APPLICATION NOTE

APNUS035 Wireless Load Balancing for Network Performance Enhancement

December 2023

Content

1. Glossary

WLB : Wireless Load Balancing

AP: Access Point

RSSI: Received Signal Strength Indicator

BSSID: Basic Service Set Identifier

STA: Station

CUR: Channel Usage Ratio

UNI1 : Unlicensed National Information Infrastructure

2. Introduction

In dense environment, one of the most common sources of Wireless network congestion, is a bad end user distribution and repartition among the available Access Point.

This bad distribution is generally due to a difference in the wireless devices behaviour in Wi-Fi Band/AP selection and scan/roaming algorithm which is generally proper to each end-device Manufacturer, even if the 802.11 protocol try to standardize the process of attachment to the wireless network.

The ACKSYS Wireless Load Balancing (WLB) feature aims to resolve this challenge and enhance the network performance for better usage of the network resources, with:
  ➢ Load balancing
  ➢ Band steering
 ➢ Roaming control

3. Wi-Fi protocol limitation and needs

WiFi devices may support two (or three) frequency bands, typically 5 GHz and 2.4 GHz bands. Clients on 2.4 GHz band suffer from cochannel-interferences due to the 802.11b/g/n limit of three non-overlapping channels.

Moreover, most of dual band devices prefer naturally to connect on 2.4GHz channels as for a same distance the signal is stronger on 2.4 GHz channel than 5GHz. **Band steering** enables clients that are dual-band capable to move to a less congested band of an AP, typically 5 GHz.

In addition, clients may suffer from congestion on the selected AP in high load conditions due to unfair load repartition within a WLAN with more than one AP. **Load balancing** allows to control clients association to different APs in a more efficient way.

Also **Roaming Control** consists of encouraging a sticky device with a bad RSSI value at the edge of the coverage area to roam to a better AP.

Example of scenario with bad end-device repartition:

AP with best signal

All Wi-Fi clients are connected to the same AP
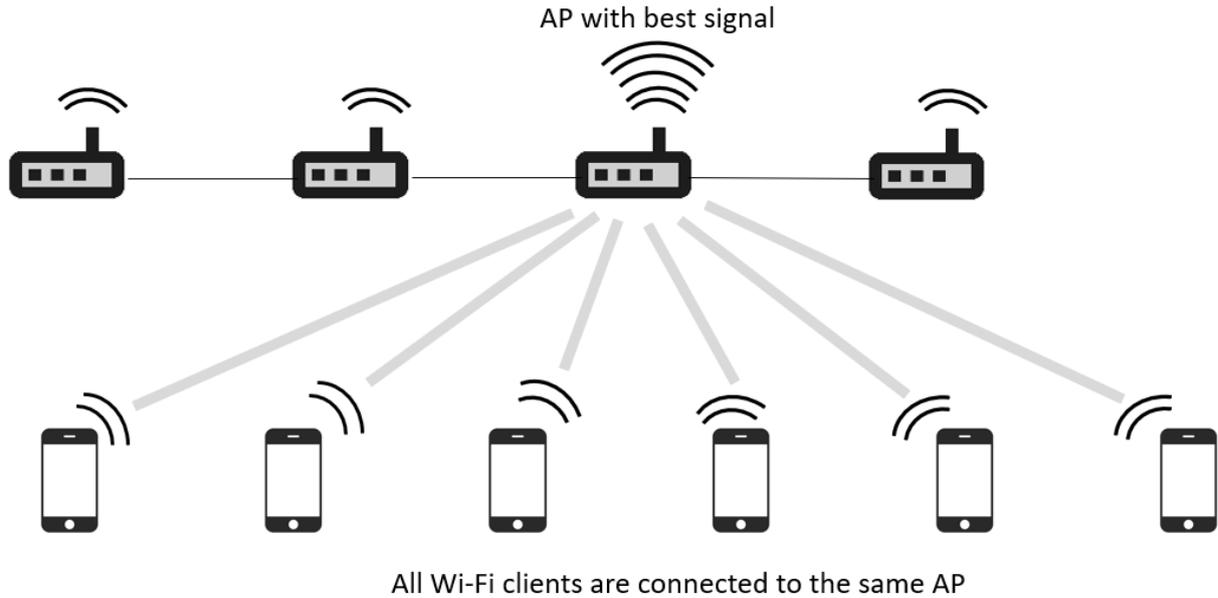
4. Load Balancing

4.1 Concept

By default a Wi-Fi client will chose the AP with the best signal. Conducing to an unbalance in the repartition among the available APs.

Load balancing allows to control WiFi clients' association in such a way that it associates clients fairly among possible APs within a Wireless LAN with more than one AP.
Each AP applies the same procedure:

- Determines whether it is the best AP candidate for this client,
- If yes:
    - o Responds to probe requests,
    - o Accepts the association request.
- If not:
    - o Does not respond to probe requests,
    - o Rejects association requests.

Load balancing aims to distribute STAs channel load among possible APs. The trivial parameter for load balancing decision is the **number of associated STAs**.

Load Balancing follows below principles:

- ❖ Each AP calculates an association score for each STA (based on the RSSI and the AP load).
- ❖ APs exchange the STAs score per AP in order to decide in a distributed schema which AP should accept the new STA.
- ❖ Each AP determines whether it is the best AP, responds to prob requests and accepts the association request if it is the case. If the AP is not the best AP, it abstains from responding to prob requests and rejects association requests **for one time**.
- ❖ At each STA prob request, the WLB daemon of the AP sends a multicast "probe announcement" message to APs belonging to the multicast group. WLB daemon implements a listening task in charge of receiving prob announcements and updating the best AP for a given STA. Prob announcements are

sent to all APs of a multicast group, containing the number of associated STAs for the AP, the AP band (2.4 or 5 GHz), and the RSSI for one STA.

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 clients to the maximum number of allowed clients per AP. Thus, each AP calculates an association score for a client, based on its CUR and its RSSI.

APs exchange via multicast traffic (via a dedicated Lan interface where all APs are connected on and can share info):

- Their number of associated clients,
- The RSSI per Station.

Then, they decide in a distributed schema which AP should accept a new client.

Example 1 - CUR Advantage:
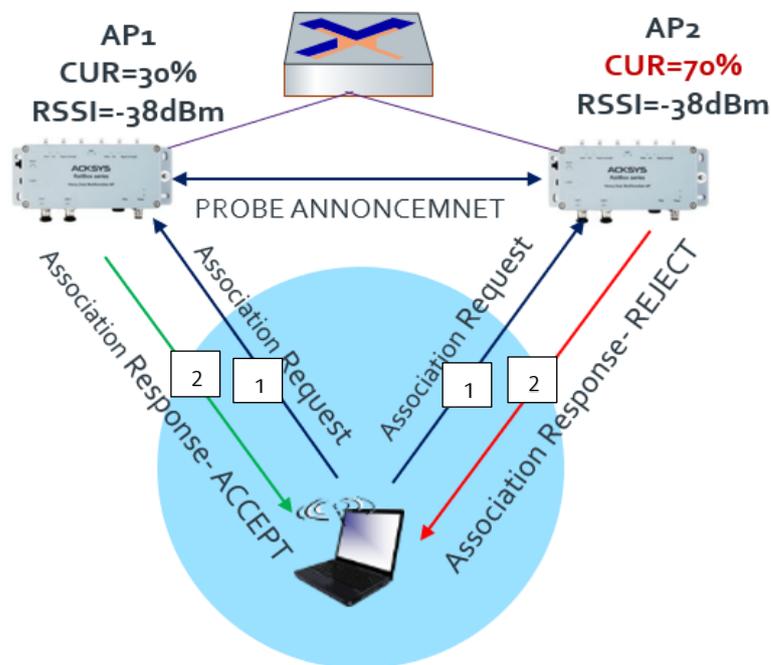
Example 2 - RSSI Advantage:
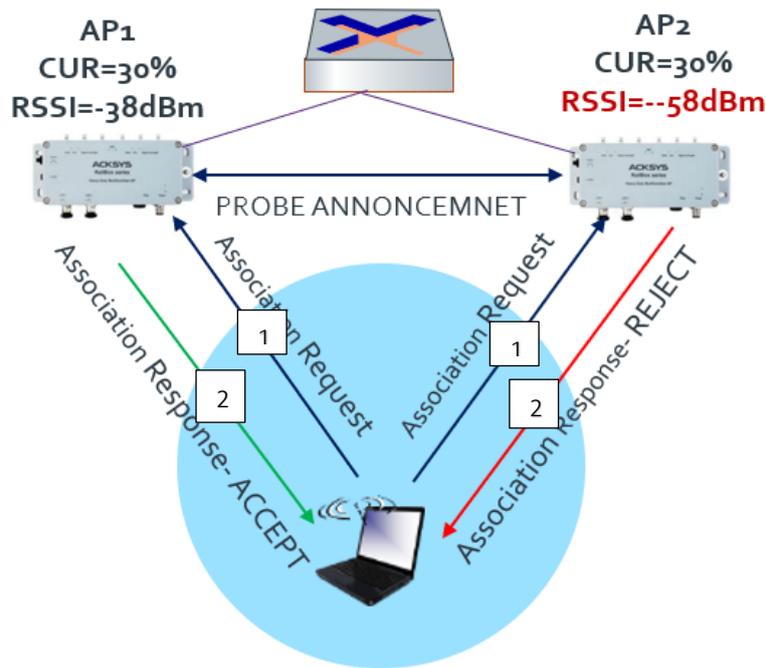
At each probe request, the WLB daemon of the AP sends a multicast "probe announcement" message to APs belonging to the multicast group.
The probe announcement contains:

- The MAC address of the source AP,
- The number of associated clients,
- The RSSI of a client.

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.

LISTENING
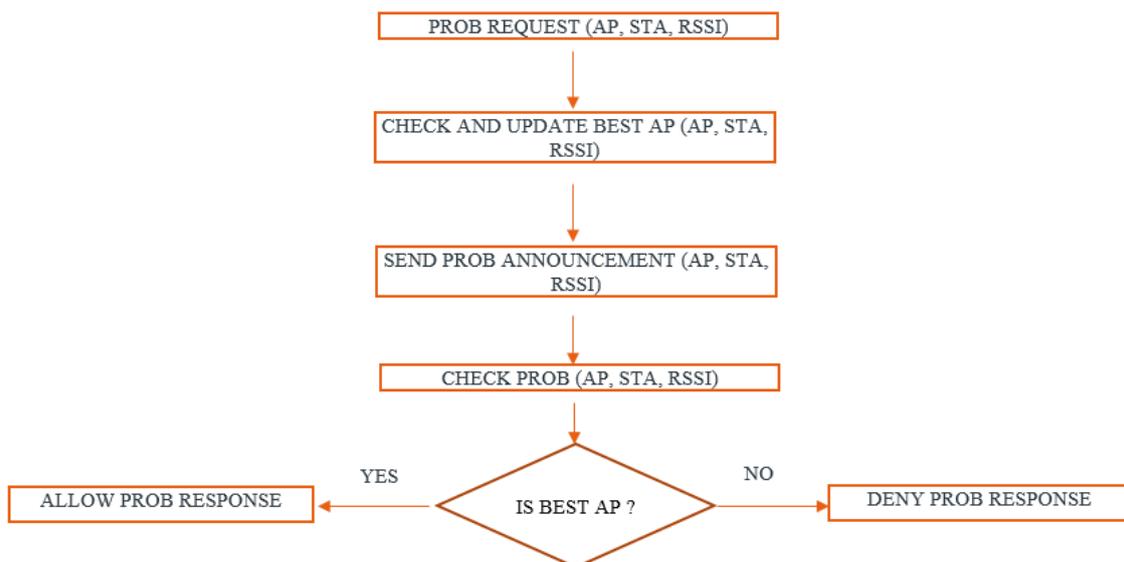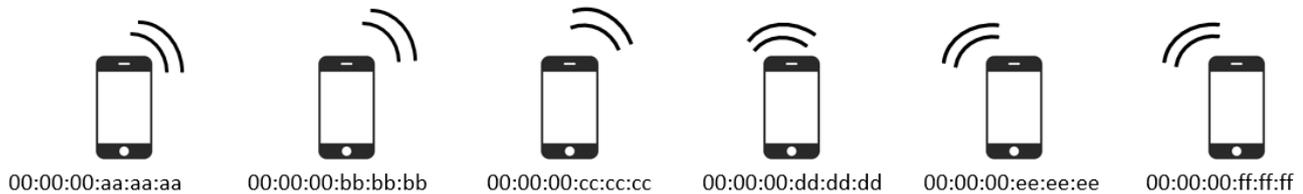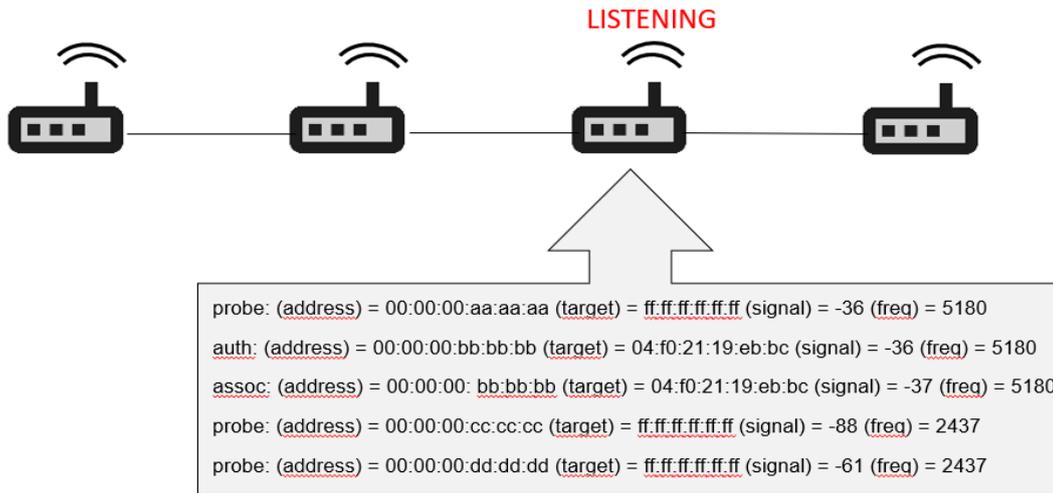
Thus, each Access Point knows which message the stations are sending, e.g.

> *probe: (address) = 00:00:00:aa:aa:aa (target) = ff:ff:ff:ff:ff:ff (signal) = -36 (freq) = 5180*
> The station with MAC address 00:00:00:aa:aa:aa sends a probe request to inform all that it detects a signal on frequency 5180MHz (channel 36) with RSSI = -36dBm.

> *assoc: (address) = 00:00:00: bb:bb:bb (target) = 04:f0:21:19:eb:bc (signal) = -37 (freq) = 5180*

The station with MAC address 00:00:00: bb:bb:bb sends an association request to AP 04:f0:21:19:eb:bc on frequency 5180MHz (channel 36) with RSSI = -37dBm.

4.2 Configuring Routers

This example will describe Wireless Load balancing configuration for 2 Aps having a common WiFi coverage zone, sharing the same SSID, connected to the same ethernet bridged network and with 60 STAs trying to connect to these Aps.

- 2 APs (AP1 and AP2) on the **same bridged network**, close to each other, configured:
  - On 2 different channels
  - **Same SSID**
  - Maximum number of **STA limited to 60 per AP (depending on your use case)**
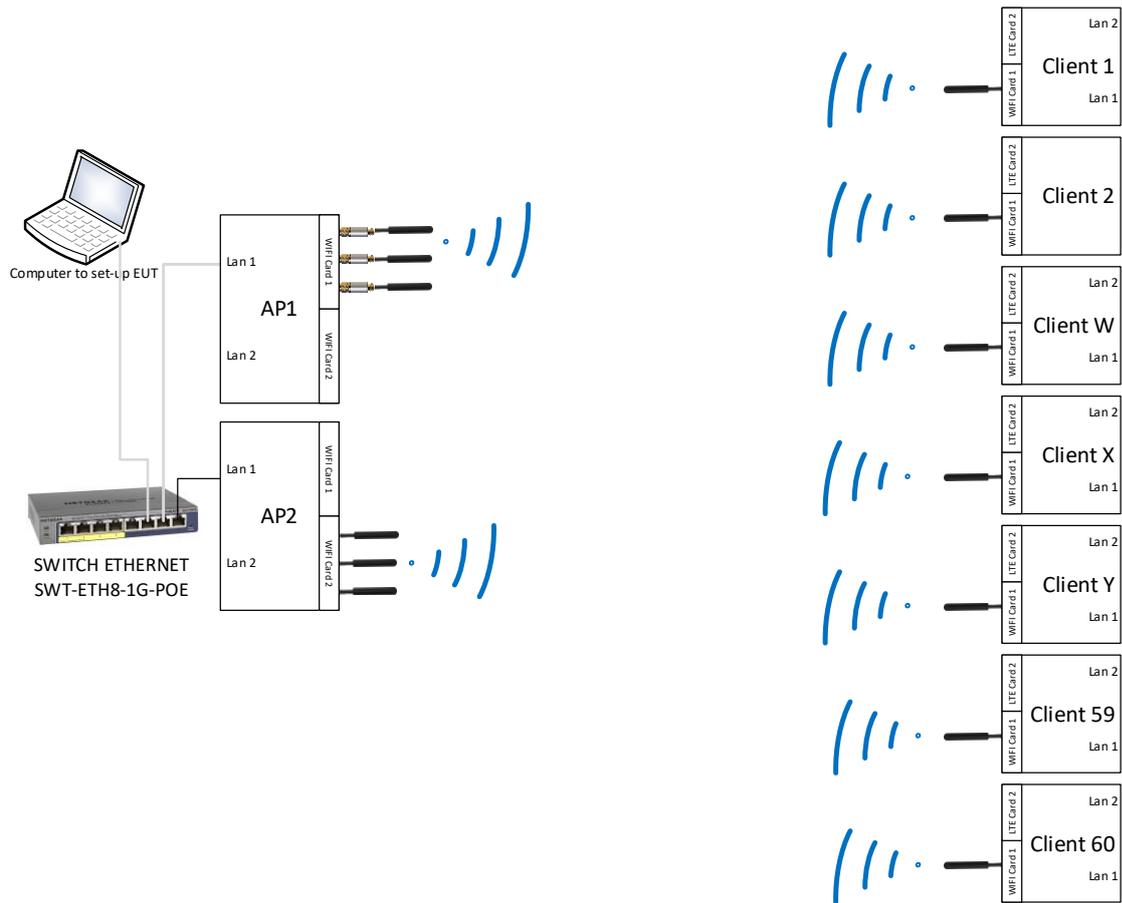
The table below contains a summary of the settings.

<u>AP1 and AP2 Configuration Example</u>

Load Balancing Configuration Example

Connect to the web interface of an AP and navigate to SETUP / SERVICES / WLB

- **Enable** association control feature
- **Enable** Load Balancing
- Configure Multicast group IP address used for AP1 and AP2 (The value of this field must match on both instances).
- Configure the time for the multicast communications
- Configure the network interface used for multicast exchange

WIRELESS LOAD BALANCING

In this page you can configure wireless association control services.

ASSOCIATION CONTROL CONFIGURATION

Enable association control feature	☑ To enable association control, please enable this option.
Enable load balancing	☑ Enable load balancing.
Enable band steering	☐ Enable band steering.
Mulicast group IP address	239.0.0.1 — Multicast group IP address used for inter-AP communication
multicast_ttl	1 — The time to live for multicast communications.
Network for multicast exchange	◉ lan: ○ lan2: ○ Cellular: — Communication link used to exchange load-balancing information
Enable roaming control	☐ Enable roaming control.

ASSOCIATION CONTROL PER SSID

Association control configuration per SSID

| SSID	LOAD BALANCING	BAND STEERING	ROAMING CONTROL
balancing	☑	☐	☐

5.   Band Steering

5.1 Concept

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

Band steering follows below principles:
- Prefer 5GHz: stations are pushed from 2.4GHz band to let them to associate to 5GHz band.
- A penalty of -5dBm is applied to RSSI observed on 2.4GHz band (for that the signal seen on 5GHz will have a better score).
- Dual-band stations are rejected for one time on 2.4GHz band if the RSSI with penalty is below the RSSI observed on 5GHz band. Otherwise, the association is accepted.

For each station, a dual-band AP keeps a record of its RSSI per band and identifies whether it's dual-band capable. Band-steering should act before a station association request, i.e. all measurement steps should be already available when a station is requesting association.

As shown in the bellow screenshot, when **Band Steering** is disabled in the WLAN. The majority of end-devices (even dual band capable) are associated with the 2.4 GHz radio. As soon as **Band Steering** is enabled, the end devices naturally move to the 5GHz band.

Band Steering Disable   **Band Steering Enable**
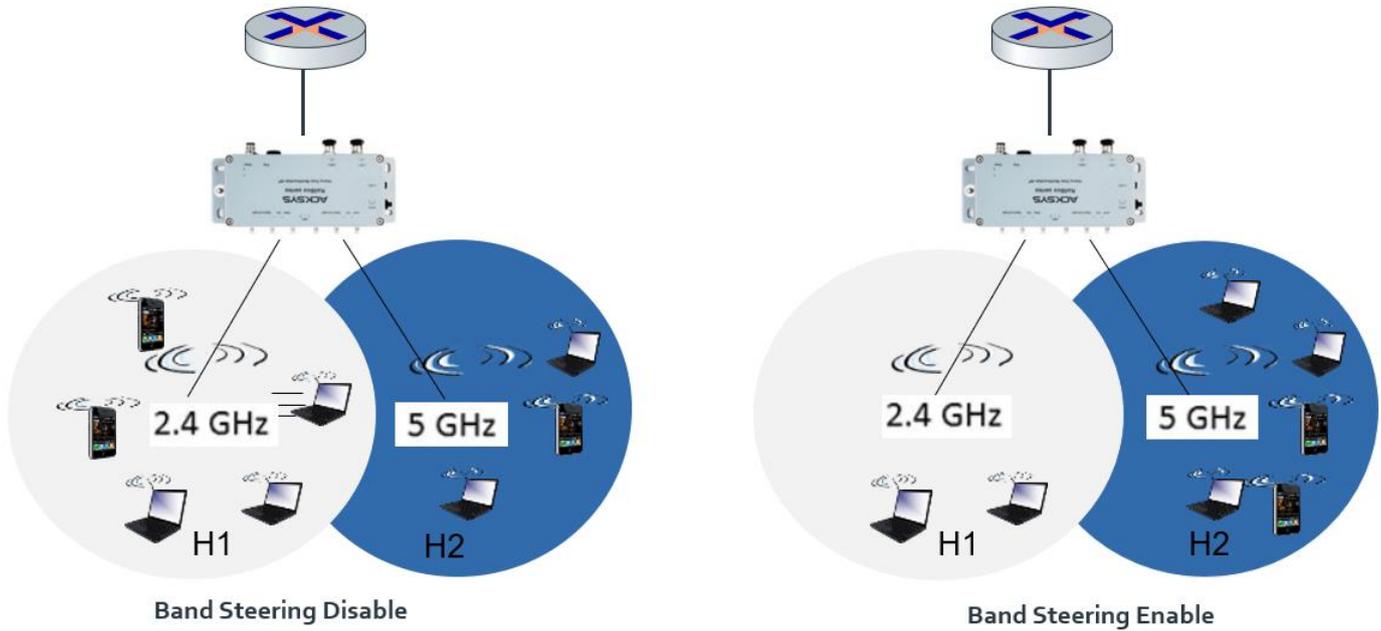
5.2 **Configuring Routers**

We will keep the same configuration for AP done for Load balancing to test Band Steering therefore only the Band Steering features is configured in this example.

Band Steering Disable   **Band Steering Enable**
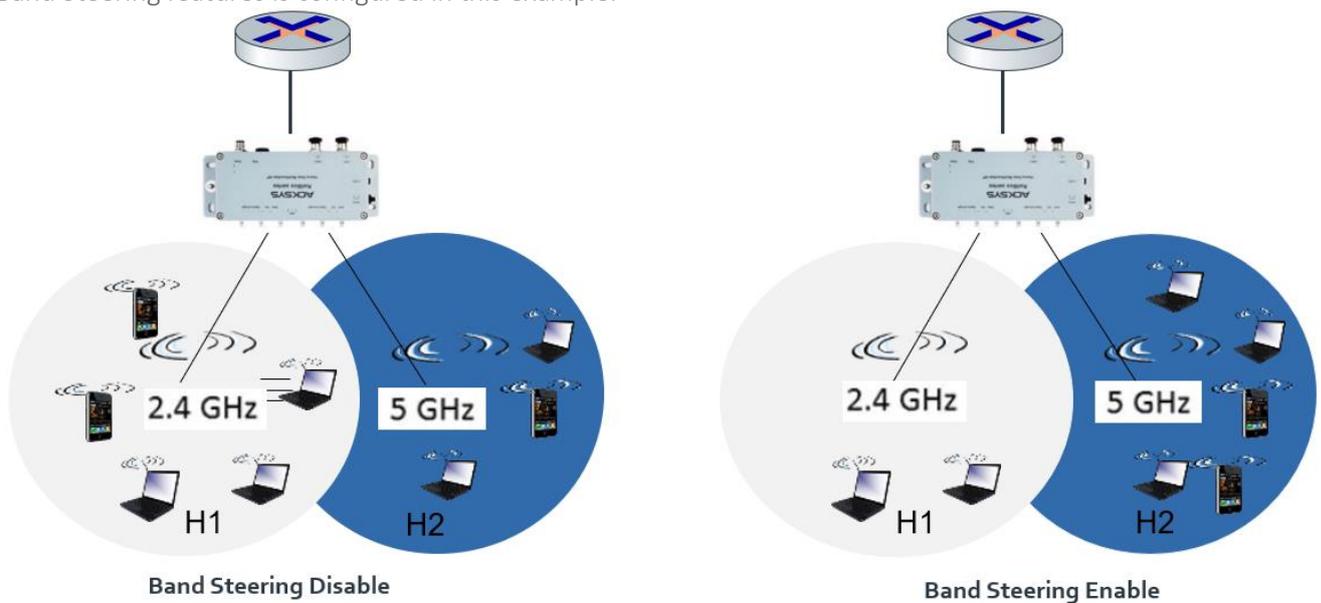
<u>AP1 and AP2 Configuration</u>

<u>AP1:</u>

AP1 is configured on 5GHz band, with SSID balancing

<u>AP2:</u>

AP2 is configured on 2.4GHz band, with SSID balancing

<u>Band Steering Configuration example</u>

Connect to the web interface of an AP and navigate to SETUP / SERVICES / WLB

- **Enable** association control feature
- **Enable** Band Steering
- Configure Multicast group IP address used for AP1 and AP2 (The value of this field must match on both instances).
- Configure the time for the multicast communications
- Configure the network interface used for multicast exchange

6.   Client Roaming Control

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 too.
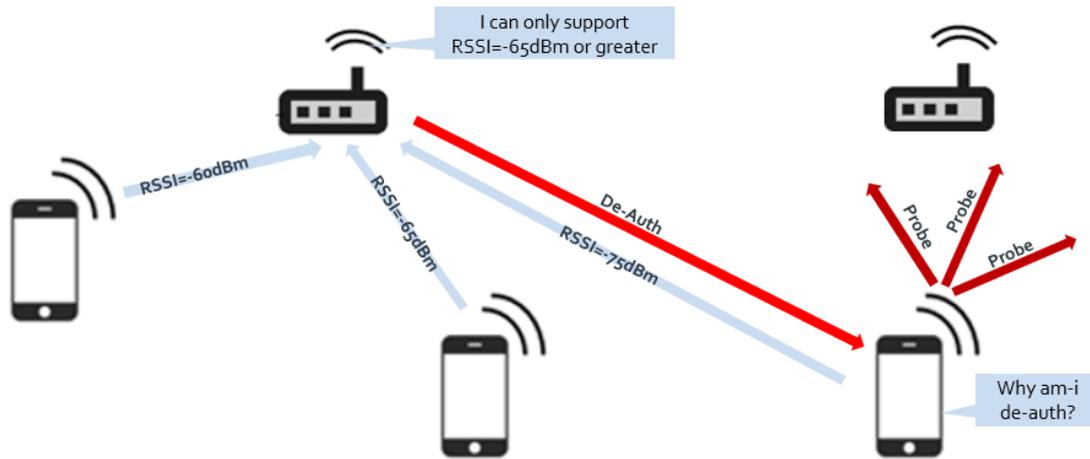

6.1 Concept

An Acksys router can be configured to monitor RSSI for associated stations on each SSID. If roaming control is activated for an SSID and the station RSSI falls below a minimum RSSI threshold, the router sends a Deauthentication request to the station's mac address. Hence, Association requests are accepted only if the RSSI is over the minimum RSSI threshold. Roaming Control follows below principles:

- **Load balancing RSSI threshold:** If a radio detects that the RSSI of a client is lower than the specified RSSI threshold, the radio ignores the association requests of the client.
- **Maximum time of denials for association requests**: If the number of times that a radio rejects a client reaches the specified maximum time of denials for association requests (3 seconds), the radio accepts the association request of the client.

Roaming control task is executed each 3s, which means that and associated station is rejected at least 3s after it's RSSI falls below the minimum RSSI threshold.
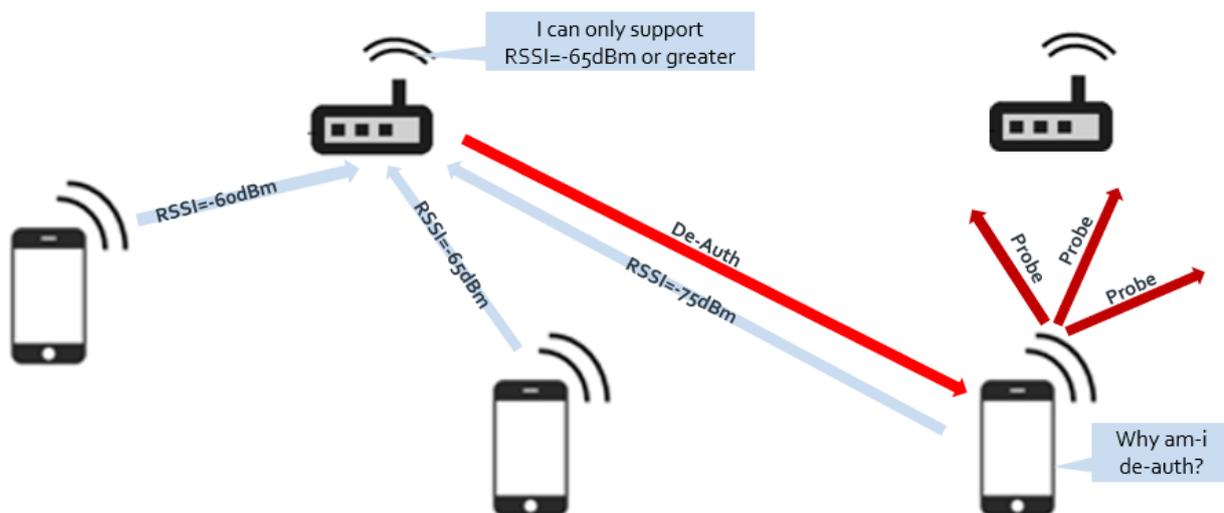
Strict roaming mechanism

When roaming control is enabled, the user must specify a RSSI threshold below on 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:

❖ **Roaming control with strict mode enabled:**

➢ **For non-connected devices:**

Devices with signals that are LOWER than *Min RSSI for association* cannot connect.

➢ **For connected devices**

After 5 consecutive signal samples that are LESS than "Min RSSI for association", the AP will disconnect the device immediately and it will not be able to reconnect until it exceeds this threshold again.

❖ **Roaming control with strict mode disabled:**

➢ **For non-connected devices:**

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

➢ **For connected devices**

After 5 consecutive signal samples that are LESS than "Min RSSI for association", the AP will disconnect the device immediately and it will not be able to reconnect until it exceeds this threshold again. Then for insisted devices:

❖ 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*

6.2 Configuring Routers

AP1 and AP2 Configuration Example

Roaming Control Configuration Example

- **Enable** association control feature
- **Enable** Roaming Control
- Configure Multicast group IP address used for AP1 and AP2 (The value of this field must match on both instances).
- Configure the time for the multicast communications
- Configure the network interface used for multicast exchange

NOTE: The **Min RSSI for association** parameter corresponds to the value below which the AP disassociates the station. Select **Strict roaming control** to strictly forbid association to all stations which RSSI is below **Min RSSI for association** (no tolerance).

6.3 Association Control Per SSID

In case you have several SSIDs defined on your Wi-Fi router, you may enable or disable each of these previous features on one or several SSID:

7.   WLB Score Calculation Formula Overview

	Option	Score	Description
WLB features	Enable	**STEP1**: **Score1** = Peer signal +100	If Only WLB is activated (without Load Balancing or Band Steering)
Load Balancing	Enable	**STEP2: Score2 =** Score1*(max_sta_num - num_sta)/max_sta_num)	If Load Balancing is activated, we multiply the previous score by a load factor: **num_sta:**the number of connected station on the AP and **max_num_sta:** the maximum number of allowed connected station on the AP
Band Steering	Enable	**STEP3: Score3=** Score2 – (10 * ap_24_capable)+10	If Band steering is activated, we add 10 points penalty for the stations scores on the 2.4 GHz APs (*with ap_24_capable = 1 if AP is on the 2.4 GHz band and 0 if AP is in the 5 GHz band*)

8.   Troubleshooting WLB

> NOTE:
> - Make sure each Access Point is configured identically with wireless association control features.
> - Please ensure full radio coverage planning before enabling WLB features

For deeper understanding of WLB behaviour, you can activate WLB logs embedded in the router, in /Tools/Logs submenu:

ASSOCIATION CONTROL CONFIGURATION

Log Output Level   Debug

Support : https://support.acksys.fr