



Wireless Design **Guide**



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INTRODUCTION

The Wireless Design Guide is written as a resource to help you properly design a wireless network. This guide walks you through the entire wireless design process, from customer interview and wireless access point (WAP) placement to configuration and installation. Whether designing a new wireless network or replacing an existing one, this design process and recommended best practices will help you deliver an exceptional wireless experience for the customer.

This guide helps meet the following goals:

1. Learn best practices for proper WAP placement
2. Determine the needs and requirements of the network
3. Choose the right number of WAPs required for the job
4. Learn how to conduct a predictive and manual site survey
5. Properly configure the WAPs for optimal wireless performance

BEFORE GETTING STARTED

Before you begin designing the wireless network, we recommend taking into account a few best practices:

INVEST IN THE PROPER NETWORKING TOOLS

During the design and deployment process, several factors need to be considered, from the size of the home and placement of the WAPs to sources of interference that can affect the wireless signals. Several tools are available to help in this process. Below are a few that we recommend.

Note: Not every project will require the use of all of these tools (further described later); however, we recommend having these tools at your fingertips to ensure you are always prepared.

Tools for all projects:

- > A **spectrum analyzer** is used to identify sources of non-WiFi interference, such as cordless phones, wireless video cameras, and microwaves. It can also provide data for WiFi signals, including signal strengths, channels, and data rates.

- > We recommend a WiFi scanner, such as the WiFi Explorer for Mac, WiFi Analyzer for Android, and WiFi Speed Spot for iOS/Android. A **WiFi scanner** is a simple WiFi troubleshooting tool used to quickly identify channel conflicts, overlapping channels, and other configuration issues that could be affecting the performance.

Tools for larger jobs with more than three access points:

- > A **predictive site survey tool** creates a heat map to estimate and predict the number of access points required based on the square footage and layout of the floorplan. Instructions on conducting a predictive site survey are available in the appendix.

Note: Packedge Network Design Services offers free network design services and a predictive site survey plan upon request to its dealers.

- > An **advanced site survey tool** is a sophisticated site survey tool that automatically measures the proper WAP placement using a heat map and advanced network analysis (channel selection, RSSI measurement, interference detection, etc).

Recommended companies:

- > [MetaGeek](#) and [Ekahau](#) are recommended companies that offer a predictive and advanced site survey, spectrum analysis, and a hybrid of both tools.
- > Several MetaGeek tools, including the hybrid site survey and spectrum analysis tool, are available for purchase directly through the Dealer Portal.

WHEN TO GO WIRED

As a best practice, we recommend connecting devices that can be connected either wired or wirelessly, such as touch screens, cameras, or media streaming systems, to the wired network first. For devices that are wireless only or require mobility, connect to the wireless network. This allows for greater throughput availability across the wireless network.

BUILD A “NETWORK DESIGN AND PLANNING” KIT

Lastly, we recommend putting a network design and planning kit together that includes a router, 8-port unmanaged switch, and WAP to be used in the wireless design and deployment process. Also, keep additional inventory on the truck in case more products are required to complete the project.

PHASE 1: DISCOVERY AND PLANNING

Objective:

Gather needed information to determine scope, size, and needed equipment for the network. Determine the device capacity, throughput, and coverage requirements for the network. These requirements will then be used to specify the type of access points needed and estimate the number of access points required for the job.

A. Customer Interview

The customer interview is the first step in learning the scope of the project and the requirements of the network. One of the primary goals of a proper wireless design is determining the device capacity, throughput, and coverage goals of the network. The information gathered in the customer interview will help determine these goals.

PROJECT SCOPE

First, understand the scope of the project. Interview questions include:

1. Is the project a new network, replacement/retrofit, or add-on/extension of the existing network?
2. Who is the Internet service provider?
3. What is the expected speed of the network?
4. What is the area of the project (indoor and outdoor)?
5. How many floors?
6. What is the location of the equipment rack?
7. What are the in-wall wiring, power accessibility, and cable run distances?

Note: *During the customer interview, request a digital copy of the floorplan or blueprint.*

NETWORK REQUIREMENTS

Planning for growth

Networks typically change in size in only one direction—they get larger. In designing the wireless network, planning for growth will pay great dividends in the long run. In addition, ask your customer about any future plans: in the next six months to two years, will there be users or new smart technology (automation system, smart lighting, security system, etc.) added to the network? Make sure to incorporate these future plans into your network requirements.

Device capacity

First, we need to determine the number of wireless devices need to be connected to the network. **Interview questions include:**

1. Maximum number of users and wireless devices that will be used on the network at any given time (on average and during peak usage)?
2. Advanced wireless smart devices on the network (for example, automation system, smart LED lighting, security system)?

The number of devices on the network will determine the types and numbers of WAPs required to support the connected devices.

WAPs can support a limited number of concurrent wireless connections without compromising performance. This is referred to as the WAP's *device capacity*. A WAP's device capacity depends on the chipset design and amount of RAM (memory) available.

The device capacity of a Packedge WAP is up to 50 concurrent client devices per WAP. If the number of devices required for the network is larger than 50, an additional WAP will need to be specified.

Note: *If the device capacity of a WAP is exceeded, client devices will experience a decrease in performance, resulting in slow connections, the WAPs locking up, and devices falling off the network.*

Throughput

Next, we need to determine the throughput requirements of the wireless network. *Throughput* is the maximum rate that data is delivered to a device. In selecting the type of WAP, it is also important to consider the antenna design (MIMO). *MIMO*, or multiple input, multiple output, is the number of transmit and receive antennas in the WAP. For example, a Packedge WK-1 has 2x2 MIMO, which indicates two transmit and two receive antennas, and Packedge WK-2 and WX-1 have 3x3 MIMO, which indicates three transmit and three receive antennas. A 3x3 WAP should be selected for a network requiring greater performance, because it provides a faster data rate and more throughput per device than the 2x2 WAP.

To determine the throughput requirements for every device, ask the following questions:

1. What types of applications are typically used? (email browsing or streaming video?)
2. What latency-sensitive/bandwidth-intensive applications are typically used, such as video streaming, 4K video, and VOIP?
3. During peak usage, how many devices are typically using more bandwidth-intensive applications?

For networks with applications that require a **smaller amount of throughput per device** for optimal performance (web browsing, reading email, streaming music, and some video streaming), select the WK-1.

For networks with applications that require **more throughput per device** for optimal performance (video streaming across multiple devices, security systems, automation system), select the WK-2 or WX-1.

Note: *In a real-world application, a customer's wireless network will never receive the maximum throughput available due to environmental factors, sources of interference, etc. On average, the network will receive up to 60% of the throughput.*

Coverage

Coverage is the range that the antennas transmit the wireless signals. Proper coverage is determined by several factors: the type of WAP (antenna design and transmit power levels), the number of WAPs, use of the 2.4 or 5.0 GHz bands, proper WAP placement, and attenuation from construction materials.

To determine the amount of coverage required for the project, ask the following questions:

1. What is the area of the project?
2. How many floors are there?
3. Are both indoor and outdoor coverage required?
4. What are the areas that are used the most and need the greatest amount of coverage?
5. Are there any locations where WAPs cannot be installed?
6. What are the types of building materials used in the project? (For example, brick, lath and plaster, metal studs, radiant floor heating, marble, granite, concrete, fish tanks)

In order to estimate the number of WAPs required for adequate coverage, consider up to 2,000 square feet (about 186 square meters) per WAP. The number of WAPs can be impacted by the type of construction material and presence of metallic structures. As an example, a brick wall can attenuate (reduce) the wireless signal by -12 dB while drywall will only attenuate by -3 dB. The final number of WAPs required will be determined during the WAP placement.

ADDITIONAL USER AND AESTHETIC REQUIREMENTS

The final part of the customer interview is making sure you have addressed all user requirements, including any design and aesthetic requests.

Interview questions may include:

1. Is a guest network required?
2. What level of support for the customer is needed?
3. Aesthetic preferences: WAPs need to be hidden, flush mounted into the ceiling, or wall mounted?

B. Network Specifications

TYPE OF WIRELESS ACCESS POINT

Using the information gathered in the customer interview, determine the type of WAPs and number of WAPs required for the job.

Packedge wireless access point matrix:

	WK-1	WK-2	WX-1
Wireless protocols	Dual-band 802.11n and 802.11ac	Dual-band 802.11n and 802.11ac	Dual-band 802.11n and 802.11ac
Antenna configuration	2x2 MIMO, omnidirectional	3x3 MIMO, omnidirectional	3x3 MIMO, omnidirectional
Device capacity	Up to 50 devices	Up to 50 devices	Up to 50 devices
Max data rates	Up to 1,200 Mbps (300 Mbps for 2.4 GHz; 867 Mbps for 5.0 GHz)	1,750 Mbps (450 Mbps for 2.4 GHz; 1,300 Mbps for 5.0 GHz)	1,750 Mbps (450 Mbps for 2.4 GHz; 1,300 Mbps for 5.0 GHz)
Coverage	Up to 2,000 square feet per WAP (186 square meters)*	Up to 2,000 square feet per WAP (186 square meters)*	Up to 2,000 square feet per WAP (186 square meters)*
SSIDs	16 with 2 guest	16 with 2 guest	16 with 2 guest
Encryption	WPA, WPA2 PSK	WPA, WPA2 PSK	WPA, WPA2 PSK, WPA Enterprise, WPA2 Enterprise
Power draw (average/peak)	10.99W/13.1W	13.49W/15.84W	11.64W/18.72W
Power Source	AC or POE+	AC or POE+	AC or POE+
Plenum rating (UL2043)	No	No	Yes
Form factors	Indoor, In-ceiling, and outdoor	Indoor and in-ceiling	Indoor, In-ceiling, and outdoor
Colors	Black and white	Black and white	White only

*Coverage is based on the 5.0 GHz band and dependent on the environment.

NUMBER OF WIRELESS ACCESS POINT(S)

After determining the type of WAPs for the job, estimate the number of WAPs based on the square footage per WAP and the square footage of the floorplan. Remember, when estimating the number of WAPs, meeting the device capacity requirements takes precedence over coverage.

If you are unsure of the number of access points required, we recommend to plan for one or two extra access points.

WHEN TO USE A WIRELESS CONTROLLER

For wireless networks with three or more WAPs, Pakedge recommends the NK-1 Wireless Controller, designed to assist you with planning, installing, and configuring multi-WAP projects. For small projects with fewer than three WAPs, the wireless controller is not required.

More information about the NK-1 Wireless Controller can be found on the Dealer Portal.

WHEN TO USE A PREDICTIVE SITE SURVEY

For wireless networks estimated to need more than three WAPs, we recommend performing a predictive site survey. Pakedge network design services, as well as recommended networking tools, can provide a heat map of wireless coverage and recommended WAP placement based on the floorplan and additional construction materials identified in the customer interview. This survey will then be validated during the on-site evaluation.

C. Initial On-site Evaluation

The last step in the design and planning phase is to conduct an initial on-site evaluation. The purpose of the on-site evaluation is to validate the scope of the project and identify real-world factors that will affect the wireless design, such as interference, building materials, and mounting options for best WAP placement. First, we will review key concepts and guidelines for the on-site evaluation followed by the final design step of identifying all environmental factors.

Note: *To make your onsite visit more productive, we recommend purchasing the WAPs required for the job and bringing them with you to the site evaluation. We understand that this is not always possible; however, having all WAPs present during the site evaluation and WAP placement process will ensure the best possible experience in deploying the wireless network.*

KEY CONCEPTS AND GUIDELINES FOR THE ONSITE EVALUATION

More WAPs does not equal more coverage

It is a common mistake to add too many access points to a site for proper coverage. To ensure you are not making this mistake, follow the proper values recommended in this guide to determine the appropriate level of coverage and proper amount of wireless signal overlap in multi-WAP projects.

Measuring coverage based on the 5.0 GHz band

Pakedge WAPs support both the 2.4 and 5.0 GHz bands. During the design process, we recommend calculating WAP placement using the 5.0 GHz band, because the coverage area of the 5.0 GHz band is smaller than 2.4 GHz. To incorporate coverage for the 2.4 GHz band, lower the Tx power of the 2.4 GHz band to provide the same level of coverage. Alternatively, disable the 2.4 GHz band on some of the WAPs and adjust the overall 2.4 GHz coverage.

Measuring the RF cell boundary, RSSI, and SNR

The **RF (radio frequency) cell boundary** is the circumference of the radio cell that each WAP produces. Identifying these boundaries for every size job is important in measuring the overlap of wireless signal between adjacent WAPs. This ensures seamless handoffs of client devices and adequate wireless coverage.

The **RSSI (received signal strength indication)** is a measurement of how “loudly” the wireless signal is received (the strength of the signal). RSSI is measured as a negative value between 0 and -120 dBm. Typically, voice networks require about -65 to -70 dBm or better, while a data network needs -80 dBm or better. RSSI value is affected by the WAP transmit power and antennas. Adjusting the transmit power changes the RSSI value.

Note: *For the best signal with Pakedge WAPs, the recommended RSSI value is -70 dBm.*

The **SNR (signal-to-noise ratio)**, measured in decibels (dB), is the ratio of the difference between the WiFi signal (RSSI) and the intrinsic noise on the channel. Interfering signal sources, such as microwaves and cordless phones, can increase the noise and degrade the SNR. SNR is measured in positive values from 0 to 120 dB. Example: -70 dB (signal) + -89 dB (noise) = about 21 dB. This means you have an SNR of 20. Recommended SNR values are between 20-25 dB.

APPLICATION CONSIDERATIONS

Sources of WiFi and non-WiFi interference

Managing and mitigating sources of interference is one of the most important goals for a well-designed wireless network. Different types of interference can reduce signal quality resulting in a loss in coverage. By determining these sources of interference, steps can be taken to mitigate their effect through proper WAP placement and configuration settings.

Examples of non-WiFi interference include household appliances, cordless phones, baby monitors, microwaves, Bluetooth devices, and ZigBee. Strong neighboring WiFi signals that are greater than -45 dBm should also be considered.

Regardless of the size of the project, a spectrum analyzer is a helpful tool in determining the types and amount of interference in the environment. Recommended spectrum analyzer tools are listed at the beginning of this guide.

Determine the best mounting options

Before determining the exact location of the WAPs, select how each will be mounted. Pakedge WAPs can be mounted to ceilings or walls.

Ceiling-mounted WAPs can be mounted on a ceiling tile, T-bar, or roof. This mounting option is the ideal solution for providing the best line of sight for connected devices as well as providing ample coverage.

When ceilings are too high or locations for ceiling-mounted WAPs are restricted, we recommend mounting the WAP to the wall. WAPs should be mounted at least 10 feet (about three meters) above the floor.

Whether the WAP is ceiling mounted or wall mounted, avoid placement near building materials like concrete, granite, and metal, which can negatively affect the wireless signal propagation.

DESIGN AND AESTHETIC REQUIREMENTS

In the final stage of the design process, review the design and aesthetic requirements provided in the customer interview. Below are possible design considerations:

1. Areas where users spend the most time
2. Location of the equipment rack
3. In-wall wiring, power accessibility, and cable run distances
4. Locations where WAPs cannot be installed
5. Outdoor coverage
6. Best WAP locations based on specified form factor (wall mounted or ceiling mounted)

PHASE 2: WAP PLACEMENTS

Objective:

Determine the most effective WAP locations. Everything up to this point has focused around building the deployment plan. Now, it's time to put the plan into motion by determining proper WAP placement.

To determine proper WAP placement, one of two processes can be followed, depending on the number of access points estimated for the job prior to going on-site:

- > **If three or fewer WAPs are required**, WAP placement can be determined by measuring the RF cell boundary using a basic network analysis tool hosted on a client device, such as a mobile phone, or from the configuration dashboard of the WAP interface using a laptop. Additional site survey tools are not required for this job.
- > **If more than three WAPs are required**, WAP placement can be determined using an advanced site survey tool to measure the RF cell boundaries and determine the best AP locations. Prior to going on-site, we recommend conducting a predictive site survey.

Use the following matrix as a guide:

	WAP placement	Predictive site survey tool	Manual site survey tool	Spectrum analysis
≤ 3 WAPs	RF cell boundary test	No	No	Yes
> 3 WAPs	Site survey tools	Yes	Yes	Yes

Note: Required concepts for WAP placement, including locating RF cell boundaries and measuring RSSI, were explored in Phase 1.

A. Three or Fewer Wireless Access Points

For jobs with fewer than three WAPs, a predictive and manual site survey can be skipped and proper WAP placement can be determined by walking the site and manually measuring the **RF cell boundary**. The RSSI values of the WAPs are measured with a WiFi analyzer tool (see “Before getting started” for recommended WiFi analyzer tools).

Tools needed for WAP placement:

- > At least one WAP. (Alternatively, if all WAPs are available, perform tests using all available WAPs)
- > WiFi analyzer tool

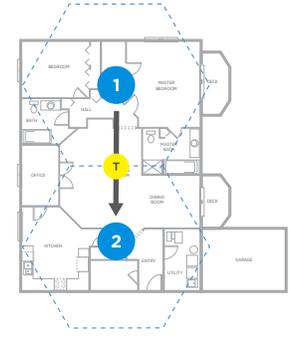
ONE WIRELESS ACCESS POINT

When one access point is estimated, we recommend placing the WAP in the central-most location of the floorplan. The 5.0 GHz band should cover the entire square footage.

1. Place the WAP in the middle of the house and power it on.
2. Log in to the WAP's interface and adjust its transmit power levels as follows: 5.0 GHz: Maximum / 2.4 GHz: 13 dBm (Medium).
3. Walk away from the WAP in a straight line. As you continue walking, use a WiFi analyzer tool on a mobile device or access the configuration dashboard of the WAP interface using a laptop to identify the RSSI of the WAP. The RSSI value should not go below -70 dBm.
4. Walk around, continually measuring the RSSI value.
5. If the value drops below -70 dBm in any areas where coverage is required, we recommend adding a second access point or adjusting WAP placement for proper coverage.



4. Before moving WAP 1 to measure the location for WAP 2, use the WiFi analyzer to test the RSSI value multiple times around WAP 1, ensuring the RSSI value does not drop below -70 dBm.
5. Next, take WAP 2 and place it in location "T." Keep the transmit power levels the same as in Step 1.
6. Similar to Step 3, continue in the opposite direction from the T location. As you are walking, use the client device, again to identify the RSSI of the WAP. When the RSSI reaches -70 dBm, stop and mark the location for WAP 2.
7. Use the WiFi analyzer to test the RSSI value multiple times around WAP 2, ensuring the RSSI value does not drop below -70 dBm.
8. Make any adjustments to the WAP placement if the RSSI value falls below -70 dBm.



THREE WIRELESS ACCESS POINTS

When three WAPs are estimated, we recommend beginning with a WAP in one corner of the house. As shown in the illustration, WAP placement will be conducted in a honeycomb pattern (similar to a triangle effect).

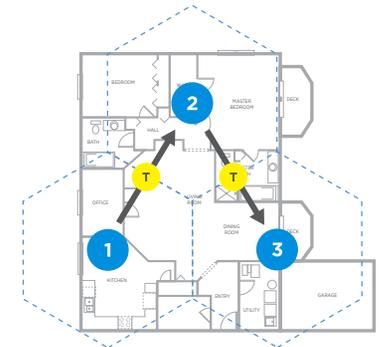
In the illustration to the right, the blue circles represent the permanent placement of the WAP, and the yellow circles represent temporary placement used while determining the boundary.

TWO WIRELESS ACCESS POINTS

When two WAPs are estimated, we recommend placing the two WAPs in two primary areas of the house that are separated by at least 40 feet (12 meters). In the illustration, the blue circles represents the permanent placement of the WAP, and the yellow circles represent temporary placement while determining the boundary.

1. Place the WAP in a corner or area with the most usage and power it on. (This is "1" in the illustration figure to the right.)
2. Log in to the WAP's interface and adjust its transmit power levels as follows: 5.0 GHz: 18 dBm (High) / 2.4 GHz: 13 dBm (Medium).
3. Walk away from WAP 1 in a straight line towards the second primary location where you've estimated WAP 2 will be placed. As you continue walking, use a network analyzer tool on a mobile device or access the configuration dashboard of the WAP 1 interface using a laptop to identify the RSSI of WAP 1. When the RSSI reaches -70 dBm, stop and mark the location ("T" in the illustration). This location will mark the edge of your RF cell boundary for the first WAP.

1. Place the WAP in one corner of the house and power it on. (This is "WAP 1" illustrated in the figure above.)
2. Log in to the WAP's interface and adjust its transmit power levels as follows: 5.0 GHz: 18 dBm (High) / 2.4 GHz: 13 dBm (Medium).
3. Walk away in a straight line from WAP 1. As you continue walking, use a network analyzer tool on a mobile device or access the configuration dashboard of WAP 1 interface using a laptop to identify RSSI of WAP 1. When RSSI reaches -70 dBm, stop and mark the location ("T" in the illustration). This location will mark the edge of your RF cell boundary.



4. Take WAP 1 and move it to location “T.” Keep the transmit power levels the same as in Step 1.
5. Use the WiFi analyzer to test the RSSI value multiple times around WAP 1, ensuring the RSSI value does not drop below -70 dBm.
6. Using either WAP1 or an additional WAP brought for placement verification, walk away in a straight line in the opposite direction from WAP 1 towards another corner of the house (see illustration as an example). As you are walking, use the client device or WAP interface again to identify the RSSI of WAP 2. When the RSSI reaches -70 dBm, stop and mark the location (“T” in the illustration).
7. Use the WiFi analyzer to test the RSSI value multiple times around WAP 3, ensuring the RSSI value does not drop below -70 dBm.
8. Repeat the same process to determine the placement of WAP 3 by following the honeycomb pattern above (refer to illustration as reference; direction is roughly 90 degrees from the direction of WAP 1 and WAP 2 to create a “triangle” effect).
9. Use the WiFi analyzer to test the RSSI value multiple times around WAP 3, ensuring the RSSI value does not drop below -70 dBm.
10. Make any adjustments of the WAP placement if the RSSI value falls below -70 dBm.

Note: *This process serves to demonstrate how to measure the RF cell boundary with three WAPs for a floorplan with a single floor. In a majority of cases, the floorplan calls for more than one floor. In this instance, follow the same process, placing the WAPs in different corners on each floor. Make sure there is ample distance between each WAP. Do not place a WAP on the second floor that is directly above the WAP on the first floor, as this will cause the wireless signals to overlap.*

B. More Than Three Wireless Access Points

For projects with more than three WAPs, WAP placement becomes more challenging—and more crucial to network success. We recommend performing a predictive site survey to estimate the number of the WAPs, RF cell boundaries, and the best placement for each WAP. Instructions for performing a predictive site survey are available in the appendix.

Next, during the job site evaluation, a manual site survey will be performed using the advanced site survey tools (Recommended tools referenced in Phase 1). For instructions on performing the manual site survey, refer to instructions for the site survey tool you have chosen to use.

Best practices during a manual site survey for optimal wireless performance

- > Client devices should be able to detect an RSSI range of -70 to -75 dBm and an SNR between 20 and 25 dB from each WAP.
- > After performing a manual site survey, it is not uncommon that additional access points will be needed after sources of interference and environmental factors are discovered. Make adjustments to the number of WAPs and WAP placement as needed for optimal coverage.

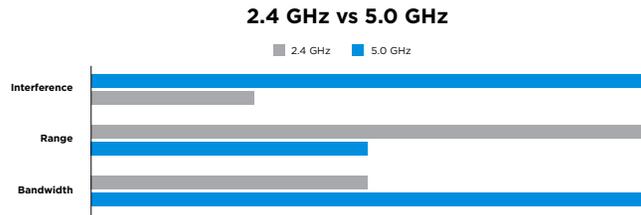
Steps to perform a manual site survey

- > Identify all sources of WiFi and non-WiFi interference using a spectrum analyzer.
- > Using the site survey tool, make manual adjustments based on the network requirements and accounting for interference. For instructions on using the site survey tool, refer to the company’s website and available resources within the tool.
- > Use the site survey tool to identify proper RSSI and SNR measurements and determine RF boundaries, thus ensuring proper WAP placement.

PHASE 3: CONFIGURATION

Objective:

Configure the access points by adjusting channel width, assigning channels to the 2.4 and 5.0 GHz bands, and setting proper transmit levels for optimal wireless performance.



Now it is time to configure the WAPs. Proper channel width, channel planning, and power settings are determined based on the device requirements, environment, and sources of interference in order to ensure the best possible wireless experience.

A. Frequency Bands

Wireless network signals broadcast on two frequency bands: 2.4 GHz and 5.0 GHz. The 2.4 GHz band provides a greater range than 5.0 GHz, but, due to its limited number of channels and frequency overlap, is more prone to interference. The 5.0 GHz band provides 23 channels, resulting in less congestion and greater throughput to each wireless device.

During the design process, it's important to consider which bands are needed to provide the best wireless experience. Most smart devices available today support both 2.4 GHz and 5.0 GHz. However, there are still devices that still support only 2.4 GHz.

	2.4 GHz	5.0 GHz
Range (usable)	300 ft (~91 m)	100-150 ft (30-46 m)
Non-overlapping channels	Three non-overlapping channels (1, 6, 11)	23 non-overlapping channels available for use
Device compatibility	Most devices	Only devices with 5.0 GHz capability
RF environment	Congested	Low congestion
Interfering devices	Many	Limited
Application	Devices not 5.0 GHz compatible, low-interference environments	High-density areas, such as urban areas and multi-tenant buildings

B. Transmit Power

The **transmit power settings** are an important component to properly place WAP and to create the necessary wireless signal overlap for a seamless roaming experience. During WAP placement, the transmit power levels were set to the following:

- > 18 dBm (High) for the 5.0 GHz band
- > 13 dBm (Medium) for the 2.4 GHz band

For all firmware versions, the transmit powers are set to **maximum** out of the box. For the best signal overlap, make sure to change the transmit power levels to the recommended values above.

Note: *Transmit powers should be set prior to setting the channels. However, now that the WAP placement has been determined, adjustments can be made, as necessary, to ensure a seamless handoff experience.*

Verifying the roaming process:

During the roaming process (the handoff of a client device from one access point to another), a client device is always searching for a stronger wireless signal to connect to. When it discovers the strong signal, it will roam to that WAP. If the client device can detect multiple strong signals, there are too many access points present or they are transmitting too powerfully. Adjust the transmit power level in one access point and test the roaming experience again. Repeat this process until the client device seamlessly hands off between each of the access points.

C. Channel Planning

Channel planning is one of the most important steps during the configuration process to mitigate interference. Every neighboring network is fighting to access the same wireless channels. Channel planning requires setting the WAPs to channels that are the least congested. These steps apply to every size of network.

Packedge WAPs have automatic channel selection, which automatically finds the best channel available on the 2.4 GHz and 5.0 GHz bands. The WAPs identify the surrounding networks and their RSSI levels, and with this information, connect the WAP to the least-used channel.

After using automatic channel selection, it is recommended to verify the channels being selected, following these best practices:

2.4 GHz band:

- > 2.4 GHz should use only non-overlapping channels (1, 6, 11).
- > By default, it is recommended to set the 2.4 GHz band to channel 6.
- > Adjacent RF cells should be set to different channels.
- > Ensure that the channel selected for each WAP is not interfering with WiFi and non-WiFi sources that you have determined in the discovery phase.

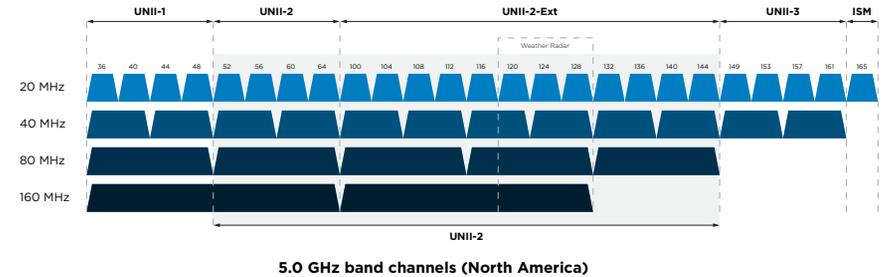
5.0 GHz band:

- > 5.0 GHz radios on each WAP should use different channels.
- > By default, it is recommended to set the 5.0 GHz band to channel 36.
- > Avoid reusing the same channels for each pair of neighboring WAPs.
- > Ensure that the channel selected for each WAP is not interfering with WiFi and non-WiFi sources that you have discovered during data collection.

D. Channel Width

Channel width (also called channel bonding) determines the rate at which data is transferred to wireless client devices. The Wireless-N standard (802.11n) specifies a channel width of 20 MHz to 40 MHz, and the Wireless-AC standard (802.11ac) specifies a channel width of 40 MHz, 80 MHz, and 160 MHz. By increasing the width of the channel, the throughput and data transfer on the wireless channel increases. However, the wider the channel, the more susceptible it is to interference and congestion. For 802.11n, a channel width of 20 MHz is the most stable solution for more dense and crowded environments, while the 40 MHz width is more applicable for open environments. For 802.11ac, the same theory applies; however, 802.11ac provides greater flexibility in changing the width due to the less congested nature of the wireless channels.

Wi-Fi Bands 5.0 GHz



For jobs with three or fewer WAPs:

- > We recommend setting the 2.4 GHz band to 20 MHz and the 5.0 GHz band to 80 MHz.
- > These settings are set by default in all Pakedge WAPs.

For jobs with more than three WAPs:

- > We recommend setting the 2.4 GHz band on all WAPs to 20 MHz.
- > For the 5.0 GHz band, the proper setting will depend on the environment:
 - Low-density, low-interference environment: Set to 80 MHz.
 - For dense, higher interference environments: Set to 40 MHz or 20 MHz.

E. Power and Channel Optimization

For jobs with three or more access points deployed, we recommend using the NK-1 Wireless Controller for global configuration and to optimize the wireless network. For more information using the NK-1 to optimize the network with additional power and channel adjustments, refer to this knowledgebase article available on the Dealer Portal: *Power & Channel Optimization with the NK-1 Wireless Controller*.

PHASE 4: FINE TUNING AND FINAL INSTALLATION

Objective:

Verify configurations and finalize installation of the access points.

A. Fine Tuning

Now that the WAPs have been configured, we recommend testing the wireless performance before the WAPs are permanently installed.

RECOMMENDED TESTS TO VERIFY CONFIGURATION

1. Verify throughput using a laptop or mobile device. Test the throughput on each WAP.
2. Verify the roaming process:
 - Run a speed test (recommended to use [speedtest.net](https://www.speedtest.net)) while walking from one WAP to the other, and repeat the test multiple times. Run the test multiple times as you walk from one WAP to the other. Confirm that the pings are received and verify that the expected speed does not drop below 25%.
 - When walking between two WAPs, the client device should automatically connect to the strongest signal. If your device begins to drop over 25% in speed, you have improper overlap and need to consider adjusting the transmit power on the WAPs you are closest to.
 - Using a client device, run a constant ping to the default gateway (router's IP address) while walking from one WAP to the other. One to five pings should drop out before connecting to the next WAP.
3. Test specific applications that the customer mentioned during the interview process, including video streaming applications.
4. Fine-tune channels and transmit powers on each WAP, as needed, based on your previous testing, to obtain optimal coverage and performance.
5. Using the site survey tools (if used), verify channels, RSSI coverage, SNR, and channel overlap for each WAP.

B. Finalize Installation

After the final verification and additional fine tuning are complete, complete the installation by finalizing the mounting positions and wiring.

**CONGRATULATIONS.
YOU HAVE SUCCESSFULLY DESIGNED
AND DEPLOYED THE WIRELESS NETWORK!**

APPENDIX

1.1 Wireless Design Checklist

BEFORE GETTING STARTED

- Invest in the proper tools (mobile network analyzer, spectrum analyzer, advanced site survey tool)
- Determine wired vs. wireless requirements
- Build a “network design and planning” kit

PHASE 1: DISCOVERY AND PLANNING PROCESS

- Conduct customer interview with recommended interview questions
 - Request floorplan or blueprint
 - Determine device capacity, throughput, and coverage needs
 - Determine additional user requirements
- Network specifications
 - Determine type of WAP: _____
 - Determine number of WAPs: _____
 - Less than three WAPs: no wireless controller or predictive site survey
 - 3+ WAPs: Wireless controller & predictive site survey
- Initial on-site evaluation
 - Purchase estimated number of WAPs (recommended)
 - Determine sources of WiFi and non-WiFi interference (recommended to use spectrum analyzer)
 - Determine best mounting options and aesthetic requirements

PHASE 2: WAP PLACEMENT

- Three or fewer WAPs: RF cell boundary test
- More than three WAPs:
 - Predictive site survey
 - Advanced site survey tool (recommended: MetaGeek or Ekahau)

PHASE 3: CONFIGURATION

- Determine frequency bands required (best practice: design based on 5.0 GHz band)
- Set transmit powers for frequency bands (2.4 GHz and 5.0 GHz)
 - Change default (maximum) to recommended settings
 - Verify roaming process (for projects with two or more WAPs)
- Run automatic channel selection and verifying channels based on recommended settings
- Set recommended channel width based on the size of the project
- (*More than three WAPs:*) Power and channel optimization recommended

PHASE 4: VALIDATION

- Validation testing to verify configuration
- Finalize installation

1.2 How to Use a Predictive Site Survey Tool

1. Obtain image files of the blueprint or floorplan (.png or .jpg) and upload them into the site survey tool.
2. Referring to the blueprint or floorplan, add various walls, doors, and windows to the map using the embedded drawing tools.
3. Mark the locations and types of building materials (draw these into the map). Building materials have different levels of signal attenuation that the tool accounts for when determining where the WAPs should be placed.

Note: This information is best gathered during the customer interview. However, if some information is missing, fill in the information you do have. The more accurate the site survey, the more accurate it can be in predicting signal attenuation and the ideal locations to place WAPs.

4. Choose the type of access point you intend to install and input the square footage this access point is specified to cover. If you are unsure, refer to an earlier section in this guide, “Network Specifications.”
5. Run the automatic placement feature to predict good locations for installing the WAPs and estimated coverage. The site survey tool uses the information entered into the tool (floorplan, square footage, objects drawn on the map, building materials, etc.).
6. Manually adjust the placement if any gaps in coverage appear or if the WAPs can't be mounted in the locations predicted.
7. Make any additional changes, such as removing or updating drawings or building materials. After the changes are made, run the automatic placement feature to update the WAP placement.

