Indoor 802.11n Site Survey and Planning

Version 1.0

VRD

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Chapter 1: Introduction

The Aruba Validated Reference Design (VRD) series is a collection of technology deployment guides that include descriptions of Aruba technology, recommendations for product selections, network design decisions, configuration procedures, and best practices for deployment. Together these guides comprise a reference model for understanding Aruba technology and network designs for common customer deployment scenarios. Each Aruba VRD network design has been constructed in a lab environment and thoroughly tested by Aruba engineers. Our partners and customers use these proven designs to rapidly deploy Aruba solutions in production with the assurance that they will perform and scale as expected.

The VRD series focuses on particular aspects of the Aruba technologies and deployment models. Together the guides provide a structured framework to understand and deploy Aruba wireless LANs (WLANs). The VRD series has four types of guides:

- **Foundation:** These guides explain the core technologies of an Aruba WLAN. The guides also describe different aspects of planning, operation, and troubleshooting deployments.
- **Base Design:** These guides describe the most common deployment models, recommendations, and configurations.
- **Applications:** These guides are built on the base designs. These guides deliver specific information that is relevant to deploying particular applications such as voice, video, or outdoor campus extension.
- **Specialty Deployments:** These guides involve deployments in conditions that differ significantly from the common base design deployment models, such as high-density WLAN deployments.

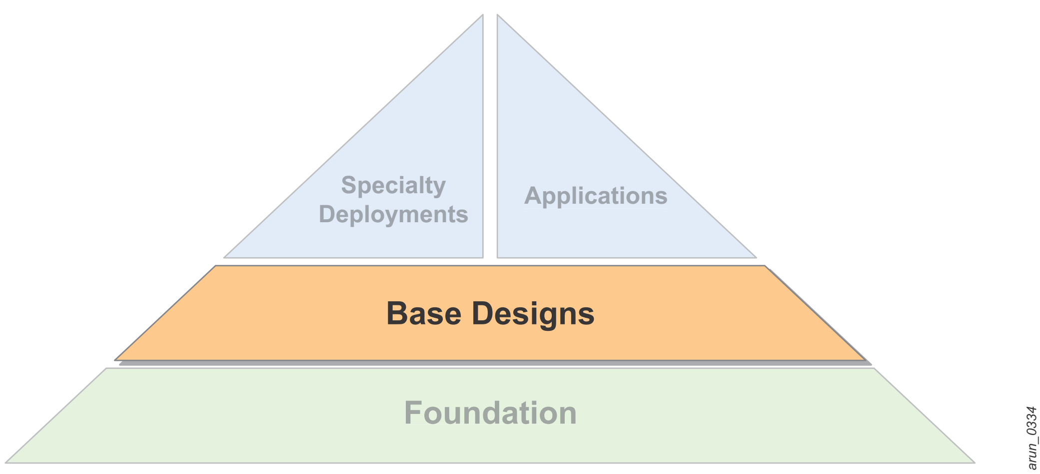


Figure 1 Aruba technology series

This VRD is a base design guide, and it describes best practices for determining AP deployments in an Aruba 802.11n wireless. This VRD describes RF design principles that will help the network engineer in these ways:

- Successfully select the correct AP model.
- Determine the number of APs required.
- Determine proper placement of APs by using software and physical site surveys.

This guide is divided into major sections that cover environmental evaluation, AP and antenna selection, and the process of performing a site survey on a facility. This guide shows the process of using the Aruba VisualRF Plan and performing a physical site survey using an Aruba Instant AP and AirMagnet Site Survey Pro software on the same facility.

This guide applies to all indoor products regardless of software version.

Reference Material

- This guide assumes a working knowledge of Aruba products. This guide is based on the network detailed in the Aruba Campus Wireless Networks VRD and the Base Designs Lab Setup for Validated Reference Design. These guides are available for free at http://www.arubanetworks.com/vrd.
- The complete suite of Aruba technical documentation is available for download from the Aruba support site. These documents present complete, detailed feature and functionality explanations outside the scope of the VRD series. The Aruba support site is located at: https://support.arubanetworks.com/. This site requires a user login and is for current Aruba customers with support contracts.
- Aruba hosts a user forum site and user meetings called Airheads. The forum contains discussions of deployments, products, and troubleshooting tips. Airheads Online is an invaluable resource that allows network administrators to interact with each other and Aruba experts. Announcements for Airheads in-person meetings are also available on the site: http://community.arubanetworks.com/
- The VRD series assumes a working knowledge of Wi-Fi®, and more specifically dependent AP, or controller based, architectures. For more information about wireless technology fundamentals, visit the Certified Wireless Network Professional (CWNP) site at http://www.cwnp.com/

Chapter 2: Site Planning Basics

The purpose of this guide is to provide network engineers with the tools they need to conduct a successful site survey and plan to implement an Aruba wireless network. This guide assumes an understanding of radio frequency (RF) and WLAN networking technology, terminology, and industry standards. An Aruba WLAN should be planned by an engineer who successfully has passed the CWNP examination for certified wireless network administrator (CWNA) or equivalent.

Planning Process

Before you deploy a wireless network, you must evaluate the environment. When you understand the environment, you can properly select Aruba APs and antennas and determine their placement for optimal RF coverage. The basic process you will follow is shown in Figure 2.

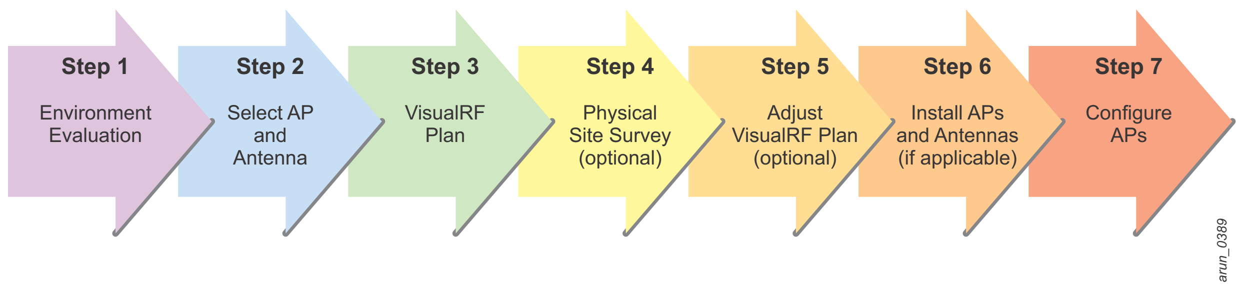


Figure 2 AP planning process

1. **Perform an initial environment evaluation:** You must know what to look for and questions to ask to effectively determine the environment type and the appropriate deployment type. The Aruba environment evaluation questionnaire and other tools provide you with this information (Chapter 3: Environmental Evaluation).
2. **Select the proper APs and antennas for the deployment:** You must understand Aruba AP and antenna types to determine the products that are best suited for the environment to provide optimal performance and RF coverage (Chapter 4: Access Point and Antenna Selection).
3. **Enter the collected and determined information into VisualRF Plan:** VisualRF Plan is the Aruba pre-deployment site planning tool. In most instances, you can perform a standard deployment based on the VisualRF Plan output without a physical site survey. This is called a "virtual" site survey. For complex deployments, you can use VisualRF Plan to generate a basic foundation for planning. But then you should visit the site to verify AP location and signal coverage (Chapter 5: Example Facility).
4. **Conduct a physical site survey (optional):** To properly characterize the RF propagation of a given facility, conduct a passive and/or active physical site survey. The various types of site surveys are explained in Chapter 5: Example Facility. When you select AP locations, you must identify the worst-case challenges in the installation environment. A walk-through is crucial to effectively plan a WLAN deployment in a complex environment (Chapter 6: Virtual Surveys Using VisualRF Plan).

5. **Make adjustments to VisualRF Plan (optional):** After a physical site survey has been conducted, the RF propagation assessment affects the best choice of actual AP locations. Aside from the general environment, specific physical obstructions such as poles, lights, ventilation, and cable runs all should be considered. Change the floor plan to adjust for these findings (Chapter 6: Virtual Surveys Using VisualRF Plan).
6. **Install the selected APs and external antennas (if applicable):** Installation guides are available with the products and on the Aruba support site at https://support.arubanetworks.com.
7. **Configure the APs:** Perform AP configuration following the best practices outline in the VRD series available at http://www.arubanetworks.com/vrd.

This guide describes the first five steps in the process. Mounting instructions for APs and antennas are available with the product and on the Aruba support site at http://support.arubanetworks.com/. Information on the configuration of APs is available in the base design series of VRDs available on the Aruba website at http://www.arubanetworks.com/vrd.

Chapter 3: Environmental Evaluation

The first step in planning the network is to fully understand the environment where you will deploy. The environment is more than the physical structure, which is important, but you also must consider the how the network will be used over time. This chapter describes how to gather the information that will help you successfully deploy a WLAN that meets the needs of the organization.

Network Usage

One of the most difficult questions to answer focuses on how the network will be utilized. Though it is easy to collect a list of common applications and devices that the company supports today, what will the network need to support over its lifetime? After the APs are installed, they typically stay deployed for 4-7 years, and in some networks as long as 10 years. One great example is the decision of whether to use an AP density that is suitable for voice or for data. Many organizations start with a less dense data-only design to save money. But they regret it a few years later when a wireless voice initiative occurs. To plan for the changes to the way the network will be used over time, you must take a lifecycle approach to network design.

The first stop in this process is the IT department because they know what is currently supported. We assume the reader is either part of an IT team or perhaps an outside vendor that supports one. However, you must also consult with managers and business leaders. Often these groups have plans that they have not yet shared with IT that could have fundamental impacts on the network. These new ideas can include completely new services or the shifting of older services from IT-based to cloud-based networks.

You should also consider the quantity and type of new devices that will be coming on to the network due to the bring-your-own-device (BYOD) trend. In the last several years, many organizations have handed out iPads and smartphones to their employees without first consulting the IT department. Of course, employees are already bringing multiple personal devices into the office and expect WLAN access. Consider that the typical “three-screen” office worker has a laptop, personal smartphone, and personal tablet. It’s possible that 66% of the devices that your network has to support aren’t even provided by the organization! As many organizations begin to allow consumer devices on to the corporate network to reduce cost and increase productivity, the device count will only continue to increase.

You must consider these factors when you plan your RF environment. Devices will be roaming more often and the density will be higher. This activity will affect the number of APs that need to be deployed, as well as the choice between single- and dual-band capable devices. Some devices will have multiple radios and transmit chains. Matching AP and device capabilities is required to take full advantage of high-speed data rates. These kinds of changes can be hard to predict, but you must consider them when you build the network to ensure that it will serve the organization well over its useful lifetime.

Determining the Environment Type

The environment type plays a large role in determining how to plan a WLAN deployment. The site conditions drive the choice of planning methodology. Use the following recommendations to help guide the decision of whether to use survey software or a traditional site survey.

Low-Complexity Environments

- Typical environments are open-plan floors with cubicles and a limited numbers of offices and conference rooms.
- Standard deployments primarily consist of APs with integral, omnidirectional or down-tilt antennas deployed at the ceiling level.
- Low-complexity environments typically can be planned using the Aruba VisualRF Plan software and managed via Aruba adaptive radio management (ARM).
- It is strongly recommended that you get a visual inspection of the facility, either in person or with pictures, to identify potential RF obstructions. However, low-complexity environments are often planned virtually with minimal risk.
- If needed, a limited active site survey can be conducted to measure RF propagation in specific areas or other circumstances that warrant relocation of an AP. These adjustments are later entered into VisualRF Plan.

High-Complexity Environments

- High complexity facilities include older construction, hospitals, warehouses, manufacturing plants, airports, aircraft hangars, bus depots, lecture halls, convention centers, historical buildings, and retail stores with floor-to-ceiling shelving. Others are built to withstand natural disasters such as hurricanes and tornadoes. Investigating the use and history of a building can tell you a lot about the need to perform a site survey. Here are some examples:
  - Hospitals and buildings with laboratories or diagnostic imaging suites are complex deployments that require careful examination. The ceiling and wall material can block RF signals (X-ray room walls). Elevator shafts, medical equipment, conduit, and other sources of RF interference can negatively impact the WLAN. In some existing hospitals, a ceiling deployment may not be possible due to the ceiling material type or infection-control requirements.
  - All buildings consisting of older construction materials should be suspect, as they may include asbestos or lead paint (pre-1968 buildings).
  - Buildings with brick or cinderblock walls, or walls covered in plaster should be tested to see to what degree they will attenuate RF transmissions. Concrete walls can have a wide range of different propagation characteristics.
  - Retail store environments and warehouses can vary greatly. Both 2.4 GHz and 5 GHz frequencies can have difficulty penetrating walls, shelving, freezers, containers, and other typical obstructions in a retail setting. Different types of products affect signal more than others. A palette of milk or water will attenuate more signal than a palette of paper towels. Therefore, it is a best practice to perform “active” testing to measure how far signals travel at the desired frequencies.

- Any facility that you think will require external, directional antennas is automatically a complex deployment.
- Factory floors and other buildings with large amounts of metal machinery, especially robotic machinery that is in motion, certainly require onsite inspection and might benefit from an active survey.
- High-density deployments, such as lecture halls and auditoriums, require special attention. If you have a high-density deployment planed, consult the VRD for these deployments at http://www.arubanetworks.com/vrd.
- VisualRF Plan should be used to generate a basic foundation for planning, but it does not replace a physical site survey in these environments. These complex environments require an onsite survey to complete the planning. It is recommended to use VisualRF Plan in these situations only to estimate the AP count and placement to save time during testing.

Wireless RF Coverage Considerations and Questionnaire

Answers to these questions help you to determine the proper Aruba AP type, prepare for the site survey, and plan appropriately for the deployment.

- What 802.11 PHY types are required over the course of the WLAN lifecycle (802.11a/b/g/n)? Without a very good reason, it is safest to assume that 802.11n will be required.
- Which RF bands will be used (2.4 GHz, 5 GHz)? Without a very good reason, always plan to use both bands due to increases in client density.
- What channel width (20 MHz vs. 40 MHz) will be used in each band? Typically 20 MHz channels are used in 2.4 GHz, and 40 MHz channels are used in the 5 GHz band. In dense deployments, speed may be traded off for capacity in the 5 GHz band by reducing to a 20 MHz channel.
- Will voice over Wi-Fi be used? This answer will affect your planning for roaming and AP signal strength calculations.
- Will multicast video over Wi-Fi be used? Use of roaming video has a similar effect as voice.
- Will real-time location services (RTLS) be used? Consider deploying AMs around the building perimeter to help with location accuracy. This deployment ensures that all clients are within the triangulation zone.
- What is the minimum desired PHY-layer data traffic rate that must be available throughout the coverage area? Do some areas have different minimum data rate needs?
- What are the desired air monitoring rates? Are dedicated air monitors required for security or compliance purposes?
- How many devices will each user have? Today Aruba recommends that you plan for at least three devices per user: a laptop, a tablet, and a smartphone. The number of devices per user also has ramifications in the design of VLANs and subnets. Consider if all devices will be active simultaneously, which also impacts AP density.
- What is the maximum number of devices desired for each AP? Typically Aruba recommends 20-30 devices per radio (40-60 per dual-radio AP). This number may be more or less depending on traffic type (voice or data), offered load, and connection type (802.11a, b, g, or n).
- What applications will be in use at the site, both presently and in the future? Bandwidth requirements help determine coverage vs. capacity requirements.

- Are any floor plan images available? VisualRF Plan supports direct importation of JPEG, GIF, PNG, PDF, and CAD (.dwg and .dwf) files for floor plan formats.
- What is the maximum transmit power of the least-capable common device in the network?
- How many transmit, receive, and special streams do the most common devices support?
- If DFS channels are being considered, do the devices most commonly used in the network support DFS channels?

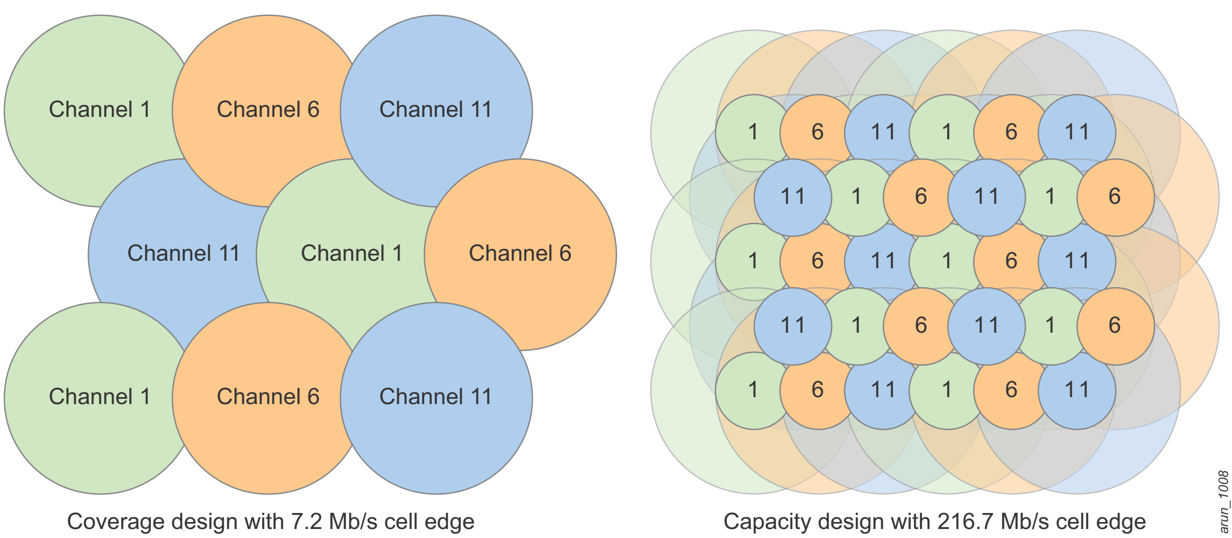
Determining the Deployment Model

It is critical that you select the correct deployment model based on the needs of the organization. There are three common indoor deployment models. The two models covered in this guide are based on capacity and coverage. The third model, high-density design, is covered in a separate VRD, *High-Density Wireless Networks for Auditoriums.*

In the cases described in this guide, Aruba recommends that you use adaptive radio management (ARM) to maintain channel and power settings and that you maximize client connectivity in the deployment. ARM is covered in the *Aruba 802.11n Networks VRD,* which is available with all of the VRD guides at http://www.arubanetworks.com/vrd.

Coverage vs. Capacity

Until the last few years, most wireless networks were deployed using a “coverage model” design. In a coverage model, the wireless designer uses fewer APs and tries to get as much range out of each one as possible. As a result, the average data rate delivered at ground level by the wireless network could be very low because those rates are able to travel the farthest due to some basic properties of radio communication. A low data rate in 2.4 GHz 802.11n is 7.2 Mb/s at the cell edges. This model worked well in the past because client devices required relatively low bandwidth for simple data applications.



Coverage design with 7.2 Mb/s cell edge

Capacity design with 216.7 Mb/s cell edge

Figure 3 Coverage and capacity

However, since approximately 2008, most new enterprise wireless LANs have been deployed using a “capacity model” approach. In this case, we use many more APs because our concern is ensuring that a minimum speed is available throughout the coverage area.

NOTE

Today, data and voice designs use a capacity approach. The primary difference between them is the choice of minimum data rate. Data-only deployments have less rigorous needs than voice deployments. For a full explanation of the data rates available see the *Aruba 802.11n Networks VRD.*

Capacity Model (High Bandwidth)

The capacity model is for dense deployments with high device counts and traffic rates. A capacity-based deployment might consist of APs placed roughly 45 to 60 feet (approx. 13.75 to 18.25 meters) apart running at 25-50% or 50-75% of power. In general, the transmit power of the AP should be set to match that of the least-capable device in the network. If the requirement is a “desk-top like” experience for employee laptops, where the employee can run multiple applications simultaneously, the site requires a capacity-based deployment. Aruba recommends capacity-based deployment for all office and education settings.

Coverage Model (Low Bandwidth)

The coverage model is for low-bandwidth deployments, coverage is required for applications such as a scanner solution or limited guest access. A coverage-based deployment might consist of APs placed roughly 70 to as much as 200 feet (approx. 30.5 to 61 meters) apart in an open space, running at 50-75% of power. If redundancy is not required, APs can run at 100% power, but this typically is not recommended. As an example, if the determined application is a scanning solution with minimal traffic, the site might be a good candidate for a coverage-based model. This deployment would consist of an AP installation base with clients that associate at greater distances and at lower traffic rates. This coverage model would mandate a ceiling deployment.

Aruba no longer recommends coverage-based deployments as networks that had very few clients previously are now seeing new services deployed.

Other Models

Two other models exist that are not covered in this guide: high-density and outdoor deployments. High-density deployments include large spaces where many devices will be present, such as lecture halls, libraries, and stadiums. Outdoor deployments cover a range of deployments including metro-mesh and point-to-point bridging. For both of these models, Aruba has published VRDs that are available on our public website at http://www.arubanetworks.com/vrd.

Ceiling or Wall Mounting

Indoor APs are typically deployed in one of two fashions: ceiling or wall mounted. Aruba recommends against desk or cubicle mounts. These locations typically do not allow for a clear line-of-sight throughout the coverage area, which in turn can reduce WLAN performance.

- **Ceiling deployments:** The majority of modern WLAN deployments are at the ceiling level. A ceiling deployment can occur at or below the level of the ceiling material. In general, it is not recommended to mount APs above any type of ceiling material, especially suspended or “false” ceilings. There are two good reasons for this. First, many ceiling tiles contain materials or metallic backing that can greatly reduce signal quality. The second reason is that the space above the ceiling is full of fixtures, air conditioning ducts, pipes, conduits, and other normal mechanical items. These items directly obstruct signal and can harm the user experience.

- **Wall deployments:** Wall deployments are not as common as ceiling deployments, but are often found in hotels and dormitory rooms. Walls are a common deployment location for large spaces such as lecture halls because reaching the ceiling is difficult. Wall deployments may also be preferable in areas with a hard ceiling where cabling cannot be run. If you are not using the Aruba AP-93H, which was designed for wall mounting, consider the antenna pattern before you deploy wall-mounted APs.

NOTE

A third mounting option is a “pico cell” design with the APs mounted below floor level. This design is used as part of a high-density network, and is covered in the *High-Density Wireless Networks for Auditoriums* VRD.

Upgrading from an Existing 802.11abg Network to 802.11n

The vast majority of customers that deployed wireless LANs based on 802.11a/b/g technologies are currently going through a refresh cycle to transition to 802.11n. One of the most common questions Aruba receives is “why can’t I just replace all of my existing APs with new APs?”. The answer is that it depends on the original AP density and the types of applications and devices that are expected to use the new network. This section describes the pros and cons of various upgrade methodologies.

1-for-1 AP Replacement

In a 1-for-1 AP replacement scenario, the older 802.11a/b/g APs are replaced with an 802.11n AP with no changes to AP quantity or placement. The problem with this model is that often the legacy deployment was designed in a coverage model based on 2.4 GHz. Because 2.4 GHz signals travel approximately twice as far as 5 GHz signals, this model is unsuitable for deploying a 5 GHz network. The resulting network will have “islands” of 5 GHz coverage and slower client connections on that band. Without complete 5 GHz coverage, advanced ARM tools such as band steering cannot be as effective at moving clients. Networks deployed with 802.11n in this model should expect the roughly the same performance at the AP coverage edge as their legacy network.

When a 1-for-1 AP replacement is proposed, Aruba recommends that a new, virtual survey be performed with VisualRF Plan and compared with the current deployment. The new survey provides a comparison of the current deployment to a more optimal 802.11n network in the same space. To determine if 1-for-1 replacement is viable, see the flowchart in Figure 4. A new plan may be required.

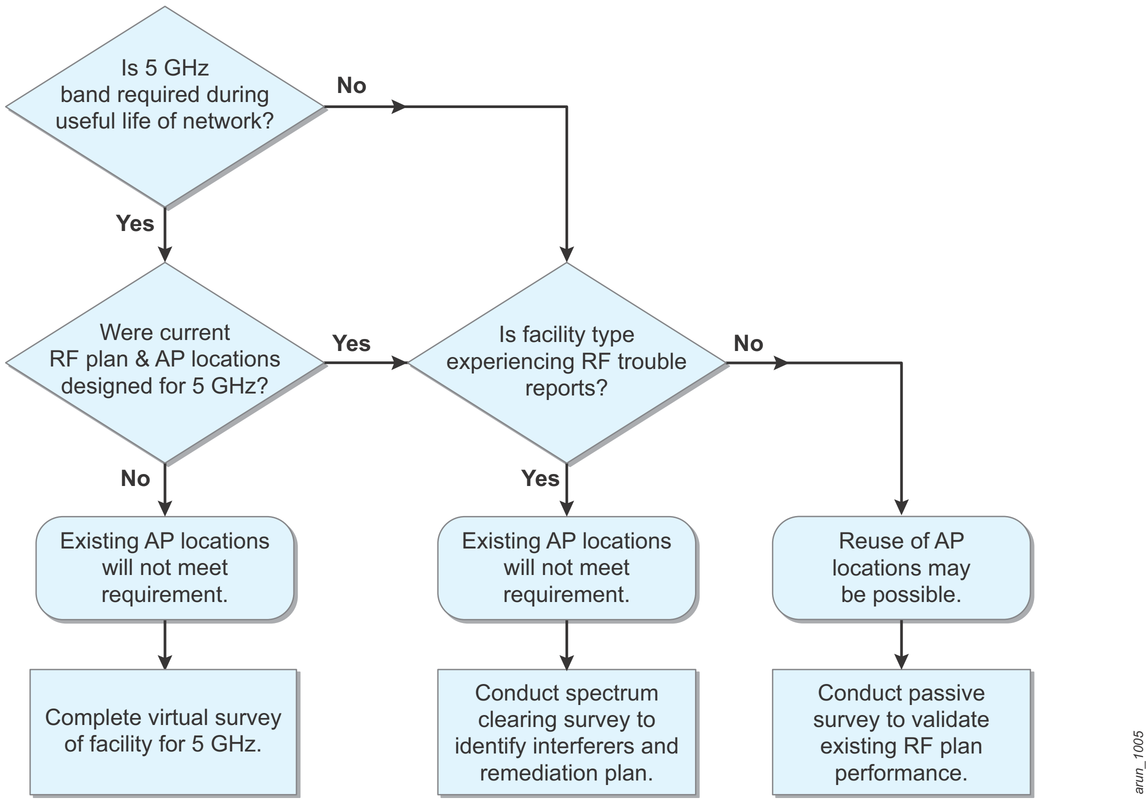


Figure 4 AP location reuse decision tree

Mixing 802.11n and 802.11a/b/g APs

In some deployments, 802.11n APs will be rolled out in phases. In the past, some organizations have chosen to deploy mixed environments with the newer 802.11n APs mixed with legacy 802.11 a/b/g APs.

Aruba strongly recommends against this practice because numerous issues with client behavior related to device roaming have been observed.

As most clients move through the network, they expect to see the same channel width and modulation types in use. Roaming from an 802.11n 40 MHz channel to an 802.11a 20 MHz channel causes some devices to become "stuck" to the higher speed AP. In some cases, devices disconnect themselves from the network, which requires manual intervention by the user.

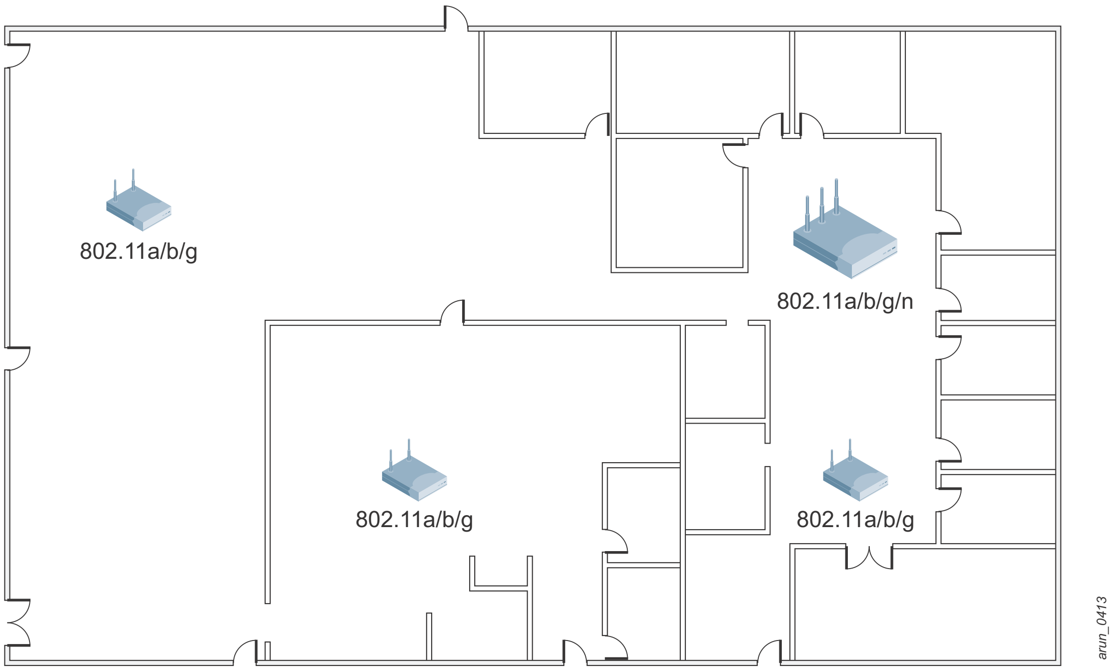


Figure 5   Mixing 802.11a/b/g and 802.11n APs

When you must take a phased approach to 802.11n deployment, Aruba recommends that you completely upgrade one floor or building at a time with new APs. This approach gives devices in that area the best chance of remaining connected to the network and provides a better user experience.

Multi-floor Deployments

In a building with multiple floors, the network engineer must stagger APs both on the floor and between floors. If APs are installed in a line directly above one another, ARM will reduce power to limit co-channel interference (CCI) and adjacent channel interference (ACI). The reduced power means reduced coverage. (See Figure 6.)

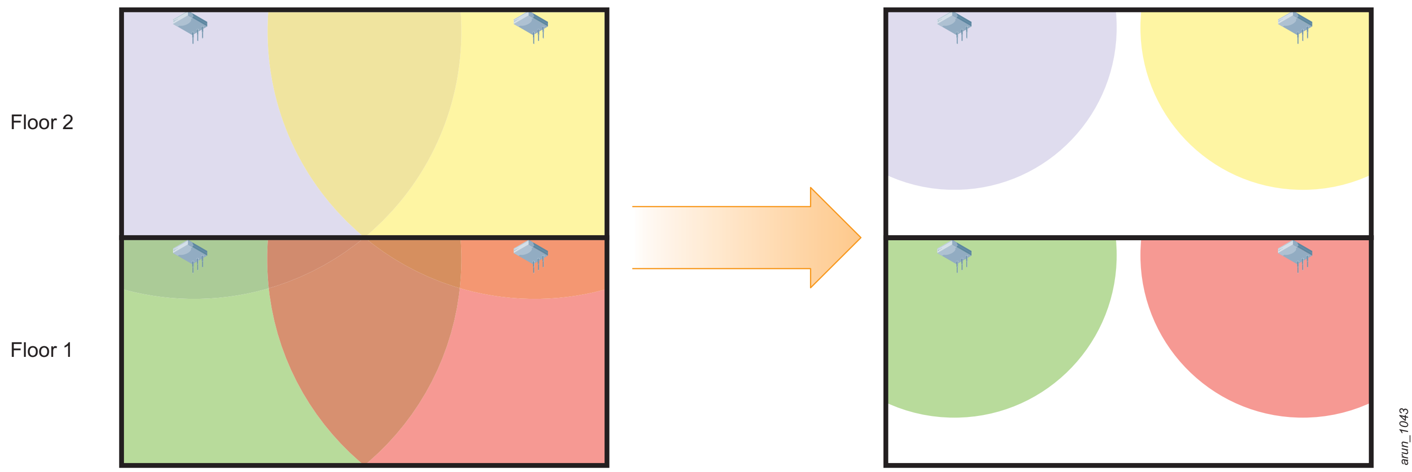


Figure 6 APs installed in a line above one another

Aruba recommends that you stagger the location of APs so that APs on adjacent floors are not vertically aligned with one another, in a three dimensional checkerboard pattern. (See Figure 7.)

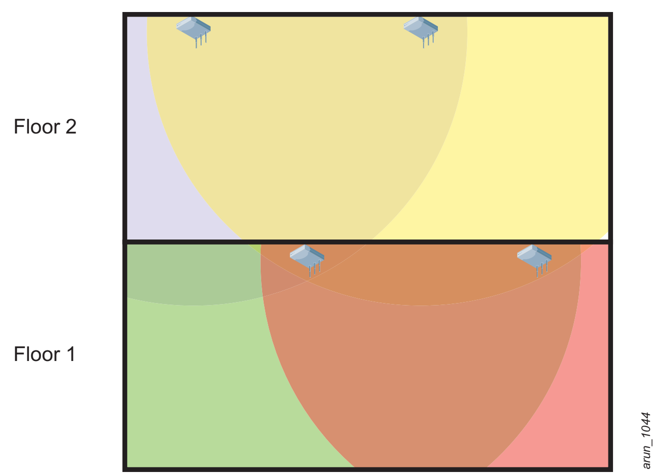


Figure 7 Staggering APs between floors

Hallway Deployments

Deployments that have APs located down the length of a hallway are often found in hotels and dormitory rooms. The idea behind this method is that the APs in the hallway can provide coverage to rooms on either side of the hallway. These APs are often placed physically close to one another due to the density of the rooms.

However, this type of deployment usually creates a lot of problems and dissatisfied users. One reason is that the hallway building materials absorb significant signal, which results in poor in-room performance. Another problem is that the APs have clear line-of-site to one another, which increases co-channel interference (CCI) and adjacent-channel interference (ACI), which results in lower throughput for users. Similar to the multi-floor deployment, the hallways are stacked vertically. This arrangement leads to additional multi-floor interference as described in the previous section. This interference causes ARM to reduce power, which exacerbates the coverage challenge in the rooms. (See Figure 8.)

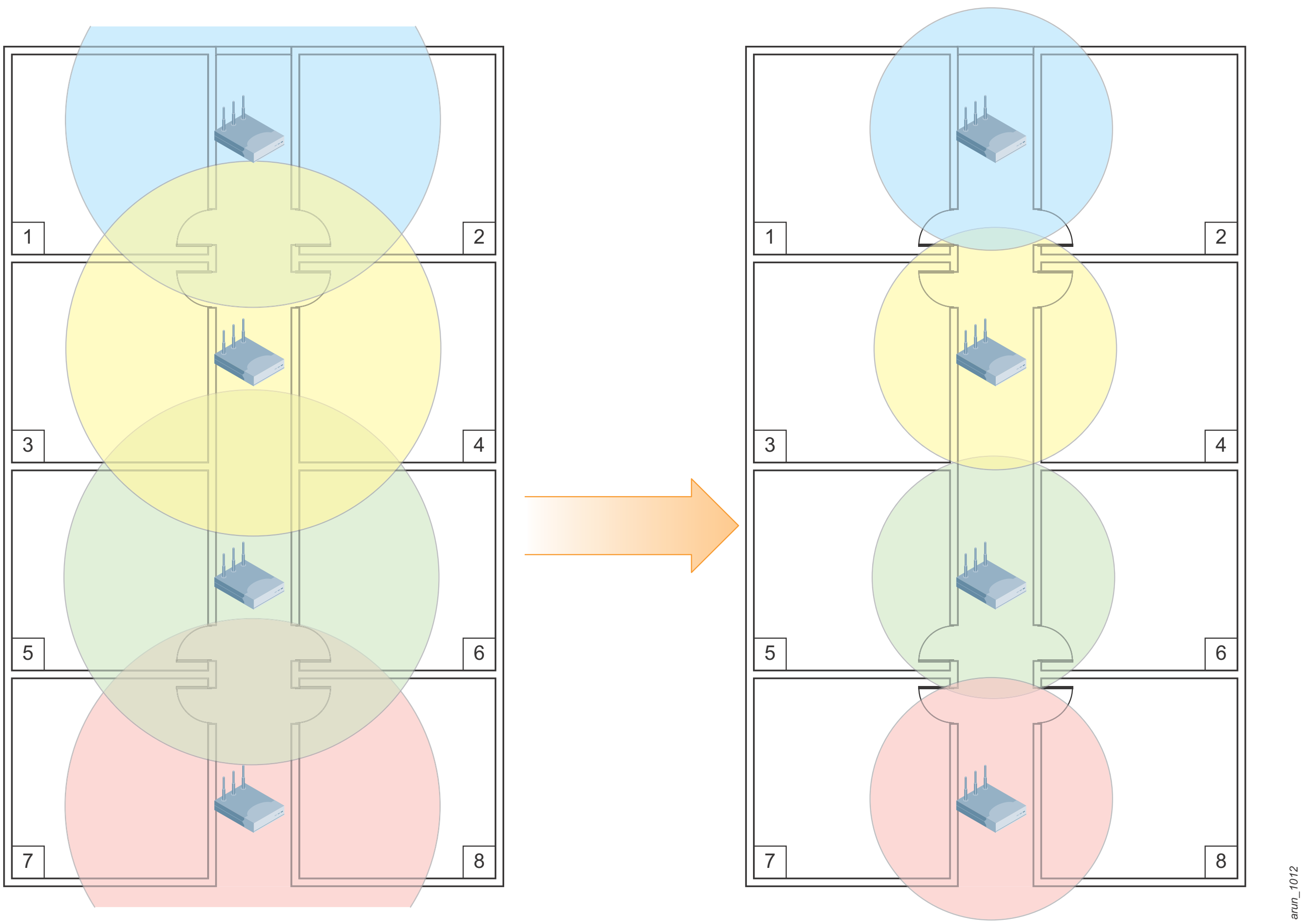


Figure 8 APs in a hallway deployment

Instead of trying to use hallway APs at high power to cover users through a wall, Aruba recommends using many room APs at low power to cover the user space directly. Depending on how much attenuation the building presents, you will put an AP in every 1, 2, or 3 rooms. You will stagger APs inside of rooms on either side of the hallway and vertically. On one floor, install an AP in every other room, and APs should not be placed in rooms directly across the hall from one another. (See Figure 9.)

In addition, from a three-dimensional perspective, Aruba recommends that you also stagger APs vertically. On the next floor, place the APs in the same manner, but the rooms should be reversed. So, the room on floor 1 that has an AP does not have an AP on floor 2, and so on. Depending on deployment requirements, the AP-93H wall box AP can be a good solution for this deployment model. Place the APs against the back wall and point them toward the hallway.

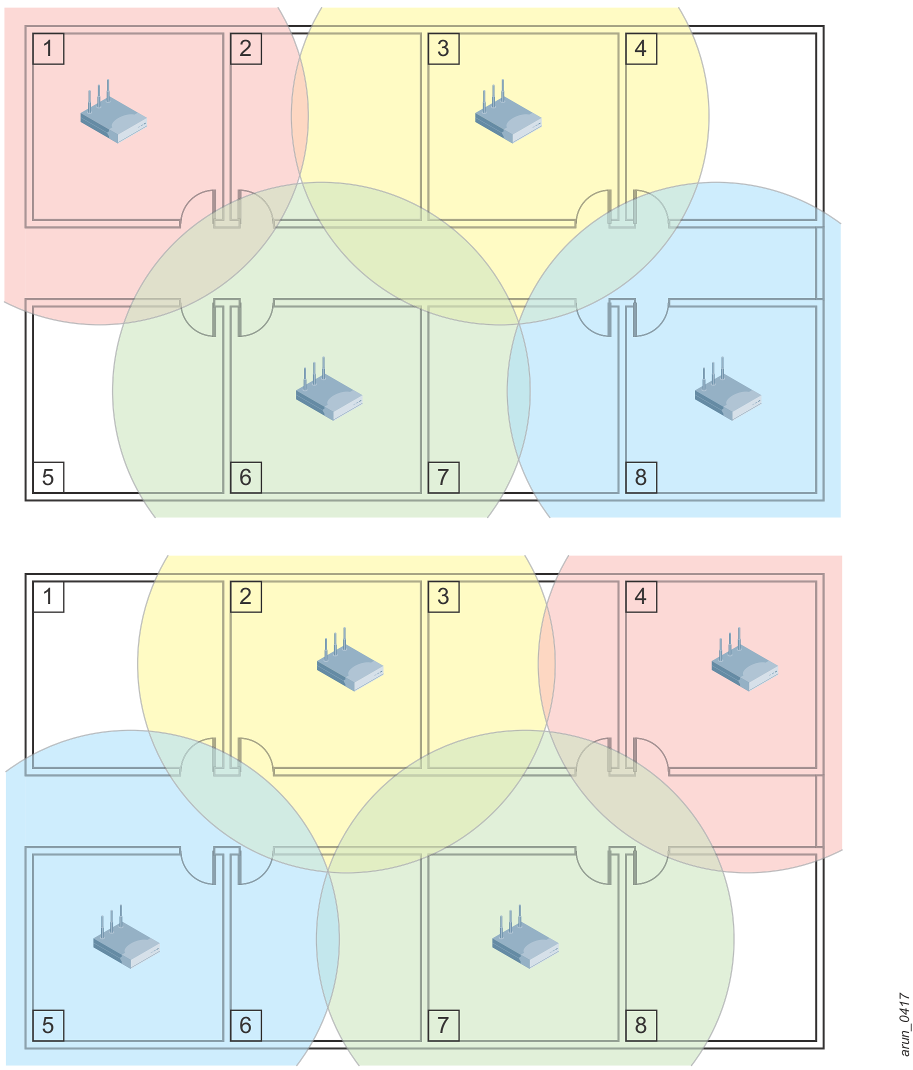


Figure 9 APs deployed in rooms

Chapter 4: Access Point and Antenna Selection

For optimal performance of your wireless network, you must understand the purpose behind proper AP and antenna selection. Choose the correct AP and antenna type to ensure that application and band requirements are met and that RF energy is directed to the correct coverage areas.

AP and Antenna Selection Process

The flow chart in Figure 10 shows the high-level process to select the appropriate AP for the deployment. Some choices, such as using only 2.4 GHz-capable APs, have substantial impact on the flexibility of future deployments and should not be made lightly. The following sections describe each of the decision points and the trade-offs that are made. It is important to fully understand the implications of the chart before you select an AP. The AP selection process uses the flow chart in Figure 10.

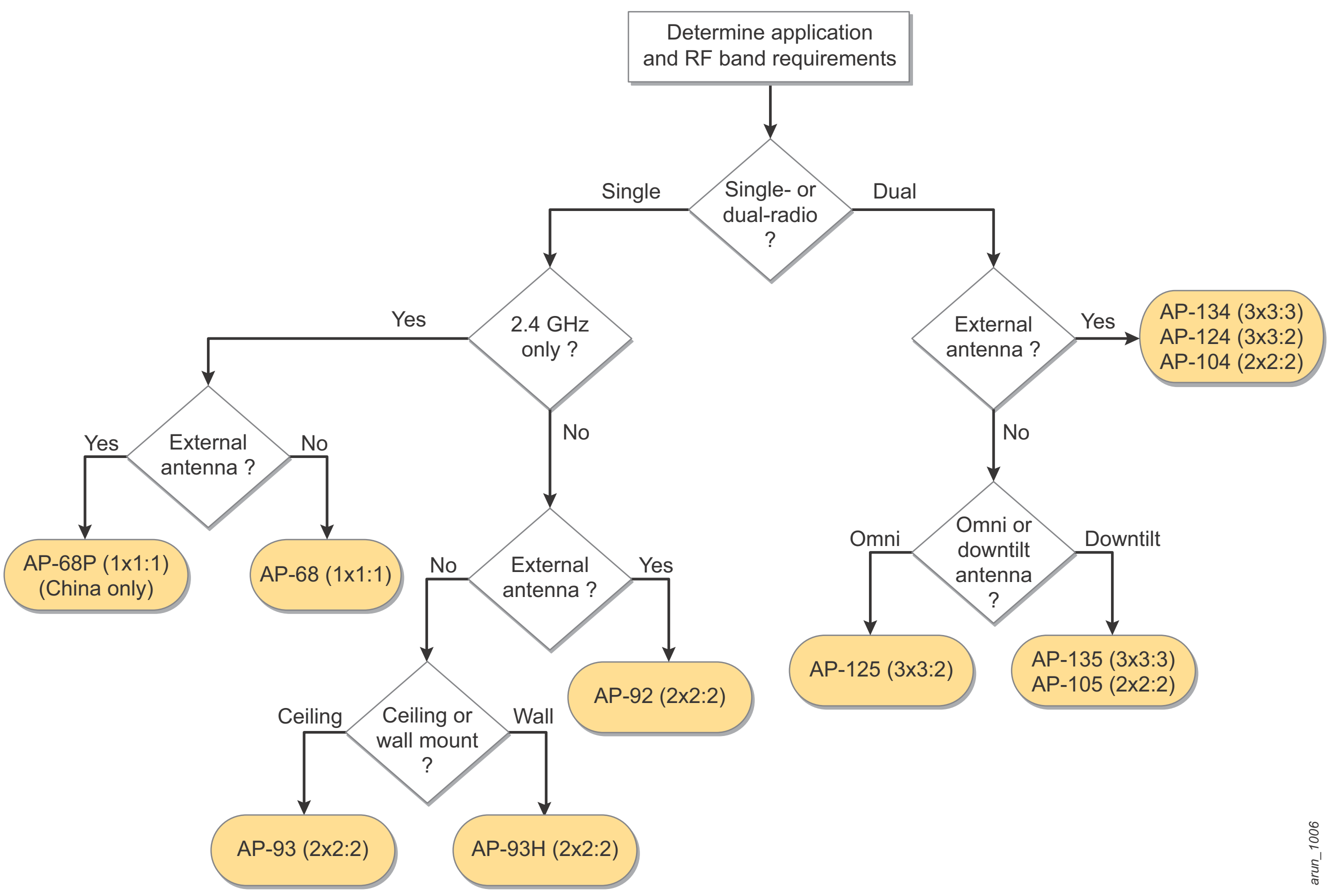


Figure 10 AP selection process

Single- or Dual-Radio APs

Starting at the top of the decision tree, the first selection to make is whether to use single- or dual-radio APs. Consider over the lifetime of this deployment, typically 4-7 years, what types of devices and device counts the AP will be expected to handle. In most cases, device counts are increasing, with a mix of clients that are often dual-band capable.

In a capacity-based deployment, you should always choose a dual-radio AP. The additional radio allows you to balance clients between 2.4 GHz and 5 GHz bands with features such as band steering, and it doubles the density of clients that can be served in a given location.

Single-radio APs are appropriate for low-density deployments and to act as air monitors. If you are selecting a single-radio AP as an air monitor, you should only select a dual-band capable AP because they are capable of scanning the 2.4 GHz and 5 GHz bands.

APs that support only 2.4 GHz should be selected only after very careful evaluation. They are limited by both their ability to access only a single band and the fact that bonded 40 MHz channels are not available, which limits the maximum PHY data rate to 135 Mb/s. Use these APs primarily for countries in the Asia-Pacific and Middle-East regions, which do not allow the use of the 5 GHz band. 2.4 GHz only APs are not appropriate for any environment where 5 GHz scanning is required, such as to meet the payment card industry (PCI) scanning requirement. Before you consider using these APs, take some time to evaluate the capacity you are planning and the use cases for the network.

Radio Count and Stream Count

Each AP in Figure 10 also lists its radio and spatial stream count in the format of:

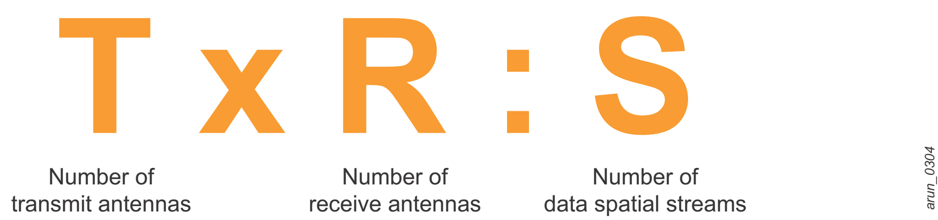


Figure 11 Radio characteristics

In general terms, more radios lead to more spatial streams being available, though it is not always a 1-1 mapping as in the case of the AP-125. The more spatial streams you have, the higher the data throughput that can be transmitted to client devices, assuming they have the same capability. As newer laptops enter the market, 3x3:3 is becoming common in mid-range models. Older laptops will vary in their radio and spatial stream count. Most tablets today are 1x1:1 devices.

If the 802.11n data rates and spatial stream terminology is new to you, it is strongly recommended that you also read the *Aruba 802.11n Networks Validated Reference Design (Version 8)*. This guide covers indoor 802.11n WLANs and is considered part of the foundation guides within the VRD core technologies series. This guide describes 802.11n technology and differences in 802.11n and 802.11a/b/g functionality.

Internal or External Antennas

For many deployments, ceiling mounted down-tilt antennas are the appropriate choice. These APs can be mounted on ceiling rails and they cover the floor below. For deployments where the APs need to be above the plenum for aesthetic reasons, external antennas may be an appropriate choice. This is especially true if the ceiling material is an RF absorber or reflector. External antennas also allow for the use of directional antennas in a challenging environment such as a warehouse.

Application and RF Band Requirements

Application usage and RF band requirements are the most important factors to consider when you select the proper AP for the deployment. It is critically important to understand the application and the types of devices that will be used to connect to the network.

Application Requirements

You must consider current and future applications that may be deployed. Today, the network may need to support only data applications that are used to run the business. However, in the future the network may need to support voice or multicast video delivery. To begin to understand the data requirements, you must understand the application requirements and define the expected use cases. Consider these items:

- Application type and average bandwidth
- Tolerance to latency, jitter, and delay
- Requirements for traffic prioritization
- Data streaming rates
- Average file transfer sizes and frequency

Some application requirements will be easy to deal with, such as email and web browsing. However, others, such as voice and multicast video, require special planning. Closely examine any custom applications to ensure a smooth transition.

RF Band Requirements

RF channels are another major decision point and they are related to the decision of whether to use single- or dual-radio APs. Understanding which RF bands are available in a particular country and the applications in use often influences that decision. RF bands matter most where a decision needs to be made between single- or dual-radio APs. In a single-radio model, each AP can serve clients on only one RF band (2.4 or 5 GHz) at a time. In a dual-radio model, both bands can be used.

Single-radio operation can be appropriate for some organizations that will only use devices that operate on one band. Examples include scanner guns, game consoles, digital video recorders, or single-mode voice handsets that are capable of supporting only the 2.4 GHz band. Dual-band capable single-radio APs also make excellent air monitors, where the AP can scan both channels. It is not uncommon to deploy dual-radio APs to serve clients and also deploy single-radio APs as full-time AMs to scan the network environment.

In other cases, user density and application types require that as much bandwidth as possible should be available to devices and applications. Some plans call for explicitly separating applications on different bands, such as having voice run on 2.4 GHz while data and video run on 5 GHz. These cases are the most common in a campus, dense user environments, or large branch deployment, where dual-radio APs are deployed.

2.4 GHz Only vs. Dual-Band Capable APs

Whether you are using a coverage or capacity approach, the rules for AP spacing are very different for 2.4 GHz vs. 5 GHz frequency radios. As the frequency increases, the distance at which a signal can be heard decreases, assuming a constant output power. On average, for any given data rate, 2.4 GHz signals travel twice as far as 5 GHz signals. This means that many more APs are required in 5 GHz to provide a level of service comparable to that experienced in a 2.4 GHz system.

In exchange for the higher density requirement, the 5 GHz spectrum offers many more channels and generally less congestion than the 2.4 GHz airspace. Bonded 40MHz channels that allow the full 300 Mb/s or 450 Mb/s data rates are possible only in 5 GHz. The 2.4 GHz airspace is shared with Bluetooth headsets, frequency-hopping (FH) devices, APs in neighboring locations, and wireless hotspots for customers. By moving to the 5 GHz band, users may need more APs, but the quality and reliability of voice and data communications increases significantly. Figure 12 shows the difference in speeds and range in an idealized model. Real world performance and 802.11n modulation and coding scheme (MCS) rates may vary for reasons beyond signal strength.

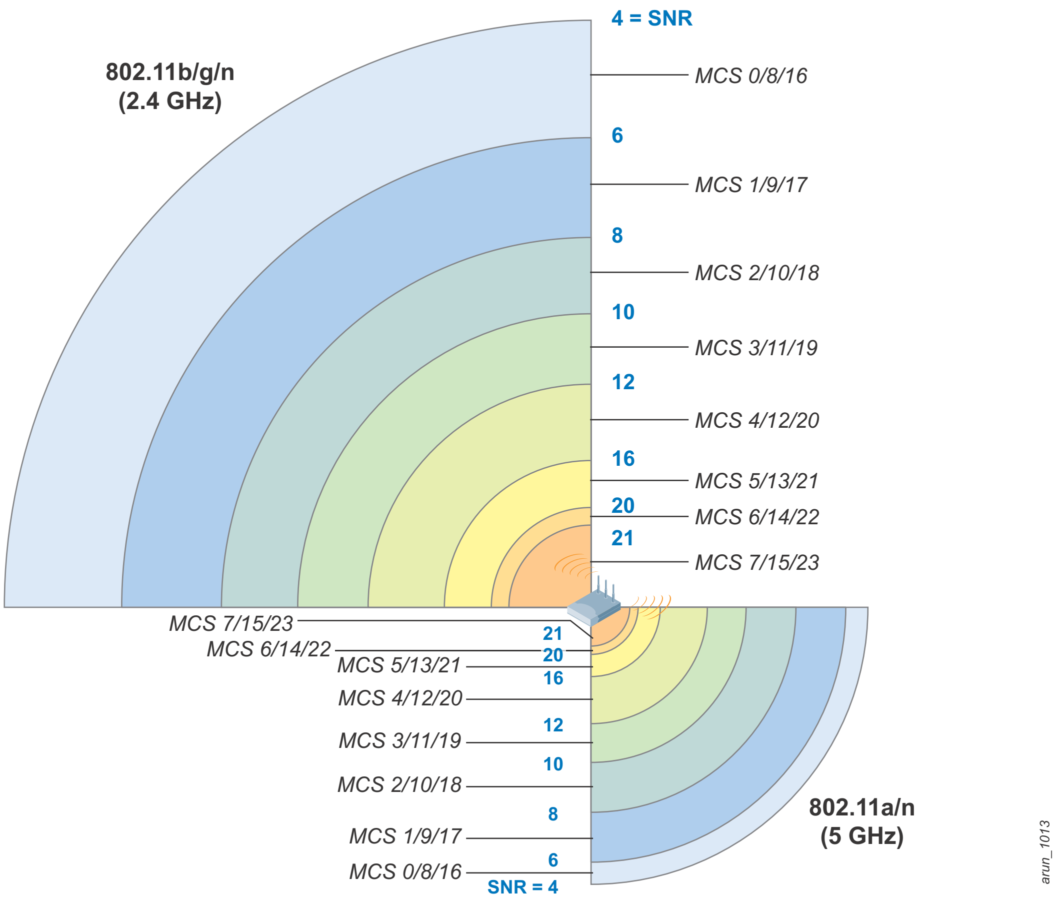


Figure 12 Cell radius varies with data rate and transmission frequency

When dual-band APs will be used, the coverage area must be planned for a 5 GHz AP density. This will result in an oversubscription in the 2.4 GHz band, which ARM can account for by adjusting transmit power. In general, each non-overlapping AP serves no more than 5,000 square feet, and usually much less if a capacity model is being deployed.

Internal vs. External Antennas

For optimal performance of the wireless network, it is critical to understand the purpose behind proper antenna selection. The correct antenna type will ensure that RF energy is being directed to the correct coverage areas. In some instances, the built-in omnidirectional or down-tilt antennas are not the correct choice for a deployment. For aesthetic reasons, the AP may need to be hidden from view. Or the nature of the connection may dictate that an omnidirectional antenna is not the correct choice. Aruba sells a wide variety of antennas to suite various deployment needs. For a complete, detailed view of the Aruba antenna line, see the antenna line matrix that is available on the VRD page: http://www.arubanetworks.com/vrd.

Omnidirectional and Directional Antennas

Omnidirectional antennas provide equal coverage in all directions, and directional antennas are engineered to deliver RF energy in a beam with a specific width and height measured in degrees. Integral, omnidirectional antennas provide low-gain performance over the entire frequency band that the AP supports (typically between 3 dBi and 5 dBi). Detachable antennas, omnidirectional or directional, are selected when a higher level of gain is required in a specific direction or for more aesthetic reasons. In Figure 13, an omnidirectional antenna has coverage that radiates in all directions compared with a directional antenna that radiates only in a narrow field.

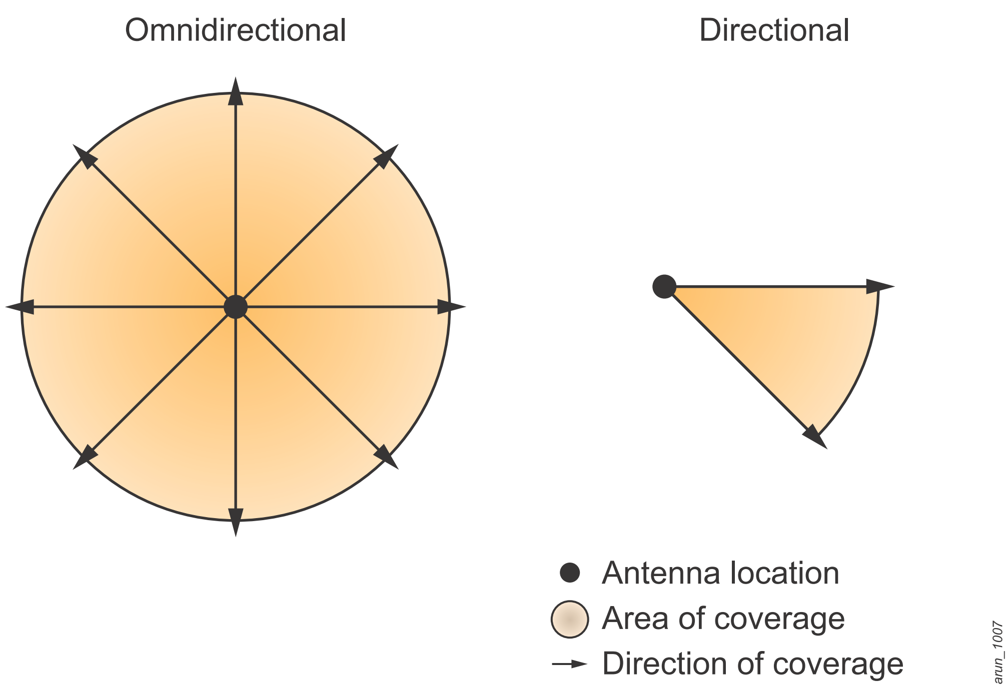


Figure 13 Omnidirectional vs. directional antennas

Aruba has standardized on a special type of omnidirectional antenna that is used in our indoor product models that feature integrated antennas. It has what is called a “squint” or “down-tilt” pattern, which is a combination of a directional and an omnidirectional antenna. It is omnidirectional in the horizontal plane, providing a full 360 degrees of coverage. And it is directional in the vertical plane, optimized to provide coverage from a ceiling mount with very little energy directed behind the AP. You can visualize this in Figure 14. The AP-93H is built to be mounted into a wall box and provides coverage for a room using a similar antenna pattern as shown in Figure 15.

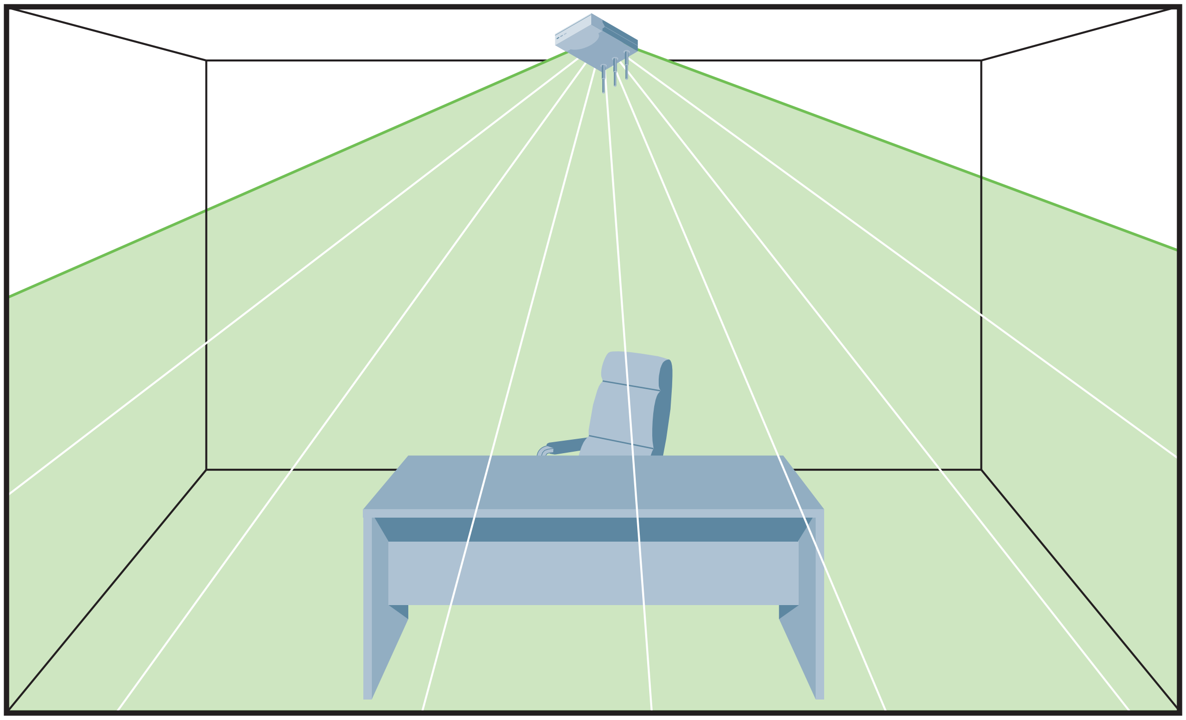

arun_1014

Figure 14 Ceiling coverage from Aruba AP with integrated down-tilt antenna

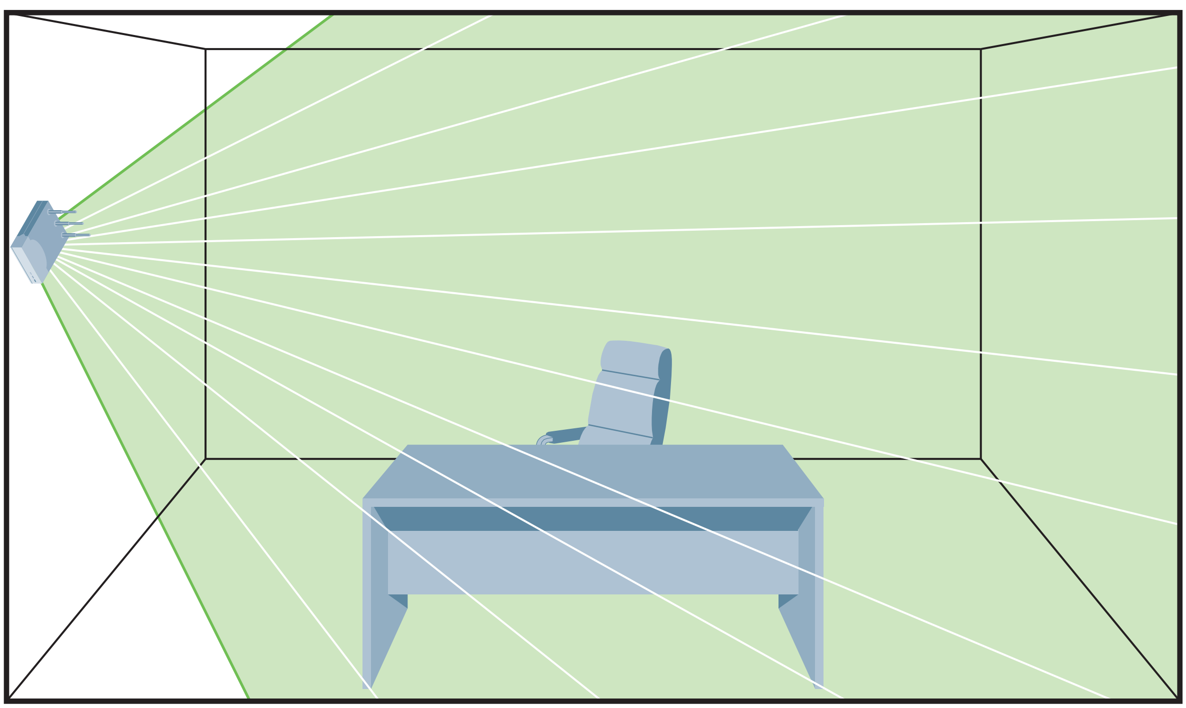

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Figure 15 Wall-mounted AP with integrated directional antenna

Antenna Beamwidth, Pattern, and Gain Considerations

Antenna gain is a relative measure of how the antenna compares to an ideal isotropic radiator. An ideal isotropic radiator would radiate power in all directions equally over a sphere, such as the sun. The relationship between gain, power, and propagation distance is detailed already in textbooks and those expressions are not repeated here. Aruba recommends the CWNP series of books for engineers looking for a solid foundation in Wi-Fi networking concepts, http://www.cwnp.com.

Antenna gain often is confused with power gain in amplifiers. However, it is important to note that antenna gain makes the power of a transmitter greater than would be predicted by calculation of the power fed to the antenna and then spread equally over a sphere. Antenna gain itself is a completely passive and bidirectional property that is determined only by the shape and construction of the antenna.

Gain is only a comparison of the apparent power to the power that would be required if fed to an ideal isotropic antenna. Gain can only be created by distorting the antenna pattern from the ideal spherical pattern. Think of this as focusing the same power that would normally distribute evenly over a sphere into a tighter region of band. Thus, the higher the gain, the more concentrated the antenna pattern must be to achieve that gain.

To visualize the concept of gain, picture a rubber ball. The surface area of the ball represents the total available power radiated by an ideal isotropic antenna over its sphere of radiation. (See Figure 16.)

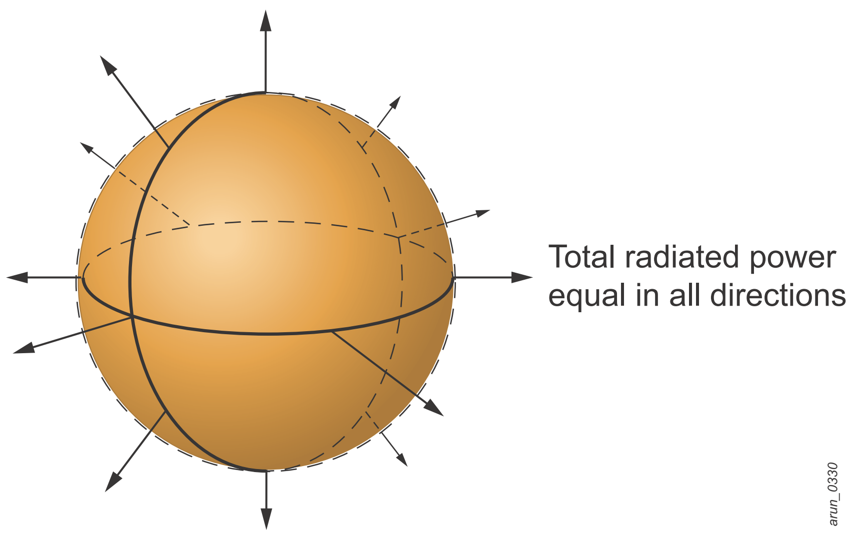

Figure 16 Equal signal strength radiated in all directions

The ball is not the most efficient way to provide network access on a horizontal floor. One way is to press down on the top of the ball and squash it down vertically. The same basic shape is kept in the horizontal plane (round), but the ball is forced to compress in the vertical plane to create a donut shape. (See Figure 17.) This example represents the concept of the high-gain, omnidirectional antenna, which achieves a greater coverage distance in the horizontal direction at the expense of coverage in the vertical areas of the radiating sphere.

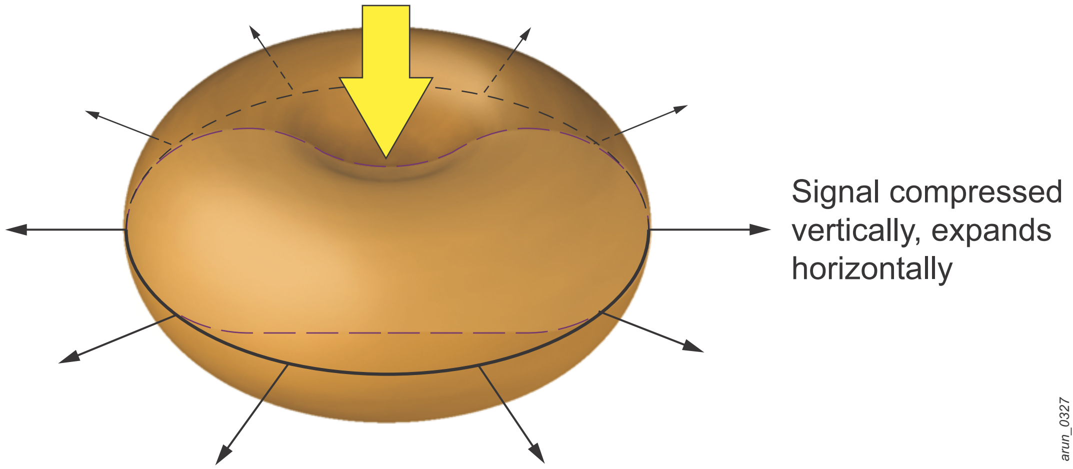

Figure 17 High-gain omnidirectional antenna

To stretch the ball primarily in one direction (instead of in all directions), force must be used to push the ball vertically and horizontally, on the sides and on the back, to force the ball to deform in a single direction. This action significantly distorts the shape of the original ball horizontally and vertically, allowing it to stretch in a single direction. (See Figure 18.) This example represents the concept of the high-gain directional antenna, which is designed to compress the entire radiating sphere into a single predominate direction.

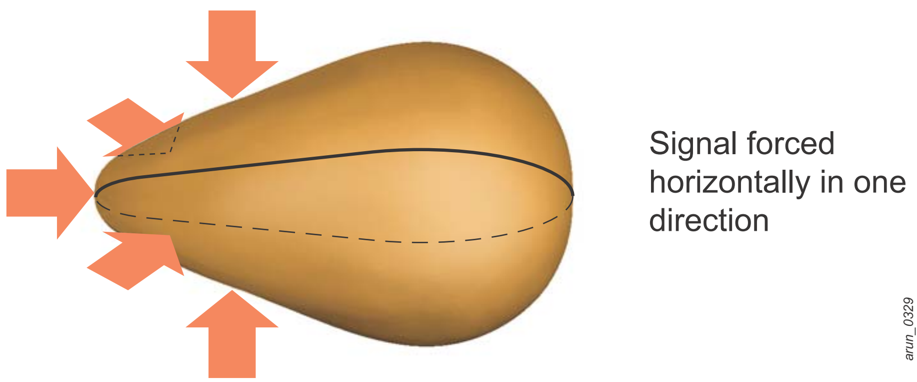

Figure 18 High-gain directional antenna

NOTE

Gain is created by forcing transmitted power to radiate in a preferred direction rather than radiating in all directions of an ideal sphere. Therefore, a high-gain signal always is accompanied by loss of available signal in some other portion of the ideal sphere. High-gain directional antennas are ideal for sites that require directed coverage in a specific area or in an extended range for bridging applications. They are not suited for sites that require uniform coverage in large areas. Remember that vertical and horizontal coverage can be affected by the use of a higher-gain antenna, and beamwidth (a measure of coverage) is always inversely related to gain.

Understanding Antenna Pattern Plots and Specifications

Traditional two-dimensional (2-D) pattern plots and beamwidth specifications require one to use some imagination because they provide only a snapshot of the information in two planes. These two planes are often referred to as the azimuth (H-plane or horizontal) and elevation (E-plane or vertical) planes. The azimuth view is considered to be the view from directly above, which views the antenna pattern on the horizontal plane. The elevation view is considered to be a side view, which views the antenna pattern on the vertical plane. It is helpful to think of these planes as “slices” of the real antenna pattern, which is actually three dimensional (3-D). Figure 19 illustrates where these “cuts” are located for a typical omnidirectional antenna pattern.

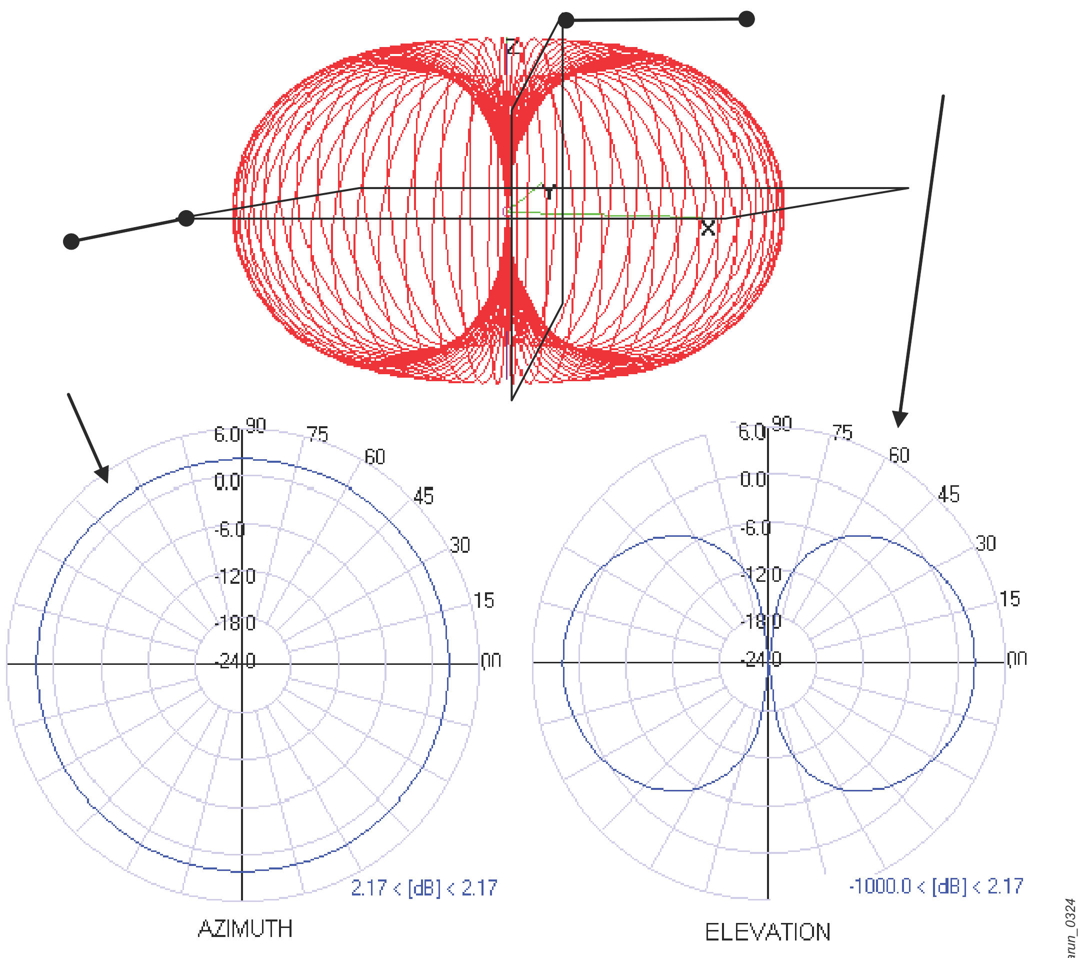

Figure 19 Antenna pattern conventions (omnidirectional pattern shown)

The antenna shown in Figure 19 is commonly referred to as the dipole pattern because it is produced by an ideal dipole antenna. The gain of this antenna is 2.17 dB, which is achieved by compression in the vertical plane (elevation) compared to the ideal sphere. To refer to the true 3-D pattern, this compression is sometimes called the donut shape. (See Figure 20.)

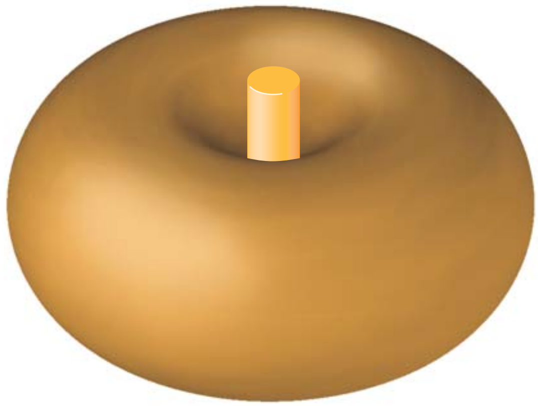

Figure 20 Donut shape compression of an omnidirectional antenna

It is evident from these figures that the 2-D pattern plots that are typically provided in antenna specifications are a simplification of the real 3-D situation. Often, 2-D plots are reduced even further to a set of simple specifications based on the antenna gain and 3 dB beamwidth.

Detachable Antenna Selection

If the AP supports detachable antennas, select the correct antenna type to support the required frequency band (2.4 GHz or 5 GHz) and desired coverage pattern.

To select the correct antenna type for the deployment, download and read the antenna product matrix. A link is available from the VRD site at http://www.arubanetworks.com/vrd.

Detachable Indoor Antenna Types

If you are new to external antennas, some of the terminology used in the Aruba antenna specifications may be imposing at first. But you will become comfortable with the terms soon because many of them are determined by the vertical or horizontal beamwidth. These are some of the terms used to describe the Aruba detachable antenna offerings:

- **down-tilt:** An omnidirectional antenna that focuses its energy downward (perpendicular to ground). Used for ceiling deployments in dense areas or in areas with high ceilings, such as manufacturing or warehouse environments.
- **sector/patch/panel:** A directional antenna that provides coverage of a focused area (or "sector"), typically parallel to the ground. Common indoor examples are 60 degree, 90 degree, and 120 degrees).

Detachable Antenna Selection Tips

- If you want omnidirectional coverage but you want a higher gain than the integral antenna supports, select one of the Aruba detachable antennas with high-gain, omnidirectional coverage.
- If the application type is air monitoring with a single-radio AP, the detachable antenna must be able to support the required frequency bands (2.4 GHz and/or 5 GHz). If multiband support is required, the antenna must be multiband-capable. (AP-ANT-1B and AP-ANT-19 are the only detachable antennas capable of omnidirectional, multiband support.)
- If a directional antenna is needed to direct RF coverage, it must be able to support all of the frequency bands that require support (2.4 GHz and/or 5 GHz).

Aruba APs

Table 1 summarizes the available Aruba indoor APs. More detailed information is available in the *access point product line matrix* available at: http://www.arubanetworks.com/vrd. The AP-134 and AP-135 feature dual 10/100/1000BASE-T Ethernet interfaces and operate from standard 802.3af and 802.3at power-over-Ethernet (PoE) sources. The secondary Ethernet interface (active only when supplying 802.3at PoE or DC power to the AP) enables secure authorized backhaul for wired network-attached devices.

Table 1 AP Features and Functions

AP Model	Radios	RF Band	802.11	TxR:S	Antenna Type	Power	Ports
AP-135	2	2.4 & 5 GHz	a/b/g/n	3x3:3	Internal omnidirectional down-tilt antenna	802.3af or 802.3at PoE or external power supply	2
AP-134	2	2.4 & 5 GHz	a/b/g/n	3x3:3	External antennas	802.3af or 802.3at PoE or external power supply	2
AP-125	2	2.4 & 5 GHz	a/b/g/n	3x3:2	Internal omnidirectional antenna	802.3af or 802.3at PoE or external power supply	2
AP-124	2	2.4 & 5 GHz	a/b/g/n	3x3:2	External antennas	802.3af or 802.3at PoE or external power supply	2
AP-105	2	2.4 & 5 GHz	a/b/g/n	2x2:2	Internal omnidirectional down-tilt antenna	802.3af PoE or external power supply	1
AP-104	2	2.4 & 5 GHz	a/b/g/n	2x2:2	External antennas	802.3af PoE or external power supply	1
AP-93H	1	2.4 & 5 GHz	a/b/g/n	2x2:2	Internal omnidirectional down-tilt antenna optimized for wall mounting	802.3af PoE or external power supply	1 uplink, 4-port access switch, 1 pass-through port

Table 1 AP Features and Functions (Continued)

AP Model	Radios	RF Band	802.11	TxR:S	Antenna Type	Power	Ports
AP-93	1	2.4 & 5 GHz	a/b/g/n	2x2:2	Internal omnidirectional down-tilt antenna	802.3af PoE or external power supply	1
AP-92	1	2.4 & 5 GHz	a/b/g/n	2x2:2	External antennas	802.3af PoE or external power supply	1
AP-68P (China only)	1	2.4 GHz	b/g/n	1x1:1	External antennas	802.3af PoE or external power supply	1
AP-68	1	2.4 GHz	b/g/n	1x1:1	Internal omnidirectional antenna	802.3af PoE or external power supply	1
RAP-5WN	1	2.4 & 5 GHz	a/b/g/n	3x3:2	Internal omnidirectional antenna	External power supply	5
RAP-2WG	1	2.4 GHz	b/g	N/A	Included external antenna only	External power supply	2

Chapter 5: Example Facility

This chapter shows how a real Aruba indoor test facility was planned using both VisualRF Plan and a traditional site survey. The test facility is shown in Figure 21. This facility is used primarily by the Aruba technical marketing team to test products in larger scale environments. This floor plan is a typical open floor plan that consists of large numbers of cubicles and a limited number of offices and meeting rooms. Using the Environmental Assessment process explained in Chapter 3: Environmental Evaluation, we would assign this a low complexity status. This type of floor plan is ideal for software-based planning.

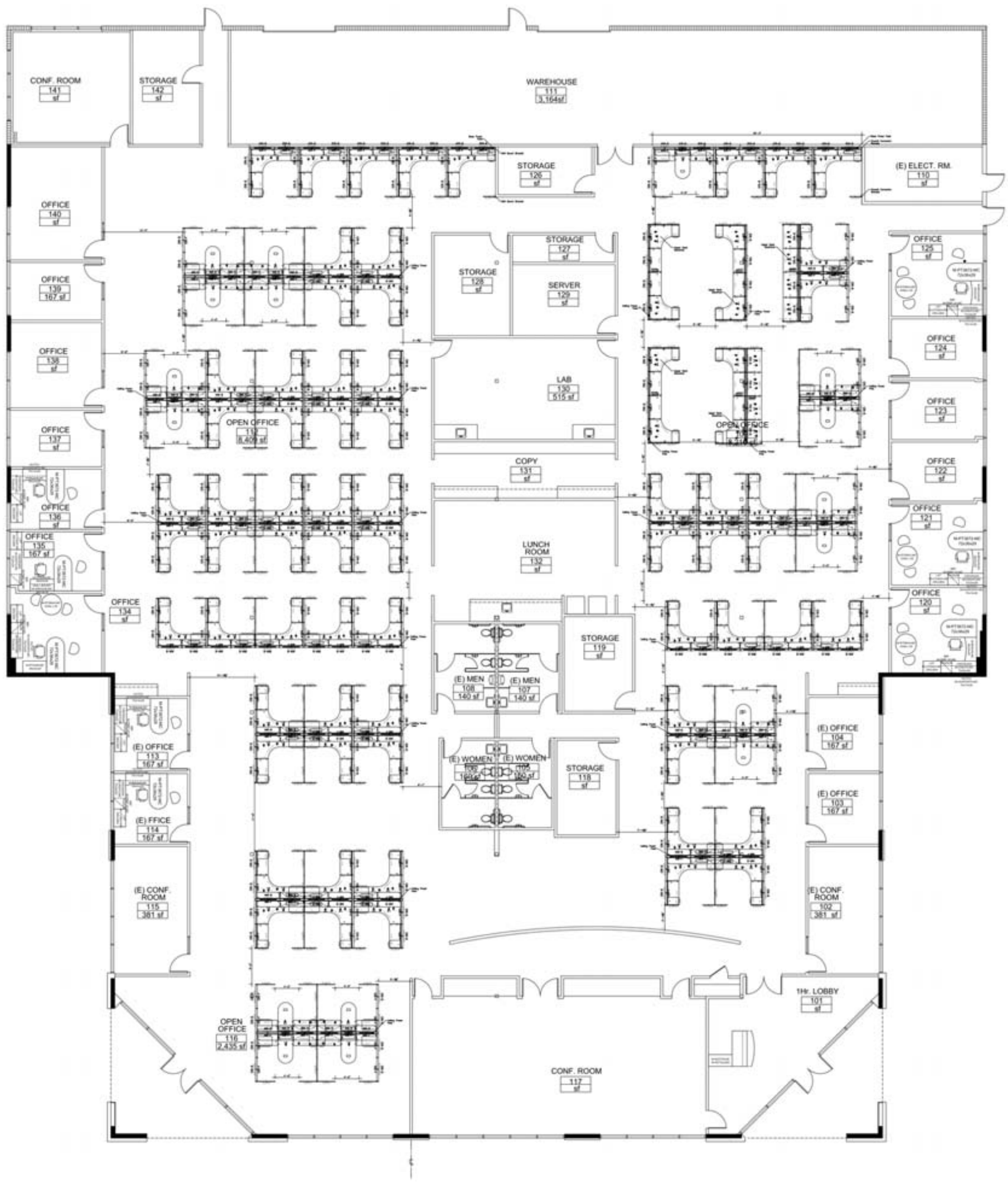

Figure 21 Proof of concept lab test facility

This facility will be the basis of the planning for both VisualRF Plan and the Site Survey chapters later in this guide. Other key environmental assessment inputs that affect the design are explained in Table 2. If you want to practice by replicating this example yourself, the graphic of the floor plan is available on the VRD page at http://www.arubanetworks.com/vrd.

Table 2 Building Data

Building Dimensions	
Width	162 feet
Length	185 feet
Number of Floors	1
User and AP Information	
Number of Users	180
Devices per User	2
Devices per Radio	20
Radio Type(s)	802.11a/b/g/n
AP Model	AP-105
AM Model	AP-93
Client Data Rates	
802.11b/g/n (2.4 GHz)	150 Mb/s (20 MHz HT Channels)
802.11a/n (5 GHz)	300 Mb/s (40 MHz HT Channels)

Survey Methods

The simple goal of an RF site survey is to accurately determine how many APs are necessary to provide a targeted minimum data rate in a given area. The survey also helps to identify where to place the APs to enable optimum performance. AP coverage can be modeled in a virtual site survey in many open office environments. Most indoor APs except the AP-93H emanate RF energy in all directions in the horizontal plane, so that the area covered by the AP using an omnidirectional antenna is a circle, with vertical as well as horizontal coverage as shown in Figure 22.

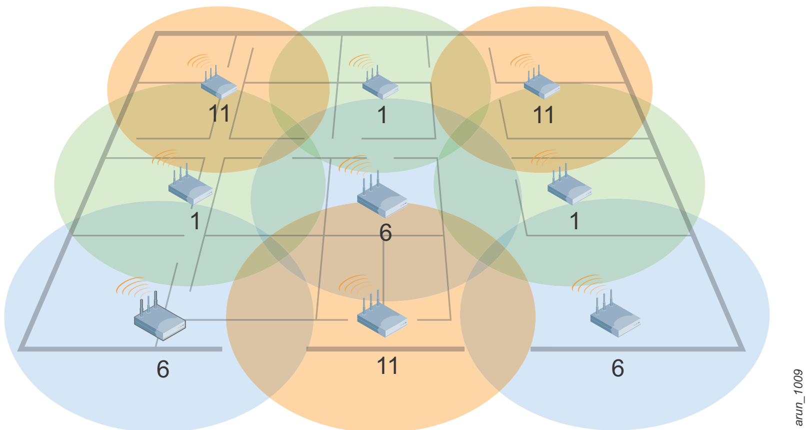

Figure 22 Theoretical RF propagation characteristics

RF coverage in the actual world differs from that of theoretical coverage, due to factors like environmental conditions, obstructions, and interference that all affect RF energy propagation. RF behavior is notoriously difficult to accurately predict in challenging environments. Environments that are more complex are more likely to require a physical site survey. Figure 23 depicts an environment where many RF obstructions exist and may require a site survey for optimal performance.

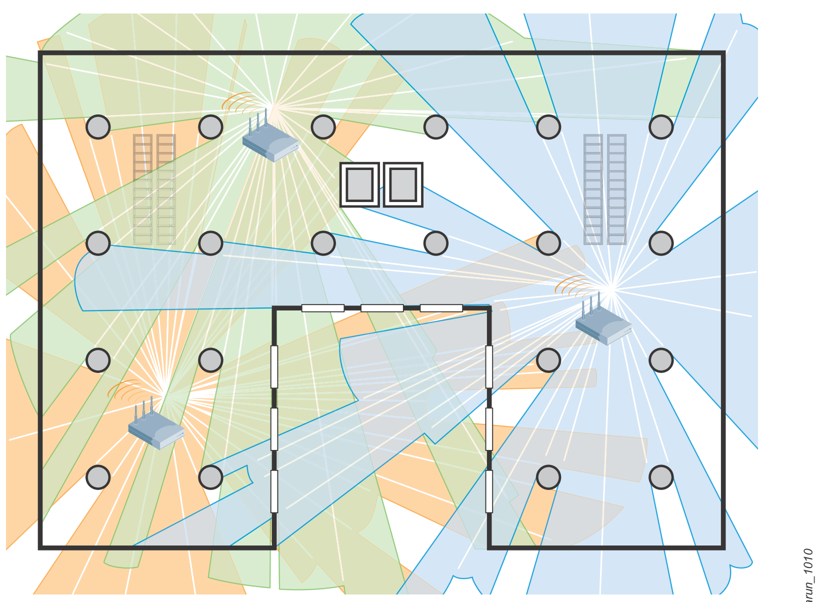

Figure 23 Realistic RF propagation characteristics

Selecting a Survey Type

The term “site survey” is really a category of activities that means different things to different people. Consulting firms and wireless integrators that provide engineering services generally offer four different types of RF site surveys. A virtual survey typically is performed in low-complexity environments, such as relatively new constructions with primarily cubicles for employees. Passive and active surveys typically are used in higher-complexity deployments. Spectrum clearing surveys are done to evaluate the level of non-WiFi interference that may be encountered in a location. Table 3 describes the basic types of site surveys.

Table 3 Types of Site Surveys

	Virtual Survey	Passive Survey	Active Survey	Spectrum Clearing
Description	Uses customer-supplied building drawings in JPG, PDF, or DWG format to place APs	Involves passive data collection of the ambient RF environment (no active testing) based on actual RF data	Involves active testing of real APs throughout a facility (indoor or outdoor) to determine the actual AP coverage footprint and RF hazards	Same as active RF survey, but also includes a spectrum analysis at each active test location
Location	Remote	Onsite (typically indoors)	Onsite	Onsite (typically indoors)
Deliverables	Marked-up JPG file indicating AP locations and controller location codes Site bill of materials	Heat maps of existing 2.4 GHz and 5 GHz RF environment Marked-up JPG showing AP locations Summary narrative analysis	Heat maps of test APs with actual measured coverage Marked-up JPG showing AP locations Detailed data analysis	Pinpoint locations of the 2.4 GHz and 5 GHz interference sources
Accuracy	*	**	***	****
Cost	$	$$	$$$	$$$$

The following chapters describe each of these survey types in detail.

Chapter 6: Virtual Surveys Using VisualRF Plan

VisualRF Plan is the Aruba AP planning software package. VisualRF Plan is available as part of the AirWave server product and as a free standalone planning tool for Windows®. The software is available for download from the Aruba support site for those with an Aruba support account at http://support.arubanetworks.com, under Download Software > AirWave > VisualRF Plan.

NOTE

VisualRF Plan relies on Adobe Flash. Be sure that Flash is installed and up to date on your machine.

When you plan a new facility, Aruba recommends using VisualRF Plan even when you expected to use a passive, active, and/or spectrum clearing survey later. The tool allows you to quickly access the facility and develop a plan and bill of materials. Later the plan can be used as the basis for other types of site survey if required. If you choose to use the offline version when planning is complete, you can import the floor plan directly into the AirWave software. Import the plan after the network is installed for use by network managers. If you do the virtual plan in AirWave, then nothing else needs to be done. This tool shows real time “heat maps” of RF coverage and allows devices to be located via triangulation. For the purposes of this guide, the offline version of the VisualRF Plan tool will be used. Using the offline tool allows users to play “what if” scenarios without disrupting the VisualRF maps on the AirWave server. This can be helpful if you are looking at changing the plan for an existing deployment.

NOTE

The offline version of VisualRF Plan is a Microsoft Windows® only software package. For Mac OS X users, running VisualRF Plan under VMware Fusion® or Parallels® requires that you disable disk sharing between the Mac and virtual machine while using VisualRF Plan.

Virtual Survey Methodology

To perform a Virtual Site Survey:

1. Complete the environmental assessment described in Chapter 3: Environmental Evaluation.
2. Obtain a current electronic floor plan of the facility.
3. Walk through the facility or obtain images of the site to compare to the floor plan. Pay particular attention to RF obstructions and building materials.
4. Ask the facilities group about building age, building materials used, and any specially shielded areas.
5. Use either Aruba VisualRF Plan or AirWave Visual RF to complete an initial placement APs on the map based on input variables collected in the environmental assessment.
6. Adjust the AP placement to account for things such as elevators, restrooms, ceiling lights, or other obstructions.
7. Save the plan and review the predicted RF coverage.

8. Add any additional APs if needed to account for coverage requirements based on the changes made to AP placement. Additional APs may be needed for high-capacity areas such as presentation rooms.

Case Study: Planning the PoC Lab Facility Using VisualRF Plan

The Aruba proof of concept (PoC) facility is used to test designs for deployment. Often it hosts customers who are visiting our executive briefing center (EBC). This dual-purpose facility acts as a test bed for large-scale roaming tests, capacity testing such as our 100 iPad demonstration, and test customer deployment scenarios for sales teams. Our goal in performing this virtual site survey is to decide on the placement of the APs for roaming testing.

Figure 24 Aruba POC lab

For a video tutorial on planning a site, see the video on AirHeads Social at:
http://community.arubanetworks.com/t5/AirWave/How-to-plan-a-site-using-VRF-Plan-7-4/td-p/20032

Creating a Campus, Building, and Floor

When you open VisualRF Plan, a list of default campuses is listed. A campus is a group of buildings in a common location. To create a new campus, click the button and name the campus. (See Figure 25.) At this time, you can safely ignore the client transmit power and desired speed drop-down boxes. Those inputs are deprecated and will be removed in a later release.

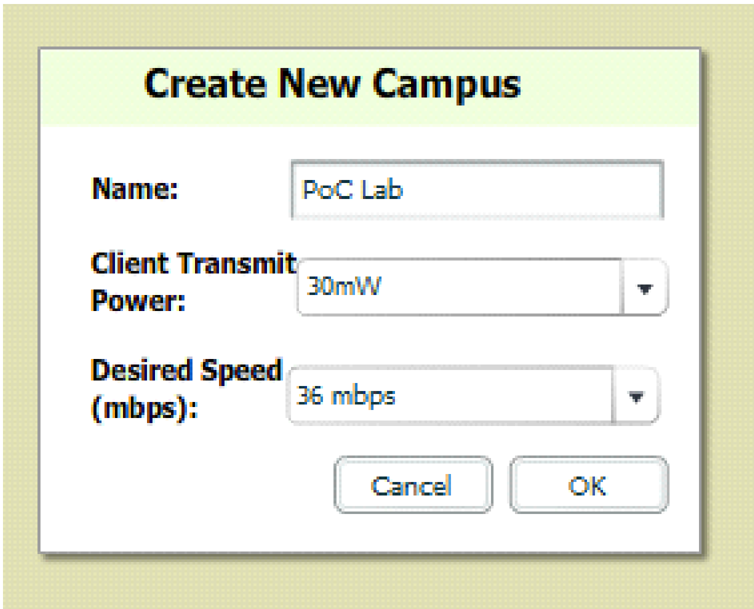

Figure 25 Create a new campus

After the campus is created, it appears in the upper left corner of the screen. Click the campus. In the new screen, enter the data you have about a building to add it to the campus. (See Figure 26.)

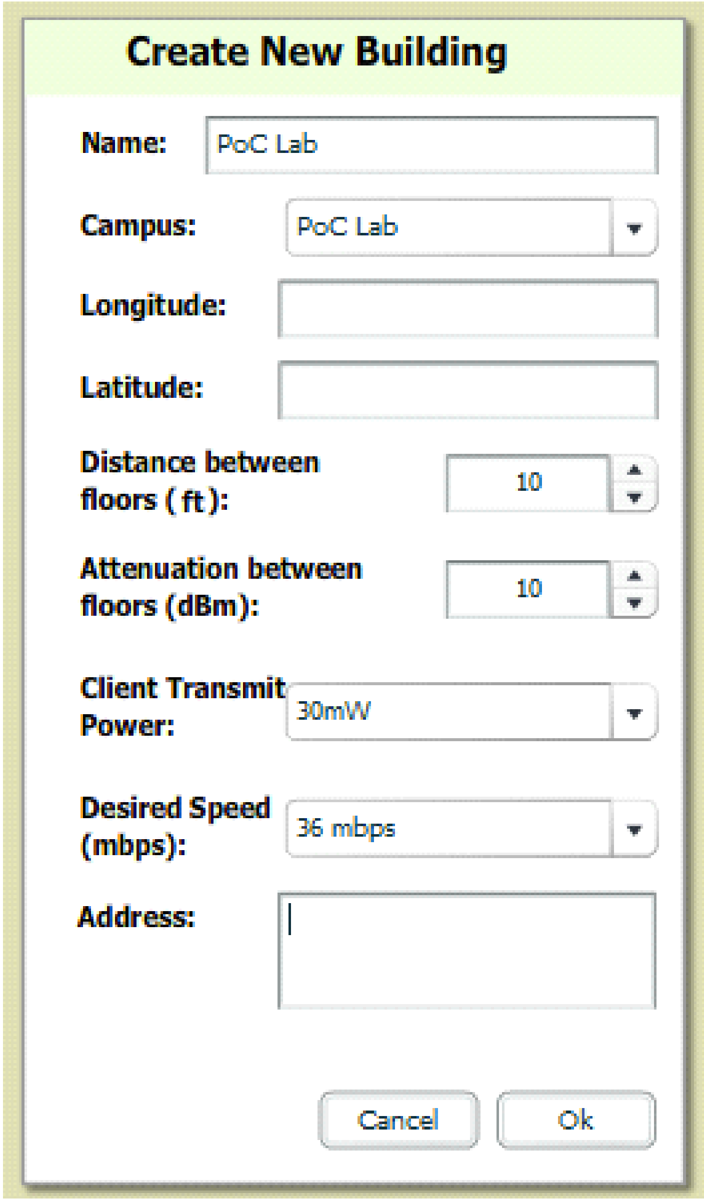

Figure 26 New building info

After the building is defined, the next step is to define the floors. In this case, we have only a single floor for the PoC facility. You are prompted to upload a floor plan. If you have a CAD drawing with dimensions exported from any of the major CAD software programs, the tool automatically sizes or calibrates the drawing. In this case, we are using an exported PNG graphic, so we measure the floor using the Manually Measure Floor button. The floor plan graphic used here contains multiple architectural measurements that we can use to do the calibration. If your floor plan lacks these features, use a known distance such as a doorway or cubicle wall. It is also important to enter a fairly accurate height for the ceiling so that RF propagation calculations between floors are accurate.

CAUTION

It is important to be as accurate as possible when you measure a floor plan. VisualRF Plan uses the size of the building to determine AP count. If the calibration measurement is incorrect, your plan will contain the wrong number of APs.

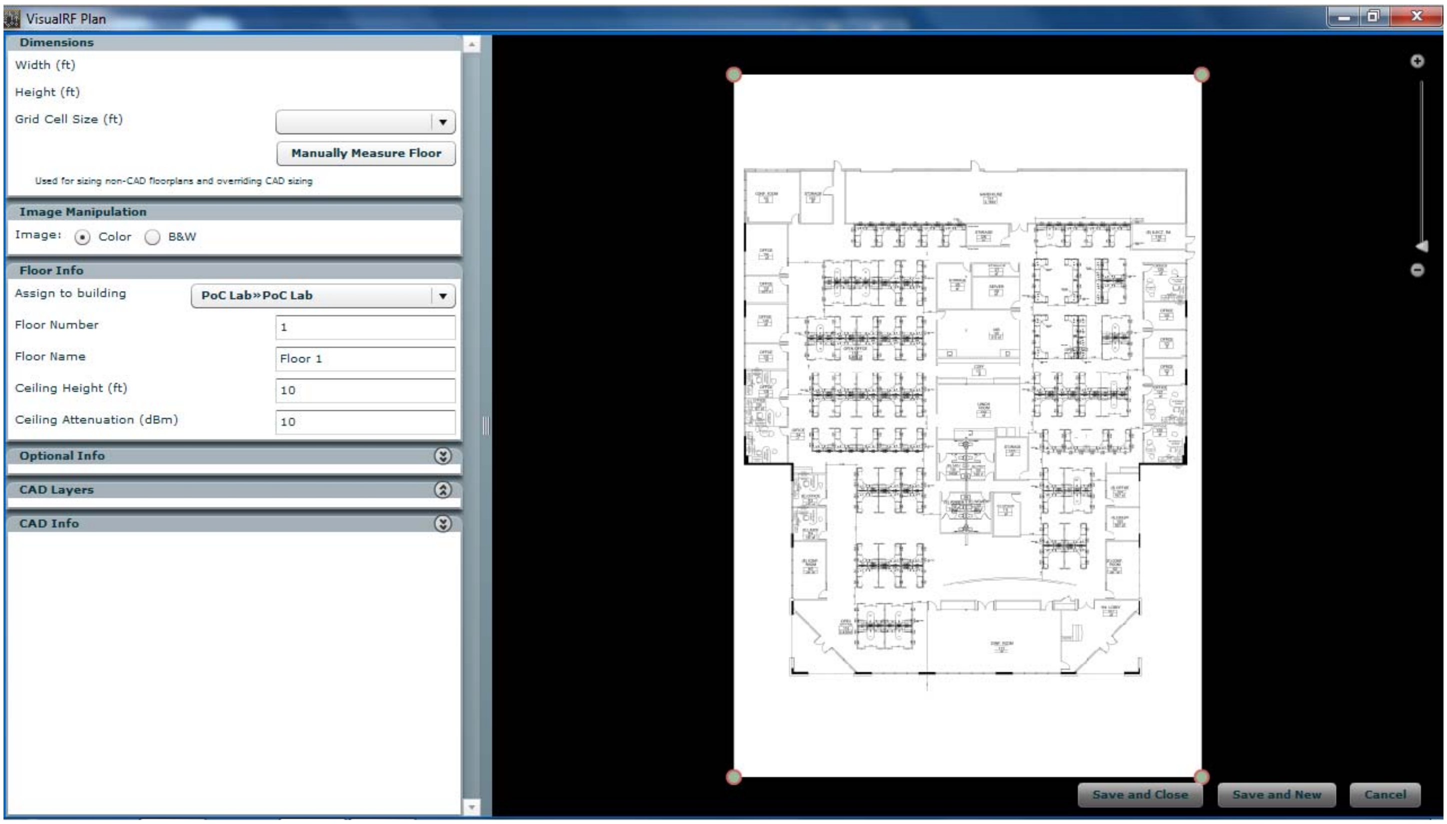

Figure 27 VisualRF Plan building floor plan setup

After your floor plan has been loaded, calibrated and saved, you can enter the floor plan and begin to plan your site. First create a deployment region. Click the **Edit** tab, and then click the **lock** icon to unlock the floor plan for editing. Then click the **Draw Region** icon to create a polygon that encloses the coverage area. (See Figure 28.)

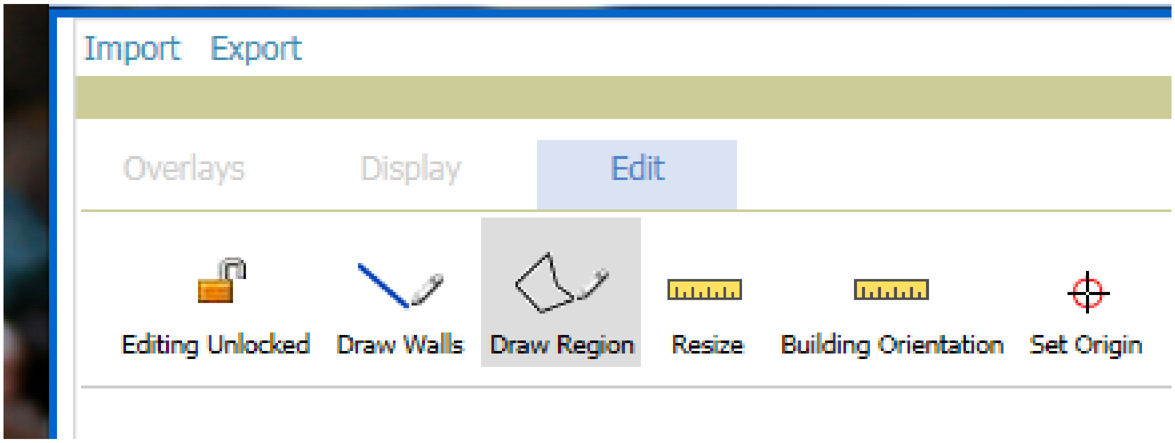

Figure 28 Unlock and draw region dialog icons

The deployment region tells the tool where APs need to provide wireless service. In this case, we outline our building and exclude our warehouse, which we will not use. To plan the region, click the exterior wall points and then double-click to complete the region. When you are finished, give the region a name and select the Planning option. (See Figure 29.)

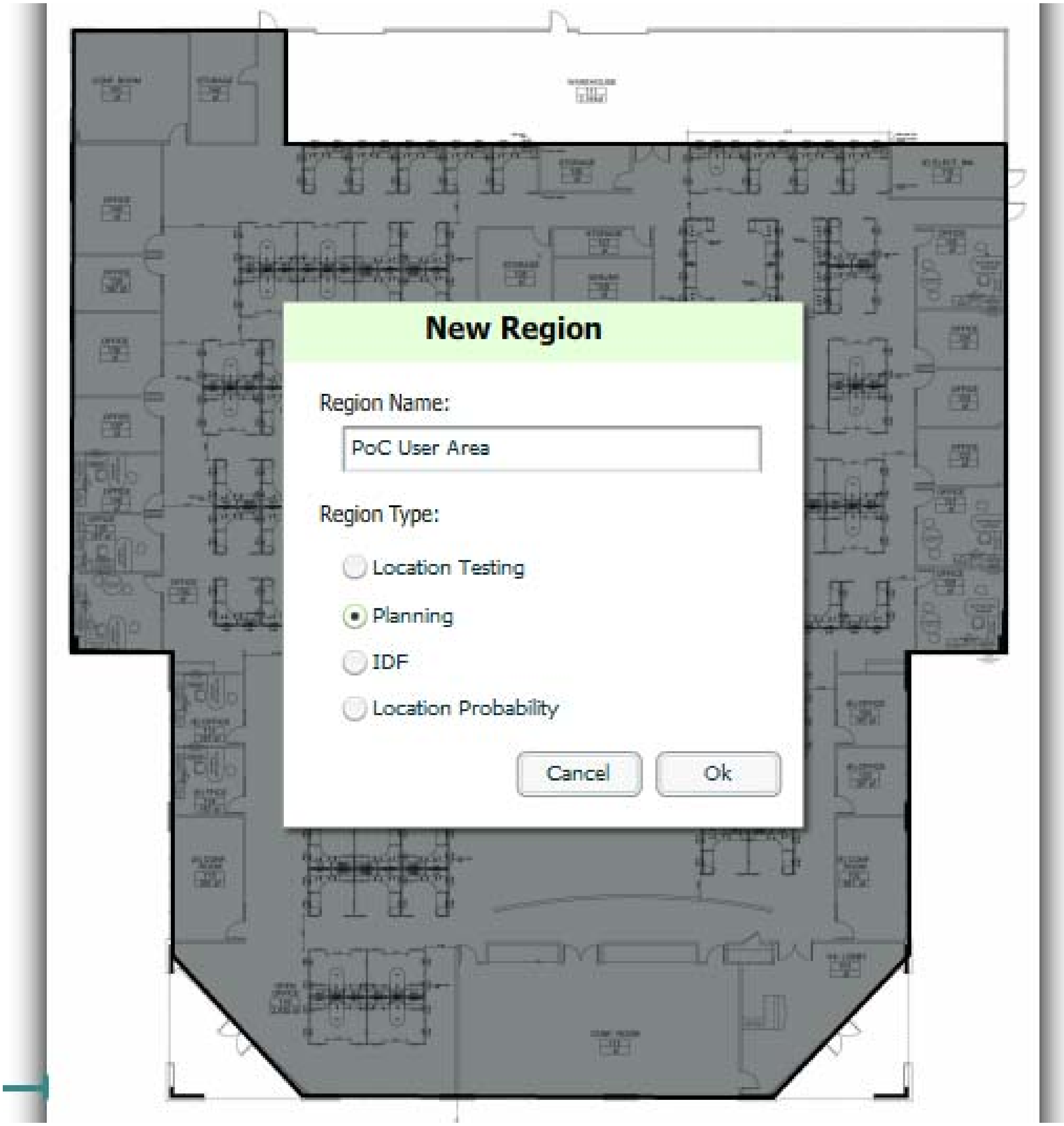

Figure 29 Completing the planning region

Now that the region is defined, you can plan your AP deployment. Right-click the floor plan and choose Reprovision APs. The AP planning dialog box is displayed, which you can populate with the information you have previously gathered. (See Figure 30.)

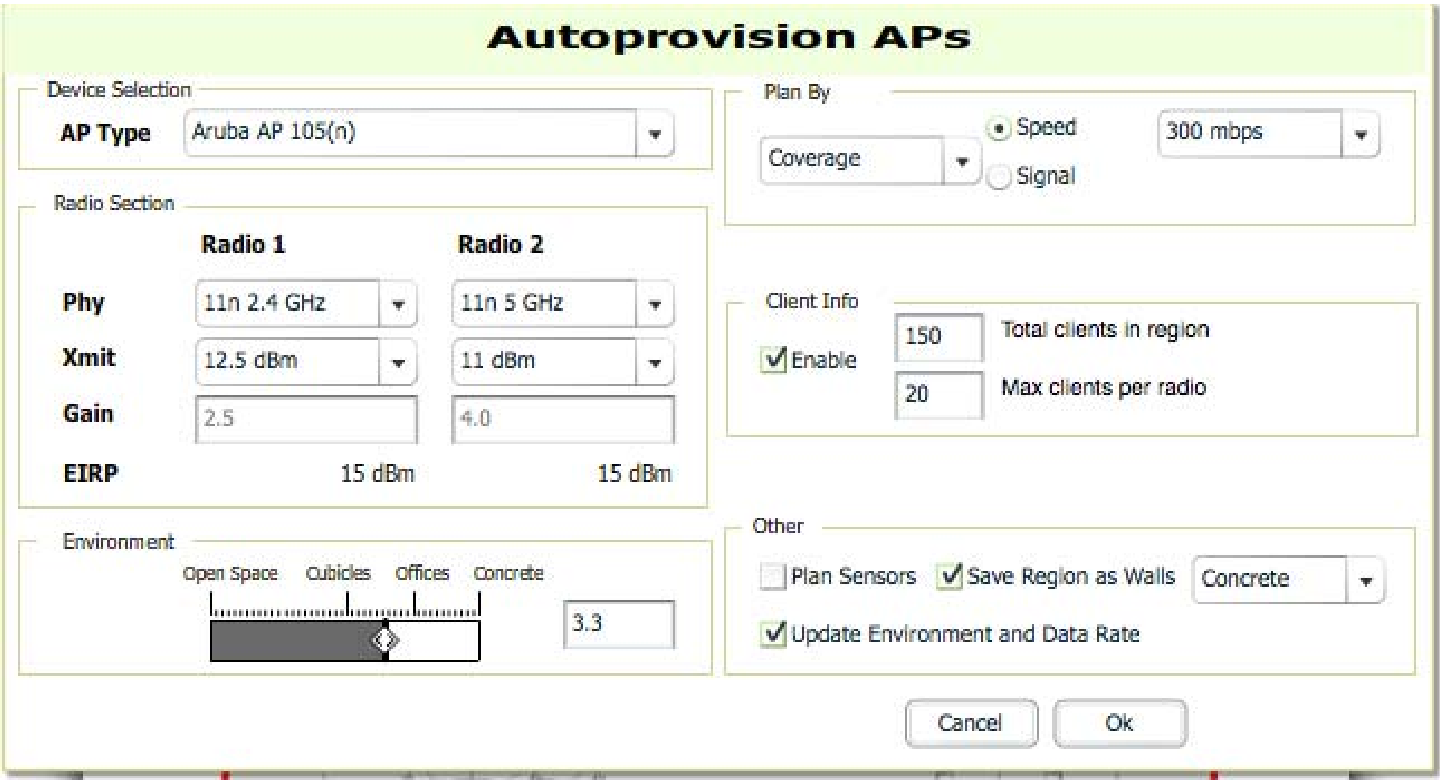

Figure 30 Provisioning an AP

In the provisioning dialog box, we modified the items as shown in Table 4

Table 4 Autoprovision APs

Feature	Setting
AP Type	AP-105
Radio 1	EIRP 15 dBm
Radio 2	EIRP 15 dBm
Environment	Midway between cubicles and offices (3.3)
Plan by Coverage	300 Mb/s
Client Info	150 clients with 20 clients per radio
Save Region as Walls	Concrete

When we make these selections, we modify how the tool determines the coverage radius of each AP. We need the tool to understand our AP characteristics and planned maximum transmit power, so we selected the appropriate AP and set the power to match the default maximum configured in the Aruba Mobility Controller. We told the tool to assume we have a mix of open cubicle space and some offices when we adjusted the slider in the middle of the two markers.

We selected our minimum speed, but also told the tool the number of clients we expect. We did this because areas of high client density can oversubscribe an AP, which means that we need more APs than would be called for by the RF power budget alone. Providing client count information causes the planning algorithm to select the greater of the AP count for coverage or capacity required. Finally, we told the tool to assume that we have concrete walls around our planning region, which makes the tool adjust the coverage that we would expect to see outside of the building as shown in Figure 31.

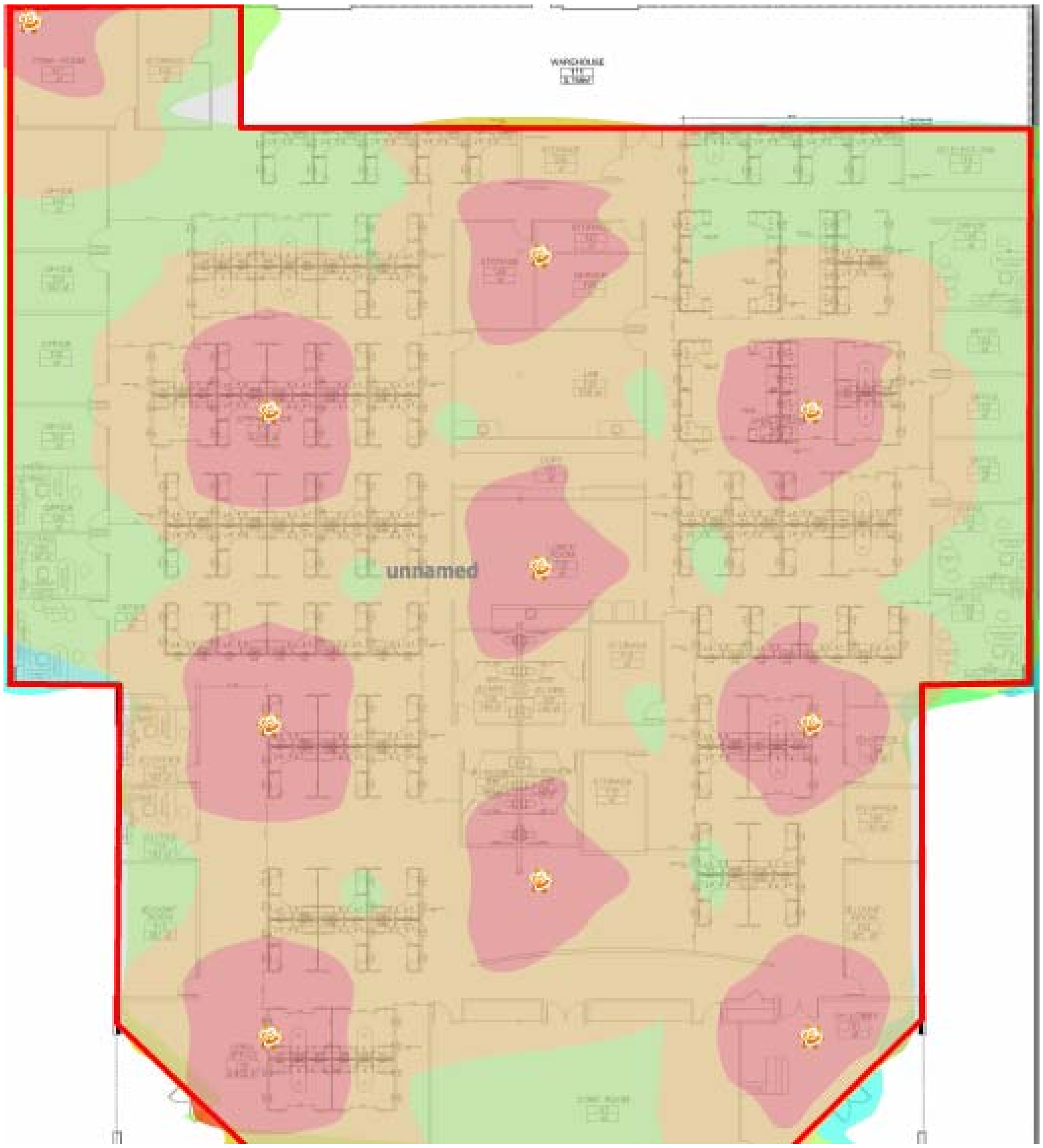

Figure 31 Generated AP plan

With this input, the tool generates an initial plan that is its idea of where the APs should go, given our parameters. The autoprovisioned plan does not know about things like elevator cores, cafeterias, and X-ray imaging suites. So a few things must be adjusted in the plan for it to work. The AP in the upper left corner can be pulled down to provide better coverage for that area. Also, the map does not show some of the obstructions in the building. The obstructions will have an impact on coverage, which is why we strongly recommend either a walk through or many pictures of the facility.

The three APs on the left side of the building happen to be placed right next to steel beams that run floor to ceiling (see Figure 24). So, we moved those over about 6 feet (1.83 meters) to the right. We chose this direction because it places the APs over more user workspaces. The plan shows that APs on the right side are placed on top of a row of overhead lights, so we must adjust those slightly as well. The AP at the center top is in a series of server and storage rooms, so we must move that down to provide better coverage to areas where people will actually work. After we make those modifications, we can save and refresh the map to see the adjusted heat map as shown in Figure 32.

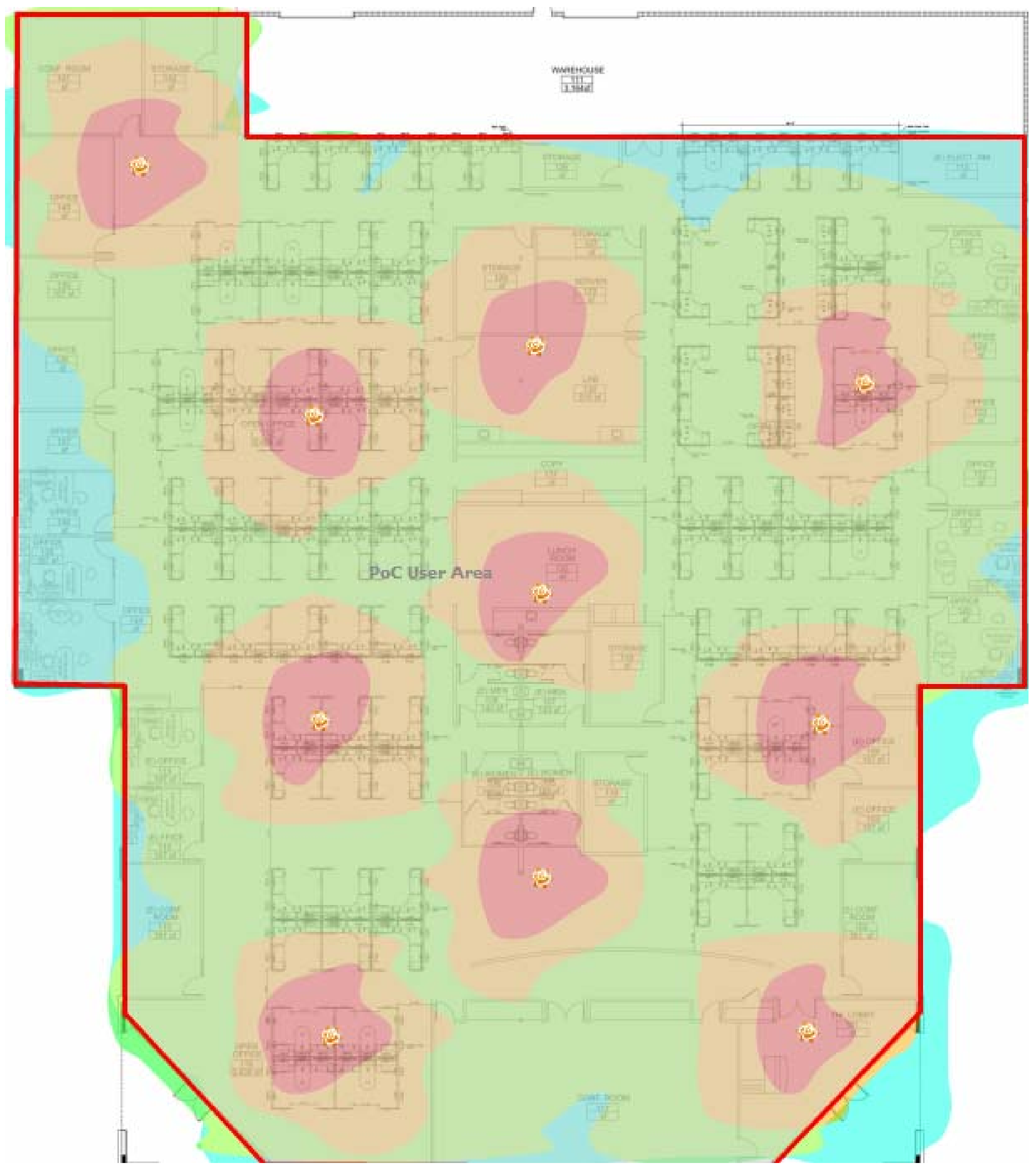

Figure 32 Adjusted AP layout

This completes the virtual site survey using VisualRF Plan. The installers can use this plan to install the APs in the facility. If you will be doing an onsite physical site survey to confirm coverage, you will use this beginning plan to start the survey locations. Continue to the next chapter, which describes how to verify the AP placement onsite.

Chapter 7: Physical Site Survey

Physical site surveys are the traditional method for planning wireless deployments of all kinds. Prior to technology advancements such as the Aruba ARM, APs were planned to use static power and channel settings as determined by the physical site survey. Though many of the same principals in planning apply today, ARM eliminates the need to carefully select exact channel and power settings. The three types of physical surveys are passive, active, and spectrum clearing.

Passive Survey Methodology

The typical wireless passive survey methodology utilizes professional survey software utilities from companies such as AirMagnet and Ekahau to measure existing signal propagation within the designated coverage areas. Due to the many varieties of building structures, designs, and materials that can impact the RF signal, the survey tool effectively captures the "actual" RF signals that originate from the APs.

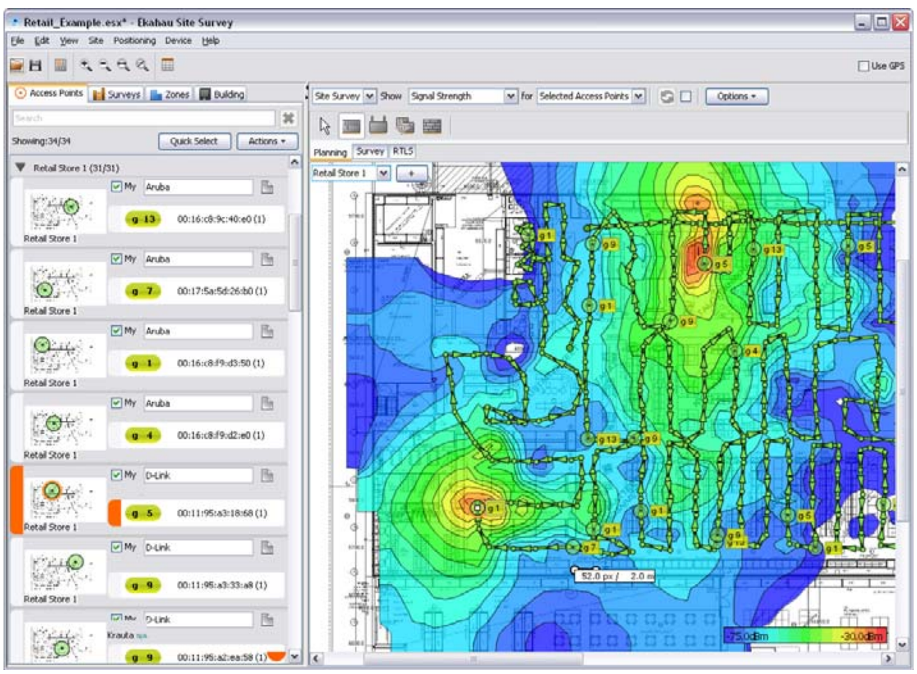

Figure 33 Passive survey with Ekahau Site Survey Professional Version 4.4

To perform a passive survey:

1. Obtain the current electronic floor plan of the facility.
2. Using the site survey software application, walk through the coverage area and sample the RF path every few feet.
3. Analyze the data to produce heat maps of the existing coverage and to look for sources of external interference.
4. Have an experienced WLAN engineer use the passive survey data to validate the choice of AP locations.

Active Survey Methodology

An active AP survey uses operational test APs for many purposes:

- To determine the best placement of the APs
- To determine the AP density necessary for a given building construction
- To ascertain any pre-existing RF conditions that may influence the outcome of the implementation

Follow these steps for each test area:

1. Obtain the current electronic floor plan of the facility, and mark the locations at which active tests are to be performed.
2. Using an Aruba Instant AP, provision the AP with ARM minimum power that will be used in the deployment.
3. Mount the AP to a portable tripod, speaker mount, or other stable, movable platform. If available, you can also mount the AP directly to the ceiling rails.
4. Position the AP at a test location and connect it to a power source and data link.
5. Use a professional site survey application to complete a passive survey of the area that immediately surrounds the test AP.
6. Repeat steps 4 and 5 for all identified test locations.
7. Have an experienced WLAN engineer analyze the active survey data to determine the proper AP density for the coverage area.

The analysis software makes hundreds of RF measurements throughout the test, which are then visualized by superimposing their values in color over the relevant facility map. (See Figure 34.) This section presents sample heat maps at 2.4 GHz and 5 GHz generated with AirMagnet during a retail survey in a grocery store. In this case, five APs were set up in the locations shown on the heat map. Because voice communications are being used, the customer requirement is for 48 Mb/s cell edge data rate (equivalent to a signal-to-noise ratio [SNR] of 20 dBm or -65 dBm minimum signal strength in the 2.4 GHz and 5 GHz bands). Configure AirMagnet with a -65 dBm display filter. As a result, areas that fall below this threshold appear gray and areas that exceed it are in color. Because almost the entire floor is in color at 2.4 GHz, the survey in the figure shows that coverage meets the requirement in that band.

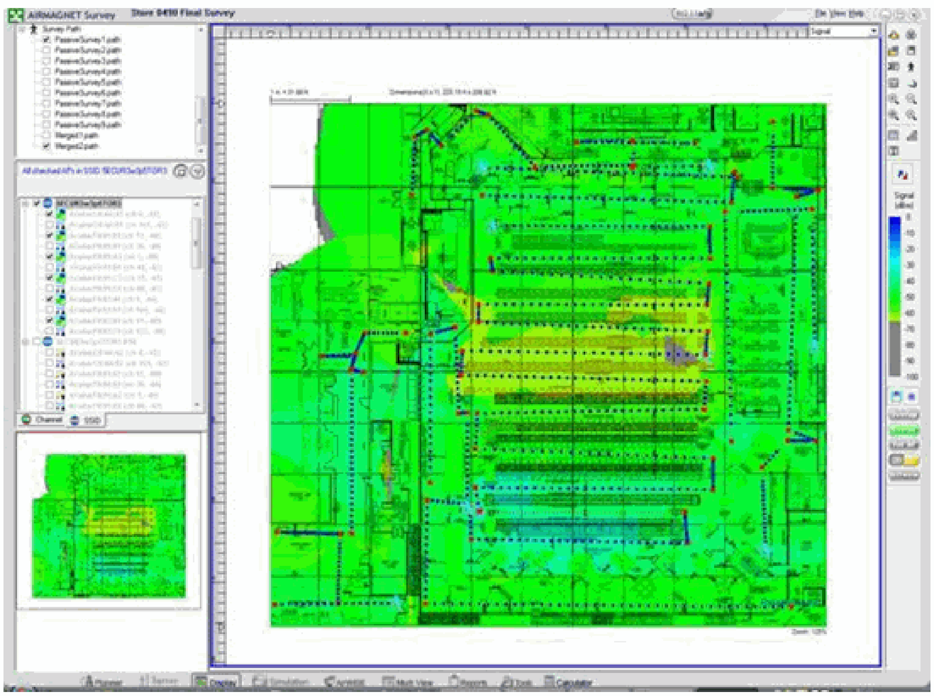

Figure 34 2.4 GHz active survey with AirMagnet Survey 6.0

In the 5 GHz band, a gray area appears in the middle of the store, which indicates that higher AP density is required. (See Figure 35.) This result occurs because Free Space Path Loss (FSPL) increases proportionally with frequency, so radio signals in the 5 GHz band travel approximately half as far as 2.4 GHz signals, assuming constant power. In addition, this part of the grocery store contains freezers, which significantly attenuate the signal. This example shows how the AP density that is appropriate for 2.4 GHz is inappropriate for 5 GHz.

Figure 35 5 GHz active survey with AirMagnet Survey 6.0

Spectrum Clearing Methodology

By its very nature, the unlicensed 2.4 GHz and 5 GHz spectrum is shared by a multitude of devices that operate in the same frequency space and create interference for one another. This situation can result in poor 802.11 network performance. Common examples of such devices include APs in neighboring stores or warehouses, cordless phones, analog and digital video cameras, Bluetooth devices, and microwave ovens in break areas. When you design a wireless network, it is important to understand the overall RF environment typical of the facility types where the network will be deployed to mitigate any interference problems. Spectrum clearing refers to the use of a portable spectrum analyzer to discover and pinpoint interference sources before the network is deployed. After the interferers have been identified, you should remove or migrate any devices you can to lower the interference effects.

The two methods to monitor the spectrum are dedicated RF software or using Aruba APs and the RFProtect® license to scan the environment.

Figure 36 2.4 GHz spectrum analyzer display

The spectrum clearing process involves these steps in a software solution:

1. Configure the spectrum analyzer to record peak, average, and maximum hold for the 2.4 GHz and 5 GHz bands. If supported, also enable a swept spectrogram for both bands. If the analyzer includes omni and directional antennas, begin by using the omni antenna.
2. Walk a carefully planned route for each selected location and look for active devices. (An active device is any electrical equipment that broadcasts or radiates in the same frequency bands as the proposed Aruba network.)
3. If strong interfering signals are observed, pause in that location and record a spectrum trace for 60-90 seconds.
4. If interferers are found, pinpoint them using these steps:
   a. Attach a directional RF antenna to the spectrum analyzer.
   b. Slowly rotate the antenna until you see an interfering source of RF energy in the 2.5 or 5 GHz band.
   c. Attempt to determine the RF channel number of the interference and whether or not it impacts your proposed network coverage.
   d. If it does impact your coverage, move the antenna closer to or farther away from the source of the signal.
   e. Using this dynamically changing signal, identify the offending device and determine its exact location.

f. Decide what to do about the interferer (remove it, shield it, or replace it for example).

Figure 37 shows results from a spectrum analyzer that shows the presence of DECT cordless phones in the 2.4 GHz band.

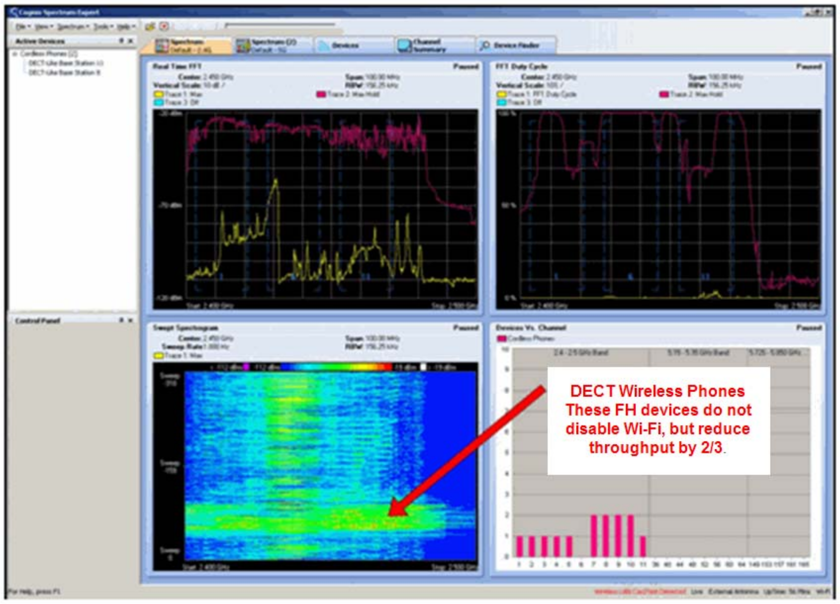

Figure 37 Display that shows 2.4 GHz interference from DECT phones

Figure 38 shows the significant interference effect of a microwave oven in the area.

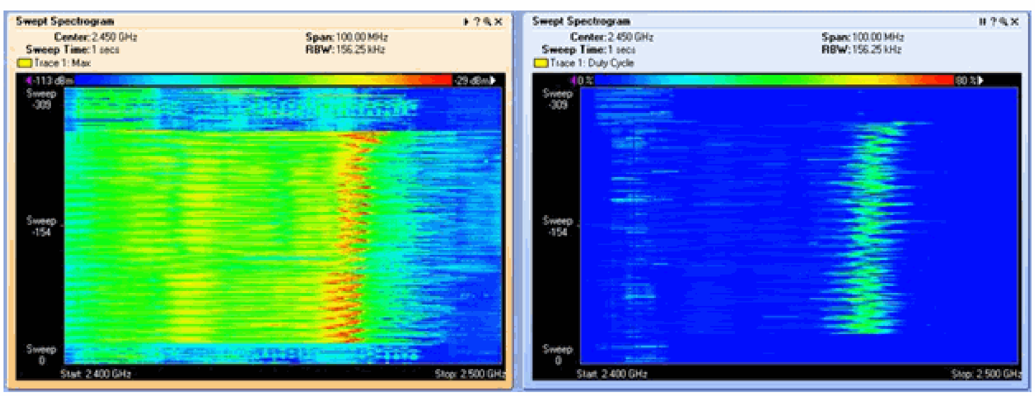

Figure 38 Display that shows microwave oven interference

If an Aruba Network is in place, many of the same charts are directly available from the AP through the mobility controller. (See Figure 39.)

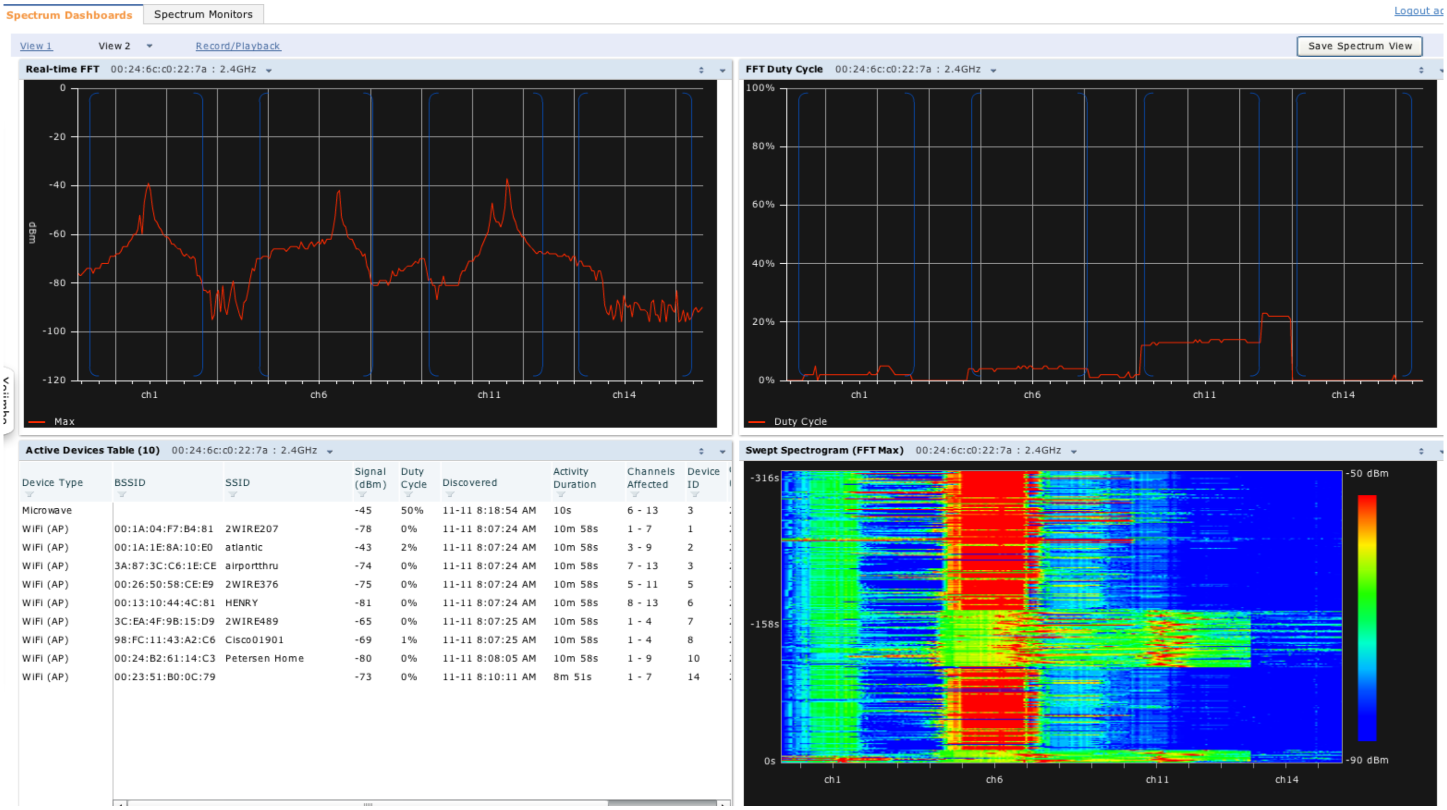

Figure 39 Aruba spectrum analysis

A set of tools that are very similar to the software solution is available in the Aruba Mobility Controller. Different Aruba AP models have different capabilities with regards to spectrum output and hybrid spectrum capabilities. For a longer discussion of the capabilities of the Aruba Mobility Controller, see the *Managing and Optimizing RF Spectrum for Aruba WLANs Application Note* available at http://www.arubanetworks.com/vrd.

Case Study: Planning the PoC Lab Facility with an Active Survey

For this planning exercise, an active site survey was conducted at the Aruba PoC Lab test facility. For details of that facility, see Chapter 5: Example Facility. We will use the plan developed in Case Study: Planning the PoC Lab Facility Using VisualRF Plan on page 37 as the basis for AP placement and as a comparison for the results. We will use AirMagnet Site Survey Pro to gather test data.

To perform the survey, first we must have actual APs for the software to visualize. In our case, our building had been previously occupied and wiring that is still in the cubicles leads back to a common datacenter. In this case, we could easily mount a controller, but because our lab had a working DHCP server in place. Instead we chose to use Aruba Instant IAP-105s for the testing. An Aruba S3500S provided power-over-Ethernet+ (PoE+) for the IAP. We also tested using the IAP, a power injector, and a laptop running a DHCP server to run the setup, which made the design more contained and less infrastructure dependent. Finally we clipped the AP to the ceiling rails, so we had a realistic test of the AP in the position it would eventually be mounted in.

The IAP broadcast an SSID in 5 GHz only using WPA2-PSK. This setup was chosen as the most self-contained method to complete our comparison testing. We also set our IAP to keep power at the minimum level that ARM would use later when assigning power levels to the campus APs. This setting allowed us to confirm that at minimum power levels we would have a solid coverage plan for 5 GHz. More details are covered in Appendix A: Using Aruba Instant in a Physical Site Survey.

We created a new building and planned our methodology for performing the survey. We had special requirements in this particular lab due to the way the lab operates. For instance, the large meeting room at the front of the building is typically used for specific, large demos and runs its own AP set. So we knew that space would have existing coverage. We also have RF cages at the back of the building that will cause shadows, so we did not spend a lot of time in those areas.

When using AirMagnet, we picked a path to walk around each AP and paid attention to signal strength and where the next AP placement will be. As we were looking for voice quality, we watched for the signal to dip below -65 dBm on the AirMagnet display as shown in Figure 40.

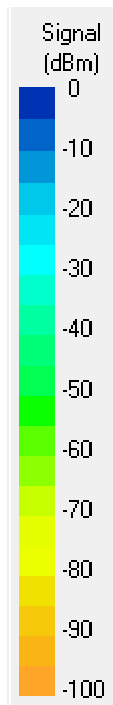

Figure 40 AirMagnet signal strength indicator

With each AP placement, we started a new survey path and we saved at the end of each pass. This results in multiple passes, which can be viewed individually or merged into a single display. Figure 41 shows the pattern walked around the location of the first AP.

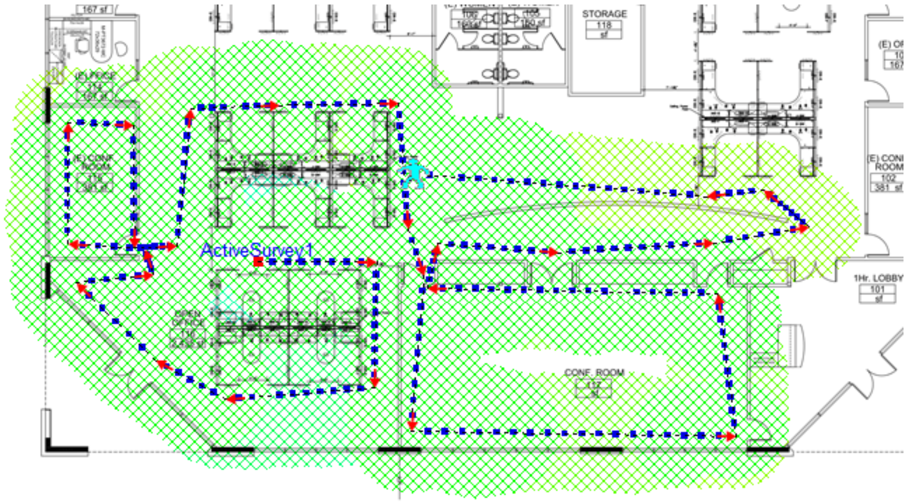

Figure 41 First pass walking pattern

After the pattern has been walked, we can change the display mode and show the signal strength measured as seen in Figure 42.

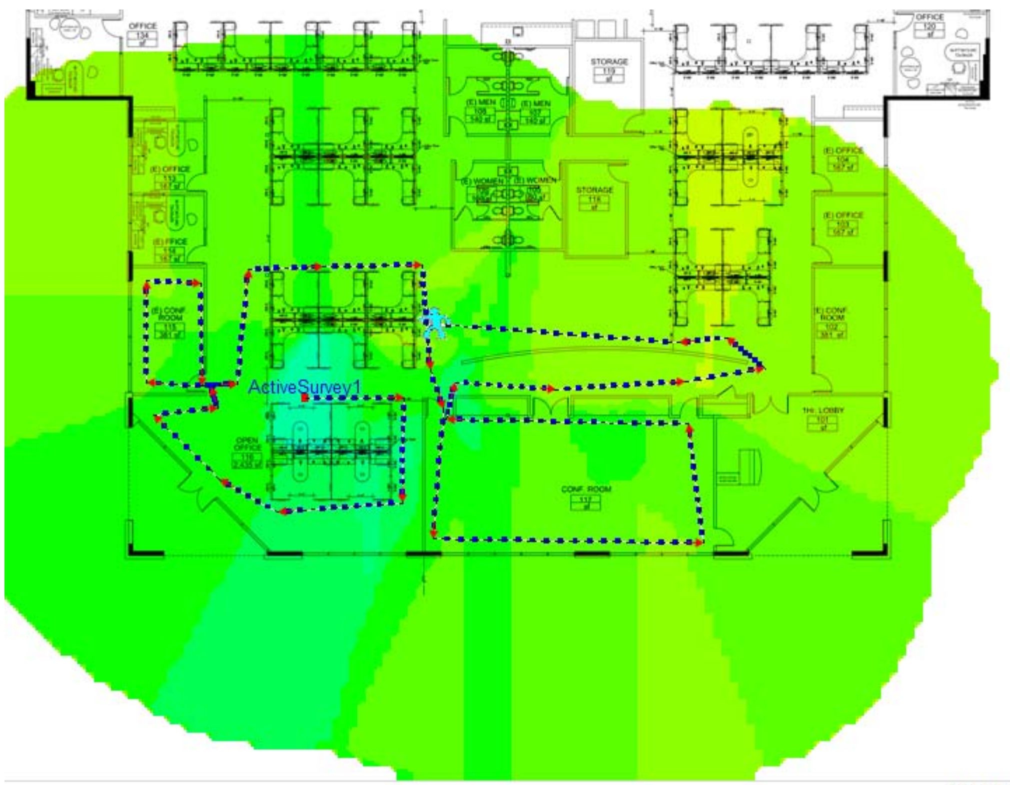

Figure 42 First pass heat map

After we complete the first pass, the AP is moved to its next location. As the testing continues, each survey path results in a similar pattern and heat map. When testing is complete, the different paths are merged into a single view. In the merged view in Figure 43 we see the path that the team walked across all the survey passes. Some areas were hit multiple times to account for the different AP placements. Some areas did not receive coverage because the building has been reconfigured since the architect originally drew the floor plan.

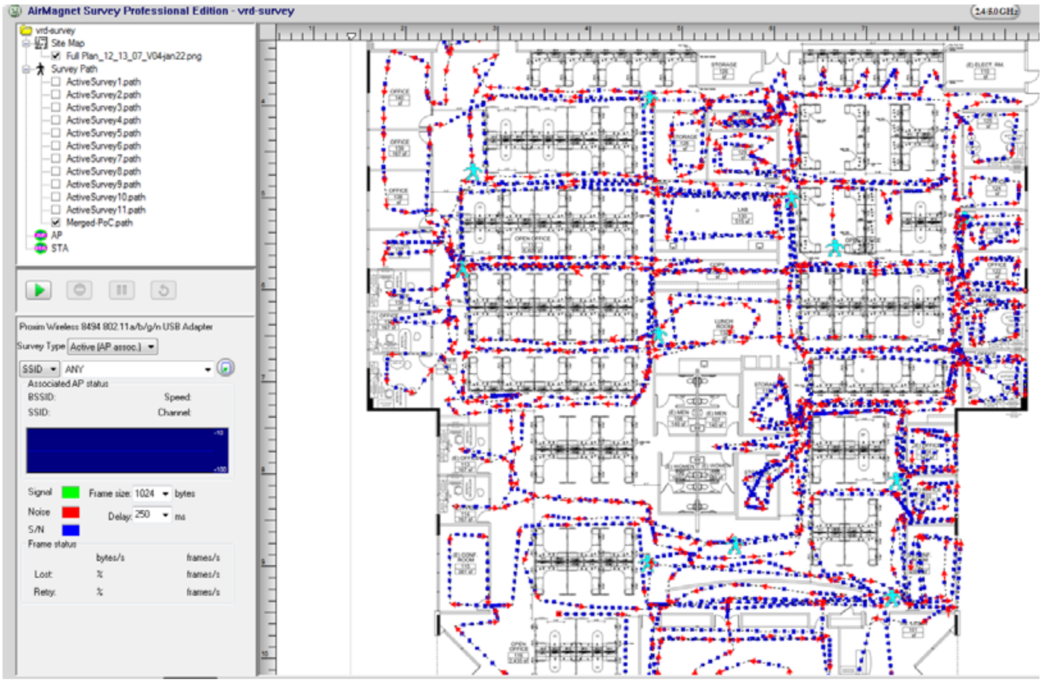

Figure 43 Merged survey path

The other thing that can be done is to display the heat map that is generated from the survey data. This map is also presented in a merged form in Figure 44.

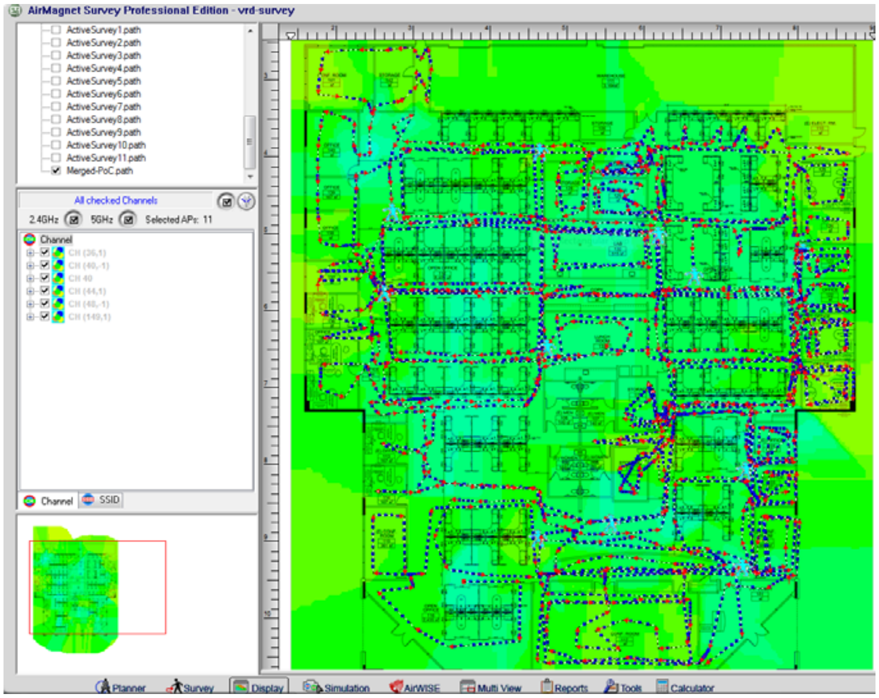

Figure 44 Merged signal strength

After the survey has been completed and the data merged, you now must determine if the AP placement meets the requirements of the deployment. In AirMagnet, move the slider representing signal strength to the minimum acceptable level and look for areas of the map that do not meet that level. In Figure 45, we have reduced the signal view to -50 dBm to show how the tool displays coverage. If we had a requirement, such as -65 dBm, we can set the slider to that level and the areas that do not support that coverage level will be grayed out.

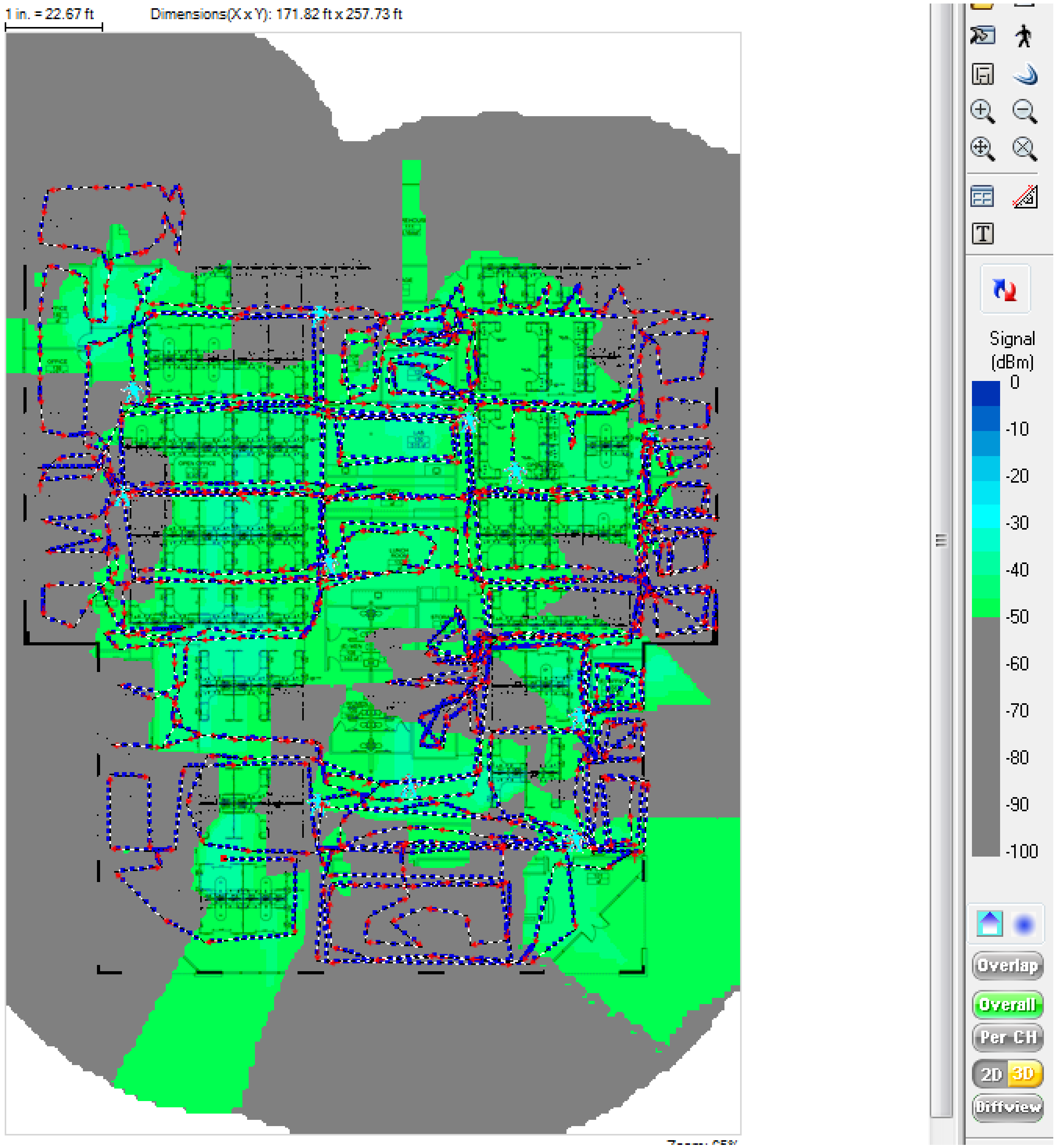

Figure 45 Areas that do not have acceptable signal strength

Site surveys are time-consuming projects. The survey of this building took approximately four hours to complete with a two-person team. You should expect that surveys will take many days or weeks depending on the size of the buildings, number of buildings, mounting options, and building materials.

Appendix A: Using Aruba Instant in a Physical Site Survey

In the past, the centralized, thin nature of Aruba APs has led to some challenging experiences for users attempting a physical site survey. Surveys are especially difficult in buildings where no wiring is present. Users tried many solutions, including rolling mobility controllers around on a cart and using RAPs with preselected channels and power in an always-on mode. Aruba Instant simplifies physical site surveys by allowing users to set up a stand-alone AP quickly that can broadcast an SSID and uses the same hardware that will later be deployed in the environment.

When you use an Instant AP, the first thing that must be solved for is power. Though an external adapter is possible to use, we found it more convenient to use a PoE switch when existing wiring was in place, or a PoE injector when it was not. In Figure 46 we show the setup using an IAP-105 and a PowerDsine PD-9001G-AC power injector. A laptop running DHCP server software was also used.

Figure 46 IAP with a PoE injector

NOTE

When using a power injector, note that the IAP needs an Ethernet link to come up until version 3.0. Without the link, the IAP assumes it is a mesh point. A mid-span power injector does not provide the link, it simply adds power as a transparent pass through. To provide the link, attach a second laptop or a switch to the LAN side of the injector.

The IAP assigns an IP address to itself if no DHCP source is discovered. We found it to be faster simply to enable a DHCP server on a laptop and connect that to the IAP through the power injector or switch. It takes about 2 minutes more to boot the AP without the DHCP server, and though that is not a long time, it does add up over the course of the day while moving the AP around a facility and waiting for it to boot. In our small test facility, that boot time would have added 20 minutes to the day. Having a laptop connected also allows for the use of tools for testing throughput.

NOTE

Be sure that your DHCP server vends a DNS address even if it is not reachable. By default, the IAP intercepts the DNS request, which is important when you are trying to reach the virtual controller address.

In our testing, we found that either an open or PSK network are the easiest to deal with when configuring the system. We allowed ARM to adjust channels just as it would in the eventual production environment, but we restricted the power setting. We set the minimum and maximum to 15 dBm, which matches ARMs default minimum power. By using this power setting, we were able to simulate the network as if all the APs had powered down to minimum.

Table 5 Summary of IAP Settings

Parameter	Recommendation
AP Power	PoE switch or power injector
Link	If a PoE switch is not used, attach a laptop or switch to the LAN side of the injector.
Encryption / Authentication	Open or PSK
Channel setting	Allow ARM to set channel, or pick a channel in the 5 GHz band.
Power setting	Set to the ARM minimum power (15 dBm by default) for both min power and max power. You can adjust this power if your clients will be using a different power level and you will be adjusting the ARM minimum on the controller or IAP.

Configuring the IAP for Survey Use

The following steps will guide you through setting up an IAP for site surveys using the previously discussed settings. Test this setup ahead of time to ensure that all of your tools work and you understand how the system operates before you go on site.

Connect the IAP to an Ethernet connection with a link and provide power. The AP boots up, which you can monitor from the console port. After the AP has booted, it begins broadcasting an open SSID called "instant." (See Figure 47.) Connect your wireless device to this SSID to begin the provisioning process.

Figure 47 Aruba Instant default SSID

After you are connected, browse to http://instant.arubanetworks.com. The IAP intercepts this address and you are taken to the web interface for the virtual controller as show in Figure 48. The default username "admin" and default password "admin" are used.

Figure 48 Virtual controller login

After you log in, you need to add an SSID and encryption. It is helpful to use an SSID that is obvious to you, because you can identify quickly that the IAP is up and running. You may also want to enable encryption using a PSK. This encryption is helpful or required for some networks, and it gives you peace of mind that no one can access the local network without your permission.

In the network box, the default Instant SSID and a link to create a new SSID are listed as seen in Figure 49. Click the new link to begin configuring your SSID.

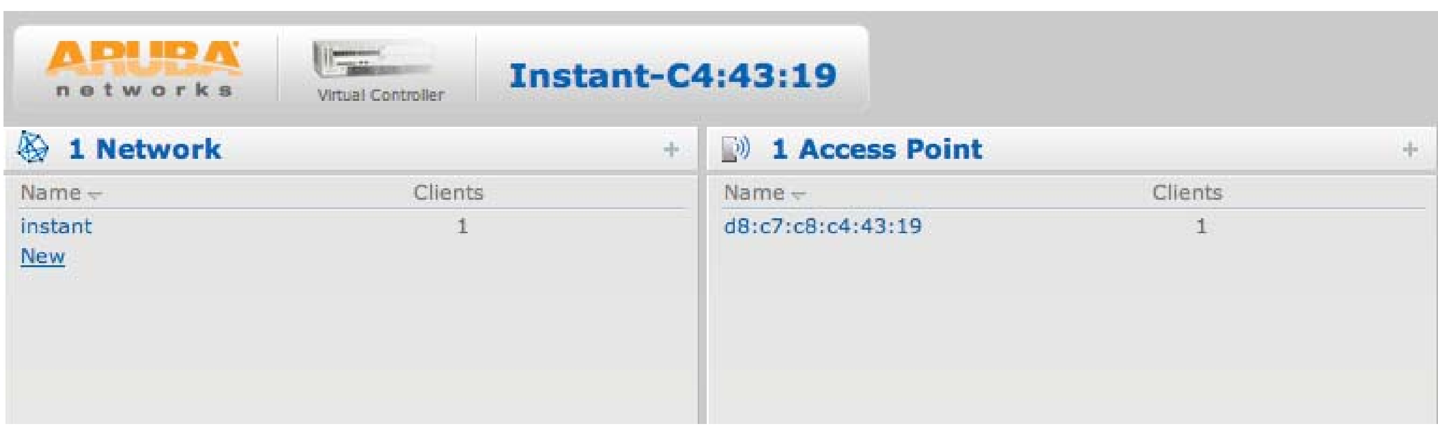

Figure 49 Default SSID and new SSID link

The virtual controller opens a new setup wizard that has three steps. Step 1 is shown in Figure 50. Enter the SSID name that you have chosen and then click **More**.

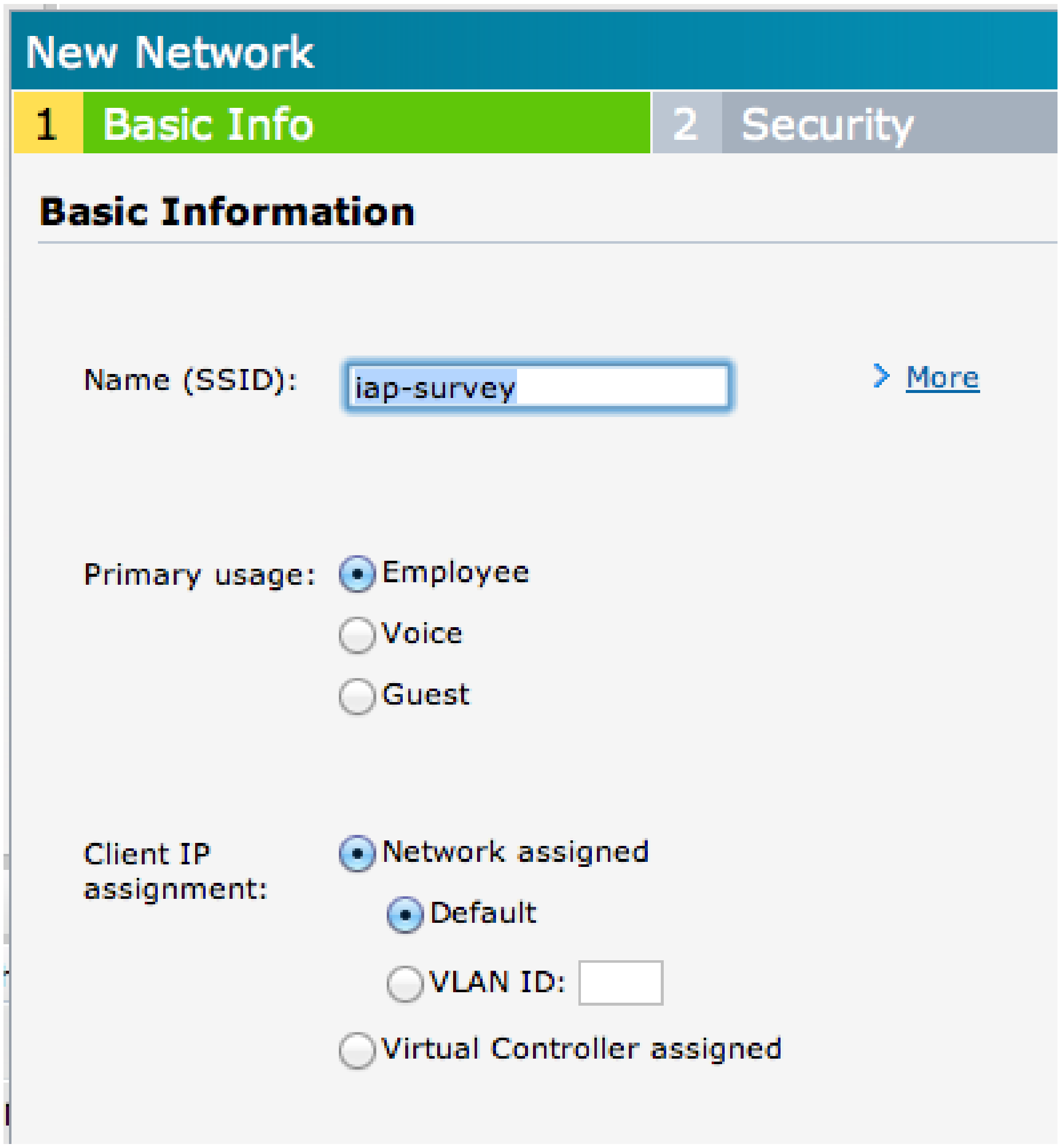

Figure 50 New SSID name

The link opens additional settings that you can use. You may want to limit your SSID to the 5 GHz band, or if you are doing multiband scanning, you can skip this step. Figure 51 shows the additional settings and the band selection.

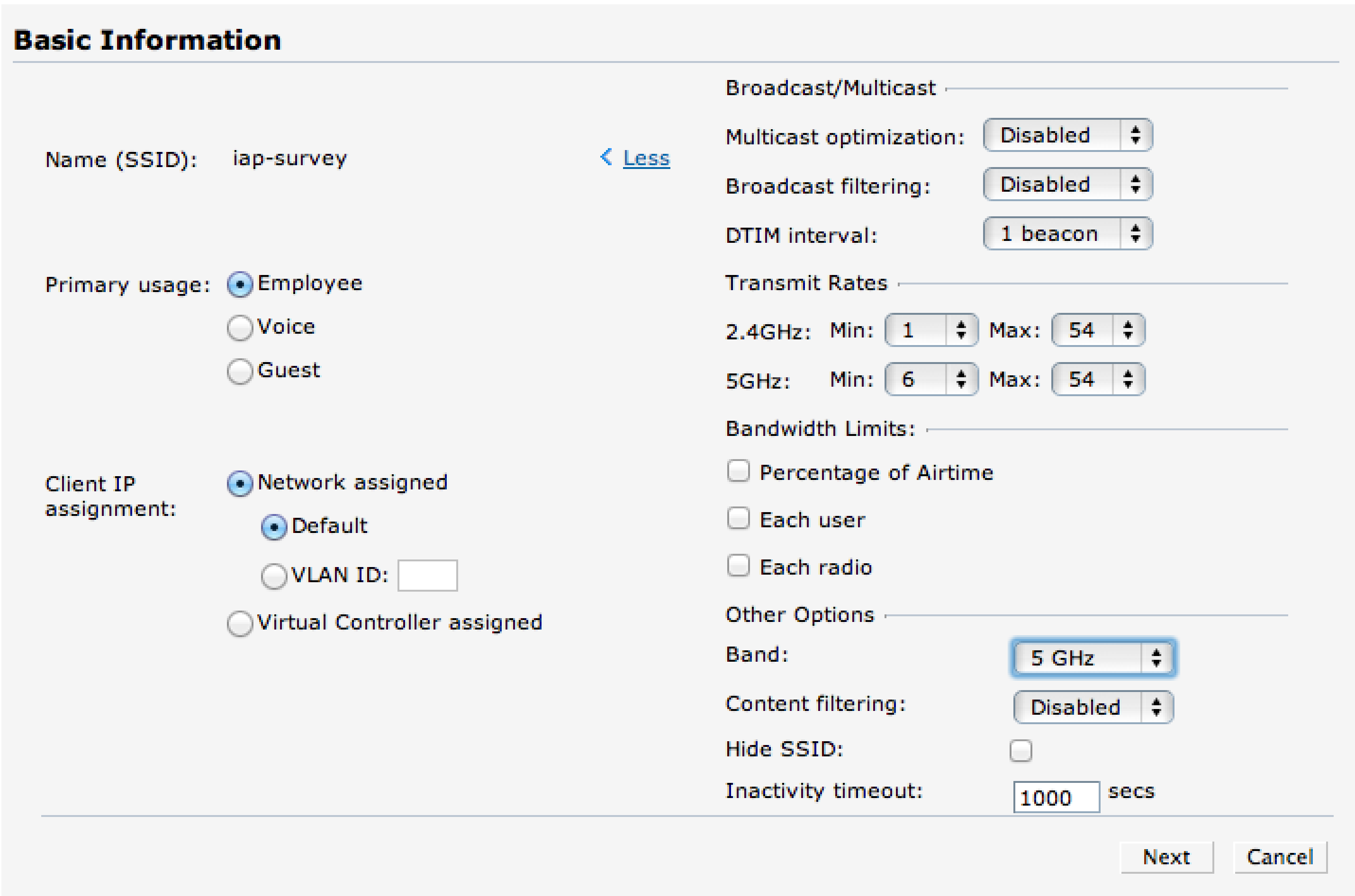

Figure 51 Setting the SSID to broadcast only on 5 GHz

Click **Next** to continue to the security settings. Here you configure the security level of the SSID, which is typically WPA2-PSK or open. If you select WPA2-PSK, enter your PSK as shown in Figure 52.

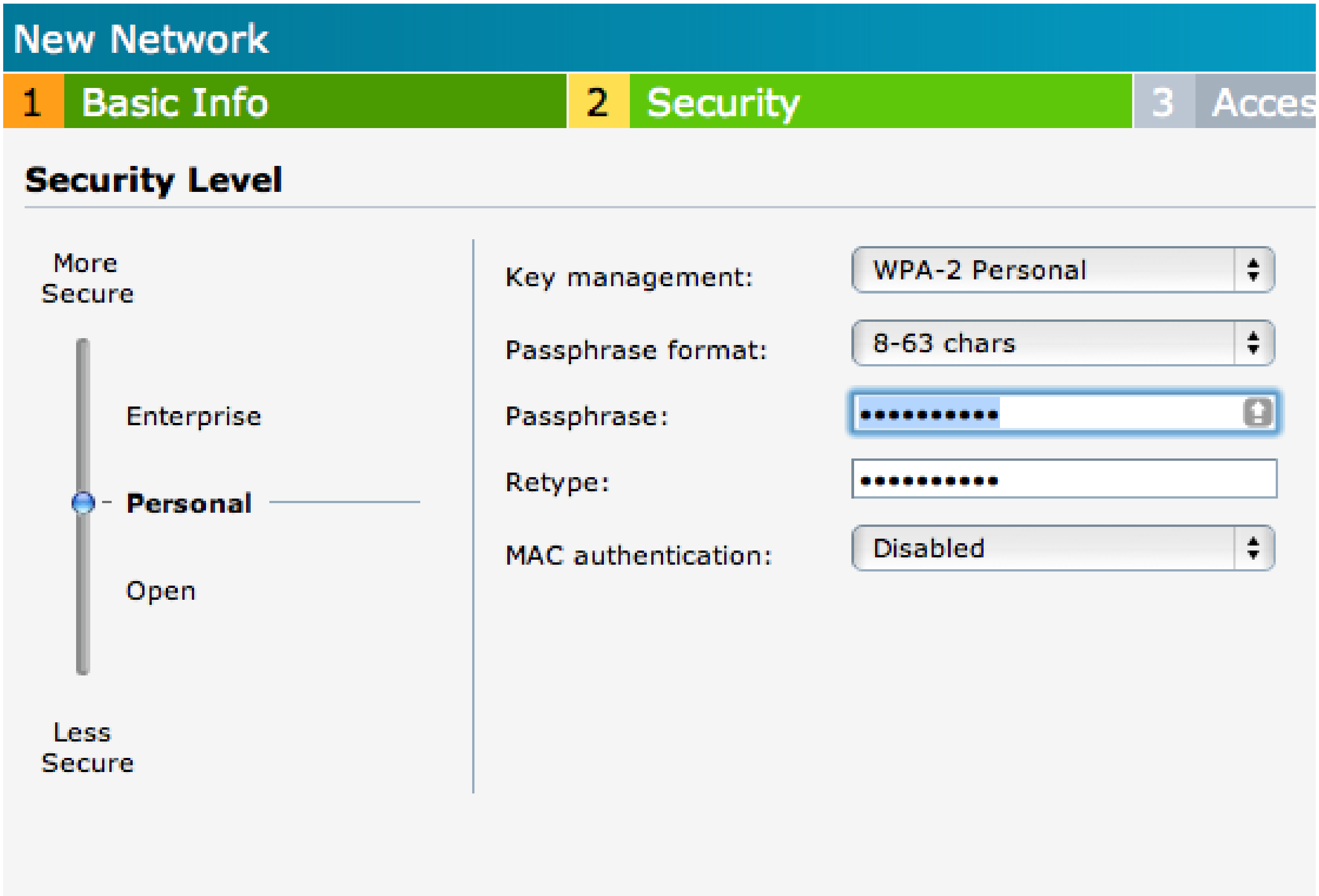

Figure 52 SSID security settings

Click **Next** to continue to the security settings. The final screen allows you to configure role-based access. You do not need to make any changes on this screen. Click **Finish** to complete the SSID setup. (See Figure 53.)

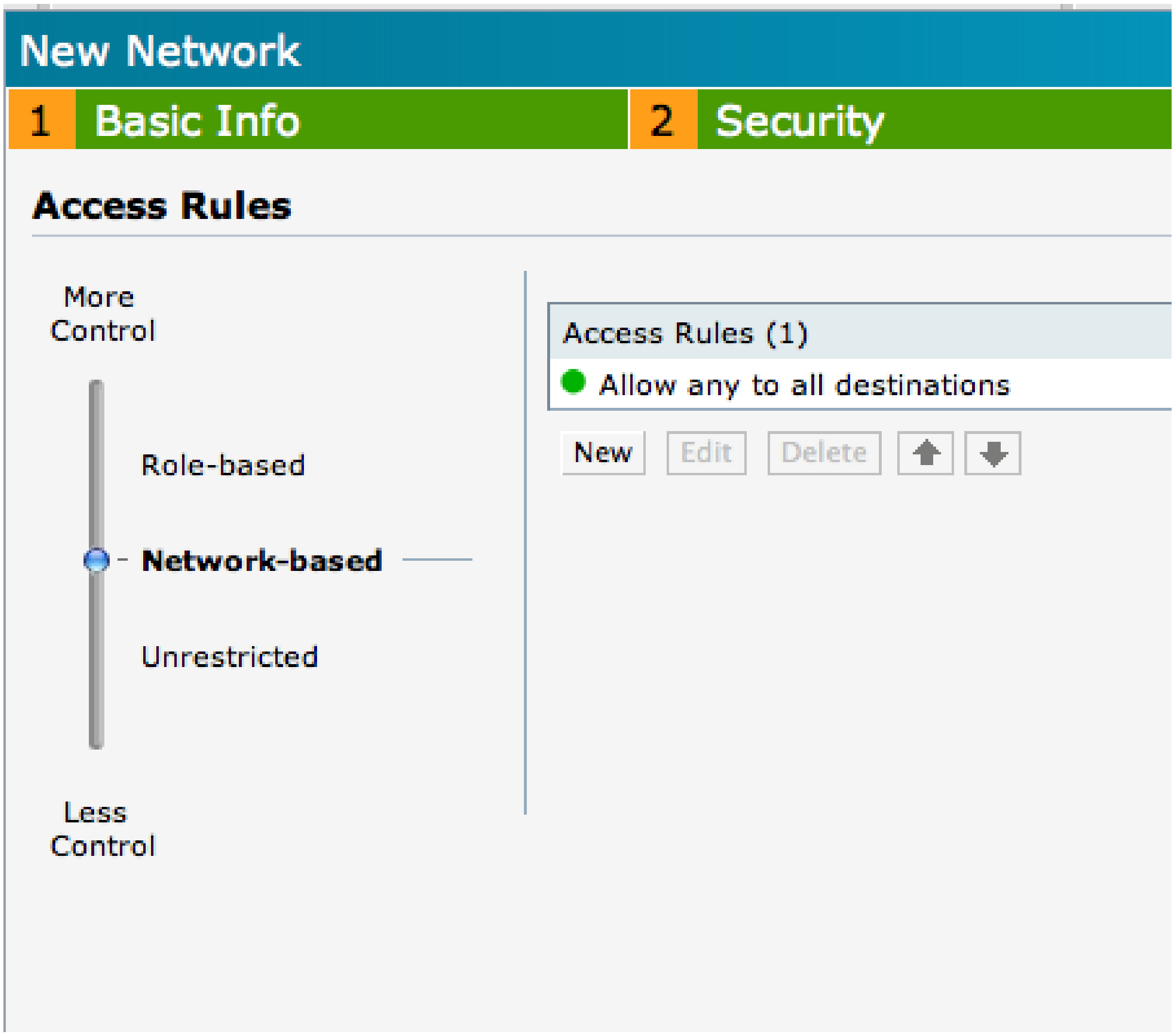

Figure 53 Access control settings

You should now see your new SSID in the network box on the dashboard. (See Figure 54.) You will use this SSID going forward.

Figure 54 New SSID is available

Connect your laptop to the new SSID you created and supply the PSK you configured when prompted to do so. When you log back into the management interface of the IAP, you will see that the Instant SSID has disappeared and the newly configured SSID is the only one present. (See Figure 55.)

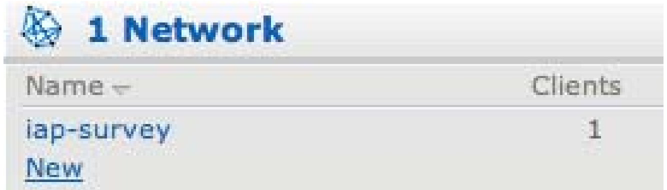

Figure 55 Connected to new SSID

The next step is to configure the ARM settings to disable power level changes. By default, ArubaOS sets the ARM minimum power to 15 dB. In this case, we want our IAP to match that minimum power. If you are not using the default minimum, adjust the power setting to match your planned configuration.

Click the settings link in the upper right hand corner and then click the ARM tab as shown in Figure 56. You must adjust the min and max transmit power to be 15 dB.

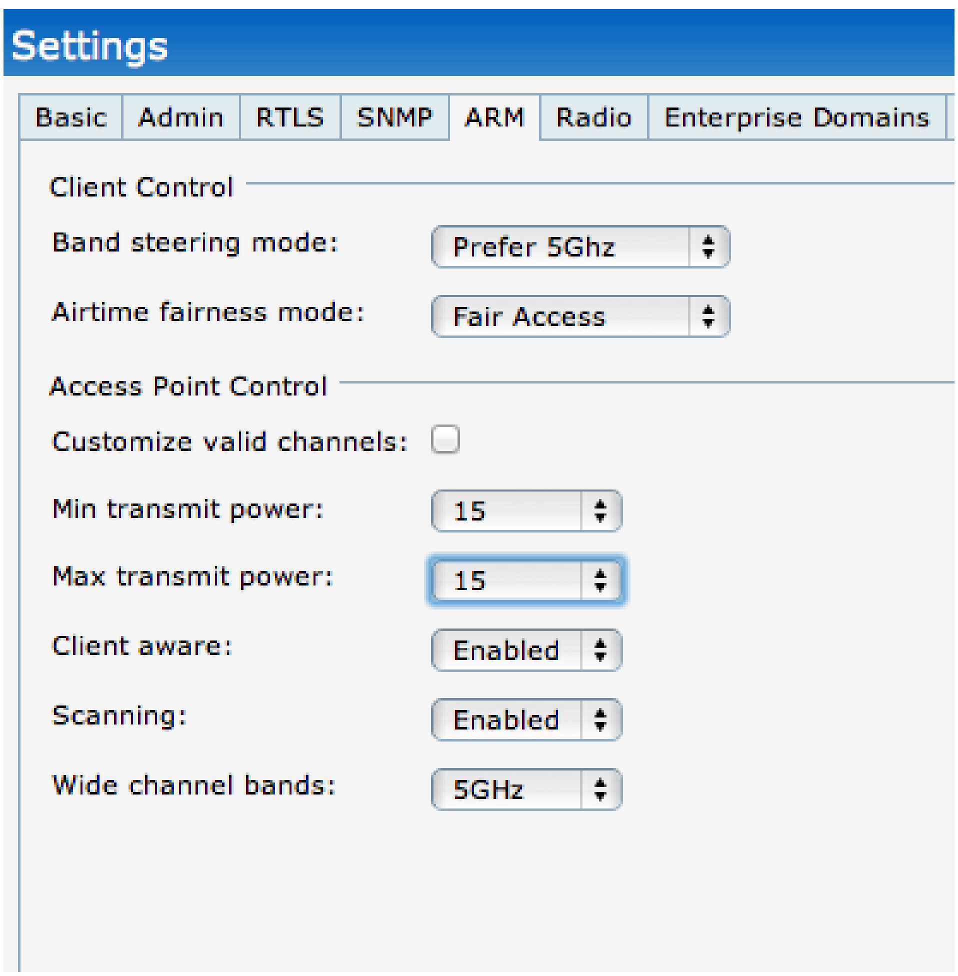

Figure 56 IAP ARM settings

At this point your IAP is ready to use for active and passive survey testing.

Appendix B: Physical Site Survey Tool Kit

Table 6 describes the basic equipment build out that is required for a physical site survey. To speed up the survey, multiple APs can be used simultaneously and will require equal increases in the additional supporting equipment.

Table 6 Site Survey Equipment List

Quantity	Device
1	Aruba Instant AP, the same AP model as will be deployed at the site if possible
1	Power-over-Ethernet injector or PoE switch
2	Long (30 feet minimum) Ethernet cables, long enough to reach from the ceiling to the floor where the power injector will be placed, and from the power injector to the laptop or cube wiring
1	Ladder, tall enough to reach the ceiling rails
1	Rolling cart to hold equipment while moving between locations
1	Laptop for providing DHCP and link to the Instant AP if a switch is not used
1	Laptop with site survey software and appropriate adapter, 4-8 GB of RAM, fast multi-core processor, and a solid-state hard drive (SSHD)
1	Distance wheel for marking off distances between APs
1	Optional – Laptop-carrying harness such as Connect-a-Desk (http://connect-a-desk.com/)

Appendix C: Contacting Aruba Networks

Contacting Aruba Networks

Web Site Support	
Main Site	http://www.arubanetworks.com
Support Site	https://support.arubanetworks.com
Software Licensing Site	https://licensing.arubanetworks.com/login.php
Wireless Security Incident Response Team (WSIRT)	http://www.arubanetworks.com/support/wsirt.php
Support Emails	
Americas and APAC	support@arubanetworks.com
EMEA	emea_support@arubanetworks.com
WSIRT Email Please email details of any security problem found in an Aruba product.	wsirt@arubanetworks.com

Validated Reference Design Contact and User Forum	
Validated Reference Designs	http://www.arubanetworks.com/vrd
VRD Contact Email	referencedesign@arubanetworks.com
AirHeads Online User Forum	http://community.arubanetworks.com

Telephone Support	
Aruba Corporate	+1 (408) 227-4500
FAX	+1 (408) 227-4550
Support	
● United States	+1-800-WI-FI-LAN (800-943-4526)
● Universal Free Phone Service Numbers (UIFN):	
■ Australia	Reach: 1300 4 ARUBA (27822)
■ United States	1 800 9434526 1 650 3856589
■ Canada	1 800 9434526 1 650 3856589
■ United Kingdom	BT: 0 825 494 34526 MCL: 0 825 494 34526

Telephone Support

- Universal Free Phone Service Numbers (UIFN):

■ Japan	IDC: 10 810 494 34526 * Select fixed phones IDC: 0061 010 812 494 34526 * Any fixed, mobile & payphone KDD: 10 813 494 34526 * Select fixed phones JT: 10 815 494 34526 * Select fixed phones JT: 0041 010 816 494 34526 * Any fixed, mobile & payphone
■ Korea	DACOM: 2 819 494 34526 KT: 1 820 494 34526 ONSE: 8 821 494 34526
■ Singapore	Singapore Telecom: 1 822 494 34526
■ Taiwan (U)	CHT-I: 0 824 494 34526
■ Belgium	Belgacom: 0 827 494 34526
■ Israel	Bezeq: 14 807 494 34526 Barack ITC: 13 808 494 34526
■ Ireland	EIRCOM: 0 806 494 34526
■ Hong Kong	HKTI: 1 805 494 34526
■ Germany	Deutsche Telkom: 0 804 494 34526
■ France	France Telecom: 0 803 494 34526
■ China (P)	China Telecom South: 0 801 494 34526 China Netcom Group: 0 802 494 34526
■ Saudi Arabia	800 8445708
■ UAE	800 04416077
■ Egypt	2510-0200 8885177267 * within Cairo 02-2510-0200 8885177267 * outside Cairo
■ India	91 044 66768150