Network Design Guide

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This network design guide provides recommendations and best practices to size and deploy a Meraki 802.11n wireless network. The target audience consists of IT administrators who need to determine the rough number and placement of Meraki access points (APs) for a wireless network. For a more detailed sizing and placement analysis (including that for a legacy 802.11a/b/g wireless network), please consult a Meraki partner.

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1. Overview

The Meraki wireless solution consists of high-performance access points (APs) that are managed by the Meraki Cloud Controller, the cloud-based service that administrators use to configure and monitor their Meraki wireless networks. With proper sizing and placement of the APs, the Meraki wireless solution can be used to provide pervasive, reliable wireless connectivity in many different types of deployments and applications, including the following:

Deployment types:

- Offices, conference rooms, and office parks
- Classrooms, dorm rooms, and campuses
- Warehouses, manufacturing floors, and inventory yards
- Hospitals, doctors' offices, nurses stations, and patient rooms
- Retail stores and shopping malls
- Hotel rooms, lobbies, and convention halls
- Residential communities

Applications:

- Guest or public WiFi access
- Internal access (e.g., for employees, faculty/students, residents)
- VOIP
- Video surveillance
- Barcode scanners
- Sensors and monitoring devices
- Digital billboards
- Wireless hotspots (with billing)

This network design guide provides recommendations to size and deploy a Meraki wireless network in some of the more common scenarios. It covers planning work that can be performed prior to receiving the Meraki hardware, along with installation work that can be performed to optimize a deployment for coverage and performance. This guide does not replace more sophisticated site survey that can be provided by certified networking professionals. However, it provides a starting point for sizing and network planning. Additional topics, such as configuration and management of a Meraki wireless network, are addressed in the Meraki Cloud Controller product manual.

2. Deployment Procedure

Deploying a Meraki wireless network consists of the following steps:

1. **Requirements analysis:** Determine how the Meraki wireless network will be used, and what requirements a particular deployment has for a wireless solution.
2. **Sizing:** Estimate the number of APs needed.
3. **Placement:** Identify possible AP placement locations.
4. **Mesh:** Determine whether mesh will be used.
5. **Configuration:** Create and configure the network in the Meraki Cloud Controller.
6. **Staging:** Connect the Meraki APs to Internet connections to upgrade to the latest firmware.
7. **Installation and testing:** Install APs, perform client tests, adjust/add APs, and repeat until satisfied.

Each of these steps is covered in greater detail in the following sections.

3. Requirements Analysis

In order to design a Meraki wireless network effectively, an administrator must understand the following at a minimum:

What client devices will be using the wireless network? Most often, a wireless network must support older 802.11a/b/g devices as well as newer (and faster) 802.11n devices. In this case, an administrator should consider deploying dual-radio APs, such as the Meraki MR14. These APs perform "band steering" by supporting the older legacy devices (e.g., 802.11b/g devices) on the 2.4 GHz band, while steering the newer, faster devices (e.g., 802.11n devices) to the 5 GHz band for better performance.

How will the wireless network be used? If the network will be used for business-critical activities (e.g., by employees), an administrator should consider designing a network that employs only 802.11n APs, which provide the best coverage and performance. Moreover, if high-throughput applications are to be supported, an administrator must ensure that the wired network infrastructure (including, perhaps, the Internet connection) has enough bandwidth to support these applications.

What is the existing RF environment? Wireless devices that operate in RF bands adjacent to the 2.4 and 5 GHz bands can interfere with the coverage and performance of a wireless network. Wireless phone headsets, for instance, can generate channel interference in the 2.4 GHz band, even if the headsets themselves operate outside of the 2.4 GHz band. An administrator can address the existing RF environment by enabling automatic channel assignment, which the Meraki Cloud Controller periodically performs using channel interference and channel utilization statistics that it receives from Meraki APs. An administrator can also enable "channel spreading" to configure Meraki APs in a network to broadcast on different channels, thereby reducing channel utilization and increasing client capacity across the overall network.

How will the wireless network connect to the wired network? In general, an administrator should try to maximize the number of Meraki APs that are physically connected to the wired network. However, where Ethernet connections are not readily available (e.g., warehouses, older historical buildings, or outdoors), an administrator will need to utilize Meraki's mesh networking capabilities. (An AP with both power and a hard-wired network connection is called a "gateway AP". An AP with power but no hard-wired network connection is called a "repeater AP". Repeater APs communicate with neighboring Meraki APs to obtain network connectivity.) Here, the administrator needs to be cognizant of the network's mesh properties. More information on mesh can be found in Section 6, "Mesh".

4. Sizing

The goal of the sizing step is to estimate the number of APs that might be required for a wireless deployment. (See Appendix A for sizing recommendations for a few common deployments.)

There are 2 primary ways in which to estimate the number of APs required for a wireless deployment:

1.1 By Number of Users

The following factors influence the number of users that a single AP can support (and, therefore, the number of APs that a particular deployment requires):

- Average number of wireless devices per user (typical: 1.5)
- Expected percentage of active wireless users (of the total number of users, typical: 25%)
- Bandwidth usage of wireless users in particular environments (e.g., high-bandwidth applications in offices, low-bandwidth applications in warehouses)

Depending on these factors, a Meraki AP can support anywhere from 20 to 100 users.

1.2 By Coverage Area

AP estimation by coverage area depends heavily on the surrounding environment. The environment's space, construction material, and obstacles (between the wireless device and the AP) all significantly affect the coverage area that a single AP can provide. Given these variables, an AP's coverage area can range from 2,000 sq. ft. (e.g., for a deployment with many walls, pillars, and other obstacles) to 20,000 sq. ft. (e.g., for an open space deployment with no physical barriers). Coverage area is also limited by the range of the wireless clients. (Client radios are usually less powerful than AP radios. At a far enough distance, a wireless client can still hear the AP, but the AP can no longer hear the client.) As a general rule, APs should be placed no further than 100-150 ft. with line of sight from wireless clients.

1.3 Considerations

In reality, the deployment environment dictates which of these two metrics—headcount or coverage area—is more important in estimating the number of APs. For instance, in an environment with a high user density (e.g., an auditorium), headcount is the limiting factor. In contrast, in an environment with RF-blocking construction materials (e.g., a classroom with cinder block

walls), coverage area is the limiting factor. By deriving estimates using both metrics, an administrator can obtain a range, which he can then use for sizing. Using the higher estimate (i.e., more APs), the administrator can reduce risk in pursuing a pervasive deployment without coverage holes. Alternatively, using the lower estimate (i.e., fewer APs), the administrator can pursue a best-effort deployment with increased risk that coverage holes might exist.

Additional APs beyond this estimate should be added to a planned deployment in order to address any unforeseen coverage or performance issues, or simply to prepare for future growth. APs should be added, for instance, if the existing RF environment is particularly noisy (e.g., there are many existing wireless devices in the area), or the physical environment is particularly challenging (e.g., the concrete walls are unusually thick). And, in general, it is beneficial to keep APs in inventory as spares so that they that can be deployed on short notice—for instance, for events or emergencies.

5. Placement

There are a few general guidelines for the placement and positioning of APs in a wireless deployment. (See Appendix A for placement recommendations for a few common deployments.)

Position high: Position an AP on a wall or ceiling so that its signal can blanket cube walls, furniture, and people moving around on the floor. If an AP is positioned too low, these obstacles can reduce an AP's coverage area.

Position close to wireless users: An entire site does not necessarily need to be blanketed with wireless coverage. Wireless coverage is only necessary in those areas where wireless users are expected. In those areas, ensure that sufficient APs are deployed for the expected device count and coverage area, and that APs are positioned close enough to wireless devices for them to hear each other. (See "Sizing" section above.)

Maximize line of sight: A wireless signal travels most effectively through open space. As such, an AP with an omni-directional antenna should be positioned to maximize its line of sight both to wireless users and to the areas that it needs to cover. For instance, an AP deployed in an office building is often well-positioned in a hallway, where it has line of sight up and down the hallway—serving wireless users sitting in cubes along the hallway, as well as wireless users sitting in offices that hang off of the hallway.

Reuse existing AP locations: If Meraki is being deployed to upgrade an existing wireless network, the locations of the existing APs may be reused if they were properly positioned originally. Reusing these locations reduces labor, since no new cables or holes need to be drilled. (Often, the Meraki mounting bracket can reuse the same holes that were used to mount the previous vendor.)

6. Mesh

A key factor in determining network design is whether Meraki's unique mesh networking capabilities need to be used. Mesh networks allow several APs to wirelessly share a single Internet connection, negating the need to connect each AP to an active Internet connection. This can save substantial wiring costs and provide significant additional deployment flexibility. In addition, there are situations where APs need to be deployed in areas where it is not possible to provide a wired Internet uplink but where it is desirable to have wireless coverage. There are several key terms and guidelines that should be understood to assure successful deployment of a Meraki mesh network.

Gateways and Repeaters: Access points that are connected directly to an Internet uplink connection, such as a DSL line from an ISP, are called gateway APs. Access points that are not connected to a wired Internet connection are called repeaters. As long as a repeater is provided power and has unobstructed, direct line of site and a strong wireless signal from a nearby gateway, the repeater will share the gateway's Internet connection. Both gateways and repeaters can serve clients. If a gateway were to lose its Internet connection, it will automatically look for a nearby gateway and failover to acting as a repeater while continuing to serve 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.

Deployment Considerations:

There are several guidelines that should be followed to ensure a successful mesh deployment:

Gateway-to-Repeater Ratio: In general, it is desirable to have as many gateway APs as possible to maximize overall network performance. In general it is recommended to plan for no more than five repeaters for each gateway AP.

Maximum Mesh Hops: There will be a throughput reduction with each "hop" in a mesh. This reduction will be ~50% for single-radio APs, and somewhat less for multi-radio APs (~10-20%). As a result, it is recommended that a mesh network be designed for no more than three hops from the gateway to client.

Multi-Path Mesh: In order to ensure that there are multiple failover paths, it is recommended that each mesh AP has at least three strong "neighbors", or other APs in the mesh that the AP can "see". Neighbors can be seen on the AP details page in the Meraki Dashboard.

7. Configuration

In reaching the configuration step, an administrator has analyzed the requirements for the wireless network, has procured some number of APs needed for the network, and has identified locations where the APs will be installed. In the configuration step, an administrator creates a network in the Meraki Cloud Controller and registers the APs into the network. The administrator can then configure the network with the settings that are appropriate for the deployment. These settings include the following:

- **Network-wide settings**, such as channel spreading and administrator accounts.
- **SSID settings** for the multiple SSIDs that the Meraki wireless network will broadcast. Per-SSID settings include:
    - **Encryption** (e.g., WPA2-Personal, WPA2-Enterprise with 802.1x authentication)
    - **Sign-on method** (e.g., click-through splash page, splash page login)
    - **Client IP addressing** (e.g., NAT mode using Meraki's DHCP server, or bridge mode using an upstream DHCP server)

Please see the Meraki Cloud Controller manual for a full description of features supported.

8. Staging

The staging step takes the Meraki APs out of the box, and it is the last step before the APs go up in their deployment locations. Staging is highly recommended to ensure that the first wireless users obtain an optimal experience from the newly installed wireless network. During staging, the administrator connects the Meraki APs to the wired network for approximately 30 minutes. The APs must be able to obtain IP addresses and reach the Internet so that they can download their configuration and latest firmware from the Meraki Cloud Controller. Administrators are encouraged to perform asset tagging and labeling of their APs at this time as well, while the APs are still easily accessible.

9. Installation and Testing

At the installation and testing step, an administrator determines whether the initial sizing and placement exercises were accurate.

Meraki recommends an iterative process when installing the Meraki APs:

1. **Install APs in temporary locations:** The APs should be deployed in temporary locations (on or near the locations identified in the placement step), so that they can be moved easily before any holes are drilled. New Ethernet cables should be at least 20 feet longer to provide a "service loop", in case the APs to which they are connected need to be moved.

2. **Test the wireless network:** With the current (temporary) deployment, an administrator can use tools to measure the coverage and performance that wireless devices can expect to obtain from the network. An Internet speed test provides an idea of a wireless user's end-to-end experience—if, for instance, a large file transfer were initiated over the web. Meraki also provides a number of other resources, including the following:
   - **http://my.meraki.com**: Every Meraki AP runs a local web server that can be accessed via this URL. The page offers a client-to-AP speed test, mesh metrics, and channel utilization statistics.
   - **Meraki Cloud Controller:** The Meraki Cloud Controller provides extensive information about the performance of a wireless network, along with "remote hands" troubleshooting tools to run tests against the network (e.g., ping and throughput tests to specific APs).
   - **Meraki tools:** Meraki provides wireless tools, such as the Meraki WiFi Stumbler, that enable an administrator to collect data about RF environments and check AP signal strengths. (See "Resources" for more information.)

3. **Adjust AP locations as required:** Based upon these tests, certain areas with weaker-than-desired signal strength or poorer-than-desired performance may be identified. Because the APs have only been installed in temporary locations, an administrator can now move them as required to address these issues.

4. **Repeat until goals are achieved:** An administrator should repeat these steps—moving APs, then re-testing the wireless network—until the network's coverage and performance goals have been achieved. At this point, the administrator can permanently install the APs in their locations.

10. Resources

Meraki wireless tools, such as the Meraki WiFi Stumbler, are available at http://www.meraki.com/tools/.

Extensive troubleshooting tips are documented in the Meraki Knowledge Base, which can be accessed at http://www.meraki.com/support/.

For more information on designing a Meraki wireless network, please contact an authorized Meraki partner. Or, you can contact Meraki directly at 1.415.632.5800 or www.meraki.com.

Appendix A: Sizing and Placement for Common Deployments

The most accurate predictive design is obtained through a site survey, which can be performed by certified networking professionals using RF scanning equipment on-site. That said, the following table provides rough guidelines for AP sizing in a handful of common environments, along with placement recommendations:

Description of Environment	Sizing by Number of Users	Sizing by Coverage Area	Placement
Office: Individual offices, cubicles, conference rooms, and lobby area. Walls consist of sheetrock with glass windows and wood doors. Cubicles consist of metal framing with fabric covering.	1 AP per 20-40 users	1 AP per 3-5,000 sq. ft.	Position in open spaces with line of sight down hallways and into rooms.
Classroom: Open room with desks and/or lab benches. Concrete/rebar walls significantly weaken RF signal penetration to other rooms.	1 AP per 30-50 users	1 AP per 3-5,000 sq. ft.	Distribute APs evenly within classroom.
Auditorium or convention hall: Open area with high user density. May contain multiple floors for mezzanine/balcony levels.	1 AP per 80-100 users	(Rarely a limiting factor)	Distribute APs evenly in venue, adding more APs where wireless users are expected to congregate.
Warehouse or manufacturing floor: Open area with low user density. May contain high metal racks, metal machinery, and manufacturing dust/fumes.	(Rarely a limiting factor)	1 AP per 15-30,000 sq. ft.	Position APs evenly in open spaces. For rows of high metal racks, position APs set back from row openings, so that an AP has clear line of sight down 1 row, and angled lines of sight to other rows. (See Figure 1 below.)
Outdoor: Open area with buildings and trees as obstacles.	1 AP per 80-100 users	1 AP per 15-30,000 sq. ft.	Position around buildings, light posts, and trees to provide line of sight to wireless users. The limiting factor in outdoor deployments is the signal strength of a wireless client's radio, rather than the signal strength of the AP.

Figure 1: Warehouse deployment, AP placement for rows of inventory racks.