Wireless Mesh Networking

In a wireless mesh deployment, multiple APs (with or without Ethernet connections) communicate over wireless interfaces to form a single network. This wireless communication between APs is called Mesh Networking. Meraki’s mesh networking functionality is automatic, self-healing and available on all Access Points.

A detailed article on designing wireless Mesh networks can be found here.

Mesh Network Components

In a mesh network, access points can be in one of two states: Gateway, or Repeater.

Gateways

Gateway access points are connected directly to the wired network, granting it an uplink to the Internet. If a gateway loses its Internet connection, it will look for a nearby gateway and automatically fail over to acting as a repeater, without dropping active wireless client connections.

Meraki determines whether a device should be a repeater or a gateway on boot when the unit sends out a DHCP request. If it receives a DHCP reply from a device on the wired network, it assumes that it has a valid LAN connection and will become a gateway AP. If a gateway AP is unable to reach the LAN gateway/upstream router, the AP will fail over to repeater mode.

Repeaters

Repeater access points are not directly connected to the wired network, instead relying on wireless mesh links to reach the Internet. As long as the repeater has power and a strong (unobstructed, line-of-sight) wireless connection to another repeater or gateway, it will form a mesh link.

Please note, it is not possible to configure a static IP address for a repeater AP; doing so will automatically designate the device as a gateway instead of a repeater.

Note: Both gateways and repeaters can serve wireless clients. It is possible to have multiple gateways in a mesh network, and repeaters will automatically choose the gateway to which it has the strongest connection.

Note: Only Cisco Meraki APs can function as repeaters and gateways. Wireless MX security appliances, Z-Series teleworker gateways, and third-party APs cannot participate in a wireless mesh.
Identifying a Repeater AP vs Gateway AP

1. Navigate to Wireless > Monitor > Access points

2. Click the wrench icon on the right-hand side and make sure the Gateway option is selected:

   ![Access points screen](image)

3. A gateway AP will be listed as "(self)" under the Gateway column, while a repeater AP will list some other AP in the network (denoting that it is using that AP as its gateway):
4. An additional way to identify a gateway or repeater AP is by checking the **LAN IP** section on the AP's details page.

5. A gateway AP will show a LAN IP address and give you the ability to assign an IP address:

![Meraki Gateway](image)

- **LAN IP**: 192.192.192.192 (via DHCP)
- **Public IP**: 10.10.10.10
- **Gateway**: 10.10.10.1
- **DNS**: 8.8.8.8
- **Ethernet 1**: 1000 Mbit, full duplex

6. A repeater AP will leave the LAN IP section blank:
Meraki Repeater

- MR66

Air Marshal: Disabled

SSIDs: Meraki

Channel: 11 (15 dBm), 44 (17 dBm)

LAN IP: (None: AP is a repeater)

Public IP: 192.192.192.192

Gateway: Meraki Gateway

DNS

7. A repeater's details page also shows information about its route to the mesh gateway. This information is displayed on the RF tab:

**Mesh routes**

<table>
<thead>
<tr>
<th>Route</th>
<th>Avg Mbps</th>
<th>Avg metric</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meraki Repeater</td>
<td>27.7</td>
<td>1431</td>
<td>100%</td>
</tr>
<tr>
<td>Meraki Gateway</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Mesh neighbors**

<table>
<thead>
<tr>
<th>Name</th>
<th>Distance</th>
<th>Channel</th>
<th>Link quality</th>
<th>In</th>
<th>Out</th>
<th>Signal in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meraki 2</td>
<td>66 m</td>
<td>44</td>
<td>58%</td>
<td>71%</td>
<td>82%</td>
<td>19 dB</td>
</tr>
<tr>
<td>Meraki 3</td>
<td>142 m</td>
<td>44</td>
<td>21%</td>
<td>37%</td>
<td>57%</td>
<td>8 dB</td>
</tr>
<tr>
<td>Meraki 3</td>
<td>142 m</td>
<td>11</td>
<td>13%</td>
<td>32%</td>
<td>41%</td>
<td>9 dB</td>
</tr>
<tr>
<td>Meraki Gateway</td>
<td>118 m</td>
<td>44</td>
<td>87%</td>
<td>94%</td>
<td>93%</td>
<td>23 dB</td>
</tr>
<tr>
<td>Meraki 4</td>
<td>128 m</td>
<td>44</td>
<td></td>
<td>19%</td>
<td>9%</td>
<td>4 dB</td>
</tr>
<tr>
<td>Meraki 4</td>
<td>128 m</td>
<td>11</td>
<td></td>
<td>9%</td>
<td>10%</td>
<td>4 dB</td>
</tr>
<tr>
<td>Meraki 5</td>
<td>98 m</td>
<td>44</td>
<td></td>
<td>43%</td>
<td>59%</td>
<td>8 dB</td>
</tr>
</tbody>
</table>
Meraki Mesh Algorithm

Meraki devices in a mesh network configuration communicate using a proprietary routing protocol designed by Meraki. This protocol is designed specifically for wireless mesh networking and accounts for several unique characteristics of wireless networks (including variable link quality caused by noise or multi-path interference, as well as the performance impact of routing traffic through multiple hops). This protocol is also designed to provide ease of deployment while maintaining low channel overhead.

As part of the self-healing nature of meshing, the access points will automatically detect each other and select the best route to a wired gateway. All Cisco Meraki APs that support meshing will automatically try to mesh if they lose their wired connection, or be available for connections from repeaters if connected as a gateway. To that end, it is generally recommended to allow auto-channel selection in networks with repeaters.

Each AP in the Meraki mesh network constantly updates its routing tables with the optimal path to network gateways. If the ideal path changes due to node failure or route metric, traffic will flow via the best-known path. Data traffic sent between devices in a Cisco Meraki network is encrypted using the Advanced Encryption Standard (AES) algorithm.

In the event of a mesh gateway failure or the emergence of a new mesh gateway with a better routing metric, all new traffic flows will be routed to the new mesh gateway. The current route to a given mesh gateway may change over time, to adapt to network conditions.

How does the AP decide to mesh?

When the AP boots up initially it will always try to get an IP address over the wired interface. If the AP does not get an IP address, the AP will then go into mesh mode and starts looking for the gateway. The AP continues to request IP address via DHCP on the wired interface even though the AP is in the mesh mode.
If an AP gets an IP address it gets into the gateway mode and starts broadcasting mesh probes.

What are mesh probes?

Each Meraki AP sends out link probe packets (known as mesh probes) at different bit rates and varying sizes. Because these packets are sent as broadcast frames, no ACK frames are needed from receiving stations. Four different types of probes at different data rates are sent in a batch of 15 seconds on both (2.4 /5 GHz) bands. All APs listen to the mesh probes and depending on the number of mesh probes correctly received, come up with a link quality metric as shown in dashboard.

How does the AP choose a gateway?

Once the AP goes in the mesh mode, The AP scans all channels to collect info from all neighbors. If a valid neighbor (in-network AP or Meraki AP) is found, it goes to that channel. The configured channel has higher precedence if a valid neighbor is found on it. If no valid neighbor is found at all from all channels, it stays on the configured channel.

Based on the scan results, the repeater AP develops a table of all the detected gateways and their corresponding link quality metrics. Additionally, the number of hops are also considered and preference is given to gateways with lower hops. Once the AP hears all the neighboring APs, it finalizes a route based on the link quality and the number of hops.

While it is not possible to select which frequency band should be used for meshing, it is possible to manually adjust channel selections to direct the AP toward a desired behavior. To do this, refer to the article on manually changing channels in a mesh network. If it is desired for two APs to mesh on 5Ghz as opposed to 2.4Ghz, then the APs should both be set to the same 5Ghz channel, but different 2.4Ghz channels. Keep in mind though that a frequency band cannot be allocated specifically for meshing, and both bands will still be available for servicing clients unless the SSID is configured to use the 5Ghz band only.

When meshing with an out of network Meraki AP, the repeater just reached out to Meraki dashboard and no client traffic is sent using this mesh connection. The idea being that the repeater can reach out to dashboard to check for any config updates.

When does a repeater look for a new gateway?

A repeater starts looking for an AP in two cases:

1. When a gateway is down: If a gateway is not reachable for 3 minutes gateway is marked as down. Immediately after a gateway is marked as down the AP starts scanning for new gateways. Will scan the entire spectrum (including 2.4 GHz and 5 GHz) and then select the best one that is available based on metrics. Higher preference is given to the configured static channel.

   If an AP received ARPs from the upstream gateway, AP will not go into mesh mode.

2. Repeater finds a better gateway: A repeater constantly evaluates the current channel it is operating on for better gateways but each AP will send mesh info every 15 seconds. If the repeater finds an AP with a better link quality metric of even 1 the AP will move to the new gateway.

How does a repeater change gateway?

In most cases, when the repeater changes gateway there are existing traffic flows that need to be considered and the repeater needs to ensure that the new gateway does not provide a degraded performance. To ensure seamless transfer of data flow and good user experience, a repeater does not move traffic flows immediately. Existing traffic flows use the old route for 5 seconds before being transferred to the new route using the new gateway.

Impact of Meshing on Throughput

Due to the half-duplex nature of wireless communication and that signals being passed through a repeater AP must be retransmitted to the next hop, throughput
is greatly reduced when using a repeater. While many factors impact wireless throughput, it is safe to assume that the addition of meshing can reduce throughput by approximately 50%, with that reduction being applied for each subsequent repeater that must be traversed to reach a gateway. Therefore, it is advised to minimize the number of hops between a client and gateway.

**Monitoring Mesh**

Mesh monitoring tools are located at the bottom of every AP detail page, which can be accessed by navigating to Wireless > Monitor > Access Points, then clicking on an Access Point.

The image below shows an example AP acting as a repeater. The time selector at the top right-hand corner will adjust the timeframe of all of the UI components in the mesh monitoring section of the UI.

The time selector may select data from:

- 2 Hours
- 1 day
- 1 week
- 1 month

**Mesh Routes**

The Routes Table shows the routes used by different flows over time. As new routes are selected, they are added to the routes table. The overall amount of traffic per-route over the time period selected is shown in the Usage column. The metric is also displayed in this table, representing a combination of loss and packet delivery times. Avg. Mbps throughput values are also provided for customers to gauge the capacity of that particular mesh route.

**Mesh Neighbors**

The Mesh Neighbors table can be found on the RF Tab on the AP details page and shows the APs that have been discovered automatically. The link quality is a metric that takes into account signal strength and packet delivery success rates in each direction. A link quality of 70% or higher is recommended for a strong link.