Grandstream Networks, Inc.

GWN76XX Series

Mesh Network Guide

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SUPPORTED DEVICES

Following table shows Grandstream networking products supporting Mesh network feature:

Table 1: Supported Devices

Model	Supported	Firmware
GWN7610	Yes	1.0.7.12 or higher
GWN7600	Yes	1.0.5.13 or higher
GWN7600LR	Yes	1.0.5.13 or higher
GWN7630	Yes	1.0.9.12 or higher
GWN7630LR	Yes	1.0.15.6 or higher
GWN7602	Yes (Only As RE)	1.0.3.4 or higher
GWN7605	Yes	1.0.15.20 or higher
GWN7605LR	Yes	1.0.15.20 or higher
GWN7615	Yes	1.0.15.20 or higher
GWN7660	Yes	1.0.19.12 or higher

Note

GWN7602 mesh feature only support RE (Repeater) role and cannot be cascading downward.

INTRODUCTION

Wireless Mesh Network is a wireless extension of the traditional wired network using multiple access points connected through wireless links to areas where wired access is not an option while also expanding the coverage of the WLAN network.

In the traditional WLAN network, the uplink of the AP is a wired network (usually an Ethernet Link):

- The advantages of a wired network are security, anti-interference and stable bandwidth.
- The disadvantages are high construction cost, long period of planning and deployment, and difficulty of change in case a modification is needed.

However, these are precisely the advantages of wireless networks. As a result, Wireless Mesh Network is an effective complement of wired network.

In addition, Mesh networking provides a mechanism for network redundancy. When an abnormality occurs in a wired network, an AP suffering the uplink failure can keep the data service continuity through its Mesh network.

The following list summarizes the advantages of using Mesh Wireless Network technology in conjunction with wired LANs:

- **Rapid Deployment:** Mesh network equipment is easy to set up and can be set up in a few hours, while the traditional wired + wireless network needs more time.
- **Network Redundancy:** Improve network reliability.
- **Increasing network coverage dynamically:** By continuously adding Mesh nodes, the coverage of Mesh networks can rapidly increase
- **Flexible networking:** APs can join or leave the network at any time as needed, which makes the network more flexible.
- **More application scenarios:** Mesh networks can be widely used in different scenarios such as warehouses, port terminals and emergency communications, in addition to the common scenarios of traditional WLAN networks such as corporate networks and office networks.
- **Cost-effective:** In Mesh network, only CAP nodes need access of wired network, so that the dependence on the wired network can be reduced to the minimum, and this could save a lot cost on purchasing wired devices and installing cables.

MESH NETWORK ARCHITECTURE

Terminology

A typical Mesh network architecture is as below:

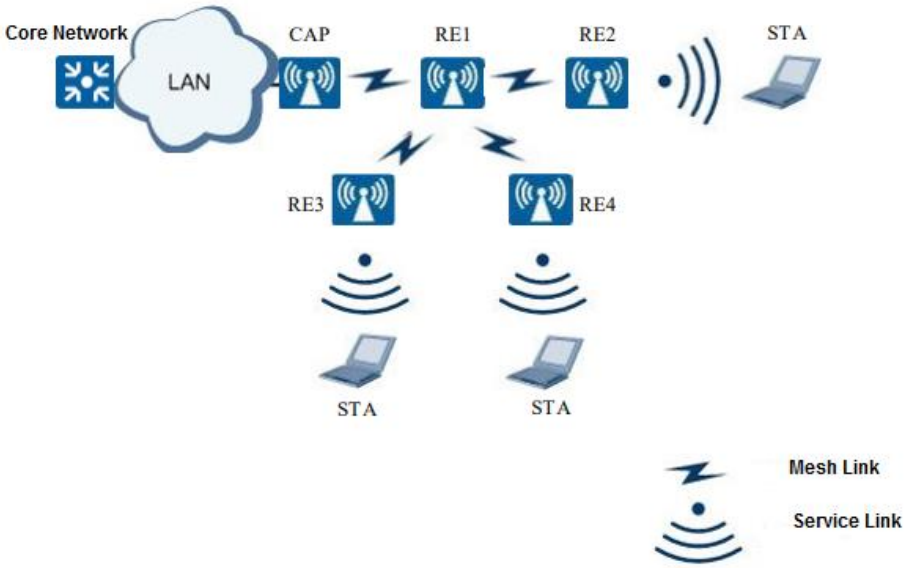

Figure 1: Mesh Network Typical Design

The following acronyms table explain the different components and words associated to this kind of architecture:

Table 2: Acronyms Table

Acronym	Description
AP	A generic wireless **access point** which can be either a CAP or a RE.
CAP	**Central AP**, an AP using a wired uplink. Master AP must be a wired CAP.
RE	**Range Extender**, an AP using a wireless uplink.
STA	A regular wireless **station**/client (Smartphone, Tablet, Laptop. Etc).
Mesh Link	A wireless **uplink** that is **connecting two REs** or **one RE to a CAP**, it uses one of existing WiFi bands (2.4GHz or 5GHz).
Service Link	A wireless **link between an AP and a STA**, used for transferring actual user data.
HT40, HT80	These terms refer to High Throughput 40MHz or 80MHz, which is a technique used by 802.11n/ac device to combine multiple 20MHz channels to have more data throughput.

Mesh Network Architecture Models

In actual networking, GWN Mesh networking mode can be abstracted into the following three modes: **chain mode**, **star mode**, and **hierarchical star mode**.

Each mode has its advantage and specifications about the environment where it is more preferable than the other modes, while taking into considerations more parameters such as radio conditions, capacity and bandwidth utilization…etc. These details will be discussed on next chapters ***[***CAP and RE Locating***]*** ***[***Topology Considerations***]*** ***[***Mesh Service Performance].

Chain Mode

In a chain networking environment, CAPs and REs are connected at a hierarchical level. This mode is applicable to networks requiring long transmission distances to cover more far ground where Ethernet wired connection is not available. Mesh links capacity should be taking into consideration on this mode, this will be discussed with more details on next chapters.

Figure 2: Mesh Network - Chain Mode

Star Mode

In a star networking environment, all REs are directly connected to the CAP for data forwarding. This mode is usually used for hotspot coverage in small squares. The remote REs directly connect to the root CAP through a wireless Mesh link to provide a wider range of wireless coverage services.

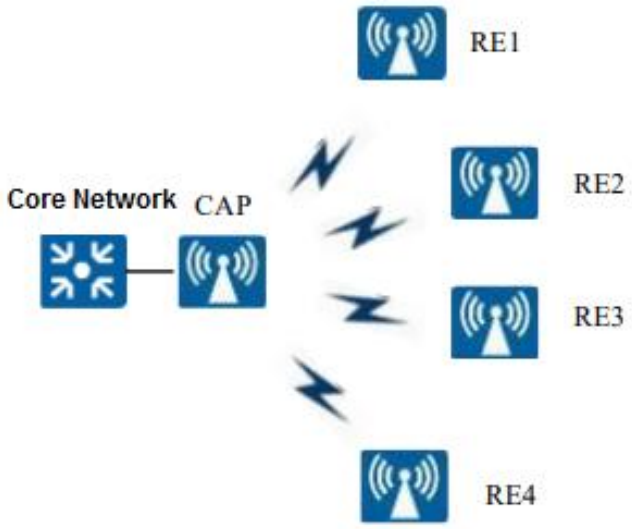

Figure 3: Mesh Network - Star Mode

Hierarchical Star Mode

Hierarchical star network is also called tree network. Hierarchical star network is composed of multiple levels of star structure connected vertically. In general, the closer a node is to the root of his tree, the better performance a node device can have. Compared to a star network, Hierarchical star network has larger coverage, and benefit of easy expanding.

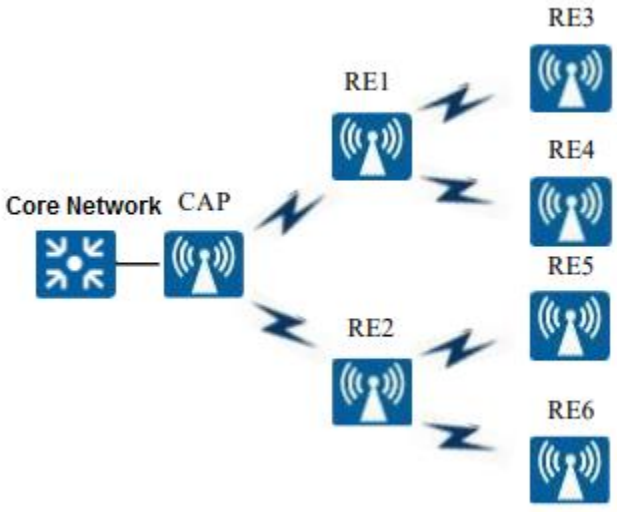

Figure 4: Mesh Network - Hierarchical Mode

Each mode has its advantage and specifications about the environment where it is more preferable than the other modes, while taking into considerations more parameters such as radio conditions, capacity and bandwidth utilization…etc. These details will be discussed on next chapters.

MESH NETWORK PLANING

CAP and RE Locating

When installing GWN access points in an environment while taking advantage of the mesh network capability introduced, installers should take the following points into considerations:

1) The air radio link between adjacent APs' antennas must be completely visible and no major obstruction in between.

2) The relative height of the AP installation is recommended not to exceed 4 meters to prevent interaction with other peripheral APs.

3) The location of CAP requires a reachable wired network, so cabling and mounting need to be considered, CAP is better to be deployed in a relatively open and unobstructed location to facilitate reliable communication with multiple RE devices in the vicinity.

4) Due to the instability of the wireless link and its sensitivity to interference, a Wireless Mesh Network is perfect for the deployment in which wired network deployment is inconvenient but air interference in relatively little.

5) Each access point should be within the range of the uplink RE or CAP access point to ensure establishment of the mesh link, below table gives the coverage range of each GWN AP mode:

Table 3: GWN76XX Max. Coverage Range

AP Model	GWN7602	GWN7600 GWN7605	GWN7610 GWN7660 GWN7615 GWN7630	GWN7605LR	GWN7600LR	GWN7630LR
Max. Coverage range	100 m	165 m	175 m	250 m	300 m	300 m

Topology Considerations

Typical networking topologies are coved in *[Mesh Network Architecture Models]* above. These topologies can be used as basic models for building Mesh Networks in various scenarios.

Mesh network technology focus more on ensuring large coverage rather than capacity. Therefore, it is not suitable as a basis solution for multi-user high capacity and concurrency scenarios. In such cases, it is recommended to combine mesh network with an increase of wired CAPs for multi-user high-capacity areas.

Following are some factors needed to be considered while planning.

Maximum Hops

Adjacent cascade APs signals are in the same channel, which results in a great decrease of data throughput. The more hops are constructed, the lower the data throughput will be.

The typical performance calculation formula is 1 / N (1 / N of CAP air interface bandwidth), where N is the number of hops.

It can be considered that the performance decreases inversely with the number of hops. Since STAs also use the same wireless channel, which causes extra usage within this channel, the recommended max number of hops is 3.

Maximum number of directly connected REs for each CAP

The number of REs attached to a CAP (Central Access Point) affects the throughput of users. When more than suggested number of REs are linked to a CAP and the wireless clients accessing the network for high data usage such as video streaming or large files download, then the CAP can easily become the bottleneck of the whole Mesh network. Especially while knowing that each AP can allow a large number of clients' associations as shown on the table below:

Table 4: Number of Clients per AP Model

AP model	GWN7602	GWN7660	GWN7630 GWN7615 GWN7630LR	GWN7610	GWN7605 GWN7605LR	GWN7600 GWN7600LR
Concurrent Clients	80	256	200	250	100	450

Therefore, you need to control the number of REs and the number of users that are attached to each CAP, increase the number of CAPs, and increase the bandwidth reserved for data service. We recommend the setups for each topology model:

a) **Chain network mode:** recommended **maximum hop of RE is 3**, that is, the number of RE does not exceed three.
b) **Star networking mode:** recommended **max** number of **REs directly connected to CAP is 4.**
c) **Hierarchical star mode: no more than 2 RE branches** are recommended under the CAP, and **no more than 2 second-level REs** connected to each first level RE.

Mesh Service Performance

Mesh channel selection: To achieve high throughput and better user experience, 5G channels with better air environment should be chosen for Mesh backhaul link. On GWN AP, Mesh on the 5G radio is enabled by default. If you need to use the 2.4GHz Mesh link, you can change it manually.

The choice of channel width: If 5G band is selected, it is recommended to use HT40 mode or HT80 to provide higher rate. 2.4G is not recommended, due to the channel interference.

Mesh Service Degradation

For the scenario in the figure below, we can assume the following:

- Mesh links use the same 5G channel.
- The 1st hop air interface bandwidth is C (Mbps) and the hop count is N.
- RE1 and RE2 respectively generate a fixed flow.
- Mesh links use the HT40 mode, and CAP provides 180Mbps bandwidth for 1x1 terminals.

In this model, traffic from RE1 to CAP occupies the 5G channel for once, while traffic from RE2 to CAP occupies 5G channel for twice.

We can come up with this formula: The peak throughput of each node in this system is C / N, and the average throughput of each RE is 2C / (N * (N + 1)) (where N is the total number of hops).

Example of bandwidth estimation: The traffic on RE1 is sent to the CAP using the 5G channel for once, so the peak bandwidth is 180/1 = 180Mbps; The traffic on RE2 is sent to the CAP using the 5G channel for twice, so the peak bandwidth is 180/2 = 90 Mbps; The average bandwidth of RE1 and RE2 is (2 * 180) / (2 * (2 + 1)) = 60 Mbps.

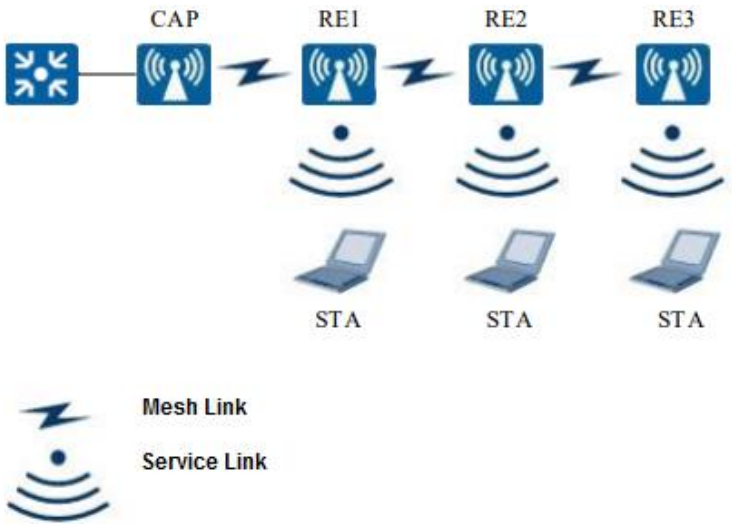

Figure 5: Sample Topology

Note: Office environment has channel obstacles and other interference factors.

Our calculation only considers the attenuation ratio. Data is only for reference. We put C = 98 in to the table below:

AP	Hops	Channel	Terminal Type	Packet Type	Channel Width	Channel	Downward Throughput in Mbps	C/N	Attenuation Ratio
CAP	0	5G	1x1	TCP	HT40	161	98		

RE1	**1**	**5G**	**1x1**	**TCP**	**HT40**	**161**	**43**	**98**	**-56.1%**
RE2	**2**	**5G**	**1x1**	**TCP**	**HT40**	**161**	**29**	**49**	**-32.6%**
RE3	**3**	**5G**	**1x1**	**TCP**	**HT40**	**161**	**19**	**33**	**-34.5%**

It can be concluded that the more hops is in the system, the more degradation the performance has. So, it is suggested that use as less hop as possible in your deployment.

Note: Mesh transmission distance is affected greatly by many factors including signal attenuation, antenna gain and environmental factors, so analysis is needed in case by case.

MESH DEPLOYMENT AND HANDLING PRECAUTIONS

The following is a list of recommendations that should be taken into consideration when deploying a mesh network solution:

1. Mesh feature is mutually exclusive with client bridge feature. That is, if the client bridge function is configured, you cannot configure Mesh.
2. In Mesh networking, if a RE is connected with a wired network, the Mesh link will be disconnected and this RE will be selected as CAP. If a CAP's wired network is disconnected, it will turn itself into a RE.
3. In order to ensure Mesh network performance, it is not recommended to use pure 2.4G mesh link.
4. RE cannot use both 2.4G and 5G at same time for wireless uplink, so 5G priority is recommended for dual-band Mesh links.
5. Mesh links and service links of each CAP use one same channel. Mesh link and service link cannot be divided into different channels, so it is suggested that the channel should be uniformly planned in the early stage of network deployment.
6. Disable Automatic Uplink Failover is not recommended, and default is unchecked.
7. To ensure service bandwidth, it is recommended that users control the scale of the network.
8. Some operations may cause the RE to be disconnected. You must reconnect the RE with Ethernet cable to recover it. For example, disable the Mesh function after Mesh link is established, or Disable Automatic Uplink Failover function. Please be aware of such changes.
9. Un-configured REs can only be found by CAP in the same LAN and cannot be found simultaneously on multi-LAN CAPs.
10. The RE should be set with DHCP Mode for a Client device connected to NET PORT to acquire an IP Address.
11. If RE is set with static IP, then using a PoE injector is recommended as any Network activity detected by the AP will cause the Mesh to fail. Otherwise user will only need to make sure that there is no DHCP Server in the network connected to the AP's Ethernet port.

MESH NETWORK SAMPLE CASE

Overview and Network Architecture

In order to meet the Wi-Fi coverage requirement of a certain office and reduce the cost of wiring construction. A company uses Mesh technology to deploy a network as shown on the diagram below:

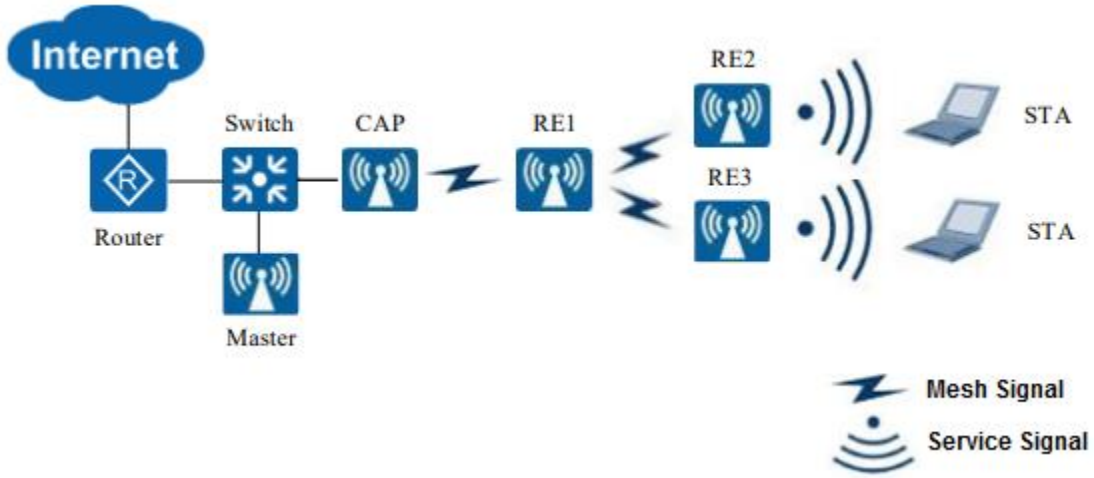

Figure 6: Mesh Network Use Case

- The router is a GWN7000 acting as default gateway for the network.
- The switch takes the role of DHCP Server to assign IP address to APs and stations.
- GWN7600LR is acting as the Master, to manage all APs on the network.
- Slave CAP is connected to the switch using an Ethernet cable.
- RE1, RE2 and RE3 access to the wireless network by using Mesh technology (RE1 is first hop connected directly to the CAP node).

Mesh Configuration Steps

1. First, we start by pairing the CAP with the master, simply connect the CAP to the LAN network and start the usual normal discovery/pairing process under the master access point.

2. Next, we need to pair the RE access points to the master. This can be done in two ways:

   A. Connect all REs to the same wired LAN as the master then perform the normal process of discovery/pairing process, and after successfully pairing the APs they can be deployed on the field.
   B. REs can also be discovered wirelessly when powered via PSU or PoE Injector, and admin can configure after discovery. This requires that the REs must be within the range of the Master or Slave's signals coverage.

Note: If there are other GWN APs broadcasting in the same field with different subnet, RE may be wirelessly connected to those networks and cannot be discovered and paired by your Master. Therefore, it is recommended to use the first method of wired pairing and then deploy those REs.

3. After that all slave access points have been deployed and paired to the master, you can directly manage them to operate the mesh network. Mesh service configuration is the same as transitional GWN WLAN. Make sure to power up the units using PSU or PoE Injector at this phase.

4. Log into the master page, and under Access Points page you can see the information, for example the AP in the "**Online Wireless**" state **is the RE** (Range Extender) with a wireless uplink to the CAP. The APs showing "**Online**" state are either a wired **master** or **CAP**.

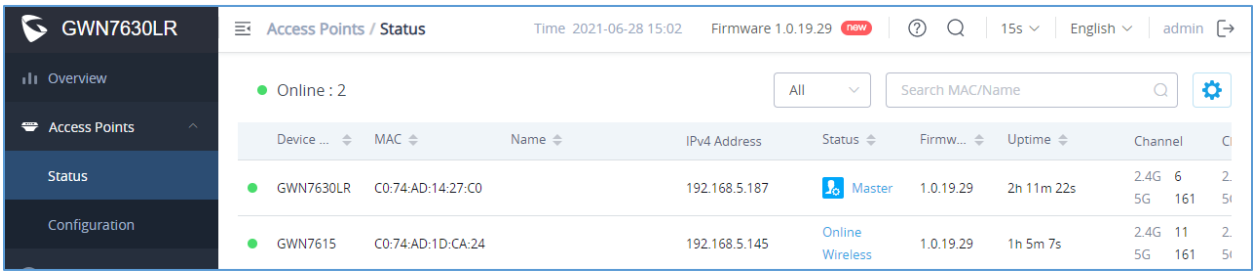

Figure 7: Access Points Status

Maintenance and Verification

For maintenance and Mesh network settings, users could navigate to the menu "**System → Mesh**" where you can select for example which band will be used to setup the Mesh links (2.4GHz or 5GHz) which 5GHz is the recommended one.

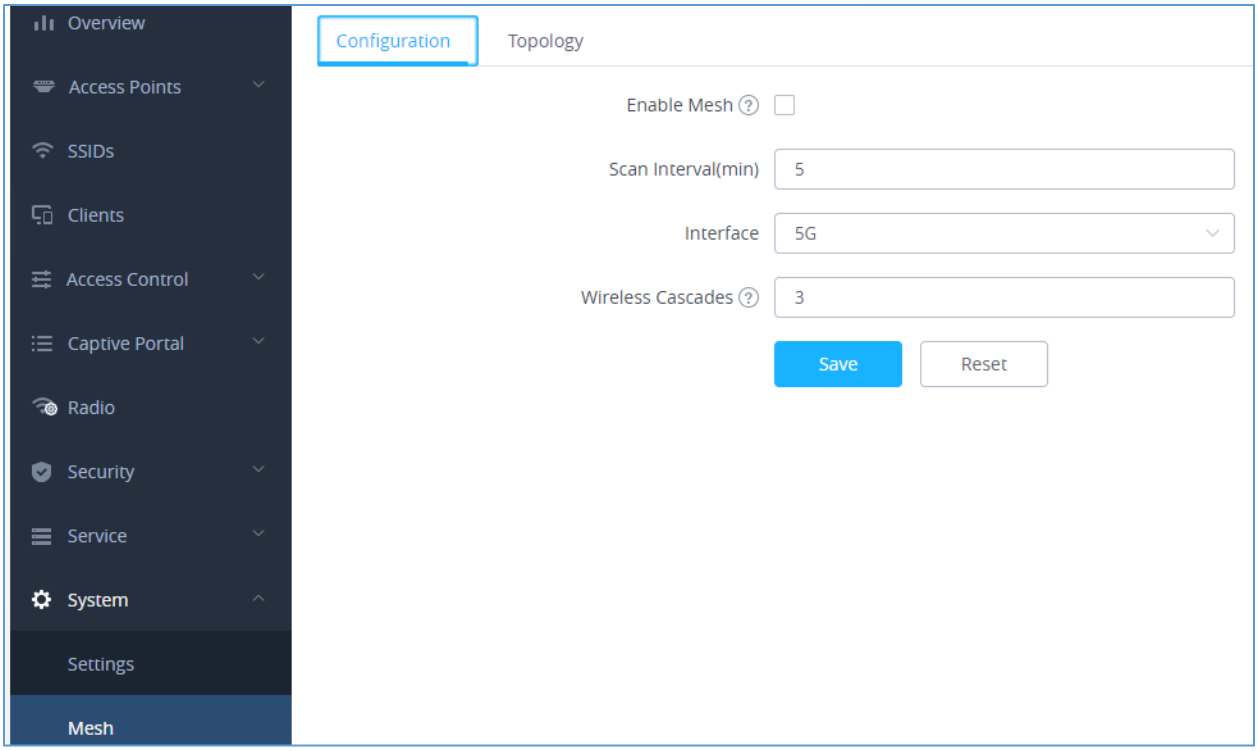

Figure 8: GWN Mesh Settings

For verification, go under **Topology** section to view the current RE topology information as shown on the screenshot below.

Note: You can click on an AP to edit it.

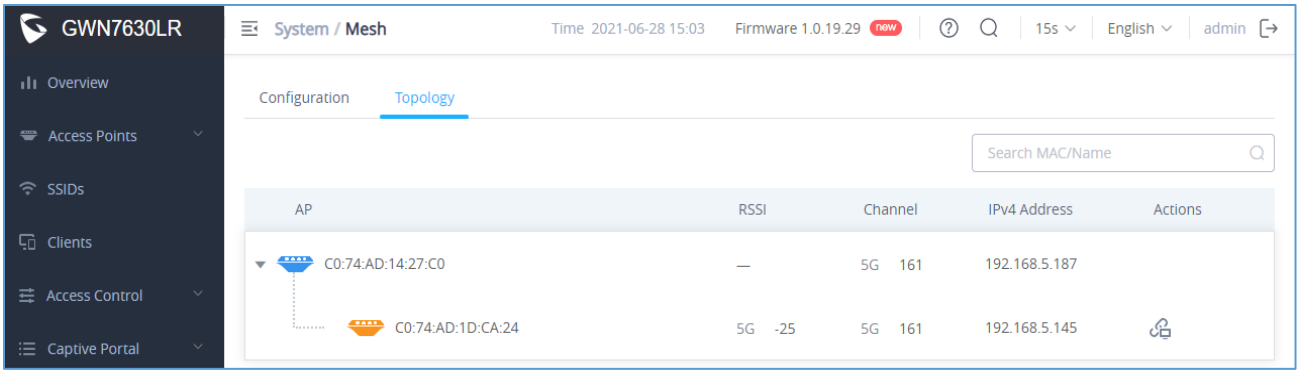

Figure 9: Access Points Mesh Topology

Once you click on an AP icon for editing, go under ***configuration*** tab to set the wireless options for this AP. By default, the feature **Automatic Uplink Failover** is enabled, and we do not recommend disabling it, since without automatic uplink failover, RE will not be able to come back online once wireless uplink is down. Other configuration items can be configured according to the actual situation. For example, the bandwidth of the Mesh link and the AP transmit power can be adjusted. The Mesh link channel needs to be modified in the CAP configuration.

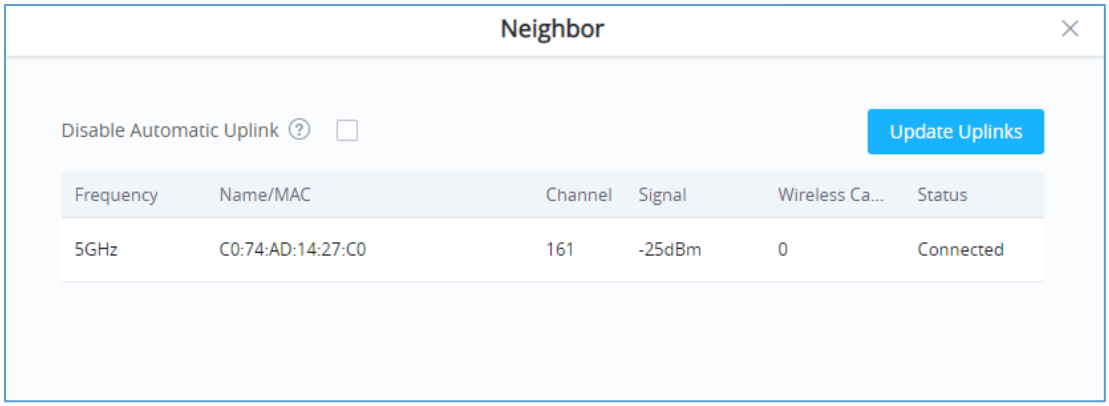

Figure 10: Access Point Configuration Items

Click also on the **Update Uplinks** tab to see the mesh uplink information scanned by the RE. Users could manually select from the list a wireless upper link. It is recommended to select the link with higher strength signal to ensure good quality for the Mesh link.

Note: During this process, the service will be temporarily interrupted to establish the link.