



# Best Practices Guide for Deploying SpectraLink 8020/8030 Wireless Telephones

July 2009  
Version H

# Deploying SpectraLink 8020/8030 Wireless Telephones

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<b>1</b>	<b>Introduction</b>	

Wi-Fi telephony, also known as Voice over Wireless LAN (VoWLAN), delivers the capabilities and functionality of the enterprise telephone system in a mobile handset. The Wi-Fi handset is a WLAN client device, sharing the same wireless network as laptops and PDAs. For enterprise use, the handset is functionally equivalent to a wired desk phone, giving end-users all the features they are used to having in a wired office telephone. The benefits of VoWLAN can result in substantial cost savings over other wireless technologies by leveraging the Wi-Fi infrastructure and by eliminating recurring charges associated with the use of public cellular networks. For end users, VoWLAN can significantly improve employee mobility, resulting in increased responsiveness and productivity.

Delivering enterprise-grade VoWLAN means that wireless networks must be designed to provide the highest audio quality throughout the facility. Because voice and data applications have different attributes and performance requirements, thoughtful WLAN deployment planning is a must. A Wi-Fi handset requires a continuous, reliable connection as a user moves throughout the coverage area. In addition, voice applications have a low tolerance for network errors and delays. Whereas data applications are able to accept frequent packet delays and retransmissions, voice quality will deteriorate with just a few hundred milliseconds of delay or a very small percentage of lost packets. Whereas data applications are typically bursty in terms of bandwidth utilization, voice conversations use a consistent and a relatively small amount of network bandwidth.

Using a Wi-Fi network for voice is not complex, but there are some aspects that must be considered. A critical objective in deploying enterprise-grade Wi-Fi telephony is to maintain similar voice quality, reliability and functionality as is expected from a wired telephone. Some key issues in deploying Wi-Fi telephony include WLAN coverage, capacity, quality of service (QoS) and security.

Polycom pioneered the use of VoWLAN in a wide variety of applications and environments, making the SpectraLink 8020/8030 Wireless Telephone the market leader in this category. Based on our experience with enterprise-grade deployments, this guide provides recommendations for ensuring that a network environment is optimized for use with SpectraLink 8020/8030 Wireless Telephones.

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## 1.1 SpectraLink Wi-Fi Release 3.0

In May 2009, Polycom delivered a major software upgrade that provided significant feature enhancements to the SpectraLink 8020/8030 Wireless Telephone when using end-to-end VoIP. Release 3.0 (R3.0) adds WLAN QoS and security features that provide IT administrators greater flexibility by increasing deployment and configuration options. The corresponding features must be supported and properly configured on the WLAN. Consult the [VIEW Certified Products Guide](#) on the Polycom web site for WLAN infrastructure products certified with Release 3.0. The [VIEW Configuration Guides](#) for approved products must be closely followed to ensure proper operation of the handset with the WLAN.

To take advantages of the R3.0 features described in this guide, SpectraLink handset software must be upgraded. Release 3.0 features are available in handset version 131.019 or above. The administrator can recognize R3.0 features from the handset administration menu or the Handset Administration Tool (HAT), which will show the following menu structure: Network Config (level 1), WLAN Settings (level 2), Custom or CCX (level 3).

Release 3.0 is available on Polycom handsets using SIP. A future release will support connections to traditional PBXs using the SpectraLink Telephony Gateway.

## 1.2 SpectraLink 8020/8030 Wireless Telephones

The information contained in this guide applies only to SpectraLink 8020/8030 Wireless Telephones (generically referred to as 'handsets' throughout this document) and their OEM derivatives. Detailed product information for the [SpectraLink 8020/8030 Wireless Telephones](#) can be found at Polycom's web site. For information on other Polycom Wi-Fi handsets, including the [SpectraLink e340/h340/i640 or 8002 Wireless Telephones](#), visit the appropriate product page at Polycom's web site.

## 1.3 SpectraLink Infrastructure

Throughout this guide references are made to SpectraLink infrastructure equipment including the [SVP Server, Telephony Gateway and OAI Gateway](#). These LAN-based devices are sold by Polycom for use with the SpectraLink 8020/8030 Wireless Telephone:

- When SVP is selected as the QoS mechanism, an SVP Server must be used.
- Telephony Gateways allow the handset to operate as an extension off of a PBX. For systems with four or fewer Telephony Gateways, the integrated SVP Server capability can be used and a separate SVP Server is not required. For systems with more than four Telephony Gateways, a separate SVP Server is required.
- The OAI Gateway enables third-party applications to send and respond to real-time text messages and alerts using SpectraLink handsets.

For additional details on any of these products visit the Polycom web site.

## 1.4 VIEW Certification Program

The [VIEW Certification Program](#) is a partner program designed to ensure interoperability and maximum performance for enterprise-grade Wi-Fi infrastructure products that support Polycom's SpectraLink 8020/8030 Wireless Telephones and their OEM derivatives. The Program is open to manufacturers of 802.11a/b/g/n infrastructure products that incorporate the requirements described in the VIEW Technical Specification and pass VIEW Certification testing. VIEW certification requirements focus on implementing industry standards for Wi-Fi networks along with meeting the specific quality of service (QoS) and performance characteristics that are necessary for supporting Polycom handsets.

For each certified product, Polycom provides a [VIEW Configuration Guide](#) that details the tested hardware models and software versions; radio modes and expected calls per AP; and specific AP

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configuration steps. [VIEW Configuration Guides](#) are available on Polycom website and should be followed closely to ensure a proper deployment.

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## 2 Wireless LAN Layout Considerations

SpectraLink handsets utilize a Wi-Fi network consisting of WLAN access points (APs) distributed throughout a building or campus. The required number and placement of APs in a given environment is driven by multiple factors, including intended coverage area, system capacity, access point type, power output, physical environment, and radio types.

### 2.1 Coverage

One of the most critical considerations in deployment of SpectraLink handsets is to ensure sufficient wireless signaling coverage. Enterprise Wi-Fi networks are often initially laid out for data applications and may not provide adequate coverage for voice users. Such networks may be designed to only cover areas where data devices are commonly used, and may not include coverage in other areas such as stairwells, break rooms or building entrances – all places where telephone conversations are likely to occur.

The overall quality of coverage is more important for telephony applications. Coverage that may be suitable for data applications may not be seamless enough to support the requirements of VoWLAN. Most data communication protocols provide a mechanism for retransmission of lost or corrupted packets. Delays caused by retransmissions are not harmful, or even discernable, for most data applications. However, the real-time nature of a full-duplex telephone conversation requires that voice packets be received correctly within tens of milliseconds of their transmission. There is little time for retransmission, and lost or corrupted packets must be discarded after limited retries. In areas of poor wireless coverage, the performance of data applications may be acceptable due to retransmission of data packets, but for real-time voice, audio quality will likely suffer.

Another factor to consider when determining the coverage area is the device usage. Wireless telephones are used differently than wireless data devices. Handset users tend to walk as they talk, while data users are usually stationary or periodically nomadic. Wireless voice requires full mobility while data generally requires simple portability. Wireless handsets are typically held close to the user's body, introducing additional radio signal attenuation. Data devices are usually set on a surface or held away from the body. The usage factor may result in reduced range for a wireless telephone as compared with a data device. Therefore, the WLAN layout should account for some reduction of radio signal propagation.

#### 2.1.1 Overlapping Coverage

Wi-Fi cell overlap must be considered when planning your VoWLAN deployment. Handsets make a determination to roam in less than half the overlapping coverage area. Therefore, the coverage area must be adequate enough so that when a voice user is moving, the handset has time to discover the next AP before signal on the existing AP becomes too weak.

A properly designed Wi-Fi network will position APs with sufficient overlapping coverage to ensure there are no coverage gaps, or "dead spots", between them. The result is seamless handoff between APs and excellent voice quality throughout the facility. Sufficient overlapping coverage is usually considered 15% to 20% signal overlap between AP cells in a deployment utilizing maximum transmit power for both handsets and APs. Smaller cells will need larger overlaps due to the potential for much smaller cell size which causes a decrease in overall overlap from a maximum transmit power deployment. The 15% to 20% of signal overlap between AP cells generally works well with a typical walking speed of the user (the average walking speed of an individual is 3 mph). If the speed of the moving user is greater (such as a golf cart, fork lift or running/jogging) then a different overlap strategy may be necessary for successful handoff between APs.

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The WLAN layout must factor in the transmission settings that are configured within the APs. The transmission of voice requires relatively low data rates and a small amount of bandwidth compared to other applications. The 802.11 standard includes automatic rate switching capabilities so that as a user moves away from the AP, the radio adapts and uses a less complex and slower transmission scheme to send the data. The result is increased range when operating at reduced transmission data rates. When voice is an application on the WLAN, APs should be configured to allow lower transmission rates in order to maximize coverage area. If a site requires configuring the APs to only negotiate at the higher rates, the layout of the WLAN must account for the reduced coverage and additional APs will be required to ensure seamless overlapping coverage.

SpectraLink handsets perform Dynamic Channel Assessment (DCA) in between the transmission of packets to learn about neighboring APs. It takes about two seconds for a DCA cycle to complete in an 802.11a eight channel deployment and approximately one second for a standard three channel deployment for 802.11b/g. In order to ensure a DCA cycle can complete within the assessment area (see Figure 1), a person moving through the assessment area must be within the area for at least 4-5 seconds to make sure the DCA starts and ends within the assessment area. Failure to complete the DCA cycle within the assessment area can lead to lost network connectivity resulting in a hard handoff, lost audio, choppy audio or potentially a dropped call.

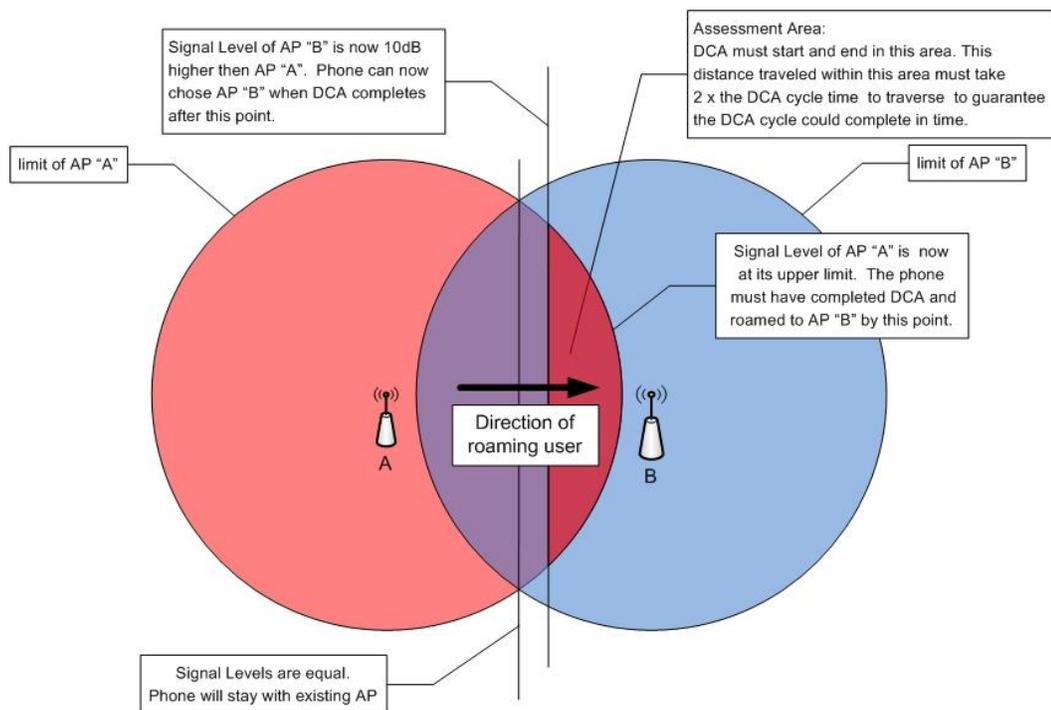


Figure 1 - Dynamic Channel Assessment (DCA)

The handset compares the signal strength of neighboring APs to determine whether to roam from the current AP. In order to roam, the handset has to determine whether other APs are either five decibels (dB) (for any first attempt associating with an AP) or ten decibels stronger (to roam back to the previous AP) than the current AP's signal. In most cases the handset only needs five decibels of signal difference

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between APs to make a decision to roam. But to prevent 'ping-pong' behavior the separation needs to be ten decibels higher for the handset to return to the previously associated AP. This behavior requires that the assessment area must have at least a ten decibel difference to enable good roaming behavior for all cases.

Corners and doorways pose a particular design issue. The shadowing of corners can cause steep drop-offs in signal coverage. This is particularly true of 802.11a. Make sure to have adequate cell overlap at and around corners so that the audio stream is not impacted by a user going around corners. This may require placement of an AP at corner locations to ensure appropriate cover and prevent RF shadows.

## 2.1.2 Signal Strength

To provide reliable service, wireless networks should be engineered to deliver adequate signal strength in all areas where the wireless telephones will be used. The required minimum signal strength for all SpectraLink handsets depends on the 802.11 frequency band it is operating in, modulation used, data rates enabled on the AP, and data rate used by the handset at any particular time.

Recommended signal strength characteristics are summarized in Table 1 and Table 2. Use these values to determine RF signal strength at the 'limit of AP A' or 'limit of AP B', illustrated in Figure 1. The handset should be in the assessment area for 4–5 seconds to allow for smooth roaming handoffs.

2.4GHz 802.11b/802.11g (CCK)					2.4GHz 802.11g (OFDM)							
Rate (Mb/s)	1	2	5.5	11	6	9	12	18	24	36	48	54
Best Practices (dBm)	-75	-70	-69	-65	-67	-66	-64	-62	-60	-56	-52	-47

Table 1 – 2.4GHz

5GHz 802.11a (OFDM)								
Rate (Mb/s)	6	9	12	18	24	36	48	54
Best Practices (dBm)	-60	-59	-58	-56	-53	-49	-47	-45

Table 2 – 5GHz

The critical factor is the highest data rate set to "Required" or "Mandatory"<sup>1</sup>. Other data rates can be set to "Supported". The highest AP data rate set Mandatory determines the RF power required by the wireless

<sup>1</sup> Access Point (AP) vendors refer to this configuration setting differently but the value indicates a data rate that clients must be capable of utilizing in order to associate with the access point. These data rates are also used for different data traffic types by clients and APs that should be considered when designing for coverage requirements.

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telephone for proper operation. Broadcast frames (beacons) utilize the highest “Basic”<sup>2</sup> data rate and multicast frames (used for the SpectraLink 8030’s push-to-talk feature and SRP handset check-ins) also use the highest data rate set Mandatory. Unicast frames (data) utilize the ‘best or highest’ data rate which supports low frame errors and low retry rates but rate scale up or down to use the ‘best’ rate of all available rates.

Referencing Table 1 and Table 2, the highest rate set Mandatory (*Required*) determines the signaling requirements for the wireless telephone in all areas (limit of AP) where they are used.

- For example, if an 802.11b/g access point has 1Mbps, 2Mbps, 5.5Mbps and 11Mbps all set Mandatory, the handset requires -65dBm in all areas.
- For example, if an 802.11b/g access point has 1Mbps Mandatory and other rates set Supported (or “Enabled”) the handset requires -75dBm in all areas.
- For example, if an 802.11a access point has 6Mbps, 12Mbps & 24Mbps set Mandatory and all other data rates set to Supported the handset requires -53dBm in all areas.

SpectraLink handsets have a Site Survey mode that can be used to validate the signal strength it is receiving from the AP. The handset also has a Diagnostics mode which can show AP signal strength, as well as other details, as received during a call. See the [SpectraLink 8020/8030 Wireless Telephone Administration Guide](#) for details on using the Site Survey and Diagnostics mode features.

Although it is possible that SpectraLink handsets may operate at signal strengths which are weaker than those provided in Table 1 and Table 2; real world deployments involve many RF propagation challenges such as physical obstructions, interference, and multipath effects that impact both signal strength and quality. Designing RF coverage to the required levels will provide an adequate buffer for these propagation challenges, enabling a more reliable and consistent level of performance with low retry rates.

## 2.2 802.11b/g Deployment Considerations

The 802.11b and 802.11g standards utilize the 2.4 GHz frequency spectrum. 802.11g networks that support 802.11b-only clients must run in protected mode to enable backward compatibility. Protected mode adds considerable overhead to each transmission which ultimately translates into significantly reduced overall throughput. SpectraLink 8020/8030 Wireless Telephones, which support 802.11a, b and g radio types, do not operate in protected mode when operating in 802.11g-only mode. The overhead associated with performing protected mode transmissions largely negates any benefits of transmitting relatively small voice packets at higher 802.11g data rates. For this reason, when SpectraLink handsets are installed on a mixed 802.11b/g network which is already running in protected mode, the handset must be configured for 802.11b & b/g mixed mode. In an 802.11b/g mixed environment a handset that is configured for the 802.11b and b/g mixed mode will only utilize 802.11b data rates and has no 802.11g functionality while this mode is enabled.

The handset operating in 802.11g-only mode must use a WLAN with data rates set so only 802.11g clients can associate. There must be no 802.11b client connected to and using the WLAN. The way to ensure only 802.11g clients use the WLAN is to set to disable all 802.11b data rates (1, 2, 5.5, and 11Mbps). It is important to include these settings for all SSIDs in the handset coverage area and not just the voice SSID, since this impacts the spectrum for the entire area.

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<sup>2</sup> The 802.11-2007 Standard defines any data rate set as required to be *basic rates*. See 802.11-2007 for additional details. (<http://www.ieee.org>)

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## 2.3 802.11a Deployment Considerations

The 802.11a standard utilizes the 5.1 GHz to 5.8 GHz Unlicensed National Information Infrastructure (UNII) frequency spectrum. Although having the same maximum throughput as 802.11g (54 Mb/s), the increased frequency spectrum at 5 GHz offers up to 23 channels, providing the potential for higher AP density and increased aggregate throughput. There is significant variation in channel availability and use between countries, however, which must be considered for any particular 802.11a deployment.

As compared with the 2.4 GHz frequency of 802.11b/g radio deployments, higher frequency RF signals utilized by the 802.11a 5GHz band do not propagate as well through air or obstacles. This typically means that an 802.11a network will require more APs than an 802.11b/g network to provide the same level of coverage. This should be taken as a guideline however, as signal propagation may also be impacted by the output power settings of the AP and the antenna type. A comprehensive wireless site survey focusing on VoWLAN deployments should be conducted to identify the specific needs for each environment.

## 2.4 Access Point Configuration Considerations

There are several fundamental access point configuration options that must be considered prior to performing a site survey and deploying a voice-capable WLAN infrastructure. SpectraLink handsets provide support for 802.11b, 802.11g and 801.11a radio types. The selection of radio type has significant impact on the overall configuration and layout of the WLAN infrastructure. This fundamental selection determines most other configuration considerations. In general, however adjacent APs in three dimensions (above, below and beside) must use different non-overlapping radio channels to prevent interference between them regardless of 802.11 radio type.

This document does not cover all issues or considerations for WLAN deployment. It is strongly recommended that Polycom Professional Services, or another suitable professional services organization, with wireless voice deployment experience be engaged to answer additional questions about configurations that may affect voice quality or wireless telephone performance. In addition, *VIEW Configuration Guides* for WLAN infrastructure, which are available from the Polycom web site, should be followed closely.

### 2.4.1 Channel Selection

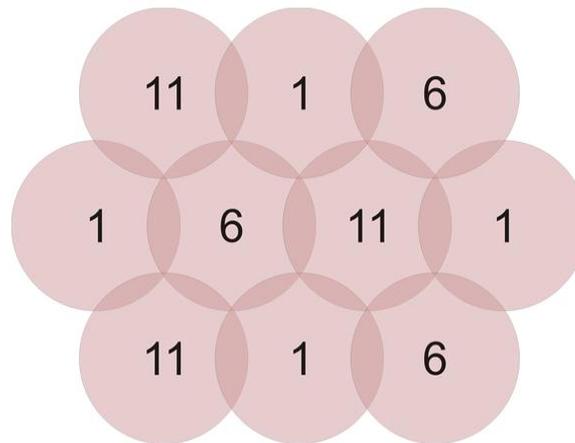
The 802.11b/g standard provides for three non-interfering, non-overlapping frequency channels - channels one, six and eleven in North America. Access points within range of each other should always be set to non-interfering channels to maximize the capacity and performance of the wireless infrastructure. Figure 2 illustrates the correct deployment methodology for 802.11b/g deployments.

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Figure 2 - 802.11b/g Non-interfering Channels with Overlapping Cell Coverage



If adjacent access points in three dimensions (above, below or beside) are set to the same channel, or utilize channels with overlapping frequency bands, the resulting interference will cause a significant reduction in the network performance and throughput, and will degrade overall voice quality. A channel space of twenty five MHz, five channels or greater should be used to configure neighbor APs for non-interfering channels. Figure 3 represents the 2.4 GHz frequency range, indicating the overlap in channel frequencies.

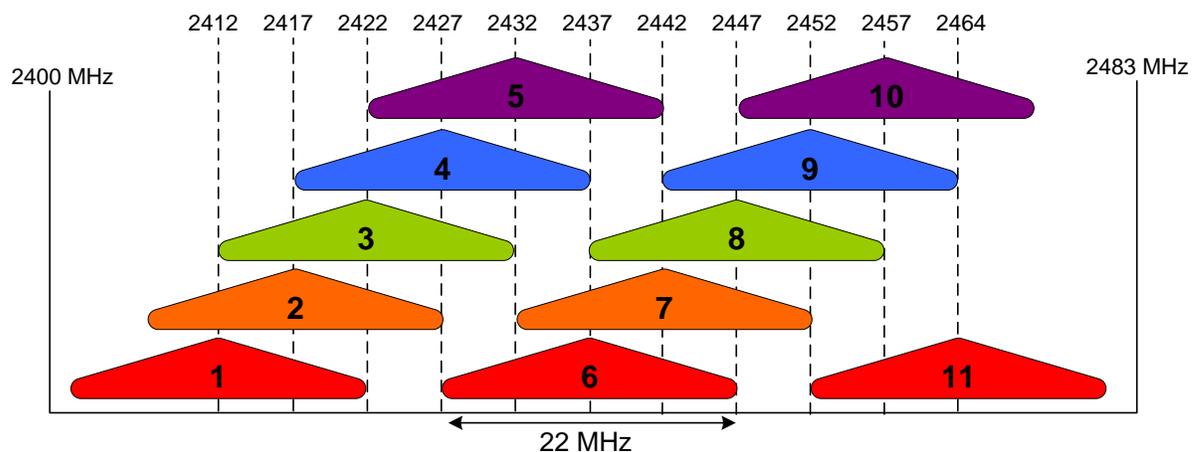


Figure 3 - 802.11b/g Channels

With more available channel options, the 802.11a standard has improved the flexibility of WLAN layouts, and enabled the possibility for greater density of APs. In an 802.11a deployment, all 23 channels are technically considered non-overlapping, since there is 20 MHz of separation between the center frequencies of each channel. However, because there is some frequency overlap on adjacent 802.11a channel sidebands, there should always be at least one cell separating adjacent channels and two cells separating the same channel. This methodology is depicted in Figure 4.

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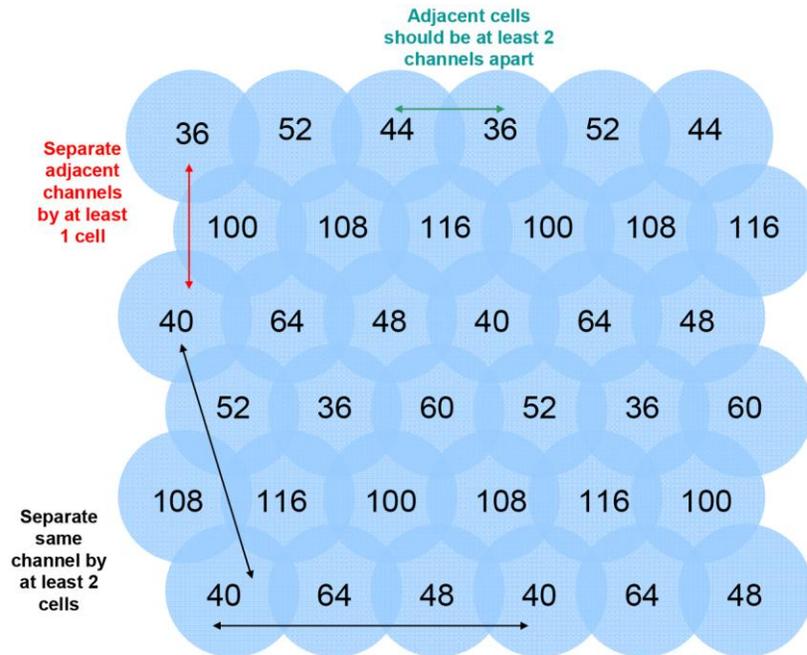


Figure 4 - 802.11a Non-interfering Channels with Overlapping Cell Coverage

There are some deployment scenarios that require limiting the number of 802.11a channels. A key reason is to improve roaming performance. With 802.11a there are four channel bands available to choose from. These channel bands comprise a number of individual channels over a specific range of frequencies in the 5GHz range. These bands include UNII-1 (5.15 – 5.25GHz), UNII-2 (5.25 – 5.35GHz), UNII-2 Extended (5.47 – 5.725GHz) and UNII-3 (5.725 – 5.825GHz). The two UNII-2 bands are DFS (Dynamic Frequency Selection) bands. The 802.11a specification identifies DFS bands as overlapping with the frequencies utilized globally by radar systems. Because of this shared use for these two frequency ranges the 802.11a standard calls for a zero contention behavior from wireless devices on the channels in these bands. This means that a DFS channel can possibly become unavailable due to the detection of radar signals by an access point on one of the DFS channels as required by the standard. Also, the full set of channels available in the U.S. may not be available outside the U.S. Refer to your local RF governing body for specific channel availability. In some cases where use of DFS channels is either not allowed due to legal restrictions or use of DFS channels is not desired, an eight-channel plan is recommended as depicted in Figure 5. As illustrated, there is still separation of adjacent channels by at least 1 cell. Same channel separation can now be a minimum 1 cell in a single plane, rather than in three dimensions, because only eight channels are being utilized instead of all 23. Many sites use this pattern with no reported issues.

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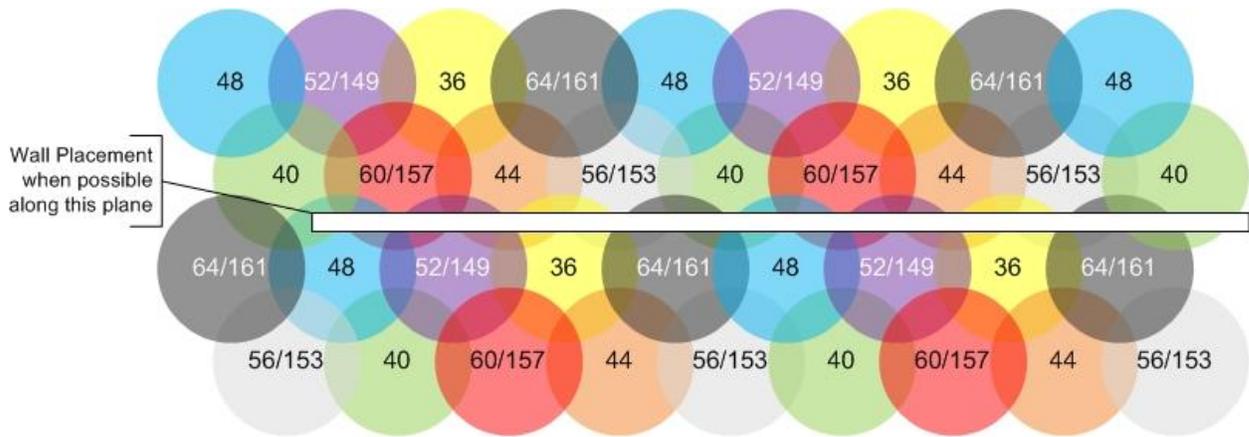


Figure 5 - Eight 802.11a Non-interfering Channels with Overlapping Cell Coverage (52/149, 64/161, etc. shows 1<sup>st</sup> DFS range channel or upper non-DFS range)

To deploy an eight channel plan for North America, 802.11a networks use channels 36, 40, 44, 48, 149, 153, 157 and 161. This will avoid the DFS channels. In Europe 149, 153, 157, and 161 are not available so the DFS channels 52, 56, 60, and 64 should be used instead. Note that the handsets were FCC certified before channel 165 was available and have not been re-certified to allow for use of this channel. Therefore WLAN deployments must avoid using this channel.

Try to design your AP cell layout so that walls can help divide the cell plane where single cell spacing is used in a single plane to help attenuate the signal when possible which will help to prevent co-channel interference. Doing so will provide optimal cell co-channel separation, as depicted in Figure 5.

Use of the eight-channel plan is highly recommended, as the handset will complete the DCA cycle in about two seconds. In contrast, using all 23 channels causes the DCA cycle time to increase to about six seconds. This increases the assessment area time, as described in Figure 1, from four seconds to twelve seconds, thus tripling the distance of overlap.

## 2.4.2 AP Transmission Power and Capacity

The AP transmit power should be set so that the handsets receive the required minimum signal strength, as defined in Section 2.1.2 of this document. For deployments with higher AP density, lower transmit power settings are typically required to prevent channel interference. Maximum AP power settings vary by band and by channel, and can vary between countries. Local regulations should always be checked for regulatory compliance considerations. In addition, maximum power output levels may vary by AP manufacturer. Where possible, all APs should be set to the same transmit power level within a given radio type. For example, set all 802.11a radios to 50 mW and set all 802.11b and 802.11g radios to 30 mW.

It is crucial to then set the transmit power of the handset to match the transmit power of the APs for that band. This will ensure a symmetrical communication link. Mismatched transmit power outputs will result in reduced range, poor handoff, one-way audio and other quality of service or packet delivery issues. SpectraLink Wireless Telephones support transmission power settings in the range from 5mW to 100mW (in the United States).

Handsets using Release 3.0 will automatically use Transmit Power Control (TPC) and will learn from the access point the maximum transmit power they should use, ensuring that the handset coverage radius

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matches that of the AP. However the handset will never exceed the power limit statically set in its handset administration menus or HAT.

For SpectraLink handsets running pre-R3.0 code, the transmission power setting must be the same for all APs in a facility, and match the handset's statically configured transmit power setting. The transmit power setting on the phone should be based on the AP's configured transmit power setting, not the EIRP (Effective Isotropic Radiated Power) of the AP. Any AP antenna gain will increase signal gain in both directions.

When running pre-R3.0 code, regardless of the selected power level settings, all APs and handsets must be configured with the same transmit settings to avoid channel conflicts or unwanted cross-channel interference. For access points that support automatic transmission power adjustments, Polycom recommends using only static power settings to ensure optimal performance of SpectraLink Wireless Telephones pre-R3.0.

In mixed 802.11b/g environments, Polycom recommends configuring the transmit power of the 802.11b and 802.11g radios to the same setting, if they are separately configurable. For example, set both radios to 30mW to ensure identical coverage on both radios. For mixed 802.11a/b/g environments, where the AP utilizes all three radios types, AP placement should first be determined by modeling for the characteristics of 802.11a, since this environment will typically have the shortest range. Then, the transmit power of the 802.11b and 802.11g radios should be adjusted to provide the required coverage levels and cell overlap for those networks, within the already established AP locations.

## 2.4.3 Interference

Interference on a wireless network may originate from many sources. Microwave ovens, Bluetooth devices, cordless phones, wireless video cameras, wireless motion detectors, and rogue APs are among the many potential interfering RF (radio frequency) sources. In general, devices that employ or emit radio frequency signals within a given radio coverage area will have the potential to cause unwanted signal interference.

Radio frequency spectrum analyzers can be used to help identify the sources of such interference. Once identified, interference is best mitigated by removing the interfering device(s) from the network area. Otherwise, it may be possible to change the channel setting of the interfering device to avoid conflict with the surrounding APs. If this is also not possible, then it may be possible to change the channel of the surrounding APs to avoid as much radio frequency overlap with the interfering device.

A documented facility-wide radio frequency usage policy will help control sources of RF energy. Ideally, any RF generating device should have prior approval before introduction onto the property or installation in any building or structures.

## 2.4.4 Multipath and Signal Distortion

For 802.11a/b/g environments, multipath distortion is a form of RF interference that occurs when a radio signal has more than one path between the transmitter and the receiver causing multiple signals to be detected by the receiver. This is typically caused by the radio signal reflecting off physical barriers such as metal walls, ceilings and other structures and is a very common problem in factories and storage environments. Multiple converging wave fronts may be received as either an attenuated or amplified signal by the receiver. In some instances, if the signals arrive exactly out of phase, the result is a complete cancellation of any RF signal. In 802.11n networks multipath is an exploited feature, rather than a potential interference problem. The multiple radios used for 802.11n (up to three in an AP) provide increased throughput. The resulting multipath effects of the multiple radios are used to obtain increased

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range and overall throughput. The remainder of this section focuses on 802.11a/b/g deployments in which it is favorable to mitigate multipath.

Multipath can cause severe network throughput degradation because of high error rates and packet retries. This in turn can lead to severe voice quality impairment with SpectraLink Wireless Telephones. Correctly locating antennas and choosing the right type of antenna can help reduce the effects of multipath interference.

AP diversity antennas should always be used to help improve performance in a multipath environment. A diversity solution uses two antennas for each AP radio, and will send and receive signals on the antenna which is receiving the best signal from the wireless client. Diversity in an AP with two antennas, which provide signaling to the same geographic area, provides a unique signal path from each antenna to the handset. This greatly increases the probability that both the AP and the handset will receive better signal quality in multipath environments. Most access points support receive diversity in that they accept the received transmission on the antenna that is getting the best signal. Some also support full transmit diversity where the transmission is made on the same antenna that was last used to receive a signal from that specific client. In order to provide optimal voice quality, Polycom recommends the use of APs supporting both receive and full transmit diversity in environments where multipath is an issue. This will help optimize the WLAN for all wireless clients. External antennas provide additional flexibility in type (omni or directional), mounting options and gain. External antennas can be separated from 4.5 inches to 5 feet at each AP radio.

Access point antennas should not be placed near a metal roof, wall, beam or other metal obstruction in any environment, as this will amplify the reflection effects. Additionally, antennas should be positioned so that they have line of sight (LoS) to most of the clients that they service. Additional instructions from the wireless network infrastructure vendor should be followed with regard to antenna selection and placement to provide correct AP diversity operation.

## 2.4.5 Site Surveys

A wireless RF site survey is highly recommended for any wireless network deployment. However, it is especially critical for VoWLAN and is essential for large or complex facilities. An RF site survey can ensure that the wireless network is optimally designed and configured to support voice by confirming RF placement, cell overlap, channel allocation/reuse, packet transmission quality, packet retry rates, and other deployment considerations. While many tools exist that allow customers to perform their own assessment, Polycom recommends a professional site survey to ensure optimum coverage and minimum interference. Polycom offers a full suite of site-survey services that will ensure a WLAN is properly configured to support wireless voice.

To verify coverage of an installed Wi-Fi network, Polycom handsets offer a site-survey mode that can be used to validate the AP locations and configurations are both correct and adequate. This mode detects the four strongest AP signals and displays the signal strength along with the AP channel assignments. The site survey mode may be used to detect areas with poor coverage or interfering channels; check for rogue APs; confirm the Service Set Identification (SSID) and data rates of each AP and include the security and QoS mechanisms supported by the AP; and detect some AP configuration problems. With SpectraLink handsets, the entire coverage area must be checked to ensure that at least one access point's output meets the signal strength requirements summarized in Section 2.1.2 of this document. If the site-survey mode indicates that two APs are using the same channel within range of the handset, it is important to adjust the channelization to avoid channel conflicts.

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After a site survey is complete, coverage issues can be resolved by adding and/or relocating APs if necessary. Overlap issues may be resolved by reassigning channels or by relocating some access points. When adjustments are made to the WLAN configuration an additional site survey or site verification should be performed to ensure that the changes are satisfactory and have not had an adverse impact in other areas of coverage.

## 2.5 Wireless Telephone Capacity

Network capacity requirements factor into the number of APs required, although in most cases the coverage area is the primary factor. Data traffic is often very “bursty” and sporadic. This is typically acceptable because data applications can tolerate network congestion with reduced throughput and slower response times. Voice traffic cannot tolerate unpredictable delays, where the bandwidth requirements are much more constant and consistent. Voice traffic can also be predicted using probabilistic usage models, allowing a network to be designed with high confidence in meeting anticipated voice capacity requirements. Beyond the standard IP telephony design guidelines, there are several additional considerations that should be addressed for VoWLAN with SpectraLink handsets.

When SVP is the selected QoS method for the handset, the SVP Server prevents oversubscription of an AP and improved load balancing by limiting the maximum number of active calls per AP. Recommended settings are AP specific and can be found in the [VIEW Configuration Guides](#) on the Polycom web site. The maximum number of active calls must be defined for each of the three possible handset radio types – 802.11b, 802.11g and 802.11a. The SVP Server determines the maximum number of wireless telephones in-call on a given AP and forces handsets to handoff when capacity maximums are reached. Although 802.11g and 802.11a networks theoretically provide increased available bandwidth for support of additional simultaneous call volume, the practical call volume limitations will depend on many factors such as data rates used, competing network traffic, and network performance. Overall, the calls per AP specified is often lower than the maximum number an individual AP may be able to support. This allows some handsets to work at lower rates (802.11b at 1Mbps and 2Mbps) and some at the highest data rates.

For Wi-Fi Standard QoS or CCX, WLAN admission control techniques are used for AP bandwidth management. When the handset is configured to use WMM it will be necessary to ensure the access point also supports WMM Admission Control. This mechanism is responsible for ensuring the AP does not become overloaded with any particular type of traffic. Depending on the AP manufacturer it may be possible to adjust the settings for individual WMM traffic classifications. Details for making these sorts of changes to APs are available in the [VIEW Configuration Guides](#) or from the AP manufacturer. See Section 4.2.3 for additional details.

### 2.5.1 Access Point Bandwidth Considerations

There are several factors which determine the AP bandwidth utilization during a telephone call. The first is the VoIP protocol used and its characteristics. The type of codec utilized combined with the packet rate will determine the size of the voice packets along with any additional overhead information required for the protocol. Payload data will generally account for 30-50% of a typical voice packet, with 802.11 and IP protocol overhead filling the rest. The 802.11 protocols include timing gaps for collision avoidance, which means bandwidth utilization is more accurately quantified as a percentage of available throughput rather than actual data throughput.

The percentage of bandwidth required is greater for lower 802.11a/b/g data rates; however it is not a linear function because of the bandwidth consumed by the timing gaps and overhead. For example, a call using standard 64 Kbps voice encoding (G.711) utilizes about 4.5 percent of the AP bandwidth at 11 Mbps, and about 12 percent at 2 Mbps. In this example, four simultaneous calls on an AP would consume

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about 18 percent of the available bandwidth at 11 Mbps or about 48 percent at 2 Mbps or about 90 percent at 1Mbps.

The maximum number of simultaneous telephone calls an AP can support is determined by dividing the maximum recommended bandwidth usage by the percentage of bandwidth used for each individual call. Note that approximately 20 to 35 percent of the AP bandwidth must be reserved for channel negotiation and association algorithms, occasional retries, and the possibility of occasional transmission rate reductions caused by interference or other factors. Therefore, 65 to 80 percent of the total available bandwidth should be used for calculating the maximum call capacity per AP. For example, if all calls on an AP are using a theoretical 5.4 percent of the bandwidth at 11 Mbps, the actual number of calls expected at that rate would be about 12 (65 percent of bandwidth available / 5.4 percent theoretical bandwidth utilized per call). Lower overall bandwidth is available when there are a greater number of devices associated with an AP or when lower data rates are used for the telephone call or calls.

Even with all of the known variables, there are many other vendor-specific characteristics associated with individual APs that make it difficult to quantify the precise number of concurrent calls per AP, without thorough testing of specific configurations. Polycom's [VIEW Configuration Guides](#) identify the maximum number of calls per AP for specific models that have been tested to be compatible with the SpectraLink handset.

When using SVP for QoS, Polycom provides the ability to limit the number of calls per AP with a configurable setting in the SVP Server. The "Calls per Access Point" setting limits the number of active calls on each AP and can be used to set aside bandwidth for data traffic. Wireless Telephones in-call are free to associate with other APs within range that have not reached the set maximum number of calls. Polycom requires this setting to be equal to or below the maximum number of calls recommended in [VIEW Configuration Guides](#). It is still possible for the number of phones associated to an AP to exceed the maximum number of calls as would be the case with any additional clients associating to the same AP. The maximum number of calls per AP will simply control how many of those associated phones will be able to enter into a call. Additional phones beyond the maximum number specified will be forced by the SVP Server to roam to a new AP that has not reached the maximum calls per AP. If no APs are available any phones beyond the maximum will display an error message indicating there is insufficient bandwidth to complete the call.

For systems configured to use Wi-Fi Standard QoS, the calls per AP are managed by the AP using standards based methods. WMM Admission Control will ensure that AP capacity and bandwidth are reserved for wireless clients based on the TSPEC (Transmission Specification) each device submits to the AP to reserve bandwidth for that device's communications. The AP will keep track of the total available bandwidth and will restrict access to network resources for clients if bandwidth becomes unavailable.

## 2.5.2 Push-to-Talk Multicasting Considerations

SpectraLink 8030 handsets provide push-to-talk (PTT) functionality using the Polycom-proprietary SpectraLink Radio Protocol (SRP) ADPCM encoding. Because the PTT mode uses IP multicasting, all APs on the subnet will transmit a PTT broadcast. This can be limited to only the APs that are handling one or more PTT-enabled handsets by enabling the Internet Group Management Protocol (IGMP) on the wired infrastructure network.

When 8030 handsets are deployed on a network with previous versions of SpectraLink handsets, some interoperability considerations must be observed. The SpectraLink 8030 handsets have 24 PTT channels plus one priority channel available. Earlier models enabled only eight PTT channels with no priority channel. When PTT is activated on a network using a mix of handset versions, only the eight common channels will be available for the older handsets.

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## 2.5.3 Telephone Usage

When the handset is used with traditional PBXs through a Telephony Gateway, the PBX interface will assemble audio, packetize it, and release these packets at a preset interval (20ms with no SVP Server). The PBX release interval is generally 20ms or 30ms. If SVP is the selected QoS method, the SVP Server will receive these audio packets and release them to the network for delivery to the handset every 30ms.

With a PBX release interval of 20ms, packets delivered to the handset by the SVP Server will have one audio payload followed by a packet with two audio payloads. This pattern, one audio payload then two audio payloads, will continue during the call. With a PBX release interval of 30ms, packets sent to the handset will have one audio payload each. In rare occasions, a PBX may use a 40ms release interval. With this audio payload release interval, packets delivered to the wireless telephone will have one large audio payload or no audio payload per packet sent to the handset. The no audio payload packets and long time between audio (two SVP packets – 60ms) payload aggravates any weakness (multi-path, retry packets, etc.) in the WLAN and will cause poor audio. Therefore, whenever possible the PBX should be configured to use release intervals of 30ms or 20ms.

Because data rate and packet rates are constant with voice applications, wireless telephone calls may be modeled in a manner very similar to circuit-switched calls. Telephone users (whether wired or wireless) generally tend to make calls at random times and of random durations. Because of this, mathematical models can be applied to calculate the probability of calls being blocked based on the number of call resources available.

Telephone usage is measured in units of Erlangs. One Erlang is equivalent to the traffic generated by a single telephone call in continuous use. A typical office telephone user will generate 0.10 to 0.15 Erlangs of usage during normal work hours, which equates to six to nine minutes on the telephone during an average one-hour period. Heavy telephone users may generate 0.20 to 0.30 Erlangs, or an average of 12 to 18 minutes of phone usage in an hour. Note that traffic analysis is based on the aggregate traffic for all users, so users with higher or lower usage are included in these averages.

The traffic engineering decisions are a tradeoff between additional call resources and an increased probability of call blocking. Call blocking is the failure of calls due to an insufficient number of call resources being available. Typical systems are designed to a blocking level (or grade of service) of 0.5 percent to two percent at the busiest times. Traffic model equations use the aggregate traffic load, number of users and number of call resources to determine the blocking probability. The blocking probability can also be used along with the aggregate traffic load to determine the number of call resources required. Traffic model equations and calculators are available at [www.erlang.com](http://www.erlang.com).

Consider a system with APs that can support six active telephone calls. If a blocking probability of one percent or less is desired, each AP can support approximately 13 moderate wireless telephones users. If the AP coverage supports 12 simultaneous calls per AP, each AP can then support approximately 39 moderate users. This allows some users to be in-call and others in standby.

The Table 3 shows maximum users per AP based on the AP's ability to handle simultaneous calls:

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User Calling Intensity	Light	Moderate	Heavy
Erlangs per User	0.10	0.15	0.20
Max Active Calls per AP	Users Supported per AP (1% Blocking Probability)		
1	1	1	1
2	2	2	2
3	4	3	3
4	8	6	4
5	13	9	7
6	19	13	10
7	25	17	13
8	31	21	16
9	37	25	19
10	44	30	22
11	51	34	26
12	58	39	29

Table 3 - Users Supported per Access Point

Areas where heavier wireless telephone usage is expected, such as cafeterias, staff lounges, and auditoriums, can obtain higher call capacity and handle more users by installing additional APs. For most enterprise applications however, the table above should be sufficient in demonstrating the number of wireless handsets supported within each AP's coverage area.

## 2.5.4 Telephony Gateway Capacity

Telephone system administrators should consider the user distribution on SpectraLink 8000 Telephony Gateways much in the same way as they do PBX line cards. Telephony Gateways incorporate a physical connection to a PBX line card. The phone system administrator should spread departments or functional areas across multiple PBX line cards and across multiple Telephony Gateways so that a failure of either component does not cause a complete wireless handset outage in one department or area. In addition, system administrators must consider that one Telephony Gateway can support a maximum of eight handsets in an active call state. While the Telephony Gateway can manage 16 wireless telephones total only eight can be in call at any one time. Therefore, heavy users should be spread across Telephony Gateways to reduce the chance of call blocking.

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## **3 Network Infrastructure Considerations**

### **3.1 Physical Connections**

SpectraLink infrastructure components, including the SVP Server(s), Telephony Gateways and OAI Gateway, must connect to a facility's LAN using enterprise-grade Ethernet switches rather than Ethernet hubs or consumer-grade SOHO switches in order to provide adequate bandwidth and limit traffic collisions and bottlenecks (see Figure 6 for reference).

Ethernet switches should be configured to statically set the speed and duplex values as appropriate for the device being connected to that port. The SVP Server should be set to the 100Base-T/Full Full-duplex transmission setting. This is required to support the maximum simultaneous voice calls and for optimal system performance. The SpectraLink Telephony Gateway and OAI Gateway products utilize a 10Base-T, half-duplex Ethernet interface and the Ethernet switch ports should be set accordingly.

Network wiring is an important component of any Ethernet-based system and is subject to local and state building code specifications. Cat 5 or better, 4-pair 10/100 Base-T Ethernet cabling must be used for SpectraLink infrastructure equipment.

Wireless bridges are sometimes used to interconnect geographically isolated Ethernet LANs or to extend the range of existing WLANs. Such devices create bottlenecks for network capacity and add delay to the overall network, which are generally not tolerable for real-time voice connections. Polycom does not support a configuration that includes wireless bridges and does not recommend using wireless bridges with any wireless network supporting voice.

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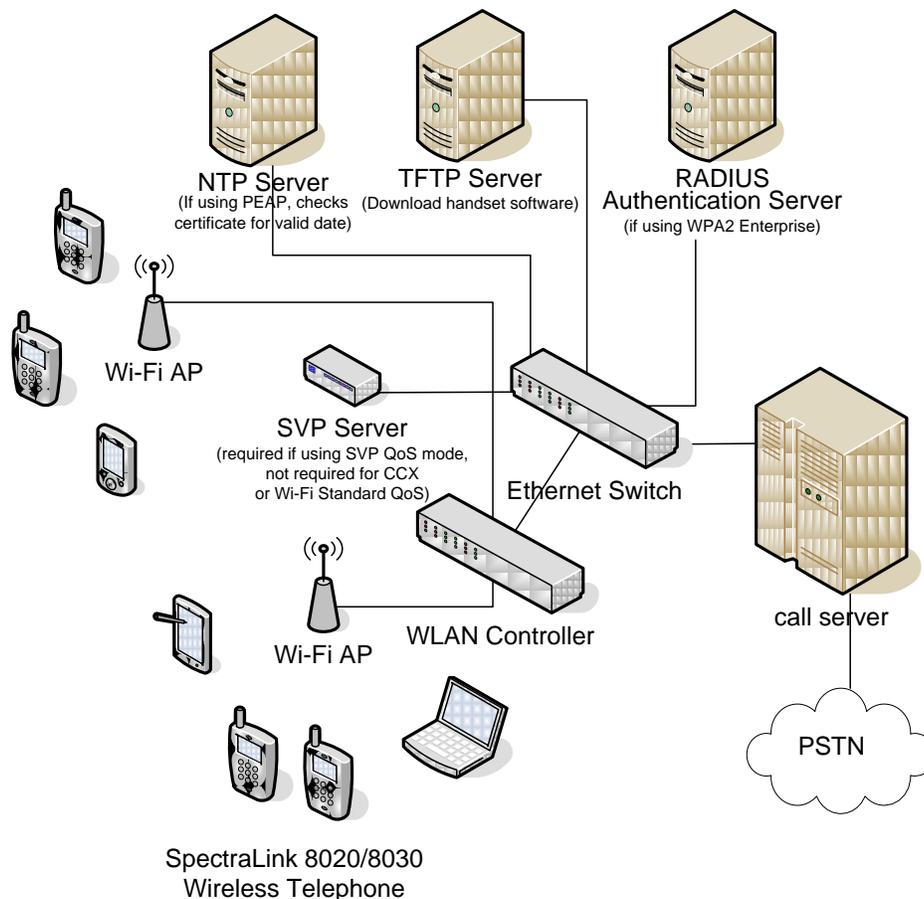


Figure 6 – Physical Connections

## 3.2 Assigning IP Addresses

SpectraLink handsets operate as LAN client devices and therefore require IP addresses to operate in the network. IP addresses can be assigned statically through the configuration menus on the handsets or dynamically using standard DHCP protocol. The Handset Administration Tool (HAT) can be used to quickly load and change administration options in the handsets, including static IP addresses. For dynamic IP addressing, a DHCP server is required.

Telephony Gateways and SVP Servers also require IP addresses that can be obtained by either static or DHCP address assignment. It is always recommended to configure production infrastructure components with static IP addresses to ensure consistent system access. When using one or more SVP Server(s), (see Section 4.1.3) the Registration SVP Server must be assigned a static IP address. The Registration SVP Server is identified by DHCP option 151 to the wireless telephones.

When operating with an IP telephony server (IP PBX), other than Avaya or Cisco, the SVP Server also requires a range of IP addresses that cover the total number of wireless telephones supported by that SVP Server. That range of IP addresses is known as First Alias IP Address/Last Alias IP Address in the SVP Server configuration menu. It is important to note that for redundancy purposes it may be necessary to assign more IP addresses to an SVP's Alias IP range than what the SVP Server would normally support.

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Each SVP Server supports up to 500 registered handsets, but this can be limited by the total number of Alias IP addresses configured in the SVP Server.

When a handset is using SVP and registers with the telephony server, one of the IP addresses within this range is used to communicate between the SVP Server and the telephony server. This IP address is used by the SVP Server as an alias to communicate with the telephony server on the wireless telephone's behalf, but will not be equivalent to the handset's IP address that was either statically assigned or obtained from the DHCP server. The range of alias IP addresses must not be used within any DHCP range or cover the IP address used by any other device. In the case where multiple SVP Servers are used for added capacity or redundancy, an exclusive range of IP addresses equivalent to the number of total users each SVP Server supports is required per SVP Server. All alias IP addresses must be within the same IP subnet as the IP address of the SVP Server they are assigned to. When using Wi-Fi Standard QoS or CCX, it is not necessary to allocate additional IP addresses for aliases.

### 3.3 Software Updates Using TFTP

All SpectraLink infrastructure components are field-upgradeable in terms of new software features and bug fixes. SpectraLink handsets utilize a TFTP client to automatically download new code when available. Deployments using Telephony Gateways to connect to a traditional PBX have an integrated TFTP server to support Polycom 8000 Series Wireless Telephone and OAI Gateway software upgrades. However, the integrated TFTP cannot be used to deliver software to the 8020/8030 wireless telephones. A network TFTP server will simultaneously update multiple handsets, while the Telephony Gateway can only update handsets one at a time. Therefore, in larger systems and newer deployments, a separate TFTP server should be used rather than using the Telephony Gateway's TFTP capability. For deployments with multiple Telephony Gateways it is recommended to utilize an external TFTP server to centralize the management and delivery of software.

The SVP Server also requires a TFTP server for software updates. The Telephony Gateway cannot be used as a TFTP server for the SVP Server code. Telephony Gateways receive software updates only through FTP updates. The OAI Gateways can receive software updates via FTP as well but if software recovery becomes necessary the OAI will utilize a TFTP server. [Software updates](#) are available from Polycom's web site.

### 3.4 RADIUS AAA Servers – Authentication, Authorization, and Accounting

As part of Release 3.0, the SpectraLink handset offers WPA2-Enterprise 802.1X security mechanisms that require an authentication server. RADIUS (Remote Authentication Dial In User Service) authentication servers are responsible for providing client level credential validation. Additionally they can perform other tasks to help ensure that security policies are enforced. Refer to Section 5.3.2 for details on the 802.1X security types supported.

The following authentication servers have been validated for use with R3.0:

- Juniper Networks Steel-belted Radius Enterprise Edition (formerly Funk), v6.1
- Microsoft Internet Security and Acceleration (ISA) Server 2003
- Cisco Secure Access Control Server (ACS), v4.1
- FreeRADIUS v2.0.1 and 1.1.7

Other RADIUS servers will likely work properly with SpectraLink handsets, but have not been tested.

It is important to note that the placement of the authentication server on the network can have a direct effect on the overall performance of the wireless handset when acquiring WLAN connectivity and during AP handoff. If the authentication server is accessible only across a WAN (Wide Area Network) link then there is the risk that additional latency will be introduced. In situations where a wireless telephone experiences a loss of coverage and must reacquire the network while in-call there is a high risk of long

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audio gaps. The required use of the fast AP handoff methods available in R3.0 help reduce the risk of 'hard handoff' situations where full 802.1X key exchanges must occur again. For more information on the fast AP handoff options see Section 5.3.2. It is always recommended that the authentication server be located within the same geographic location as the network to which it will be providing authentication services.

### **3.5 NTP Server**

NTP (Network Time Protocol) servers are used to provide uniform time information to network devices. Many customer sites already use NTP servers for other servers and network infrastructure. This same NTP server can be used for the wireless telephones as well. The handset uses information obtained from the NTP server to display the current date and time.

When using WPA2 Enterprise, the handset will also use the NTP server information to determine start/end date validity for loaded PEAP certificates. If an NTP server is not present in the network the wireless telephone will be unable to determine when a PEAP certificate has expired. If an NTP Server is present and the handset determines the PEAP certification is invalid, the handset will not operate and display an error message.

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## 4 Quality Of Service (QoS)

Polycom pioneered VoWLAN for the enterprise and remains the market leader today. One key success factor has been our SpectraLink Voice Priority (SVP) mechanism for QoS. This method is proven to deliver enterprise-grade voice quality, battery life and call capacity for SpectraLink 8020/8030 handsets. With Release 3.0, Polycom has added two new options for QoS: Wi-Fi Standard QoS and CCXv4. Both of these methods rely on existing and/or emerging industry standards to deliver enterprise-grade handset performance.

SVP and Wi-Fi Standard QoS are detailed in this section. Because CCXv4 involves QoS, security and radio management features, it is detailed in Section 6.

Critical note: All handsets on the WLAN using a given radio type (2.4 or 5 GHz) must have the same QoS setting for the system to work properly. Deploying handsets with different QoS settings within the same WLAN radio type is an unsupported configuration.

### 4.1 SpectraLink Voice Priority (SVP)

Quality of service (QoS) is a means of providing a level of service that will result in a network connection of acceptable quality. Typically this results in providing different levels of service for different applications, depending on their requirements. When data and voice are competing for bandwidth, such as in a WLAN, it is necessary to have mechanisms to prioritize voice packets over data, preserve battery life for handsets, and allocate appropriate AP bandwidth for the associated device's applications. The original 802.11 standard did not provide a QoS mechanism, so Polycom developed SVP to allow delay-sensitive voice and asynchronous data applications to coexist on a Wi-Fi network without compromising voice quality.

Excellent voice quality for SpectraLink handsets is ensured on a shared Wi-Fi network using SVP. Adopted by the majority of enterprise-class WLAN vendors, SVP is well-proven and guarantees audio quality on a shared voice and data network. SVP is compatible with 802.11 standards, but uses proprietary methods for packet prioritization, battery management and call admission control. Access points generally use random back-off intervals that require all types of traffic to contend for access to the wireless medium with equal rights. However, treating all traffic equally can cause significant delays to voice traffic. Modifying the AP behavior to recognize and prioritize voice packets increases the probability of better performance while continuing to treat asynchronous data packets normally. The two operations that comprise SVP in the AP, minimizing random back-off and priority queuing, require a packet-filtering mechanism. Packet filtering requires recognizing the packet's type. SpectraLink packets are registered as IP protocol ID 119 at layer 4. The SVP Server performs packet delivery timing through the AP to the wireless telephones, which is critical for ensuring seamless handoffs among APs and for enhanced battery management. The following section offers a more detailed explanation of timed delivery.

#### 4.1.1 SVP Infrastructure

To trigger SVP in the APs from the wired side of the network, a Telephony Gateway with integrated SVP Server and/or a standalone SVP Server is required. Telephony Gateways can provide SVP support for small installations with four or fewer Gateways. A SVP Server is required for applications using an IP telephony server or using more than four Telephony Gateways.

#### 4.1.2 SVP Server Capacity

A single SVP Server supports 120 simultaneous calls when used with Telephony Gateways or 80 simultaneous calls with an IP telephony server. Multiple SVP Servers can be used to increase capacity to

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support up to 850 total calls (which can support approximately 8,000 Wireless Telephones) for IP telephony server interfaces. When used with Telephony Gateways, the total number of users is limited to 640 (40 Telephony Gateways). For smaller IP telephony interface deployments, 10 and 20-user SVP Servers are available. Refer to Polycom's [SpectraLink 8000 SVP Server Administration Guide](#) for additional information regarding the maximum number of simultaneous calls and wireless telephones supported by multiple SVP Servers.

### 4.1.3 Multiple SVP Servers

For installations with multiple SVP Servers, call resources are automatically allocated between the APs and the SpectraLink Wireless Telephones by those devices' Media Access Control (MAC) addresses. In most instances, because of the large number of wireless telephones and APs expected in such an application, the distribution of call processing will be relatively even across all SVP Servers.

Some installations with multiple SVP Servers (SVP code < 17x.033) are configured to have a primary ("master") and one or more secondary servers. If a secondary SVP Server fails and can no longer be detected, the packet handling will automatically be redistributed among the remaining servers. All active calls associated to the failed secondary SVP server will be lost during this process, however the affected wireless telephones will check-in with available SVP servers without manual reconfiguration. In the case of a master SVP server failure, the wireless telephone system will be disrupted. To minimize downtime related to a failed master SVP Server or a single server, it is recommended that a spare SVP Server be readily available. The network administrator can assign the IP address of the failed unit to the replacement SVP Server. Alternatively the number of SVP servers can be scaled to ensure that if one or more SVP servers fail that all handsets can be allocated to the remaining SVP servers. This will require that sufficient alias IP addresses be made available on all SVP servers to support the allocation of additional handsets to the remaining SVP Servers.

More recent installations with multiple SVP Servers (SVP code  $\geq$  17x.033) use the "SVP Self Healing" feature and do not use the Master/Slave concepts of earlier versions. There is, however, a designated primary SVP Server, called the Registration SVP Server, that has its IP Address defined either statically in the Wireless Telephone network configuration or acquired from DHCP option 151, thus allowing the Wireless Telephone to initially check-in to the telephone system.

Updated handset firmware is required to take full advantage of SVP Self-Healing functionality. See Table 4 for the firmware revisions where SVP Self-Healing functionality was first introduced.

SVP $\geq$ 17x.033 with	Handset model	Handset code
Alcatel	MIPT 310/610	$\geq$ 120.012
Avaya	3641/3645	$\geq$ 117.016
NEC	MH150/160	$\geq$ 131.005
Nortel	6120/6140	$\geq$ 115.015
SIP	8020/8030	$\geq$ 131.001

Table 4 – Handset Code Versions That Support SVP Self-Healing

The SVP Server acts as a proxy for the handset by sending and receiving packets to/from the call server or PBX. In some IP implementations, the SVP Server also performs Network Address Translation (NAT) for the handset. The main functions for the SVP Server to perform are indicated in Table 5.

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Function	SVP Server 1 (Registration)	SVP Server 2
<b>Manage handsets</b>	Proxy between voice platform and handset	Proxy between voice platform and handset
	Send/receives all packets to/from handset	Send/receives all packets to/from handset
	Considered 'home' SVP Server	Considered 'home' SVP Server
<b>Manage voice packet delivery by the AP</b>	Limit maximum handsets in-call per AP (static number entered by administrator)	Limit maximum handsets in-call per AP (static number entered by administrator)
	Receive packets from the 'home' SVP Server and forward to handset though currently associated AP	Receive packets from the 'home' SVP Server and forward to handset though currently associated AP

Table 5 – SVP Server Functions

The process by which the handset is able to get onto the network and register with the SVP Server and telephony platform is a handshake process which requires multiple steps. Figure 7 is a reference diagram followed by the step-by-step description of the handset and SVP Server packet handshake.

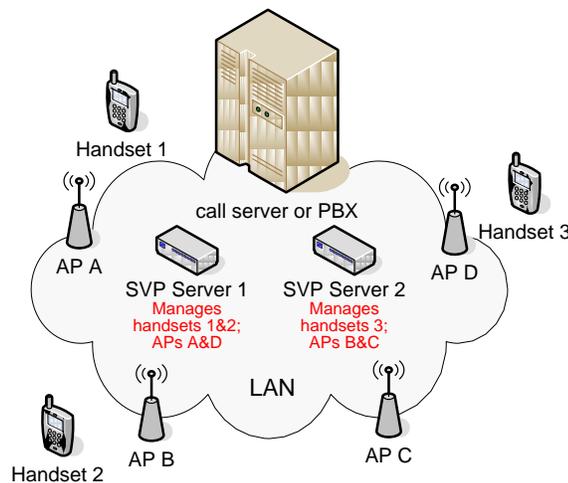


Figure 7 – Multiple SVP Servers

- Handset 1 registers with SVP Server 1
  - Handset 1 always sends its packets to SVP 1
    - SVP 1 forwards handset 1 packets to the call server or PBX
    - The call server or PBX sends packets from the telephone this handset is in-call with to SVP 1
    - SVP 1 sends packets to the SVP managing the handset 1's AP
  - When handset 1 is using AP A (associated with) it receives packets from SVP 1
  - When handset 1 is using AP B it receives packets from SVP 2

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- When handset 1 is using AP C it receives packets from SVP 2
- When handset 1 is using AP D it receives packets from SVP 1
- Handset 2 registers with SVP Server 1
  - Handset 2 always sends its voice packets to SVP 1
    - SVP 1 forwards handset 2 audio packets to the call server or PBX
    - The call server or PBX sends packets from the telephone this handset is in call with to SVP 1
    - SVP 1 sends packets to the SVP managing handset 2's AP
  - When handset 2 is using AP A it receives packets from SVP 1
  - When handset 2 is using AP B it receives packets from SVP 2
  - When handset 2 is using AP C it receives packets from SVP 2
  - When handset 2 is using AP D it receives packets from SVP 1
- Handset 3 registers with SVP Server 2
  - Handset 3 always sends its packets to SVP 2
    - SVP 2 forwards handset 3 audio packets to the call server or PBX
    - The call server or PBX sends audio packets from the telephone this handset is in call with to SVP 2
    - SVP 2 sends packets to the SVP managing handset 3's AP
  - When handset 3 is using AP A it receives packets from SVP 1
  - When handset 3 is using AP B it receives packets from SVP 2
  - When handset 3 is using AP C it receives packets from SVP 2
  - When handset 3 is using AP D it receives packets from SVP 1

## 4.1.3.1 Scenario One

Scenario One assumes that the handset has registered to SVP Server 1, associated to Access Point A, and managed by SVP Server 1 (Figure 8)

- Handset communicates only to SVP Server 1 in this case

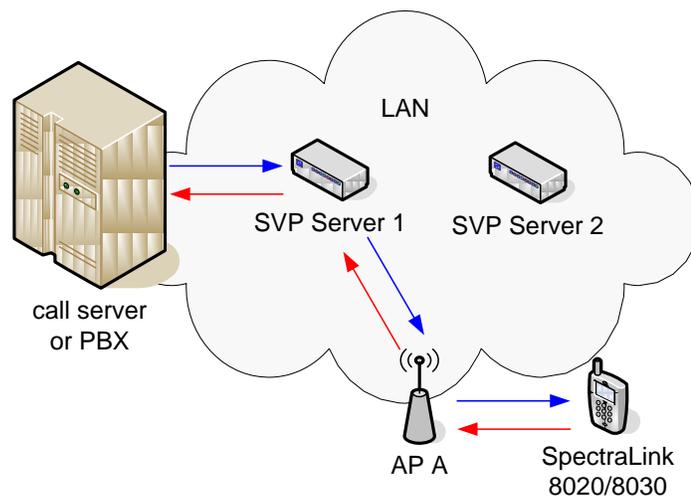


Figure 8 - Scenario One

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## 4.1.3.2 Scenario Two

Scenario Two assumes that handset has roamed to Access Point B and is managed by SVP Server 2 (Figure 9)

- Packets to handset (from call server or PBX) are first sent through its Home SVP Server (Server 1), then forwarded to SVP Server 2, and then transmitted by AP B to the handset
- On the return trip the handset communicates back through AP B to its “Home” SVP Server (Server 1) and back to the call server or PBX

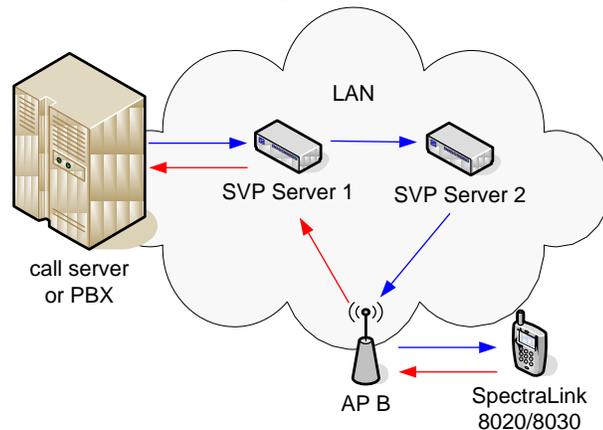


Figure 9 - Scenario Two

Calls between handset may bypass the call server or PBX and connect directly between SVP Alias IP addresses. Control messaging will still go to /from the call server or PBX.

As a final note, the wireless telephone learns about all available SVP Servers IP addresses when it powers up and does the “SRP Check-In” with the Registration SVP Server (identified in DHCP option 151 or set statically). Once the handset are aware of all SVP Servers even if the Registration SVP Server identified by DHCP option 151 goes down, the handset will still find another SVP Server to use. This is the SVP self-healing concept in action.

Any new or replacement wireless telephones may fail to Check-In if the SVP Server identified by DHCP option 151 is down. The new handset has not yet learned the list of all SVP Servers and does not get a response to its Check-In Request. In this case, check the SVP Server identified by DHCP option 151 for operational status.

Note that it is not possible to create an IP array of the SVP Servers in the DHCP option as the handset would not understand this and would instead display “No SVP Response” on the screen. DHCP option 151 is required for the handset when it is operating with an IP protocol but is not required when the handset is working in a Telephony Gateway environment.

When wireless telephones do the first SRP Check-In Request with the registration SVP Server, the registration SVP will load balance the handsets across all available SVP Servers. It will tell the wireless telephone to Check-In with another SVP Server based on a load balancing algorithm. This algorithm does not guarantee an even distribution of handset across all SVP Servers. The wireless telephone will do an SRP Check-In with this designated SVP Server.

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Once connected to the SVP Server the handset will establish its connection to the call server or PBX, then will become operational and be ready to make or receive calls.

#### 4.1.4 DSCP for SVP Deployments

Quality of Service on the wired network must also be taken into consideration. With any VoIP system there is a need for QoS to be configured from end-to-end in order to effectively ensure good audio quality and performance. Even systems that are implemented with only voice and no data clients there is still a need for QoS to ensure background services do not interfere with the audio.

For SVP deployments, the SVP Server is responsible for providing packet prioritization and timed release for specific time slot deliveries to all wireless phones. Additionally, the SVP Server must have its QoS tagging configured to use DSCP (Differentiated Services Code Point) tags that will be properly recognized by the wired and wireless network in order to provide for low latency packet transport. There are six different DSCP tags that can be configured in the SVP Server. It is best to always refer to the network manufacturer's documentation to see what DSCP tags are supported natively and which will need to be configured to give high priority to all the of handset's traffic. By default all SVP Server DSCP tags are set to a value of zero or four. A valid DSCP tag range is from 0 to 63.

The SVP Server has the following DSCP tag types available:

- Administration – Network administration services such as telnet and FTP
- In Call – All traffic from the SVP Server to handset during an active call
- Standby – All traffic from the SVP to handset during standby
- RTP – All in-call audio traffic from the SVP Server to call server or PBX
- PBX – All control traffic from the SVP Server to the call server or PBX
- Inter-SVP – All traffic sent to other SVP Servers which maintains connectivity

The recommended values for these traffic types should be determined by your network infrastructure manufacturer and/or call server or PBX manufacturer. However, in most environments specific DSCP tag values are considered to be the expected or default DSCP values.

The recommended DSCP tag values for the defined traffic types are:

- Administration – Default or 0
- In Call – 46
- Standby – 26 (If using PTT the DSCP tag should be changed to 46)
- RTP – 46
- PBX – 24
- Inter-SVP – 46

All DSCP values defined here, regardless of what values are used, must be configured for appropriate priority throughout the network to ensure end-to-end QoS functionality; including setting the appropriate DSCP tags on the SpectraLink handset. It is critical that voice receive the highest priority to ensure the user experience is as good as possible.

#### 4.2 Wi-Fi Standard QoS

As an alternative to the use of the SVP Server for QoS, the SpectraLink 8020/8030 handsets have the option to use Wi-Fi Standard QoS. Used together, Wi-Fi Multimedia (WMM), WMM Power Save and the forthcoming WMM Admission Control QoS mechanisms provide an enterprise-grade, standards-based alternative to SVP. The handset is compatible with AP implementations of the three WMM features and all three are required to deliver enterprise-grade QoS without an SVP Server. Therefore, use of all three

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WMM specifications is highly-recommended by Polycom and is the default operating mode of the handset if Wi-Fi Standard QoS is selected. However, Polycom does offer the flexibility to disable the use of WMM Admission Control. See Section 4.2.3 for additional detail and possible negative effects. The use of WMM and WMM Power Save are required for Wi-Fi Standard QoS mode.

The WMM specifications are each based on a component of the 802.11e standard, which was ratified in 2005 by the IEEE. 802.11e is a 'toolbox' full of features and the appropriate tool can be used by applications for QoS on the WLAN as long as both the client device and the AP support them.

To use Wi-Fi Standard QoS, the AP needs to support and be configured to enable the corresponding features. Consult the appropriate [VIEW Configuration Guide](#) for enabling these features in your WLAN product.

The use of all three WMM specifications is highly recommended by Polycom and is the default operating mode of the handset if Wi-Fi Standard QoS is selected. However, Polycom does offer the flexibility to disable the use of WMM Admission Control. See Section 4.2.3 for additional details. The use of WMM and WMM Power Save in both the handset and AP are required for Wi-Fi Standard QoS mode.

In addition, Proxy ARP is an AP feature that optimizes bandwidth utilization by limiting the amount of broadcast and multicast traffic that is sent over the WLAN. Enabling Proxy ARP allows a given access point to forward traffic to a handset in standby or in-call; thereby, decreasing delays in the delivery of voice packets to the handset. When Wi-Fi Standard QoS is used, the APs are required to have Proxy ARP enabled.

## 4.2.1 WMM

WMM is based on 802.11e Enhanced Distributed Coordination Access (EDCA). Wi-Fi networks that implement WMM optimize the allocation of shared network resources among competing applications by prioritizing media access depending on the traffic type. This approach brings flexibility in networks that have concurrent applications with different latency and bandwidth requirements.

WMM defines four access categories derived from 802.1d, which correspond to priority levels, as shown in Table 6. Although the four access categories were designed with specific types of traffic and associated priorities in mind, WMM relies on the application to assign the appropriate access category for the traffic they generate. Once the application assigns each packet to an access category, packets are then added to one of four independent transmit queues in the AP and client. Once transmitted onto the wireless network applications may compete for available bandwidth, resulting in packet collisions. When this happens the access category used will determine the retransmission timing. The higher the priority level, the lower the required wait time and random backoff window. High-priority packets transmitted by the client device that are assigned to AC\_VO wait for two slot times with a random backoff of 0-3 slots. Whereas low-priority packets assigned to AC\_BK wait for seven slot times with a random backoff of 0-15 slots.

WMM Access Category	Priority level	802.1d tags	Client wait time + random backoff window (slots)	SIP traffic type	SRP traffic type (SpectraLink Radio Protocol, used with Telephony Gateways)
Voice (AC_VO)	highest	7, 6	2 + 0 to 3	Voice	In call
Video (AC_VI)		5, 4	2 + 0 to 7	Call control	Not in call

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<b>Best Effort (AC_BE)</b>		0, 3	3 + 0 to 15	Other (PTT, OAI, RTLS)	Other (PTT, OAI, RTLS)
<b>Background (AC_BK)</b>	lowest	2, 1	7 + 0 to 15	Not used	Not used

Table 6 - WMM Access Categories

## 4.2.2 WMM Power Save

The second component of Wi-Fi Standard QoS, WMM Power Save, is based on the IEEE 802.11e Unscheduled-Automatic Power Save Delivery (U-APSD) mechanism and is an enhancement over the legacy 802.11 power save mechanism used pre-R3.0. The application-based approach used in WMM Power Save enables individual applications to decide how often the client needs to communicate with the access point and how long it can remain in a 'restful' state. In addition, WMM Power Save increases transmission efficiency because the same amount of data can be transmitted in a shorter time and using fewer frames. Two benefits of WMM Power Save for the SpectraLink 8020/8030 are to conserve battery life and to make AP handoff decisions without the risk of missing packets.

Power save behavior is negotiated during the association of a handset with an AP. WMM Power Save or legacy power save is set for each WMM access category transmit queue separately, as shown in Figure 10. For each access category queue, the AP will transmit all the data using either WMM Power Save or legacy power save, using the assigned WMM QoS mechanism.

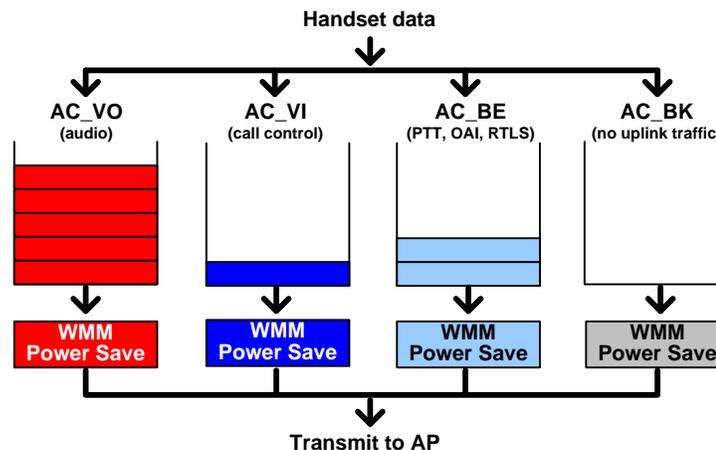


Figure 10 – WMM Queues Using WMM Power Save

Applications that do not initiate power save can still coexist with WMM Power Save enabled applications on the same device. In this case, data from the other applications will be delivered with legacy power save.

The transmission process begins with the handset sending a trigger frame on any of the WMM access categories using WMM Power Save to indicate that it is awake and ready to download any data frame that the AP may have buffered (Figure 11). After the AP receives the trigger frame, it sends an acknowledgement frame (Ack) to indicate it is ready to send the data. Each frame transmitted by the AP indicates whether more data for the handset is buffered (more data = 1). When the AP is ready to stop sending downlink data it sends an EOSP (End of Service Period) message to the handset. If the handset

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has uplink data to send it will need to send a new trigger frame to the AP. Otherwise the EOSP is the handset's indication to resume low power mode.

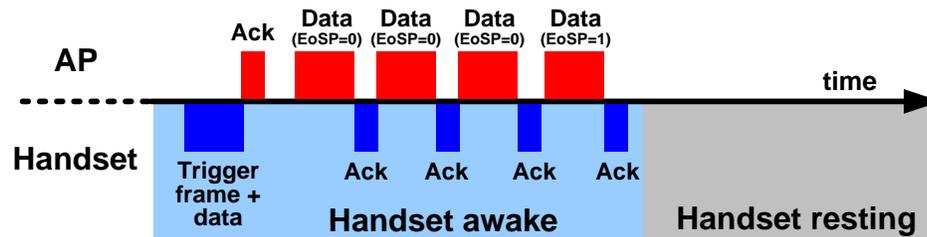


Figure 11 – WMM Power Save Timing

## 4.2.3 WMM Admission Control

The third component of Wi-Fi Standard QoS, WMM Admission Control, allows the AP to manage its available 'air time' based on traffic requirements submitted by associated clients and rejects requests if insufficient resources are available. Use of WMM Admission Control avoids over-subscription of the AP, therefore preserving and protecting QoS for all associated devices. For this reason, use of WMM Admission Control is the handset's default operating mode when Wi-Fi Standard QoS is selected and is the recommended best practice. However, Polycom does offer the flexibility to disable the use of WMM Admission Control in the handset in order for it to participate in WLANs where WMM Admission Control is not used or not supported. Additional details and possible negative results on this setting are provided at the end of this section.

WMM Admission Control uses another optional feature from 802.11e, which is critical to delivering enterprise-grade VoWLAN. The Admission Control facility adds the capability to manage how the total medium time is reserved and used by various devices and QoS priorities. The AP controls the medium time by allocating a percentage of the total time, measured on a per second basis, in response to requests from each participating client. Any client that does not participate in the admission control allocations must send only low-priority traffic (typically assigned AC\_BE and AC\_BK). For this reason, all wireless devices using AC\_VO or AC\_VI will also need to use admission control to maintain their QoS settings.

Participating WLAN clients gain an allocation of medium time by sending an explicit request to the AP, called an ADDTS (add traffic stream) Request, describing the nature of the traffic flow the client anticipates it will use. This includes factors such as total bandwidth in bits per second, average packet size, expected PHY data rate, etc. From this the AP can determine how much medium time the client is likely to use as well as gain some understanding of the expected traffic flow – whether it is a flow with few, large packets or many, small packets, for example, or whether the traffic is bursty or fairly regular. The SpectraLink handset will indicate its traffic as small, frequent packets at a consistent flow. From the client's ADDTS Request, the AP can enforce a number of policy decisions in determining whether the traffic flow requested will fit well into the existing traffic streams. Usually, there is spare bandwidth available, and the AP will admit the traffic and the client proceeds normally, using WMM and WMM Power Save techniques to do the packet transfers.

Occasionally, the AP may determine that the traffic load already in place on the AP is incompatible with the requested traffic stream. In this case, the AP refuses the ADDTS Request, letting the client know that if it starts to exchange packets at the described rate, it will impact its own or other clients' QoS. The client is then free to try another nearby AP instead, thus ensuring that all clients' traffic will maintain a high level of QoS.

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Typically, admission control is enabled only for high-priority traffic, usually AC\_VO and AC\_VI. The lower-priority traffic will not significantly impact the QoS of the higher-priority traffic in the case where the medium time is over-used, so this is acceptable, and it leaves an option for client devices that do not support admission control to use AC\_BE and AC\_BK.

In most respects, WMM Power Save and WMM Admission Control are separate facilities and operate independently. However, the same mechanism that supports WMM Admission Control, the ADDTS Request, can also be used to more finely tune control over WMM Power Save. This allows a client to go beyond simply setting the power save mode for each access category transmit queue. With an ADDTS Request, a client can separately control the uplink and downlink directions of each access category. This allows the client more flexibility over which types of traffic will be buffered and how they will be delivered by trigger frames, thus allowing it to optimize the 'restful' state times and durations.

The benefits of using WMM Admission Control for VoWLAN are clear; handset audio quality is preserved and protected by avoiding over-allocation of AP resources. Therefore, its use is highly recommended and is the default setting when Wi-Fi Standard QoS is selected for the handset.

However, there may be circumstances in which the use of WMM Admission Control may not be feasible or practical. One example is the use of both the SpectraLink 8002 and 8020/8030 handsets in the same WLAN. SpectraLink 8002 models use WMM alone for WLAN QoS. This capability matches well with the typical SMB (small to medium business) environment to which the 8002 is targeted – few users, low-end/low-cost APs, and limited technical staff. The SpectraLink 8020/8030 models, on the other hand, are designed for enterprise-classes deployments where robust QoS is required due to the complexity of the network.

Like the SpectraLink 8020/8030, the SpectraLink 8002 use AC\_VO for voice packets and AC\_VI for control packets. But because it does not participate in admission control, it should not be used in networks where WMM Admission Control is mandatory for the high-priority AC\_VO and AC\_VI access categories. Otherwise the voice packets transmitted and received would be forced to use AC\_BE or AC\_BK, likely degrading audio quality. For this reason, if the 8002 and 8020/8030 are used in the same WLAN, WMM Admission Control should be set to optional in the 8020/8030s and the ACM (Admission Control Mandatory) setting in the APs should be cleared for AC\_VO and AC\_VI. This configuration can not only be used for WLAN compatibility with the 8002, but to share the network with any other devices that use AC\_VO and AC\_VI but do not have support admission control. The result of this configuration is the 8020/8030 operates using WMM and WMM Power Save, but there is no admission control on the WLAN. In heavily-loaded networks the result can be poor handset audio quality. Therefore, careful planning to ensure adequate AP bandwidth is necessary.

#### 4.2.4 DSCP for Wi-Fi Standard QoS Deployments

Differentiated Services Code Point (DSCP) is a field in the header of IP packets for packet classification purposes. DSCP is used to indicate an assigned priority level to individual packets that will be used through the network. For traffic going from the handset to the call server, WMM access categories address WLAN prioritization, and DSCP addresses prioritization on the wired network.

Once Wi-Fi Standard QoS mode is selected on the handset, the administrator will see a submenu for configuring DSCP values for outgoing Voice, Control and Other packet types. The default values are:

- Voice – 46
- Control (call control) – 26
- Other (PTT, OAI and RTLS) – 0

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Default DSCP values can be accepted or replaced. Regardless of the DSCP values selected, the WMM access categories will be used for sending the various traffic types through the WLAN as indicated in Table 6.

For traffic from the call server to the handset, call server DSCP determines priority on the wired network, but is also used by most WMM-capable access points to determine which WMM access category to use when placing the packet over the air. Please refer to your WLAN vendor's documentation for detailed instructions on how to map DSCP values to WMM access categories. Refer to your call server vendor's documentation for setting DSCP values for traffic from the call platform.

It is highly recommended that the DSCP values for the different types of traffic out of the call server (voice or control) match the settings entered in the phone administration menu or HAT.

### **4.3 Cisco Client Extensions, Version 4 (CCXv4)**

The SpectraLink 8020/8030 handset supports a third QoS method, using Cisco Client Extensions Version 4 (CCXv4). CCX is a set of requirements for client devices operating on a Cisco WLAN that use industry standards, including the WMM mechanisms, and a few Cisco-specific features, providing IT managers predictable client behavior and uniform deployments. The handset is certified for CCXv4, which is specifically designed for voice applications. Selecting the CCX mode on the handset provides enterprise-grade QoS without an SVP Server. Because CCXv4 involves more than QoS, including security and radio management features, it is detailed in Section 6.

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## 5 Security

Proper security provisions are critical for any enterprise Wi-Fi network. Wireless technology does not provide any physical barrier from malicious attackers since radio waves penetrate walls and can be monitored and accessed from outside the facility. The extent of security measures used is typically proportional to the value of the information accessible on the network. The security risk for VoWLAN is not limited to the typical wired telephony concerns of eavesdropping on telephone calls or making unauthorized toll calls, but is equivalent to the security risk of the data network that connects to the APs. Several different security options are supported on SpectraLink Wireless Telephones. Determining the proper level of security should be based on identified risks, corporate policy and an understanding of the pros and cons of the available security methods.

### 5.1 VoWLAN and Security

VoWLAN has specific characteristics that influence the supported security mechanisms. For instance, a Wi-Fi handset generally has a simple user interface, limited computing resources and is battery-operated. The packet delay tolerance is very low compared to a device primarily used for data applications. In addition, a voice handset is highly mobile within the coverage area, requiring frequent handoffs between APs as the user roams throughout the facility.

When the handset roams between APs and maintains WLAN connectivity it is referred to as a 'soft' handoff. During soft handoffs the voice stream is maintained and there should be no perceptible changes in audio quality while the user is in-call. A 'hard' handoff occurs when the handset loses AP connectivity and must re-acquire the WLAN. In this case, audio impairments are possible. The degree of the audio degradation is influenced by the security method used; the more complex the mechanism, the greater the duration of time in the security exchange.

Selection of a WLAN security method is a trade-off between the degree of security, the end-user experience and the complexity of management. Generally the most secure methods require the greatest degree of management and have the greatest potential negative impact on the end-user experience. Polycom offers several security options that span the range from basic protection with minimal effort to robust protection with involved IT management. The handset's security options are described in this section.

### 5.2 Wired Equivalent Privacy (WEP)

SpectraLink Wireless Telephones support Wired Equivalent Privacy (WEP) encryption as defined by the 802.11 standard. The handsets can use either 40-bit or 128-bit key lengths. WEP is intended to provide the same level of security over a wireless LAN as on a wired Ethernet LAN. Although security flaws have been identified, WEP still provides strong encryption that requires an experienced and dedicated hacker to break. While WEP is often not an acceptable option for many high security or privacy focused enterprises, it is still useful and provides reasonable performance for voice due to the shortened key exchange process.

### 5.3 Wi-Fi Protected Access (WPA)

Recognizing the need for stronger security standards beyond WEP, the IEEE developed the 802.11i standard, which includes stronger encryption, key management, and authentication mechanisms. Wi-Fi Protected Access (WPA) is based on draft 3.0 of the 802.11i specification and uses TKIP (Temporal Key Integrity Protocol) encryption. WPA2 is based on the ratified 802.11i standard. The major enhancement of WPA2 over WPA is the inclusion of the Advanced Encryption Standard (AES), which is widely accepted as one of the most secure encryption algorithms available.

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WPA2 has two different authentication modes, Personal and Enterprise, both of which are supported on the SpectraLink 8020/8030 Wireless Telephone. Authentication is the process that occurs after WLAN association in which the handset and authentication server verify each other's credentials, then allow the handset access to the network.

### 5.3.1 WPA Personal, WPA2 Personal

Personal mode uses a password-based authentication method called Pre-Shared Key (PSK). Personal mode is good for time-sensitive applications such as voice, because the key exchange sequence is limited and does not adversely affect roaming between APs. The PSK can be entered in hexadecimal or as an ASCII passphrase from the handset's administration menu or the HAT. The handset supports both WPA Personal and WPA2 Personal modes.

### 5.3.2 WPA2 Enterprise

With Release 3.0, the SpectraLink 8020/8030 handset added support of WPA2 Enterprise. Enterprise mode requires a WLAN device to mutually validate credentials with an 802.1X authentication server on the network every time the device roams to a new AP. With each roam, authentication delays may cause dropped packets resulting in audio dropouts. The size of the credentials used and the location of the RADIUS authentication server can significantly impact the duration of the delay. Larger credentials are more secure, but take more time to process. RADIUS servers that are local and reside on high-speed Ethernet switches are faster to respond to authentication requests than those in remote locations.

Because the use of WPA2 Enterprise requires 802.1X authentication by the device and that exchange can cause delays at each AP handoff, Polycom requires the use of a fast AP handoff mechanism. Fast AP handoff techniques allow for the part of the key derived from the authentication server to be cached in the wireless network, thereby shortening the time to renegotiate a secure handoff. The handset offers two 802.1X authentication types (PEAP and EAP-FAST) and two fast AP handoff techniques (OKC and CCKM) for WPA2 Enterprise. The combination of the selected 802.1X authentication type and fast AP handoff mechanism is expected to result in soft handoffs as the handset user roams the facility.

#### 5.3.2.1 PEAPv0/MSCHAPv2

PEAP (Protected Extensible Authentication Protocol) was developed by Microsoft, Cisco and RSA Security for 802.1X authentication on WLANs. PEAPv0/MSCHAPv2 is one of the most-commonly used subtypes. PEAP makes use of a server-side public key certificate to authenticate the server and creates an encrypted tunnel to exchange information between the server and the client. Larger certificate key sizes provide stronger encryption, but are more computationally intensive and therefore take more time to process. This longer processing time to perform the 802.1X key validation means that the handset cannot communicate with the rest of the network for a longer time, and cannot receive or transmit audio packets, resulting in missing audio. While the handset supports key sizes of 512, 1024, 2048 and 4096 bits, a key size of 512 or 1024 bits is recommended, as these sizes balance the degree of security with the need to maintain audio during WLAN acquisition.

PEAP root certificates must be loaded using the Handset Administration Tool (HAT). Each handset supports a single root certificate in DER format loaded into non-volatile memory. Other certificate formats exist, and can be translated to DER format by third party tools before being loaded using the HAT. A username (relates to the device name, not necessarily an end-user) and password are entered via the HAT or handset administration menu.

Certificates carry a validation period (start and end date of validity). When using a certificate, the handset will attempt to check its validity by using time information available from an NTP server, and in certain cases from the call server. If no time information is available, the certificate is assumed to be valid,

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making the use of a time source optional. If the certificate is deemed expired (or not yet valid) the handset will stop operating and display an error message. Note that because access to NTP is available much earlier in the boot up process than access to the call server time, providing an NTP server provides stronger security, protecting handset firmware downloads and checking in with the call server.

## 5.3.2.2 EAP-FAST

EAP-FAST (Extensible Authentication Protocol-Flexible Authentication via Secure Tunneling) was created by Cisco as a replacement for LEAP (Lightweight Extensible Authentication Protocol) (see Cisco FSR, in this section). EAP-FAST has since gained adoption by WLAN vendors besides Cisco and is growing in popularity.

Rather than relying on certificates, EAP-FAST use a Protected Access Credential (PAC) to establish a tunnel in which client credentials are verified. PAC files may be provisioned either over-the-air (called server unauthenticated or Phase 0) or manually via the HAT. Server unauthenticated provisioning is easy to manage, but offers a lesser degree of security than manual provisioning. The administrator must choose between the two methods by weighing the desired level of security with ease of management.

## 5.3.2.3 OKC

Opportunistic Key Caching (OKC), sometimes called PMK (Pairwise Master Key) caching, is a fast AP handoff technique specified in the 802.11i standard. OKC has growing support among enterprise WLAN vendors and is the only standards-based fast AP handoff method supported today. Check Polycom's VIEW Certified Products Guide to find a list of WLAN products tested for OKC support.

The combination of either PEAP or EAP-FAST and OKC is expected to result in soft handoffs, once the initial 802.1X exchange has occurred establishing network connectivity for the handset. The soft handoffs occur as the user roams within the coverage area and the WLAN infrastructure retains authentication key information for the associated clients. Therefore, the RADIUS server does not need to be reached at every handoff and the duration of the authentication exchange is fast enough to maintain audio quality. Hard handoffs occur when the handset loses AP connectivity and subsequently the handset must re-acquire its connection to the WLAN. When WPA2 Enterprise is the selected security method and connectivity is lost, a full 802.1X authentication with the RADIUS server is required during the re-acquisition. Once the handset has re-acquired the network after a hard handoff, soft handoffs will resume as long as OKC is used and WLAN connectivity is maintained. OKC must be supported and properly configured on the WLAN. Consult the [VIEW Configuration Guide](#) for your WLAN product to ensure proper operation.

## 5.3.2.4 CCKM

Cisco Centralized Key Management (CCKM) is a Cisco-proprietary fast AP handoff method and therefore only supported on Cisco APs. CCKM is required for CCX certification and will automatically be used if CCX operating mode is selected for the handset. CCKM is also available for use with Cisco APs through the Custom menu options.

The combination of either PEAP or EAP-FAST and CCKM is expected to result in soft handoffs, once the initial 802.1X exchange has occurred establishing network connectivity for the handset. The soft handoffs occur as the user roams within the coverage area and the WLAN infrastructure retains authentication key information for the associated clients. Therefore, the RADIUS server does not need to be reached at every handoff and the duration of the authentication exchange is fast enough to maintain audio quality. Hard handoffs occur when the handset loses AP connectivity and subsequently the handset must re-acquire its connection to the WLAN. When WPA2 Enterprise is the selected security method and connectivity is lost, a full 802.1X authentication with the RADIUS server is required during the re-

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acquisition. Once the handset has re-acquired the network after a hard handoff, soft handoffs will resume as long as CCKM is used and WLAN connectivity is maintained. CCKM must be properly configured on the Cisco APs. Consult the [VIEW Configuration Guide](#) for your Cisco products to ensure proper operation.

### 5.3.3 Cisco Fast Secure Roaming (FSR)

Cisco's Fast Secure Roaming (FSR) mechanism uses a combination of standards-based and proprietary security components including Cisco Client Key Management (CCKM) (see Section 5.3.2.4), LEAP authentication, Michael message integrity check (MIC) and Temporal Key Integrity Protocol (TKIP). FSR provides strong security measures for authentication, privacy and data integrity along with fast AP roaming on Cisco APs.

## 5.4 Using Virtual LANs

Virtual LANs (VLANs) can be used to segregate traffic into different security classes. By using separate VLANs, data traffic can utilize the most robust but processing-intensive security methods. In order for voice to operate efficiently in a WLAN, it is critical that it be separated from the data traffic by using VLANs, mapped to WLAN SSIDs.

The 802.1Q standard establishes a method for inserting VLAN membership information into Ethernet frames via header-information tags. SpectraLink infrastructure equipment and SVP do not generate or forward these tags, but are otherwise compatible with 802.1Q up to the Ethernet switch ports used for the SpectraLink equipment.

## 5.5 MAC Filtering and Authentication

Most access points can be configured to allow or deny association of wireless clients based on their unique MAC address, which can be used as a method of securing the WLAN. This process generally works well, but can cause some performance issues on some APs and is never recommended when using voice on a WLAN.

## 5.6 Firewalls and Traffic Filtering

The traffic filtering capabilities of firewalls, Ethernet switches and wireless controllers can also be used as an additional security layer if configured to allow only certain types of traffic to pass onto specific areas of the LAN. To properly provide access control, it is necessary to understand the type of IP traffic used by the SpectraLink handsets. When using SpectraLink Telephony Gateways to interface to a traditional PBX or an SVP Server in an IP PBX implementation, the handset uses the SpectraLink Radio IP Protocol (IP ID 119).

While the SpectraLink handset will generally work through a firewall if the appropriate ports are made available, this is never recommended. Firewalls create a great deal of jitter in the network which can severely limit the successful, on-time delivery of audio packets to the wireless telephone. Additionally, the use of ICMP redirects is not supported because of the extreme delay this can result when the gateway of the SVP Server or handsets is changed dynamically. SpectraLink handset requires less than one millisecond of jitter from the SVP Server to handset. This will be difficult to achieve if there are multiple 'hops' between the SVP Server and handset.

For an IP telephony server interface, the ports used depend on the IP telephony protocol of the telephony switch interface. The SpectraLink Wireless Telephones, Telephony Gateways and SVP Server use TCP and UDP and other common IP protocols from time to time. These include DHCP, DNS, WINS, TFTP, FTP, NTP, Telnet, ARP and ICMP. Polycom uses proprietary UDP channels between the infrastructure components i.e. UDP ports 5454 - 5458. The push-to-talk (PTT) mode of the SpectraLink 8030 Wireless

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Telephone uses the multicast IP address 224.0.1.116, which other model handsets and SpectraLink infrastructure components also employ to locate and maintain connection with each other. Some other common ports between the SVP Server and call server will be RTP traffic on ports 16384 through 32767. The port used will be chosen randomly by the phone and call server at the time of call setup. The Real Time Location Service use UDP port 8552 by default (configurable in the Administration menu or HAT).

## 5.7 Virtual Private Networks (VPNs)

Virtual Private Networks (VPNs) are secure, private network connections. VPNs typically employ some combination of strong encryption, digital certificates, strong user authentication and access control to provide maximum security to the traffic they carry. They usually provide connectivity to many devices behind a VPN concentrator. The network can be broken into two portions - protected and unprotected:

- 1) The area behind the VPN server is referred to as the “protected” portion of the network. Sensitive, private network equipment such as file servers, e-mail servers and databases reside in this portion.
- 2) The area in front of the VPN server is referred to as the “unprotected” network, where the wireless APs and less sensitive network equipment often reside.

VPNs offer an extremely effective method for securing a wireless network. Many network administrators implement VPNs to maintain the integrity of their WLANs by requiring wireless users who need access to the protected portion of the network to connect through a VPN server.

Most voice devices, such as the SpectraLink Wireless Telephones, do not require access to the protected portion of the network (see Figure 12). Placing the handsets, SVP Server(s) and Telephony Gateways on the unprotected network and requiring data users to connect to the VPN ensures that the network is protected against hackers seeking to access sensitive information within the network core.

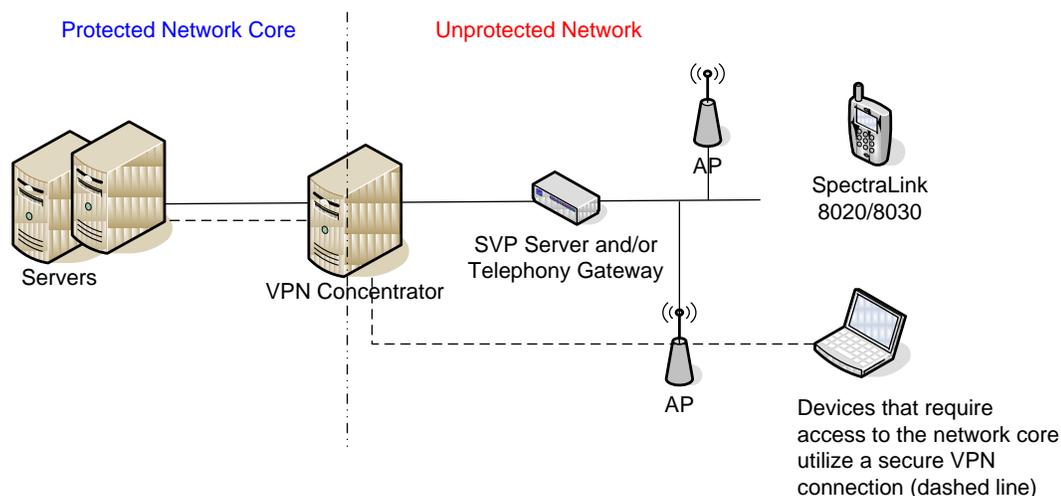


Figure 12 - Deploying SpectraLink Wireless Telephones with a VPN

## 5.8 Diagnostic Tools

The SpectraLink handset provides three comprehensive diagnostic tools to assist the administrator in evaluating the functionality of the handsets and the surrounding wireless infrastructure. These tools are: Run Site Survey, Diagnostics Enabled, and Syslog Mode.

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**Site Survey** can be used to evaluate the radio coverage within the facility where the handsets are deployed by testing the signal strength, or to gather information about access points regardless of the SSID.

**Diagnostics Enabled** is used to evaluate the overall quality of the link between the handset, access point, and other infrastructure equipment such as IP PBX, SVP Server, and gateways. The handset's diagnostics are enabled through the handset admin menu and are used while the handset is in the 'off hook' state.

**Syslog Mode** allows the handset to send various Syslog messages such as Successful and Failed handoffs along with reason codes indicating why the handset chose to handoff to a particular AP; Call Starts and Ends; AP RSSI, audio statistics; security errors and other information. Refer to the Diagnostic Tools section of the [SpectraLink 8020/8030 Wireless Telephone Administration Guide](#) for a detail explanation of information provided by each of the Diagnostic tools.

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## 6 Cisco Compatible Extensions (CCX)

Cisco Compatible Extensions (CCX) is Cisco's partner interoperability program that requires Wi-Fi client devices to support a common set of WLAN industry standards as well as utilize a few Cisco-specific features. CCX partners become certified by implementing and being tested to support a specific set of requirements. The SpectraLink 8020/8030 handsets have achieved [CCXv4 certification](#), which requires support of all the mandatory features specified for CCX versions 1-4.

CCXv4 was designed for voice applications and its features provide an alternative QoS option to SVP, using the WMM suite of protocols for QoS. CCXv3 focuses on security, requiring enterprise-grade authentication mechanisms along with a fast AP handoff technique to preserve voice quality. CCXv1 and v2 are considered foundational, providing basic Wi-Fi interoperability.

By selecting CCX mode from the handset menu, all mandatory features are automatically enabled including, but not limited to:

- WMM (see Section 4.2.1 for a description of this feature)
- WMM Power Save (see Section 4.2.2 for a description of this feature)
- Cisco Call Admission Control (CAC)
- CCKM (see Section 5.3.2.4 for a description of this feature)
- Transmit Power Control (TPC) (see Section 2.4.2 for a description of this feature)

The only configurable option in CCX operating mode is the selection of either EAP-FAST or PEAP for 802.1X authentication (see Section 5.3.2) and the setting of DSCP values (Section 4.2.4). CAC is only used in CCX mode, but all other features are available in Custom mode. Therefore, the administrator may choose to use only some of the features listed above through the Custom mode menu.

When CCX mode is enabled, the handset signals this capability by advertising support of CCXv4. If a Cisco AP responds with the corresponding capabilities then the handset will operate in CCX mode. If the handset is set to operate in CCX mode but does not find an AP that offers this capability it will not connect to the WLAN and display an error message.

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## 7 Subnets, Network Performance and DHCP

Subnets are used to create a boundary between network segments. Although these boundaries are logical, they become like a physical boundary for mobile network devices moving throughout the enterprise. When a device with an established IP data stream (such as with an active phone call) attempts to roam across a subnet boundary, it must obtain a valid IP address within the new subnet. During this process, the data stream cannot be re-established automatically and the connection (voice call) is dropped. In the case of SpectraLink Wireless Telephones, the handsets should be power cycled to obtain a new DHCP IP address. The handsets can automatically recover in the new subnet from a lost network connection with the original subnet, but the 40-second failure and recovery time generally warrants cycling the power. Please note that in order for the phone to continue functioning in the new subnet the DHCP scope must contain the appropriate DHCP options to allow the phone to regain connectivity with the voice infrastructure.

Some APs, Ethernet switches and third-party devices have implemented methods to facilitate subnet roaming. While these methods are transparent to the client device and are fundamentally a good approach to accommodating multiple subnets, they often cause enough delay and jitter to manifest poor voice quality and the tradeoffs might make such solutions unattractive for voice applications.

Since the push-to-talk feature of the SpectraLink 8030 Wireless Telephones use multicast IP packets, a PTT call will generally be isolated to a single subnet. With the deployment of IP multicast routing it is possible for the multicast traffic that is normally pruned at the network boundary to be passed into one or more other subnets. Please review your network manufacturer's documentation for information on how to properly configure multicast routing.

There are additional subnet requirements for Wireless Telephones based on the infrastructure components that are used, as described in the following sections.

### 7.1 Subnets and Telephony Gateway Interfaces

SpectraLink Wireless Telephones, Telephony Gateways and SVP Server(s) generally must reside on the same subnet. This is required because SpectraLink handsets use IP multicast messages to initialize the handset registration on the Telephony Gateways. In addition, The Telephony Gateways and SVP Server(s) use multicast to discover each other and stay synchronized. Most routers deployed in multi-subnet Ethernet environments are configured to filter out multicast and broadcast messages. Unless a router is configured for multicast routing, if a handset is powered up on a different subnet than the Telephony Gateway to which it is registered, the multicast message will not reach the Telephony Gateway to establish a connection.

### 7.2 Subnets and IP Telephony Server Interfaces

With an IP telephony interface, the SVP Server can be placed on a separate subnet from either the APs or call server. The handsets will find the SVP Server and call server on another subnet through the default gateway option statically configured in the handset or via DHCP option 3 when using a DHCP server for IP addressing. The SpectraLink handset learns the IP address of the SVP Server by static configuration or by DHCP Option 151.

SpectraLink Wireless Telephones can be deployed across multiple subnets when used with an IP telephony server if the performance requirements outlined below are met. One of two deployment scenarios described in this section can be used, depending on needs and infrastructure capabilities. Keep in mind that the handsets will never actively roam across a subnet boundary without power-cycling the

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handsets unless a VIEW Certified layer-3 roaming infrastructure is used in accordance with the VIEW deployment guidelines.

In one deployment scenario for accommodating multiple subnets, each subnet is treated independently with respect to the SVP Servers and wireless network, but each subnet can still provide service to a single IP telephony server. One or more SVP Server(s) can be deployed on each subnet just as with a single subnet system, including identifying the registration SVP via DHCP option 151 or static configuration. In the second scenario, a single SVP Server (or set of SVP Servers with one registration SVP) is deployed, generally on the same subnet as the IP telephony server. The single (Registration) SVP Server is identified to all phones via DHCP option 151 or static configuration, regardless of what subnet the phone is operating in. This scenario requires fewer SVP Servers to be installed, but requires higher performance from the router (see performance requirements in Section 4.1).

The ability to cross a subnet boundary exists in either scenario, but the SpectraLink handsets will need to be power cycled to obtain a new IP address within the new subnet. In addition, other configuration considerations must be addressed. Because users will not want to re-administer the wireless telephones to a separate subnet, Extended Service Set Identifier (ESSIDs) should be the same or the handsets should be set to the “Learn Always” mode, the security mode and associated key should be the same or turned off, and DHCP should be used.

### 7.3 Network Performance Requirements When Using SVP

Ethernet packets containing voice as their payload have short, useful lifetimes, making the timely delivery of voice packets essential. Routers can introduce latency and delay between the SVP Server and the APs, or the call server and the APs in Wi-Fi Standard QoS mode when the SVP Server is not present, resulting in poor voice quality.

Ethernet connectivity from the call server or other voice endpoint to the SVP Server should never exceed 100 milliseconds of network delay (one way), 30 milliseconds of network jitter, and 2 percent packet loss end-to-end, regardless of the physical properties of the link. The link from the SVP Server to the APs should be under 100 milliseconds of network delay, one millisecond of jitter and less than two percent packet loss. In both cases, the jitter requirements are for wired network jitter and do not include the RF link.

When using SVP for QoS, one function of the SVP Server is to control the timing of packets through the AP. The SVP server delivers audio packets to the wireless telephone every 30 millisecond when in call. The delay between the SVP Server and the AP needs to be controlled and consistent. Wired QoS (DSCP) is one aspect of ensuring voice packets have highest priority. The jitter requirement between the call server and the SVP Server is a function of how the audio is packetized for encapsulation in the SpectraLink Radio Protocol (SRP) and the packet queuing in the SVP Server.

Jitter between the SVP Server and the AP should be measured at the wired Ethernet connection to the AP. If the AP is a lightweight AP attached to a wireless controller and Polycom has VIEW Certified the system, jitter can be measured at the entry to the wireless controller. However it is better to measure jitter at the AP's Ethernet interface if the AP does not connect directly to the wireless controller. For this handset in call measurement, the SVP Server is delivering packets at 30 millisecond intervals with no jitter. The time is measured from the arrival of one packet from the SVP Server directed to a single wireless telephone to the next packet from the SVP Server to the same wireless telephone. The jitter measurement is the time difference from the ideal 30 millisecond arrival of packets at the AP. See Figure 13.

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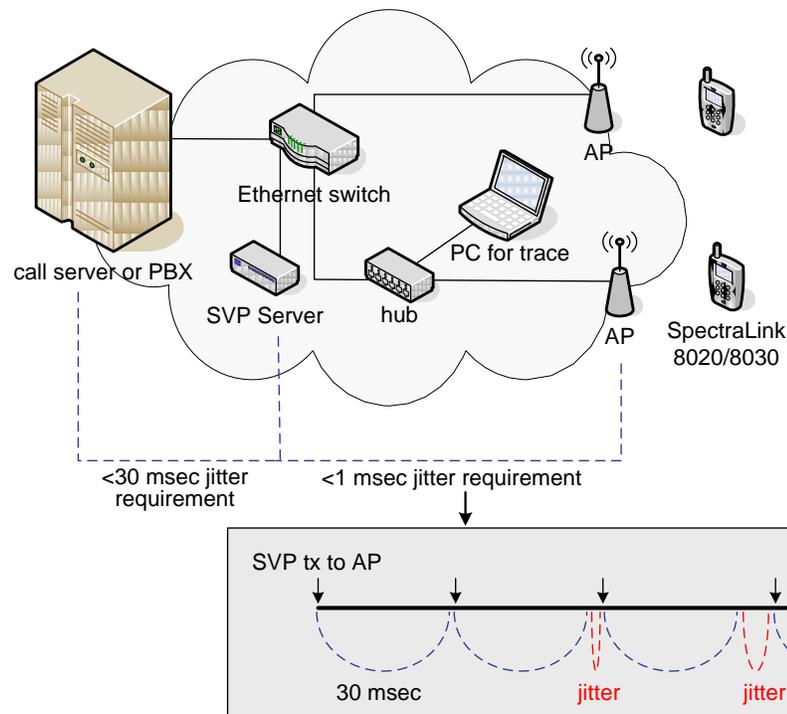


Figure 13 - Measuring Network Jitter

In a multiple SVP Server configuration, jitter is measured from the SVP Server that is responsible for the traffic through a given AP to a wireless telephone. This may be different than the SVP Server that is acting as a proxy for the wireless telephone to the IP PBX. Refer to Section 4.1.3 for additional multiple SVP Server information.

SpectraLink handsets have a diagnostic option that includes jitter measurement. The calculated jitter shown in this mode is not the jitter described above because it includes delays in the AP, radio link and queue times inside the wireless telephone. Jitter information from the handset diagnostic mode should only be used as a guideline for diagnosing major network or radio link problems.

## 7.4 DHCP Requirements

The SpectraLink Wireless Telephone is configured by default to utilize DHCP in order to obtain an IP address and the necessary DHCP options to allow the phone to operate normally. For the different IP protocols available with the SpectraLink handset there are a number of different DHCP options that would be used. However, there are also a number of DHCP options that are universal required regardless of the IP protocol implementation. Additionally, the DHCP options required for a Telephony Gateway implementation vary somewhat from the IP protocol deployments.

Operationally, the handset functions the same regardless of the implementation when using DHCP. This means all that is changing is the DHCP options the handset will require in order to function properly. For Telephony Gateway deployments the handset will acquire its IP address from the DHCP server Scope Address Pool and its Subnet mask in addition to the most basic options from the DHCP server Scope Options. The expectation when deploying a Telephony Gateway system is that the handset will reside on the same IP subnet as the Gateway in order to generate and transmit the necessary multicast frames that

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will allow it to locate and register with the Telephony Gateway. Once the handset registers, the remaining options that would normally be handled via DHCP, such as TFTP, are provided by the Telephony Gateway.

When the license option in the wireless phone is set for one of the IP protocols the handset will require several other DHCP options in order to function properly. In addition to the base DHCP options required by the Telephony Gateway implementation the handset will also require DHCP options 151 and/or 152. Option 151 is specifically the IP address of the Registration SVP Server. Option 152 is for deployments that are running an OAI Gateway where the option field is populated with the IP address of the OAI gateway. These options are only accepted as an IP address by the handset.

DHCP Option 66, as defined by RFC 2132, provides the address of a TFTP server. A TFTP server is required for any SIP implementation and is only required in other IP protocols when software updates are needed. It is recommended that a TFTP server be made available regardless of the implementation. In SRP deployments the Telephony Gateway can act as a TFTP server but it is only capable of servicing a single handset at a time. Additionally it is not possible to use the Telephony Gateway TFTP server to provide software to the 8020/8030 handset types, due to file size. Because of these limitations an external TFTP server is advisable and is often required in order to serve multiple clients at once.

Additional DHCP options are supported on the SpectraLink Wireless Telephones and can be configured in the DHCP scope appropriate for the IP scope servicing the phones. See the Table 7 for the list of DHCP options typically used and their purpose.

DHCP Option	Value Expected	Purpose
1	IP Address (i.e. 255.255.255.0)	Subnet Mask
3	IP Address (i.e. 192.168.1.1)	Default Gateway
6	IP Address (i.e. 192.168.1.10)	DNS Server
7	IP Address (i.e. 192.168.1.20)	Syslog Server
15	String (i.e. mycompany.com)	Domain Name
42	IP Address (i.e. 192.168.1.30)	NTP (Network Time Protocol)
66	IP Address (i.e. 192.168.1.40)	TFTP Server
151	IP Address (i.e. 192.168.1.50)	SVP Server
152	IP Address (i.e. 192.168.1.60)	OAI Gateway

Table 7 – DHCP Options

Depending on the IP protocol implementation additional DHCP options will be required to support the call server. The options will likely include additional TFTP server addresses and the IP address of the call server. These DHCP options should be provided by the call server manufacturer to ensure the appropriate information and values required for those options are correct for the specific IP protocol deployment.

While the wireless telephone does support using a DNS server, as shown in Table 7, it is not recommended to do so. Using DNS creates a dependency on a service that may not be reliable when the services a phone provides can be critical. By using DNS there is also the addition of latency in transactions that the handset must complete with the DNS server which could lead to undesirable behavior from the wireless telephone. Please note if DNS is necessary then DHCP option 15 is also required. Without both DHCP options 6 and 15 the wireless telephone will not be able to complete DNS queries

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## 8 Conclusion

The SpectraLink 8020/8030 Wireless Telephone uses Wi-Fi technology to deliver a full-featured mobile extension to a call server or PBX. The purpose of this document is to outline the network design criteria for a successful VoWLAN deployment. By applying the guidelines described in this document, networking and telephony professionals can confidently design and deploy a Polycom Wi-Fi telephony solution.

Some of the key takeaways include:

- Voice and data applications have different attributes and network requirements. Several aspects of the WLAN infrastructure, including coverage and capacity planning, require special considerations for voice traffic.
- Reliable QoS is a requirement for any enterprise voice application. Wireless VoIP is especially vulnerable to many WLAN processes that can affect voice quality, including wireless traffic contention and security authentication delays.
- Selection of a security method for SpectraLink 8020/8030 handsets is a balance between the degree of security required, the complexity of management and acceptable roam time performance. Polycom offers a wide breadth of options along the WLAN security spectrum.
- Several network design attributes need to be considered before deploying a VoWLAN solution, including the use of subnets and complex network topologies that may affect the performance of SpectraLink handsets.
- Polycom's dedication and expertise helps ensure proper deployment for VoWLAN.

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