Retail Wi-Fi

Designing Retail Wi-Fi Networks:
Challenges & Best Practices

iBwave

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Everything, Everywhere, Always:

The Explosive Growth Of Retail Wi-Fi

Retail Wi-Fi environments are ubiquitous in fact they've likely begun to pop up at lemonade stands and yard sales. Or soon will be. That's because never before has a more mutually beneficial relationship between technology, commerce, and consumers been possible. Wi-Fi networks need to be designed for optimal reliability and responsiveness, and that allows them to anticipate & accommodate future growth and technological innovation.

But success doesn't happen in a vacuum. All of the time and effort put into planning a high-performance Wi-Fi network is far outweighed by the potential for return. It comes down to 3 key steps; planning, design, and validation.

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Designing and deploying a bulletproof Wi-Fi network in a commercial retail environment is a complex undertaking but leveraging the right tools and best practices against the potential pitfalls can make it much easier.

Planning: Understanding the Environment

Simply put, the retail environment is any physical space where consumers might enter into transactional relationships with commerce. It's a definition that's as broad as a big box store but carries with it individual operational & technical specifications as narrow as an aisle in a corner mom & pop shop. Another way to look at it is; wherever there are consumers seeking to make purchases, there are mobile devices seeking connections and information. From megamalls to supermarkets, to small shops, indoor and outdoor shopping venues, low and high density, multistory or subterranean, widely dispersed franchise and chain operations, cold storage, backroom office, food & beverage operations, including all the public spaces that connect them, and finally the countless multiple large-surface distribution centers that keep retail commerce supplied. High-performance Wi-Fi networks aren't a nice-to-have, they're must-haves, and each type of retail environment presents different challenges for network planning and deployment.

Indeed, the Wi-Fi network has become the backbone of a digital retail environment, connecting staff, consumers, data-rich mobile apps, and the IoT together to provide information, assistance, continuous contact, and transaction while helping commerce better understand buyer behavior. We're well past counting how many shoppers go through the turnstile – retail Wi-Fi networks let us understand why they went through it, where they're most likely to go, how much they'll spend, and how to tailor the consumer experience to best suit the individual.

If it's done right. That's what best practices are all about.

Retail Wi-Fi Networks: Connecting The Stakeholders

Commercial retail Wi-Fi networks function on multiple overlapping planes split between consumer usage, operations, and security. They connect consumers with the outside world and to the retail environment – they connect staff to consumers – and in turn staff & consumers to the IoT while linking the IoT to distribution centers. Ultimately, the sum of the collected data is made available to commerce to help improve the consumer experience.

Connecting Consumers

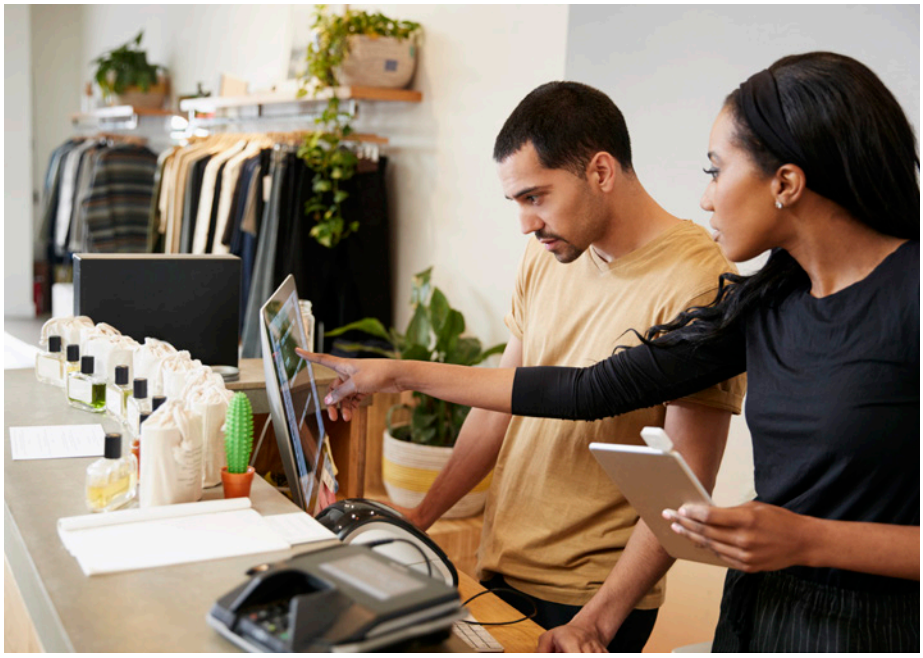
ICT and a well-designed retail environment Wi-Fi network serve a broad spectrum of stakeholders, including consumers. Consumers carrying mobile devices benefit by staying connected online, accessing email, navigating the physical space, employing AR, comparing prices & services, and receiving push-notifications from retailers. They also appreciate doing all of these in a seamless, high-speed network without inconvenient throughput bottlenecks. It's a level and quality of service they've come to expect.

Consumers can also use available technology within the retail space, accessing in-store computers, watching videos, display walls, right down to shopping cart LCD displays. All of this technology, in turn, connects to the network and feeds relevant information to the consumer based upon their location and even product choices in real time as they're placed in the cart using RFID tags or smart labels.

Retail businesses and their consumers benefit the most from a stable, resilient network. Commerce through streamlined operational communications coupled with the collection and analysis of data, and consumers through an improved shopping experience – and both have come to expect nothing less than excellence. That's delivered through top-notch Wi-Fi network design, planning and validation.

Connecting Commerce Staff

Staff and operations also require a reliable retail Wi-Fi network in order to function at the most basic level. Collaboration, communication, transaction and consumer interaction all benefit from an increase in speed, efficiency, and complicity. Inventory databases can be queried and updated at the point of purchase, work-orders dispatched, e-mail accessed, and working documents printed. The internal Wi-Fi network offers an enormous potential allowing for back-office integration with retail operations, location-based services that facilitate stock retrieval in distribution centers, automation control, and oversight, roaming services, voice-over Wi-Fi communication.



But Wait. There's More.

That's now. The retail Wi-Fi universe is expanding exponentially, and what's cutting edge today is sure to be commonplace within 20 minutes. We've touched upon a fraction of a Wi-Fi network's potential within the retail environment. A well-designed network needs to factor in growth and the addition of future technologies like 802.11ax, as well as allow for the inclusion of older legacy ones. Not every consumer is lined up outside the nearest tech store waiting to buy the latest smartphone. And you can bet that an increasing number of devices will be looking to connect to limited APs within your network. Will it be ready? Will you be ready?

Let's look at some of the key challenges planning and deploying a retail Wi-Fi network can entail.

Understanding The Challenges of Retail Wi-Fi

Retail Wi-Fi network design and deployment is anything but a one-size-fits-all scenario. Proper planning and implementation are as varied as the venues in which retail commerce exists. Building construction, aesthetics, end-use, traffic density and patterns, and network usage all affect network integrity, stability, and resilience. The single most important factor assuring there is thorough and unhurried planning, design, and validation of that network. Doing otherwise can prove costly, and time-consuming.

Coverage, Capacity, Compatibility, Confidence

All retail Wi-Fi network challenges can be reduced to those of coverage, capacity, compatibility, and confidence, and these, in turn, affect general Wi-Fi network performance, network security, and backhaul cabling.

Coverage

It all starts at the access point (AP) where devices link to a retail Wi-Fi network, and because Wi-Fi is a shared medium it is imperative that connected devices are able to communicate with each other. Improper AP planning and deployment can create "hidden nodes", where devices are known to the AP, but invisible to one or more other connected devices sharing the AP. Insufficient APs, less-than-optimal AP and/or client localization, client density (# of connected devices/ per AP), and AP/client power balance can all trigger retail Wi-Fi network issues, all of which can be anticipated by analysis, planning before a single piece of equipment is installed, and thorough validation once it is in place.

The architectural design of any building can have a marked effect on connection integrity and propagation. Everything from construction materials to ceiling height, metal elevators and structural components, fire-rated doors, tinted windows to furniture, storage area racks, production lines and the presence of other radio spectrum transmission equipment can impede connection and propagation. Things in plain view, as well as many hidden structural elements can impede the propagation of Wi-Fi radio signals, furthermore, signal attenuation through various materials differ widely across both 2.4 GHz and 5 GHz bands.

Other factors such as rogue hotspots and rogue APs, usually the result of staff or clients with their own APs, anyone enabling their smartphones with a mobile hotspot, using a Mi-Fi device to set up their own network and using their mobile cellular network to backhaul to the internet can create serious connection bottlenecks. Convergence of several devices transmitting simultaneously on the medium frequency spectrum can seriously impact network integrity and impede security. Segmentation of a network into staff/operational and guest streams through the use of separate physical cabling, or VLANs can alleviate these issues and are best determined by an evaluation of the relevant security requirements of each individual network.

Capacity

Capacity is a key challenge for many venues, but in particular for a retail space where many people and devices flow in and out on an hourly basis. Traffic density, or the number of physical devices connected to each AP, and in turn that shares a common network, can serve to throttle performance, and as the amount of data travelling over networks increases exponentially so does the stress upon them. Each AP is limited to a set number of connected clients, and total AP count can often fall below that required during peak demand. Staff use (official and personal), those who bring their own devices, the number of devices per person, the explosion of IoT devices, and the massive bandwidth requirements exacted by data from video, voice of Wi-Fi, digital smart displays, kiosks, and location-based indoor services can tax a network, so planning must take into consideration that the total amount of throughput will only continue to increase over time.

Compatibility

As fast as Wi-Fi technology can change, the backlog of still usable legacy devices grows. The cost of replacing structural network components, such as inventory scanners or P.O.S. devices can be prohibitive, and it's good practice for any business to make use of them for as long as they remain compatible with the newest components of the network. Ensuring backwards, and forwards compatibility is simply part of sound retail Wi-Fi network planning. We're on the cusp of the IEEE 802.11ax release, heralding the advent of HEW (high-efficiency wireless) across 2.4 and 5 GHz spectrums and the accompanying devices, and while functioning at much higher data rate requirements networks will still need to interface with legacy devices.

Then there are the unknown unknowns… new equipment, IoT appearing in new device types, innovative technology applications for business, and business processes, client devices with increasing capabilities, new capabilities, and the consumers, staff and intermediaries all connecting to the retail Wi-Fi network - your retail Wi-Fi network.

Confidence

Security is another facet that can be affected by backwards and forwards compatibility. Everything from basic server machines, to routers, switches, APs, client devices to P.O.S and distribution center hardware employ a wide range of security technologies and protocols need to have a common reference point for security. The ISO/IEC 27001 outlines Information Security Management System standards over 14 different domains and is the current benchmark, but beware, the goalposts will move. Infrastructure security is a related consideration, where each zone needs to be properly secured and able to authenticate and authorize device connection and network use while limiting the RF signal propagation. Then, of course, legacy devices that use older security protocols add another layer of complexity, making for a witch's brew of potential problems.

Assuring that several generations of devices, each with progressively more advanced technologies can all get along and play nice is a challenge that is only overcome by planning ahead. Building in compatibility is truly a third cornerstone challenge of the retail Wi-Fi network.

One More Thing… Backhaul Cabling

Backhaul cabling also figures into the retail Wi-Fi network equation. It's crucial to be fully aware of the capacity of locally-based servers with centralized management systems, wireless LAN controllers, client IP address assignment, and just as importantly, network speed (10Mbps to 10Gbps), and the inevitable presence of switches and routers.

Now, let's get down to the business of planning, designing, and validating a retail Wi-Fi network that mitigates, if not eliminates, many of the potential issues we've just outlined.

Retail Wi-Fi Best Practices.

Do It Once. Do It Right.

With any luck our discussion to this point about what could go wrong with an improperly planned retail Wi-Fi network hasn't discouraged you. Regardless of end-use, size, or complexity, it takes the right tools that equip one with the proper vigilance and foresight required to plan, design, and validate a world-class Wi-Fi network. Whether it's a sprawling urban mall or a pop-up kiosk, a franchise operation or distribution center, it is possible to cover a lot of ground by following a comprehensive checklist. Ours will help you evaluate your needs, anticipate growth, and design a retail Wi-Fi network that is robust, reliable, and resilient, more than able to meet the standards for coverage, capacity, compatibility and confidence. It's all about getting it right in the first place.

Customer Requirements Preplanning Checklist!

Years of accrued experience have demonstrated time and again that a lack of a rudimentary Wi-Fi skill set among staff, and the reluctance to employ full-time or third-party ICT personnel to properly, survey, design and validate the plan for a retail Wi-Fi network are at the root of most connection, performance and security issues.

So, let's get started on the right foot with our handy preplanning checklist!

Not all of these will apply to your circumstances, but we've built-in a considerable overlap and redundancy in these "must-dos", so chances are your unique scenario will be covered completely.

Customer Requirements Preplanning Checklist:

What to Know

- Evaluate and anticipate the services you'll need to offer over your network. (Voice over Wi-Fi, email, internet access, inventory control, work orders, smart digital displays, etc.)
- Evaluate and anticipate the application types you'll be deploying. (Voice, video, data)
- Evaluate the optimal segmentation of data and number of logical networks your setup may need upon launch, and as the demand on the network grows.
- Evaluate the location and architectural parameters:

1. Building materials – the presence of concrete, metal, tinted windows, high ceilings, fire-rated doors, and any other RF propagation inhibitors)
2. The immediate vicinity surrounding your location. Urban with a lot of bleed-over from competing Wi-Fi networks.
3. Do you have a digital version of a current floor plan of your location that can be imported into our iBwave Wi-Fi® design software for AP placement and RF predictive modeling?
4. Do you foresee high-density areas that may need to host many client devices?
5. Do you want to include the exterior as well as interior network coverage?
6. Is there an existing network infrastructure, including legacy or other, and backhaul cabling?
7. Will existing backhaul cabling restrict the optimal localization of APs along its backbone? It is recommended to use a professional grade Wi-Fi RF design tool like iBwave to best determine AP positioning to ensure proper coverage and capacity requirements.
8. Is it a requirement for your APs to have a look & feel that is in harmony with architectural design, fit, and finish. Does the building owner/design approver prefer them to be out of the way and invisible? Does your installation's propagation profile permit hidden APs?
9. Will exterior APs be required, and if so need to be equipped with protection from the elements?

- Evaluate and anticipate your retail Wi-Fi network's connection and capacity needs.

1. How many active client devices do you estimate might connect to the network at peak hours? Are there specific areas that will have more connections than others?
2. Do you know what those peak hours will be? Is the venue a 24-hour distribution center or is your network limited to regular store hours?
3. Are you subject to local regulations (FCC, CRTC) governing RF propagation, frequency limitations, maximum allowable transmission power and EIRP (Equivalent Isotropically Radiated Power) or other relevant limitations?
4. Will you require seamless roaming capability?
5. Will you need location-based services or real-time location services such as asset tracking?
6. Will you build-in sufficient failover ability and redundancies, particularly in the case of warehouses and distribution centers, to ensure seamless operation even at peak critical times where the network is subject to higher stresses?

- Evaluate and anticipate your retail Wi-Fi network's backward and forwards compatibility requirements.
  1. Should you plan for full IEEE 802.11-1997 to IEEE802.11ax compatibility?
  2. What's your cut-off for backward compatibility?
  3. Will you support a wide range of legacy devices?
  4. Do you anticipate the need for PoE (Power over Ethernet) capabilities?
  5. Which protocols will your network need to support? (IPv4/IPv6)

- Evaluate and anticipate your retail Wi-Fi network's security needs.
  1. Will you network require the hiring of a Security Manager that understands your current and future security needs, compliance with security regulations and their integration into the network, and stay abreast of rapidly changing network security technology?
  2. Are you fully aware of the Payment Card Industry Data Security Standards PCI-DSS) that govern P.O.S and mobile P.O.S. payment system transaction and how to configure your network in compliance of them?
  3. Are you hoping to include a wireless intrusion detection and prevention system?
  4. Have you factored in the need for preventing unlawful signal interception?
  5. Is there value in hardening your network equipment and infrastructure against present and future vulnerabilities?
  6. What about other security requirements such as captive portals, guest access control, RADIUS ability (Remote Authentication Dial-In User Service) and secure billing.

- Operationally speaking…
  1. Has a finance manager or CFO made sufficient allocation of funds available for the design, deployment and continued maintenance of a robust retail Wi-Fi network?
  2. Have you weighed leasing versus purchasing a network setup?
  3. Is a project manager entrusted with control and coordination of the myriad of details on which the successful implementation of your new network depends?

Different Networks for Different Venues

Perfect Network. Perfect Fit.

Architectural and end-use considerations are often those factors that most affect the design of a reliable retail Wi-Fi network. Setting up a secure network that provides bandwidth sufficient to serve a high-density environment at peak hours varies wildly across retail environments. So, size really does matter. As does the complexity of the layout, building materials, proximity to other live networks, and of course, the intended use of each local network. A distribution center has very different configurationally demands than a corner store or mobile kiosk.

Large Shopping Malls

While not all large shopping malls share identical layouts or consistently use the same building materials in the same way, the parallels from instance to instance warrant following a set of retail Wi-Fi network design and deployment guidelines that can apply to most locations. The collective Zen of large shopping malls is fairly reliable, so a generalized list of best practices is entirely justified, and by chance, available here.

Modern megamalls are an AP localization expert's dream. Countless surfaces, corridors, alcoves, food emporia are connected by miles of wall and ceiling – but this is a silver lining with a cloud. Creating a seamless roaming environment in a veritable sea of protuberances, dead-ends, surfaces of varying RF opacity, metal frameworks and what is a long list of competing wireless networks all housed in substantial square-footage is an enormous challenge. Accurate floor plans and deep knowledge of the structure can go a long way to finding the right places to install APs.

One practice that has proven efficient in overcoming these many hindrances is the use of external antennae that connect to APs, extending their range and quality of propagation by limiting multipath issues, along with co- and adjacent channel interference (CCI & ACI). Client devices by default roam to the channel with the strongest signal, and advanced Wi-Fi solutions can use band steering to balance devices between 2.4 GHz and 5 GHz to optimize network performance. Airtime Fairness also comes into play, helping to balance time and data throughput across devices that use different generations of technology, and hence operate at a range of communication speeds. Interference can be counteracted by Radio Resource Management (RRM) that allow for the detection of interference while automatically allocating Wi-Fi channels to devices in the most efficient way.

Keeping every roaming device connected reliably no matter its location is another major hurdle to plan for when designing a Wi-Fi network for a large shopping mall. Most APs are set to a limited number of connected devices as described in an association table, and once any given device has moved out of range or over its effective RF horizon that device will be automatically shunted to the most logical available AP. Because large shopping malls are ideal settings for high-density traffic, conditions are ripe with potential for that switchover to fail, resulting in a "sticky client". Worse still, the AP association table may not be refreshed fast enough, and devices will be faced with a Denial of Service (DoS) thanks to swamped APs unable to add new addresses. Although conditions can vary dramatically according to all of those factors discussed here and in other sections, the rule-of-thumb stipulates that all things equal, a maximum of 30 clients per AP radio transceiver represents the practical cap in most situations.

Business analytics and big data farming & processing are other increasingly necessary services required of large shopping mall retail Wi-Fi networks. Their efficient, effective operation must be planned for if an uninterrupted, reliable stream of actionable data is to be collected.

Here are a few pointers for best-practice locationing:

- Include at least 3 additional APs above and beyond peak network needs to perform RF triangulation, trilateration and fingerprinting. It'll relieve stress on those APs needed, and being used by consumer client devices.
- Ensure that supplemental APs are equipped with built-in or external USB adaptors for Bluetooth Low Energy (BLE) or vBLE (virtual) for positioning purposes
- Hyperlocation Antenna Arrays can also serve to improve stability and accuracy of data gathering.

Finally…

Expert, smart planning of a retail Wi-Fi network within a large shopping mall is always a case of "forewarned is forearmed." Roaming, propagation, signal fidelity, the ability to adjust to and serve unpredictably large traffic densities and device user intentions, and of course data collection and analysis depend on success out of the gate. A shopping mall is a big place to have to tear down and reconfigure an entire Wi-Fi network. Everything is doable… but why would you want to?

Large Supermarkets, Big-Box & Department Stores

Large Supermarkets

Large supermarkets, big-box, and department stores built along the principles of the large continuous single surface, often enclosed in an open area, often with few or no structural dividing walls save for back office and storage areas – so they're big, but they behave quite differently than shopping malls.

Internally exposed metal frame construction is prevalent in modern supermarkets, as are endless rows of racks, pipes, ducts, metal roofs, and panoply of hanging lights, wiring and other substantial obstructions that can wreak havoc on a Wi-Fi network. Grocery stores can be home to countless thousands of metal containers, big-box stores are prone to ceiling-high racks for storage and retrieval of products with a wide range of RF signal attenuation properties. Furthermore, consider that continually shifting inventory levels also affect RF signals – a fully-stocked shelf affects RF propagation more than a partially stocked or empty one.

Grocery Stores

Grocery stores, but increasingly big-box and department stores also house considerable refrigerated storage units. Sure, we call them refrigerators or freezers, but this is a technical eBook, so, best use the smarty-pants term. All kidding aside, even refrigerated areas need to access the network, usually for inventory management via barcode scanners. Cold and RF equipment have never been the best of friends (e.g., APs don't always work, antennae frost up), but with a little foresight you won't freeze them out of your retail Wi-Fi network.

Department Stores

Department stores present their own unique challenges with multiple aisles, metal racks, and consumer product categories that can cause very different RF signal attenuation. Clothes, toys, electronic consumer goods, furniture, and hardware all affect communication to and from APs and can lead to challenging conditions for a retail Wi-Fi network. Aesthetics figure more importantly in the department store setting, where interior design is geared to an experience that delivers a heightened sense of hospitality – so choosing AP locations and AP design that lends itself more readily to décor, and hence are less intrusive, is a good idea. Ideally, the APs being used should match the ceiling color so that they can then be placed in locations not visible to consumers – but caution needs to be exercised when placing them above the ceiling as metal mounts and infrastructure often found inside the ceiling tiles can have a severe impact on RF propagation.

In department stores especially, it all comes down to keeping the consumer and their devices connected as seamlessly and effortless as possible under all network load scenarios. Consumers want access to their devices, the internet, email, social media, navigation, and location-based services. Merchants want the opportunity to push through special offers on products to those consumers in the vicinity of active, connected client devices. The digital merchant/client connection singlehandedly drives crucial data collection and can provide a wealth of information on how to tailor the retail experience for consumers. Understanding consumers contributes in turn to modifications in retail Wi-Fi network design over time, evolving and improving along with current consumer behavior.

At first glance, one might think that any large area retail venue resembles any other, but as our examination of large shopping malls contrasted with supermarkets, big-box and department stores has shown, these are not birds of a feather. They're all big, they're all subject to high traffic density, but they need to be approached in unique ways.

Small Retail Shops & Convenience Stores

Size matters, but that doesn't mean the small retail space is any less reliant on a solid, reliable retail Wi-Fi network. The definition of the small retail environment long outgrew the family-run store on Main street and now encompasses independent establishments, single units of a large brand chain, or any of the multiple forms of franchise operations. While smaller spaces necessarily mean less Wi-Fi equipment, and likely a less complex structure, in no way does that imply that they require less initial network planning. Indeed, network design and deployment of smaller networks can pose unique challenges and require equally unique solutions. Whatever the size, traffic density, or RF signal propagation issues, the small retail space Wi-Fi network needs to be thought through.

Certainly there is less of a demand for broad, deep data collection and analysis, but in the case of brand chains or franchise operations, they may become as important as in large surface area retail setups. Roaming is also less crucial, but if a mall shop's local retail Wi-Fi network communicates with the parent mall's Wi-Fi network, then consideration will have to be given to handoff between networks to ensure a seamless consumer experience.

Small stores and shops are often huddled into the same areas, resulting in a storm of competing RF signals in proximity to each other, all vying for that elusive connection with a consumer device that might lead to a sale. Adjacent shops rarely set aside time to discuss channel allocation, spectrum use, and signal bleed… so work that into your network design.

As in larger venues, architectural details and building material, shop layout, and the nature of the products sold are all factors that belong in the equation. For example, the coffee shop is a haunt for Wi-Fi devices, with a fluctuating traffic density and the need to for long, uninterrupted connections. But coffee shops are often densely packed with people, seated on metal chairs, beside metal tables, each with one or more mobile device plugged in, sometimes with their hotspots turned on. All of these things can impact the Wi-Fi signal strength and a customer's experience with the network. Like larger venues, smaller retail Wi-Fi environments are hostile places for the enterprising AP and its associated network. Your network design has to acknowledge what the RF signal will be travelling through, reflecting off of, and struggling to overcome.

The good news is in most cases only a limited number of APs are usually required, and a network can be set up more simply. But an absence of a complex environment doesn't imply the absence of a need for expertise – planning is still key. The rigor and ability to plan flexibly and easily remain the domain of the Wi-Fi design software. Location of APs within the shop, the minimum number of APs and their relation to each other, anticipated device use, and traffic areas must still be determined – the laws of good Wi-Fi network design don't change just because the space has.

Their smaller size does allow shops to have an advantage over larger, more complex retail Wi-Fi network design – the flexibility to rely on external resources without the threat that surrendering autonomy might seriously hinder security. Plus, it's comparatively easy to reboot a simple network with few nodes than one with hundreds all depending on each other. This same flexibility allows for the viability of cloud-based solutions in the case of groups of franchised shops, thus shifting management of the network to a third-party IT department. Using larger cloud-based options helps in the efficient management of multiple smaller locations and may permit access to useful business data analytics services.

As in much larger retail establishments, intimate knowledge of the RF environment, coverage and capacity required to deploy the optimal Wi-Fi network can't come down to guesswork. It has to be informed.

Distribution Centers

Distribution centers are the key commercial hub that connects manufacturers and merchants. They are the pivot point in the levers of the consumer economy – if they're out of order, everything soon follows suit. All of the efficiencies created by just-in-time production, on-time delivery and peak-time consumer traffic are erased if the critical keystone that is the distribution center fails to deliver – both figuratively and literally. Distribution centers exist in a lock-step relationship with consumer retail operations – it's an absolute symbiosis, and they must integrate themselves into the digital communication and data pipeline if they are to remain relevant. And they tell a story of a retail Wi-Fi network that is as unique as their environment.

Logistics determine much of the day-to-day operations of the modern distribution center, and in turn they're dependent on, and connected to the equipment and personnel that ensure logistics viability. Automated robots, forklift and mechanized product-retrieval & shipment preparation, inventory, environmental control, as well as back office, exterior and shipping areas all need to interact with the Wi-Fi network, and it communicates with retail outlets which are connected to consumers connected to an endless online universe.

RF coverage in distribution centers can encounter similar challenges to the large single-surface retail operation, such as supermarkets and department stores, and indeed distribution centers resemble big-box stores in many ways, so an overlap exists when it comes to best practices.

Architectural considerations can include high ceilings, metal framework and roofs, exposed metal ducting, a forest of hanging light fixtures, wiring and a myriad of other important obstructions – and food distribution centers can obviously be home to a high density of refrigerated units. Then there is the ceiling-high industrial grade shelving which introduces addition surfaces to interfere or reflect RF signals, and those shelves are filled to capacity with a host of products with a vast range of attenuation values. If those seem daunting, consider that the distribution center is a fluid environment, with stock changing places frequently, and regularly. So, how best to work with, or around these limitations?

Directional antennas are a good start. They're the ideal solution to avoid RF leakage, and hence maintain the security of the network. Strategic AP location design is another. This alone can go a long way to compensate for the rapidly changing conditions in an active distribution center by anticipating the most probable fluctuations over time. Creating a Faraday cage to limit RF propagation beyond the facility is highly recommended; easily achieved by applying metallic paints or installing wire mesh lining on predetermined wall surfaces. Distribution center security is not complete without proper data and communication encryption protocols in place, and so it's imperative this be implemented into the Wi-Fi network layers. Authentication, verification and proprietary data depend on it. So does the bottom line.

Certain AP designs already sport advanced designs and are able to serve as virtual controllers, completing automatic channel selection and allocation, network assurance from the perspectives of client and host, offering captive portal technology, management dashboard interfaces and a host of cutting-edge security features. Newer dual-band AP units also provide coverage beyond the 2.4 GHz spectrum and into the 5 GHz one where there are less limitations on available channels. Cost of these full-featured AP units is directly proportional to how advanced they might be.

Back Office

As with most other consumer retail environments, the nerve center of operations is away from the eyes of the consumer, tucked into back offices which are necessarily the hub of the associated retail Wi-Fi network, and it's as vulnerable to performance and security issues as any other part of the network. Like the warehouse, storage, shipping, and external areas, it is best to provide connectivity at both the 2.4 GHz and 5 GHz level with dual-band interior APs. Because the floor plan of a back office area will necessarily be different from the warehousing areas, any Wi-Fi network implementation needs as thoughtful a design process as the rest of distribution center. As a physical space, AP use and localization is closer to that of a large shopping mall than a single-surface space.

Voice over Wi-Fi, video, audio, file transfer, email, and real-time inventory and security require multiple APs, and this can engender interference, channel overlap, and countless other potential propagation issues and throughput bottlenecks. The use of additional external direction antennae is a good practice for use in specific targeted locations to avoid signal bleed and potential security lapses. Don't be shy to use enough APs, choosing units that can handle a high volume of concurrent connections and support QoS (Quality of Service) technology that work to prioritize data.

Distribution center retail Wi-Fi networks need to be as efficient, and include as many redundancies, as the logistic protocols and procedures they support. As the indispensable hub of an entire planet's worth of retail establishments, the pipeline of a world economy depends on them – and their Wi-Fi networks.

The Great Outdoors

No, we're not referring to the mountains and forests an hour south (or north) of the city where you take in a week's worth of fishing, paddle boarding, or competitive BBQing a couple of weeks a year… we mean those critical areas that surround the exterior of our shopping malls, supermarkets, department stores, groups of small shops and distribution centers. Depending on the operation those open-air areas need to be able to rely on a stable, secure retail Wi-Fi network every bit as much as the enclosed business areas do. Consumers and their devices, and other network hardware depend on an uninterrupted link to and from your premises to the immediate exterior around it. The wireless consumer experience begins well before your door, so make sure your network is open to more than the four walls where final transactions take place.

Thankfully, managing best practices in adjacent outdoor areas is more straightforward, but specific recommendations do apply.

The first is the weather. The elements can spell trouble for the exterior components of your retail Wi-Fi network. Cold, heat, excessive dryness and of course humidity all take their toll on equipment, so verify that it's protected and accessible for easy maintenance. APs hardened for outdoor use are always the best choice, and exposed cabling should always be weather and UV resistant.

Availability of reliable power and backhaul data cabling or meshed wireless backhauls are must-haves. Special consideration must be given to indoor parking areas which will severely limit cellular services, GPS communication, and the propagation of RF signals.

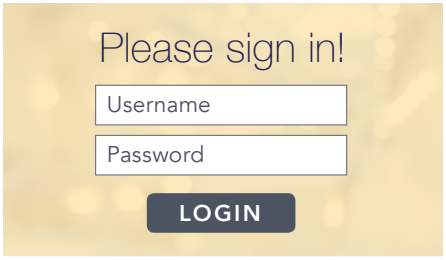
The great outdoors is no reason to cut corners or jury-rig a network – it needs every bit the attention your interior retail Wi-Fi network will receive. Planning and the proper Wi-Fi network design tools remain your best friends, so the time to buddy up is now.

The Essential Technology Shopping List

No matter the venue, it's essential to equip your network with as modern a technology toolkit as possible. Cost is always a factor, with more advanced systems and features invariably being more expensive, both to acquire and to train personnel in its use. But what you invest up front in modernization you save on the other end by being able to keep a system relevant and viable for longer periods. The first technology to be superseded and deprecated will always be the oldest, and least advanced. Something to think about…

So what should a well-designed retail Wi-Fi network include? What are the must-haves and nice-to-haves of a happy, healthy network? Here's a quick point-form guide to those features that should be seriously considered, plus a checklist of additional important technology best-practices that can add flexibility and resilience to your network design.

Key Technical Features



Captive Portals

Essential if you're to grant users access to your network. Captive Portals can also help guide users to in-house and other proprietary services that can in turn serve to collect data on consumer behavior. However complex a captive portal, the simpler the better, and the more likely both merchants and consumers will be happy.

Location-Based Services

An important bedrock of data collection, location-based services provide additional depth & breadth to the precision of the conclusions that can be drawn from the analysis of the raw data compiled. Consumer traffic and density patterns, geofencing data and purchase patterns can all be readily determined from the use of location-based services.

Management & Analytics Support

This is crucial for the efficient and seamless operation of your retail Wi-Fi network, the collection of data, and just as importantly, its distillation, analysis and finally the formulation actionable conclusions. No network runs itself! Yet…

VPN

Virtual Private Networks have been leading technology headlines for some time, and while the need for individuals to acquire their services for private use is questionable, the need to a retail Wi-Fi network to operate one are less ambiguous. A retail Wi-Fi network already is a VPN of sorts but wrapping it in an actual VPN framework can add to its security, and the subsequent compartmentalization can serve to mitigate the issues created by complexity.

Gigabit Ethernet Port Count

Nothing ruins a retail Wi-Fi network's day like dropped connections, DoS due to traffic surging over capacity, or the complete lack of essential failsafe redundancies. It may not be an exaggeration to say you can never have enough gigabit Ethernet ports. You can always count on needs eventually meeting and surpassing whatever capacity was initially built into them. Maxing out your gigabit Ethernet port count helps forestall the inevitable.

Power Over Ethernet

IEEE 802.3 standardized power-over-Ethernet in 2003, allowing for the convenience of concurrent data and power transmission over a common Ethernet cabling. It can save on infrastructure costs and time required for installation – plus it can keep a network up and running during shortages if connected to a backup power source.

Swimming The IEEE Sea

IEEE 802.11 governs most of the world's wireless networks. It's a comprehensive set of standards, and many of its amendments were established to regulate those systems subordinate to the core Wi-Fi network. Here are a few:

- IEEE 802.11ac MU-MIMO ((Multi-User Multiple Input Multiple Output)
- IEEE 802.11ax HEW (High-Efficiency Wireless)
- IEEE 802.11v Client management
- IEEE 802.11k Radio resource management
- IEEE 802.11w Management frame protection
- IEEE 802.11i Data frame security

Want to know more?

An overview of the IEEE 802.11 standards and its amendments can be found at https://en.wikipedia.org/wiki/IEEE_802.11

Technology Best Practices Checklist

Channels Do:

- Use the 20 MHz channels (1, 6, 11 or 1, 6, 9, 13) exclusively within the 2.4 GHz range. Never use the 40 MHz channels in the 2.4 GHz range (US only channels).
- Use the 20 MHz channels (36, 40, 44, 48, 52, 56, 60, 64) within the 5 GHz range. (US only channels).
- Use the 40 MHz channels (34, 38, 46, 54, 62, 102, 110, 118, 126, 134, 142, 151, 159) within the 5 GHz range (US only channels).
- Use the 80 MHz channels (42, 58, 106, 122, 138, 155) within the 5 GHz range (US only channels).
- Use the 160 MHz channels (50, 114) within the 5 GHz range (US only channels).

  Did you know? 80 MHz channels are often used but because it occupies a wider range of the spectrum there is no increase in data transfer rates.
- Keep the 2.4 GHz and 5 GHz SSIDs as separate networks, giving them similar names (e.g.: Guest_2.4GHz & Guest_5GHz).
- Opt for equipment that support band steering to dynamically allocate channels.
- Include support for DFS (Dynamic Frequency Selection) channels (52-144) in the 5 GHz range.

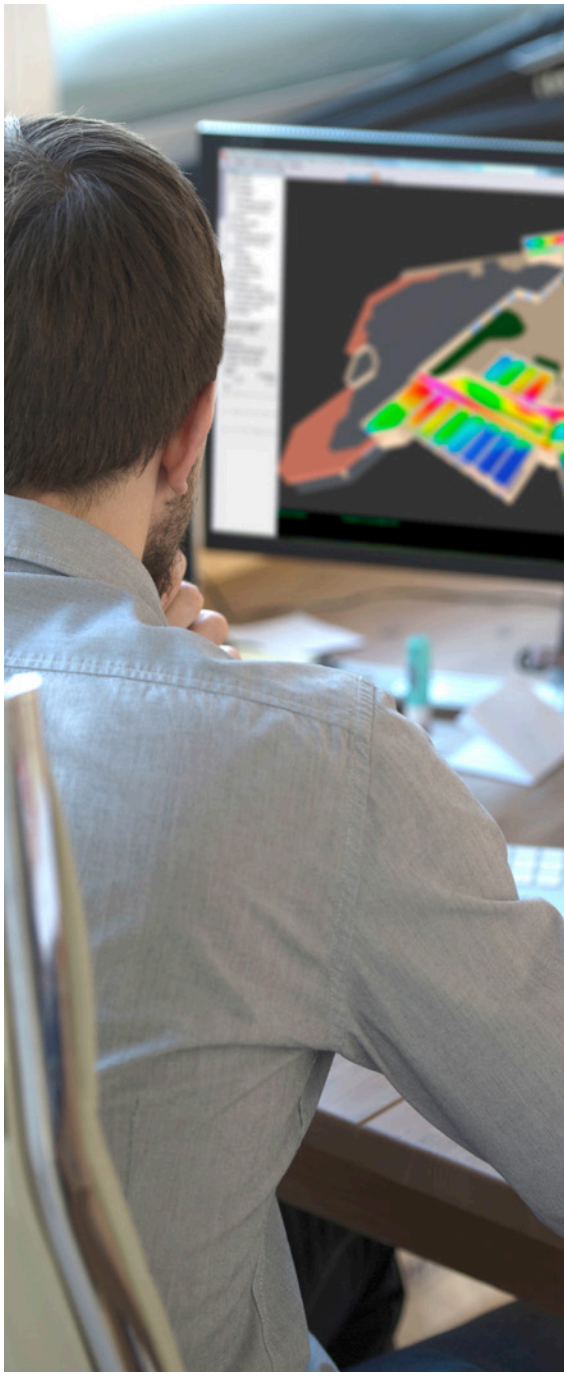
  Want to know more? http://clients.mikealbano.com has an extensive list of devices that operate in this spectrum. Ensure that all AP equipment also supports DFS.
- Implement DHCP (Dynamic Host Configuration Protocol) so that a range of free and working IP addresses are reserved and assigned in order to assure client devices detect and acknowledge the connection. Assigned IP addresses that are not renewed return to the pool of available addresses ensuring a continuous supply for devices seeking connection.
- Think in 3-dimensions when designing your retail Wi-Fi network. Office spaces are tricky places for RF signal propagation. A reliable network acknowledges the ABCs of the X, Y and Z axes!
- Use separate channels for APs located on different floors to prevent co-channel interference and avoid impeding network performance.
- Include Wi-Fi network access in elevators. This can be accomplished via a shaft-certified cable or using a wireless backhaul.
- **ALWAYS, ALWAYS** make good use of monitoring tools to ensure a reliable, seamless experience for connecting devices and consumers. Vigilance is key for the proper operation of wired and wireless networks, from the connection to the IP to server use, backhaul use and reliability, and efficient problem-free RF signal propagation.

Using iBwave Wi-Fi® to Design & Deploy Wi-Fi Networks in Retail Spaces

Great. We've gone over the issues and obstacles facing any retail Wi-Fi network, traveled the halls & open spaces of the multiple venue types and their specific challenges, and touched upon a few of the many best-practices that go into the planning of a successful deployment and operation. This is dense, demanding material, and a rigorous approach to design isn't merely good thinking, it's absolutely essential.

But a retail Wi-Fi network can be considered in some ways to be organic in nature. It grows, evolves, and must compete against its surroundings and the constant challenge of extinction by obsolescence. In this case, driven by the relentless advance of technology. The complex clockwork of what is a functioning, reliable, forward-thinking retail Wi-Fi network has a lot of moving parts – and so ensuring its proper design means a myriad of details come into play all of them governed by the uncertainties of locale, regulation, architecture, use, traffic and how these might change over the short and long term.

It's not comforting to have to consider that the Wi-Fi network approaches the definition of a classic study in chaos theory. What is comforting is that we've developed our iBwave network design software with exactly this in mind; the streamlining & simplification of planning, designing, validating, and deploying superior Wi-Fi networks. That's the sole focus of our iBwave Wi-Fi® software. So, what does that look like in practice?



iBwave Wi-Fi®: Rethinking The Box.

iBwave Wi-Fi® is a Wi-Fi network planning, design, and validation software. It's hard to think that any high-performance network could be realized without the invaluable assistance of such a tool, determining the right design based on those countless mutable parameters, conditions and limitations discussed in previous chapters.

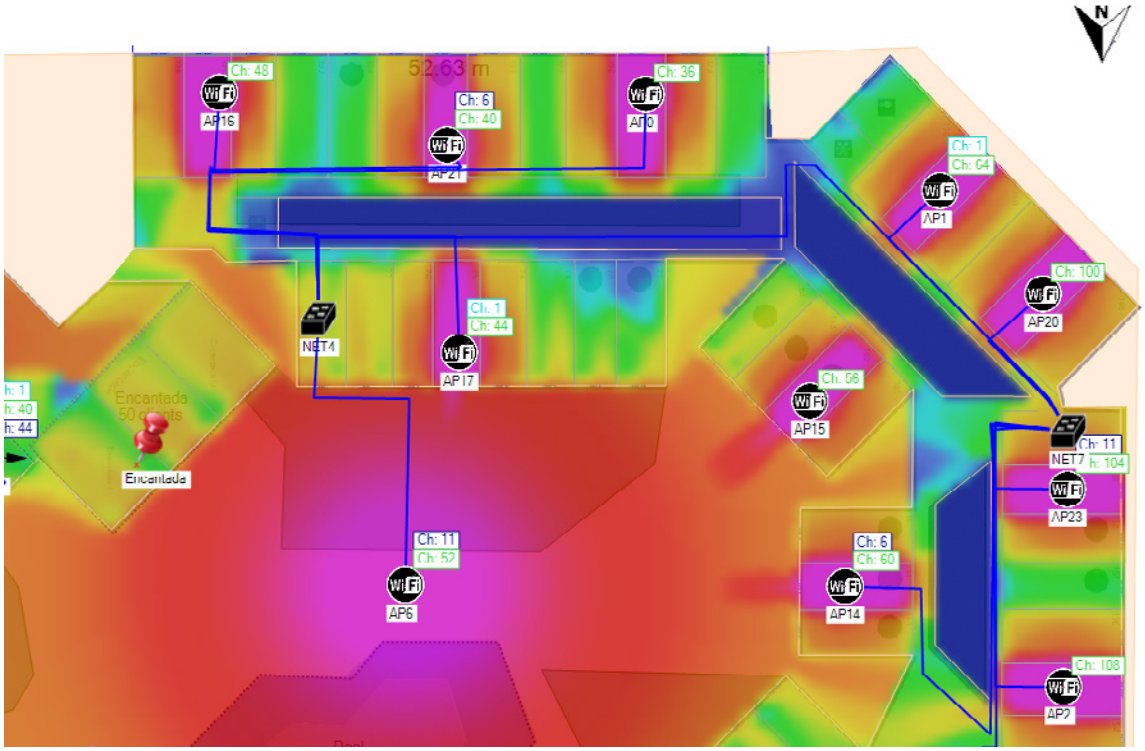
iBwave Wi-Fi® helps pull it all together; from advanced 3D modeling, radio frequency choice to channel planning, cable routing, AP placement, switches, PoE switches, wireless LAN controllers, and how all of these work together and work within a defined physical space. It takes a powerful solution to let you explore multiple configurations for optimal RF signal propagation based on network traffic vs. capacity at peak on/off periods, bandwidth consumption estimates, anticipated applications, technology options and allows you to tweak each of those variables ad infinitum and achieve a level of customization and optimization that every ideal retail Wi-Fi network should enjoy.

In short, planning with purpose, design that delivers, and validation you can rely upon, every time.

iBwave Wi-Fi®: Your Virtual Network Design Sandbox

Picture it. The clean slate that is your new retail environment – every last architectural detail, materials, exterior and interior areas. That's what iBwave Wi-Fi® does, and it's that environment that becomes the framework upon which iBwave Wi-Fi® plans 3D visualizations of your network's components letting you test each against your retail space and other network elements, all in real time. Add network infrastructure, APs, cabling, switches and instantly understand RF signal propagation issues and other potential problems.

Let's look at the key features of the software to help you design Wi-Fi within retail environments.



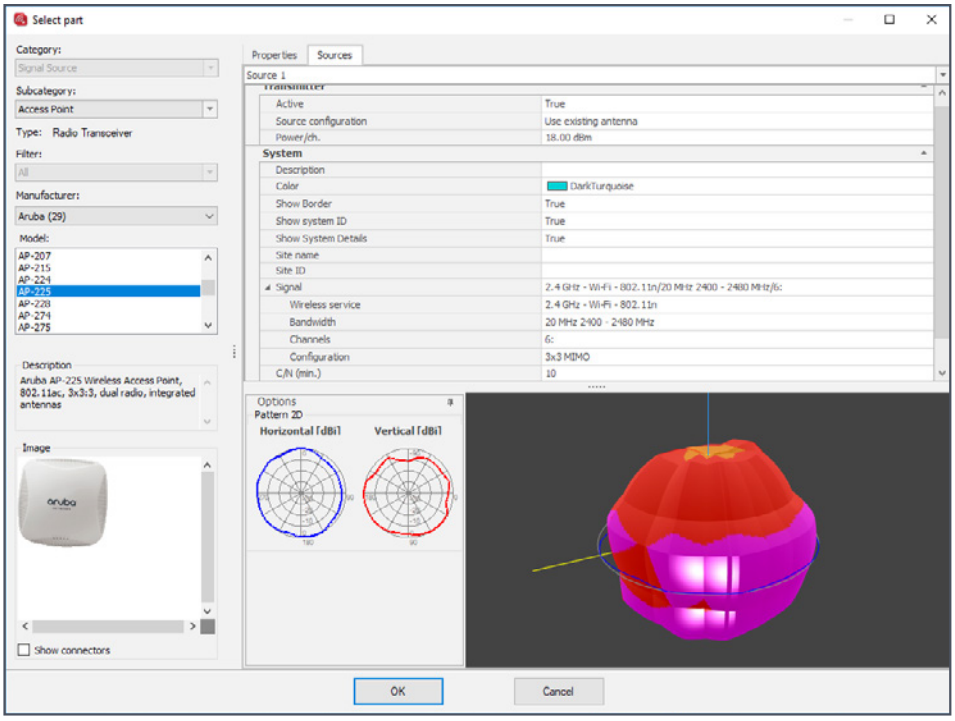
AP Placement Made Simple

In the floor plan simulation above we've added 4 APs; iBwave Wi-Fi® can do this automatically by predetermining their best localization based on estimated highest RF propagation values, or it can be done manually. In the resulting Signal Strength heatmap, the purple areas indicate better propagation areas (-40 to -45dBm) and so a strong, reliable RF signal, while the blue ones point to less desirable propagation areas (-80dBm). iBwave Wi-Fi® software determines probable signal strength according to the size of the area requiring coverage, coverage requirements, selected APs, building material, cable length, anticipated traffic & traffic density patterns, and any other structural and physical restrictions that can serve to help describe the operational environment to iBwave Wi-Fi®.

iBwave Wi-Fi® can also automatically calculate channel allocation to ensure that there is no overlap, reducing the risk of co-channel interference. In this example, four of the allocated channels occupy the 20 MHz bandwidth in the 5 GHz spectrum and do not overlap, while channels 1 and 6 operate in the 2.4 GHz range and are also non-overlapping. AP 16 and AP 0 have switched off their 2.4 GHz radios and so are not actively assigning channels in that spectrum, again, to limit RF propagations and prevent channel co-channel interference.

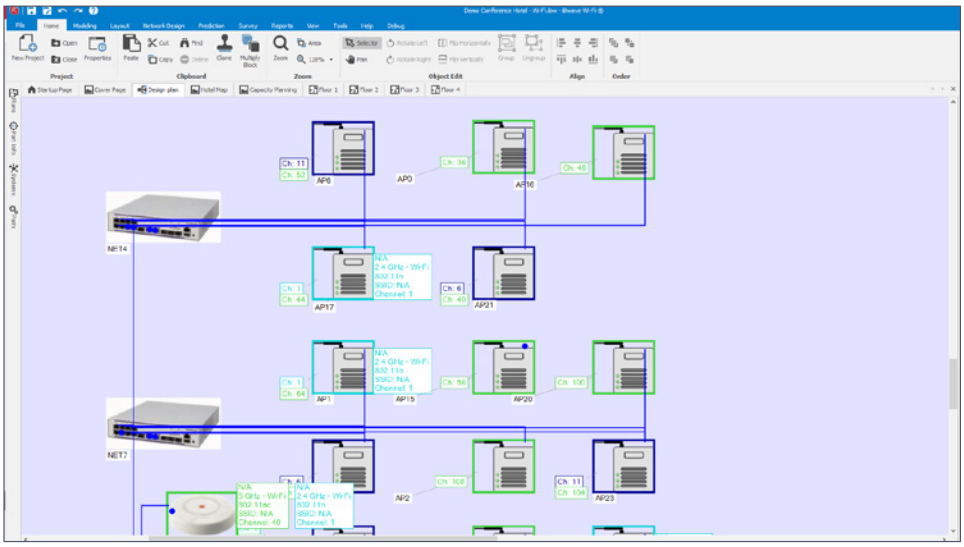
Beyond software, iBwave Wi-Fi® is a guide, mentor, educational tool, and the ultimate Wi-Fi network planning multitasker.

This is an example of an individual AP properties window in iBwave Wi-Fi. It presents the user with clear, detailed AP technical description on the left and lists the manually configurable values in the 2 tabbed panels on the right. Transmission power, dual-band support, supported technologies, and the presence of enterprise-level APs give iBwave Wi-Fi® network designers the flexibility and precision required to fine-tune efficiency, throughput, and propagation in this dynamic sandbox environment. Here 2 and 3D antenna patterns are illustrated. Nothing comes closer to the real thing, short of deploying a true physical prototype, testing it, debugging, reinstalling, and testing it again.



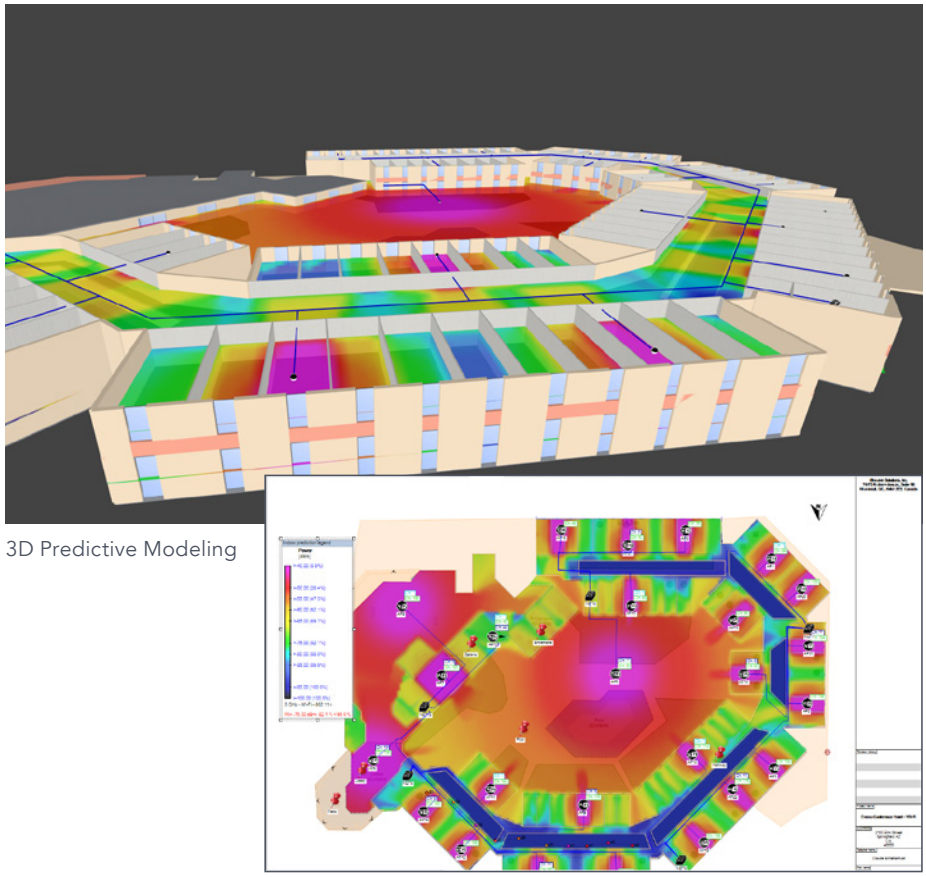
APs From The Ground Up & Inside Out.

Port planning between PoE and normal switches or APs is also made simpler and more intuitive. At a glance an iBwave Wi-Fi® network designer can determine if sufficient port capacity has been built into the virtual network or if additional switches might be required.



Port Planning For Optimal Capacity

With all of the components in place, or even during the incomplete active design stage, it's a snap to gain an insight into how the network will perform across both the 2.4GHz and 5GHz bands. Running individual heatmaps for signal strength, SNR, co-channel interference, among others, and displaying the prediction results gives the user an accurate gauge of network performance once installed. Used before actual construction of the physical space it can even serve to guide architects so that RF signal propagation is actually improved by intentional design decisions. The 3D prediction view can display other important RF signal information such as; best channel, signal-to-noise ratio, maximum achievable data rate, the presence of co-channel interference, client capacity/zone, and average downlink data rate.



3D Predictive Modeling

iBwave Wi-Fi®: Validation

Validation is among the most important final steps in the deployment of a retail Wi-Fi network and iBwave Wi-Fi, or the companion iBwave Wi-Fi® Mobile, make quick work of it. In fact, all it takes to complete validation is a Windows-based device (Microsoft Surface, Lenovo IdeaPad, Acer Switch) or an Android tablet using the iBwave Wi-Fi® Mobile app. While iBwave Wi-Fi's network design simulation determines the optimal localization for the server, APs and all related infrastructure, only real-world, real-time testing can offer final validation.

iBwave Wi-Fi's interpolation feature allows the user to visualize actual RF signal propagation during a site walk and ascertain channel allocation, signal-to-noise ratio, and signal strength at specific areas where interference due to limitations in floor plan or architectural design to evaluate their impact on client reception, and ultimately, user experience.

Active site surveys can also be completed using either iBwave Wi-Fi® or iBwave Wi-Fi® Mobile, which tests network bandwidth between client and multiple server locations to best compensate for fluctuations in Local-Area and Wide Area Networks (LAN / WAN).

Validation represents the concretization of the physical emplacement of a retail Wi-Fi network designed on iBwave Wi-Fi® and ensures that the network is performing as designed. Too often a failure to obtain accurate prediction is the result of insufficient time given to the modeling and design a venue. Subsequent validation of the network can lead to costly redesign and troubleshooting which may delay final activation. With iBwave Wi-Fi, the accuracy of prediction has been tested over and over again and proven to be incredibly precise – meaning only nominal tweaks or troubleshooting are required once the network is live.

iBwave Wi-Fi® & Other Wi-Fi Services: Playing Nice.

iBwave Wi-Fi® focuses primarily on the infrastructure that supports Wi-Fi networks, and so the viability and interoperability of the myriad of hardware and service options a retailer decides to add to that framework are not covered by iBwave Wi-Fi® but fall under the domain of a comprehensive ICT system. Validation of a wireless network's routing, access control lists, firewall settings, AP testing, performance management, assurance, and seamless monitoring & reporting among many others, need to be undertaken separately to assure the network and peripherals together still meet customer requirements.

Any new or upgraded wireless or wired network installation should, as a rule, be subject to a usage-trend analysis as traffic and density patterns are apt to change over time, or as new services, technologies, and device types become available. Moore's Law is the top of the iceberg, technological innovation for new-adopters is usually a generation beyond whatever network you're likely to install, so periodic, systemic evaluation of the performance of your network across all its parameters is imperative; once a year at minimum, more often should you feel that technology is outpacing it at more substantial rates. Vigilance, caution, and a firm grasp on the fact that change is imminent no matter how up-to-date you are.

Thanks…

We admit it. Any book is as subject to the effects of rapid change in the world it seeks to describe as the technology it hopes to explain. Ours is no different. That applies more today than it did a decade ago, and less so that it will in a year. Retail Wi-Fi Network Best Practices places into context many of those things you'll need to know before you begin planning any retail Wi-Fi network – indeed before the first concrete is poured in your new location. What can go wrong, what's known, what's unknown, what's unknowable, and proposes the best ways to address these, and the countless other issues sure to be encountered during the planning, design, and deployment of a network.

We're here to make life, and Wi-Fi networks a little easier. Thanks for taking the time to read Retail Wi-Fi Network Best Practices.

There will be no film or sequel. But a podcast isn't out of the question.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