WHITE PAPER

ACHIEVING A BEST-IN-CLASS WIRELESS INFRASTRUCTURE

The 802.11ac standard gives organizations an opportunity to improve their Wi-Fi network performance and capacity — and to better serve all users.

Executive Summary

Today's increasingly mobile workforce demands ubiquitous, fast wireless access to meet the changing needs of the modern organization. The Wi-Fi networks that used to support this access often grew organically and were not engineered to support the widespread, high bandwidth needs of users.

The advent of the 802.11ac Wi-Fi standard provides IT professionals with the opportunity to both upgrade their network capacity and redesign their wireless strategy to better support the rapid rise of mobile computing. The new standard boosts performance through a number of improvements including wider channels and better modulation techniques.

Adopting an 802.11ac strategy can increase the value that IT delivers to an organization's mission. IT professionals should understand the technical features of 802.11ac and how organizations can prepare their networks for this new technology. They can use a number of strategies when adopting 802.11ac, as they strive to implement a best-in-class wireless network.

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The Situation

Mobility is changing the way that organizations work. Employees often tote multiple devices for work. At a meeting, a worker may carry a smartphone in his or her pocket, use a tablet during the meeting and under the table slide a bag containing a notebook computer and portable wireless scanner. In fact, a 2014 survey by Aruba Networks, *Are You Ready for #GenMobile?*, showed that nearly 40 percent of enterprise employees said they own four or more connected devices.

Some of those devices may be actually owned by the organization and managed by its IT staff while others may be personally owned devices used to access enterprise data and applications on the organization's network. This scenario is far different from the world that businesses faced a decade ago when wireless networking was much more limited in scope.

Wireless networks are no longer an add-on to an enterprise's core network; Now, they are the core network. Wi-Fi has moved from a novel member of the "bells and whistles" category to an essential tool that allows employees to become more productive.

In this environment, IT professionals must invest in the reliability and robustness of their wireless networks and design them to support the continued growth of mobile computing expected to occur over the next few years. Wireless assessments are also part of this analysis. These investments can be much more cost-effective than many other expenditures.

Unfortunately, the way wireless networks evolved does not position them to effectively contribute business value. In many cases, wireless networks began as an experiment in new technology and then grew in an incremental fashion as adoption increased.

This led to networks that are not actively managed, which often lack the sophisticated monitoring and configuration found in wired networks. Adding this rigor to new and existing networks will help ensure that an enterprise's wireless infrastructure is well positioned to meet current and future needs.

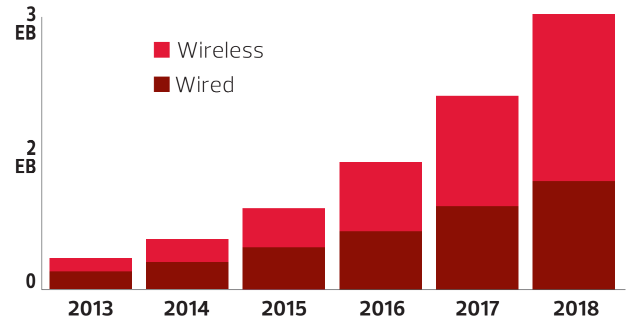
Currently, most organizations see an equal number of wired and wireless devices on the network. Over time, analysts expect to see this balance continue to shift until wireless devices outnumber those with traditional wired connections. This growth will largely come from the addition of new devices to the network, as users increasingly bring more personally owned devices to work and IT organizations remove unused wired connections.

Increased Wi-Fi usage will create new demands for bandwidth capacity and the security technology necessary to support new users. Organizations may not currently be positioned to meet these needs and must evaluate their upgrade plans as the network continues to grow.

Users will continue to expect the wireless network to enable access to enterprise applications and data. As those applications evolve and data sets increase in size, they will require higher bandwidth connections to the network for individual devices.

The 802.11ac wireless standard uses 5GHz technology to meet these needs at no added cost over 802.11n networks. It provides organizations with the ability to iteratively improve their network in the coming years as the state of 802.11ac networking improves. Older standards, such as 802.11n, will not allow this improvement and will quickly become insufficient to meet business needs.

2018: Total Wireless Traffic 9x Larger than 2013



Monthly Traffic (Exabytes) Source: Cisco June 2014

Networking Becomes Wireless

The expected growth of wireless networking will rapidly outpace the continued growth of networking as a whole. A recent Cisco Systems analysis estimates that total traffic on enterprise networks will double before 2018, while wireless use will experience a ninefold increase over the same period.

Cisco estimates that five years from now, Wi-Fi networks will carry more than 50 percent of the world's network traffic. The world is quickly becoming wireless, and current wireless network deployments are simply not sufficient to meet these demands.

Over the past two decades, enterprises have built wireless networks to accommodate a powerful trend toward mobile computing. These networks began with administrators simply attaching autonomous wireless access points to the wired network in strategic locations.

As the deployment of APs increased, network engineers found themselves spending significant amounts of time manually coordinating APs to ensure that they used spectrum efficiently and did not interfere with each other. This led to the adoption of centralized wireless controller technology that automatically coordinated and synchronized APs.

The next wave of change in wireless networking technology focused on bandwidth. Initial wireless networks using the 802.11a, 802.11b and 802.11g standards supported throughput rates ranging from 11 to 54 megabits per second. These simply weren't sufficient to meet the demands of high-bandwidth applications.

In response, network engineers began to deploy wireless networks that followed the 802.11n standard. This standard allowed the use of radio spectrum in both the 2.4GHz and 5GHz bands and allowed APs to make use of new multiple-input, multiple-output (MIMO) antennas. By embracing these new technologies, 802.11n networks were able to break the bandwidth ceilings of earlier standards and achieve throughput rates up to 450Mbps.

These wireless networks served enterprises well, but users are beginning to push up against the limits of 802.11n technology and are demanding increased capabilities from their wireless networks. The projections made by industry analysts support the need for enterprise IT professionals to take immediate action to prepare their networks for the next boom in wireless.

Current network deployments are simply unable to support the expected ninefold increase in wireless bandwidth consumption. Now is the time for enterprises to begin making plans for the deployment of networking technology that will break the 1Gbps barrier and support business needs into the next decade.

Benefits of a Wireless Infrastructure Solution

Wireless networking provides a number of unique benefits to the enterprise. These come in the form of both increased user productivity and improved efficiency of IT operations. As organizations evaluate potential investments in deploying and upgrading wireless solutions, they should continue to evaluate these benefits and position themselves to maximize the return on those wireless infrastructure investments.

Wireless networking increases both the productivity of end users and their ability to work in a collaborative fashion. The "anytime, anywhere" nature of wireless networking allows staff to recapture time that would normally be spent waiting and use it in a productive manner, checking small items off their "to do" lists and freeing up office time for tasks requiring more focused attention.

The collaborative benefits of wireless networking are apparent in organizations that have truly embraced mobility. Consider, for example, a meeting where staff members gather to develop a product marketing strategy. In the past, after such a meeting, one staff member would develop a draft to be circulated among the team. After circulating that draft, team members unable to agree on the strategy would require another meeting, and perhaps several more before coming to a consensus.

In a mobile world, the members of this same team can all bring tablets to the meeting and use collaboration software to edit the document together on a projection screen. The same meeting could be used to ensure that everyone agrees on the key points. By editing the draft together, the team is able to more quickly build a consensus and reduce the number of meetings required to produce the final strategy document.

The benefits of wireless networking also extend to the enterprise's technology environment. Wireless networks are easier to deploy and relocate on a permanent or temporary basis. When a new location comes online, the use of wireless networking requires less time to set up and reduces the amount of cable required to outfit the location.

These benefits directly affect the bottom line, reducing both the cost and time required to get the network up and running. These reductions allow the deployment of wireless networks in a much more flexible fashion, providing both new and temporary users quick access to networking.

Why 802.11ac?

802.11ac wireless networks will be the dominant standard for the next decade and will iteratively improve to meet changing enterprise networking requirements. Now is the time for organizations to adopt this standard and position themselves to meet the future needs of their businesses.

As organizations upgrade their networks, they should seek to deploy 802.11ac wherever possible. The costs of deploying this technology are equivalent to similar 802.11n networks, but the new standard provides the added benefit of future-proofing. It is likely that any 802.11n networks deployed today will need to be completely retrofitted before they reach the end of their serviceable life, while 802.11ac networks will continue to serve organizations for many years to come.

The primary benefit organizations will achieve by adopting 802.11ac networking is increased performance across a ubiquitous wireless network. The speeds supported by 802.11ac far surpass the maximum capability of 802.11n networks.

Current 802.11ac (Wave 1) deployments are able to break the gigabit barrier, achieving wireless throughput of up to 1,300Mbps, almost triple that of 802.11n networks. Scheduled enhancements of 802.11ac (Wave 2) capability will further boost this maximum until it exceeds 6Gbps.

Leveraging this performance boost is the only way that wireless networks will be able to serve future high-bandwidth business applications. Some brands, for example, Apple, Samsung, HTC and others, already offer devices that support 802.11ac. Other manufacturers are likely to follow suit, as 802.11ac networking becomes the new norm.

One of the key technical drivers behind the increased performance capability of 802.11ac is its use of the 5GHz spectrum, rather than the 2.4GHz spectrum used by earlier technologies. The 2.4GHz spectrum is used by a wide variety of technologies, including cordless telephones, surveillance systems, garage door openers and other consumer products.

Wireless networks operating in this space must contend with interference from those devices, reducing their ability to effectively use radio spectrum. The 5GHz spectrum, by contrast, is much less congested, providing clean radio space for wireless networking.

During the transition to 802.11ac technology, enterprises must support a backward-compatible network that allows devices that do not support 802.11ac operation to access the network. In the short term, this may mean operating both 2.4GHz and 5GHz networks until older devices, using the 2.4GHz-only 802.11b and 802.11g standards, disappear from the network.

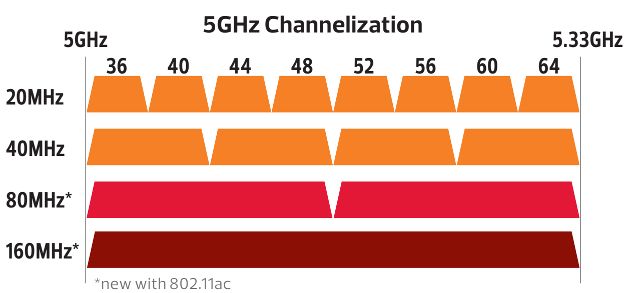
Once these devices are eliminated, the enterprise may shift to exclusive use of the less congested 5GHz band. APs operating in this band are backward-compatible with 802.11n, allowing both legacy and new devices to take advantage of the same wireless infrastructure.

The increased performance of 802.11ac is also driven by the fact that the standard makes it possible to use larger chunks of radio spectrum for communication between a device and a wireless AP. In 802.11n networks, channels are limited to 40 megahertz in width, which constricts the amount of data that may be pushed through them.

The initial releases of 802.11ac (Wave 1) technology require the use of 80MHz channels, doubling the amount of data that may be passed over the connection simultaneously. In addition, the 802.11ac standard provides for future expansions (Wave 2) to 160MHz channels, quadrupling the data transfer capabilities of 802.11n.

Significantly Increased Speed

This graphic illustrates the differences in channel size, ranging from the 20MHz channels used by earlier 5GHz protocols to the 40MHz channels of 802.11n and the 80 and 160MHz channels allowed by 802.11ac. Channel-bonding technology allows for the simultaneous use of multiple channels, further increasing the maximum throughput of 802.11ac networks.



Another technological improvement in 802.11ac allows radios to pack more data onto each transmission through a technique known as quadrature amplitude modulation (QAM). A version of this technique, known as 64QAM, existed in 802.11n and is responsible for the maximum speed of that standard. In 802.11ac, the maximum number of values for QAM is increased from 64 to 256, a technique known as 256QAM, offering a 30 percent rate increase with a single stream.

The disadvantage to using QAM is that it requires much more precision from the radios in both the wireless client and the wireless AP. QAM works by reducing the tolerance for error and is only possible when the radios are functioning well.

It is likely that this range will improve throughout the 802.11ac deployment cycle as wireless radio manufacturers focus on improving the quality of transmitters and receivers. Each improvement will result in increased range of signals using higher QAM rates.

802.11ac also brings improvements to a technology known as multiple-input, multiple-output. MIMO technology uses multiple antennas both on clients and APs to increase the performance of the wireless network. 802.11ac brings two major improvements in MIMO technology. The first involves the use of spatial multiplexing.

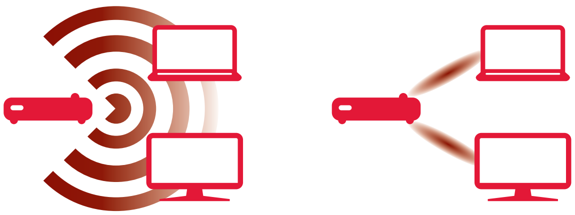
In this approach, each antenna is used to transmit and receive different portions of the data signal. Each of these transmissions is known as a spatial stream, and each spatial stream can carry data proportional to the channel size. The MIMO implementation in 802.11n is limited to four spatial streams while 802.11ac (Wave 2) doubles that limit to eight spatial streams, thereby doubling the maximum possible throughput of the network.

The second MIMO enhancement in 802.11ac is the potential rise of multiuser MIMO (MU-MIMO). In this approach, the various antennas used in MIMO may be shared among multiple clients. The AP is then capable of communicating with multiple users at the same time, increasing the total simultaneous user capacity of the AP.

802.11n networks do support spatial multiplexing, but all of the spatial streams must be directed at the same wireless client. This is a technique known as single-user MIMO (SU-MIMO). While MU-MIMO has great potential, it is important to note that the technology is not yet finalized and will only become available in future releases of 802.11ac products.

Like earlier wireless technologies, 802.11ac supports the use of beamforming. In a standard Wi-Fi network, the antennas on an AP transmit their signals in an omnidirectional pattern, forming a sphere centered on the access point itself. This is highly inefficient, as the actual device communicating with the AP is in only one of those directions. Beamforming uses multiple antennas to steer the signal toward the client device. This increases the amount of the signal that reaches the client,

How Beamforming Works



Beamforming manipulates RF parameters allowing a "sweet spot" to change to where the device is. This feature makes the Wi-Fi network operate more like a switched one supporting multiple simultaneous communication rather than the traditional "shared" access media. That way, beamforming can:

- Allow the network to adapt to the client signal strength and location
- Help significantly increase reception for less powerful devices
- Continue to constantly adapt to optimize each device
- Use 802.11ac to help the client and access point (AP) exchange data allowing for it to work better
- Help reduce interference problems

improving the range and capacity of the wireless network. In addition to these benefits, beamforming reduces the power necessary for communication and improves the battery life of wireless clients.

Beamforming was available in 802.11n networks, but the 802.11n standard did not specify how beamforming was supposed to work, and manufacturers implemented different approaches to beamforming that were not compatible with each other. As a result, beamforming technology was not widely used on 802.11n networks. The 802.11ac standard addresses this deficiency by including a standard method for beamforming that promises to make its use much more widespread on newer networks.

The rollout of 802.11ac technology will take place in multiple waves over the coming years. Wave 1 products are already on the market, and Wave 2 products are expected in late 2014 or 2015. Here are some of the key differences between them:

- Wave 1 products support transmission rates of up to 1.3Gbps using a maximum of 3 spatial streams. They support channel widths of up to 80MHz and the use of SU-MIMO.
- Wave 2 products will support transmission rates up to 6.9Gbps using a maximum of 8 spatial streams. They will support the new maximum channel width of 160MHz and will support both SU-MIMO and MU-MIMO operation.

Both Wave 1 and Wave 2 products support the use of 256QAM modulation. It is important to note that the features of Wave 2 are not yet finalized and may change before the release of Wave 2 products. IT professionals should pay careful attention to the evolution of 802.11ac technology and note changes as they occur.

Organizations considering upgrades to their wireless networks should begin adopting 802.11ac technology, rather than waiting for future waves or continuing the deployment of 802.11n technology. There is no cost difference between 802.11n and 802.11ac radios, and the technical benefits of 802.11ac make it a far superior choice for modern wireless networks. Improvements in MIMO, beamforming, channel width and QAM will provide dramatic speed and capacity enhancements over older network technologies.

Further, just as 802.11ac APs are backward-compatible with previous wireless standards, future waves of 802.11ac technology will retain backward compatibility with earlier waves. Therefore, IT organizations should see no disadvantage to implementing a rolling upgrade that installs the most current technology available at any point in the upgrade cycle. Organizations that continue to install new 802.11n APs will likely find themselves retrofitting those networks with 802.11ac devices in the near future.

Tips and Considerations for an 802.11ac Upgrade

As organizations prepare to deploy 802.11ac networks, there are several pieces of advice that they should keep in mind:

- As the enterprise replaces network switches, IT administrators should consider purchasing devices capable of implementing the 802.3at Power over Ethernet Plus (PoE+) standard. The next generation of wireless APs will require more power to function effectively, and putting a PoE+ infrastructure in place now may save money later.
- At the same time, design switch uplinks so they are prepared for 10Gbps or more connections between the edge and distribution/core layers.
- When pulling cable for wireless APs, pull dual CAT6 cables to each location. The second wave of 802.11ac will support dual uplinks, and pulling cable later to retrofit will result in increased hardware and labor costs.
- While working through a wireless network, network admins should retire old devices that may be degrading overall network performance. This includes both legacy APs and 802.11b clients.
- IT managers should perform a *wireless site survey* and best practices assessment against the network using internal expertise or a consultant to identify additional areas for improvement and inspect RF spectrum for incompatibilities.

An additional benefit is that devices on 802.11ac networks will realize up to 4x better battery life.

802.11: By the Numbers

STANDARD	FREQUENCY	THROUGHPUT	RANGE
802.11b	2.4GHz	11Mbps	100 feet
802.11g	2.4GHz	54Mbps	100 feet
802.11a	5GHz	54Mbps	50 feet
802.11n	2.4–5GHz	300–450Mbps	50 feet
802.11ac, Wave 1	5GHz	433–1,300Mbps	50 feet
802.11ac, Wave 2	5GHz	3.4Gbps	TBD

Preparing the Network for 802.11ac

An enterprise planning to deploy 802.11ac, either in the short term or as a long-term objective, can take steps now to begin preparing the network for the transition. It is important to remember that rolling out new wireless capabilities requires attention to the wired network and back-end supporting infrastructure. Organizations can prepare for the transition by keeping these 10 principles in mind:

1. **Review the existing wired network:** Wireless networks still remain connected to a wired network beyond the AP. Organizations should plan to begin their wireless transition with a thorough review of the wired network to ensure that appropriate capacity exists to support current and planned wireless growth.
2. **Plan for backward compatibility:** Switching to a new wireless standard is best done as a phased transition. While it may be possible to upgrade the network infrastructure all at once or in large segments, it is normally not possible to do the same for wireless clients. Organizations will likely wish to retain legacy clients through the end of their useful life and will need to retain 2.4GHz networks during that transition.
3. **Review management and operations requirements:** One of the most common causes of failure for networking initiatives is a project-based mentality that fails to take into account the ongoing maintenance and support requirements for the new service once it goes into production. As organizations roll out 802.11ac, it is important to develop a change management and support plan. It should answer questions such as:
   - How will users and devices be transitioned to the new network?
   - Who will support the 802.11ac network in production?
   - Does the support team have an appropriate skill set, or is additional training required prior to rollout?
   - Is the division of responsibilities among the help desk, front-line support staff and networking groups clear?
4. **Use enterprise-class 802.11ac solutions:** Networking vendors are now offering a variety of enterprise-grade 802.11ac solutions. These devices integrate with existing enterprise network management tools and provide the sophisticated management capabilities that allow remote device configuration and tuning. Projects that seek to deploy a new wireless standard throughout the enterprise may also use the opportunity to enhance network management capabilities.
5. **Plan for capacity, not throughput alone:** Planning a wireless network deployment requires putting thought into both the bandwidth that will be consumed by wireless clients and the total number of clients that will be accessing the network. Locations where an organization expects large concentrations of end users, such as auditoriums, conference rooms or waiting areas, require a greater density of APs than less congested locations.
6. **802.11ac technology will improve client performance:** Every time users gain access to a technology that provides greater network capacity, new use cases quickly arise to consume the available bandwidth. For example, when both Wi-Fi and cellular networks gained sufficient capacity, users quickly began adopting mobile video applications that consumed the increased bandwidth. It is likely that the improved client performance that results from adopting 802.11ac networking will have a dramatic effect on bandwidth consumption. APs with multiple radios should even help improve performance of devices using older 802.11 standards.
7. **Plan for gigabit-at-the-edge switching:** Regardless of where they are in the 802.11ac adoption cycle, organizations should begin planning their edge switching infrastructure to support greater capacity. This requires using switches that support gigabit connections to APs and Power over Ethernet 802.11at. Given the long lifecycle of switching equipment, it makes sense to begin deploying this technology immediately. Organizations that fail to do this will find themselves upgrading their edge switches long before the scheduled end of their useful life.
8. **Use 10/40/100Gbps or more connections from the edge to the core:** As organizations extend gigabit connections to the edges of their networks, the aggregation of those edge connections will also require additional capacity. Network planners should plan to meet this demand with 10/40/100Gbps connections between edge and core switches.

9. **Core switching will require at least 10/40/100Gbps interfaces:** The final link in the upgrade chain is that the core switches that aggregate connections from the edge must be capable of handling multiple 10/40/100Gbps connections. As with edge switches, core switching devices are long-lifecycle, high-cost purchases. Even if an organization plans to wait until Wave 2 of the 802.11ac equipment is available and mainstreamed, they should still plan to upgrade core switches with sufficient capacity during the next upgrade cycle.

10. **Radio frequency (RF) designs should be done from a 5GHz perspective:** Remember that the 5GHz spectrum has dramatically different RF properties than the 2.4GHz spectrum; 5GHz signals have shorter ranges and are much less tolerant of physical barriers, such as walls, doors and windows. Organizations will find that they cannot simply replace their 2.4GHz APs with 802.11ac devices. RF studies done in conjunction with new construction or network upgrade projects should be conducted with 5GHz networks in mind to avoid added cabling and construction costs during an eventual 802.11ac implementation.

Preparing the network for the imminent or eventual use of 802.11ac wireless technology requires that enterprises consider many different design elements. The sooner planners begin preparing for the upgrade, the more time they will have to fit required upgrades into scheduled equipment purchases and replacements, reducing the future costs of an upgrade initiative.

802.11ac Migration Checklist

Many organizations are working on the migration of existing wireless networks to the 802.11ac standard. There are three things that should be done to lay the appropriate groundwork for this new technology:

1. Perform a *wireless site survey* to identify readiness for 802.11ac. (Don't rely on an analysis that was done previously for a different wireless standard.) Organizations transitioning from a 2.4GHz network, remember that 5GHz signals have reduced capability to penetrate walls and other obstacles, and the deployment of APs may need to be adjusted to optimize for 802.11ac.
2. Budget for wireless upgrades to ensure the adoption of 802.11ac technology as quickly as possible. While there is no cost difference between 802.11n and 802.11ac equipment, upgrading still requires a capital investment. Fortunately, upgrades may be done on a rolling basis to smooth out the expenditures over time.
3. Plan for 802.11ac Wave 2. While the benefits offered by 802.11ac Wave 1 are significant, be ready to upgrade equipment to Wave 2 technology down the road. Some vendors are planning for this transition in advance by offering APs that will eventually support Wave 2 technology through the addition of a plug-in module.

Best-in-Class WLAN Setup

Organizations should actively manage wireless networks to the same standards used for their core local area networks. As users continue their shift to using mobile devices even when in the office, these LANs become critical assets to the organization and should be managed strategically.

Today, many users forgo the use of wired networks and rely entirely on wireless connections, and this trend is likely to continue. Enterprises that anticipate this need and strategically manage wireless LANs achieve enhanced wireless performance and increased user satisfaction.

Actively managing the wireless network requires the use of network management tools to automate routine tasks and gain new insight into network activity through user behavior analytics. Fortunately, the same software used to manage wired networks normally has the ability to perform sophisticated management of wireless networks.

Best-in-class network managers use a "single pane of glass" approach to manage as much of the network as possible from a unified console. These consoles provide converged access management, visibility into the network usage patterns of users and applications, and cross-functional views that support different types of network analysis.

Best-in-class wireless networks must also promote strong security. Organizations increasingly transmit sensitive business information wirelessly, making the security of those networks paramount. Wireless network security goes beyond simply enabling Wi-Fi Protected Access encryption on the network and includes the use of specialized wireless security tools. Some technologies that organizations may wish to consider deploying on wireless networks include mobile device management (MDM) capabilities.

MDM software allows the enterprise to actively manage the mobile devices used by employees. Enterprise administrators may use MDM to remotely apply security policies to the smartphones and tablets used by staff to ensure that they operate in a manner that protects the sensitive business information that they store and transmit. This may include requiring a strong device passcode and encryption, limiting the installation of apps on the device and providing remote wipe capabilities for lost or stolen devices.

Best-in-class wireless networks also prioritize network traffic that is important to the business. This includes the classification and prioritization of network use based upon the application in use and the identity of the user. For example, a cashier attempting to complete a point-of-sale transaction should have higher network priority than a data entry clerk watching a training video. Similarly, applications that depend on low-latency network connections, such as unified communications, should have priority over uses without latency restrictions, such as viewing web pages.

CDW: A Wireless Partner That Gets IT

CDW can assist with all phases of your 802.11ac network upgrades, serving as a one-stop shop for all wireless networking needs. CDW embraces a multipartner approach to ensure that you receive balanced, independent information about the wireless networking products available from numerous vendors and how they can be used to optimize your organization's needs.

Your CDW account manager can draw on the expertise of network solution architects who specialize in integration between the wired and wireless networks, to ensure getting the best performance while securing data.

Our services include: site survey, WLAN design, hardware configuration, deployment, readiness assessments, post-install support, security assessments and knowledge transfer. CDW solutions include: voice and video over WLAN, Wi-Fi analytics, high-density public venues, unified wireless architecture, autonomous access points, indoor and outdoor mesh, wireless VoIP, bring-your-own-device (BYOD) and RFID/asset tracking.

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- Procurement, configuration and deployment of the final solution
- Ongoing product support throughout the lifecycle of your wireless network

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