no Access Points are detected, this may indicate an issue with the **antennas** or the **radio module**. If access points are detected, verify that the **SSID**, **frequency**, and **security settings** are correctly aligned with the client's configuration:



Additional recommendations

For better WIFI connectivity troubleshooting, please :

- Ensure APs are broadcasting the correct SSID.
- Check signal strength and noise levels using a spectrum analysis tool if needed.
- Make sure firmware and configuration are up to date on both the client and AP.

Support : https://support.acksys.fr