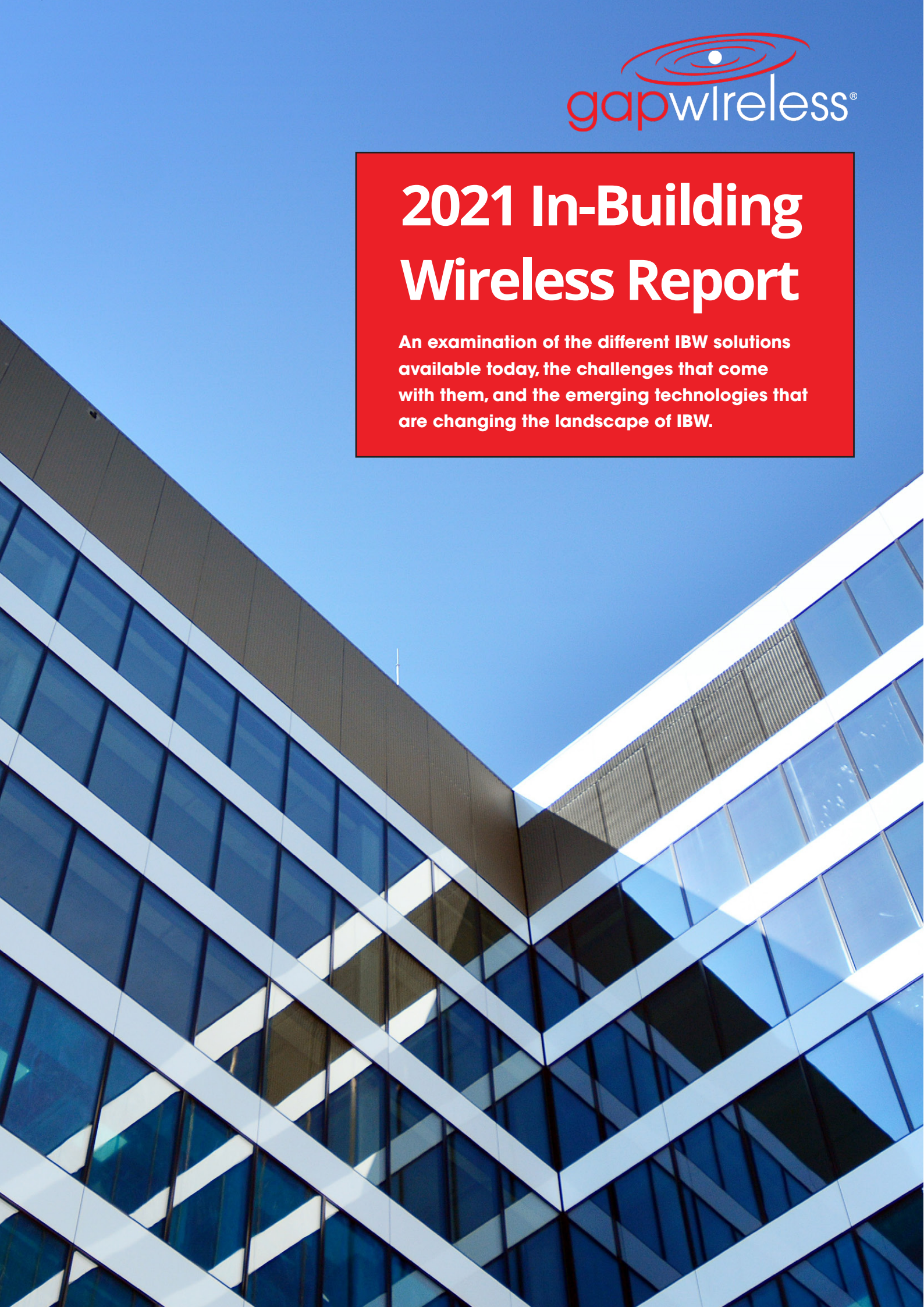
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2021 In-Building Wireless Report

An examination of the different IBW solutions available today, the challenges that come with them, and the emerging technologies that are changing the landscape of IBW.



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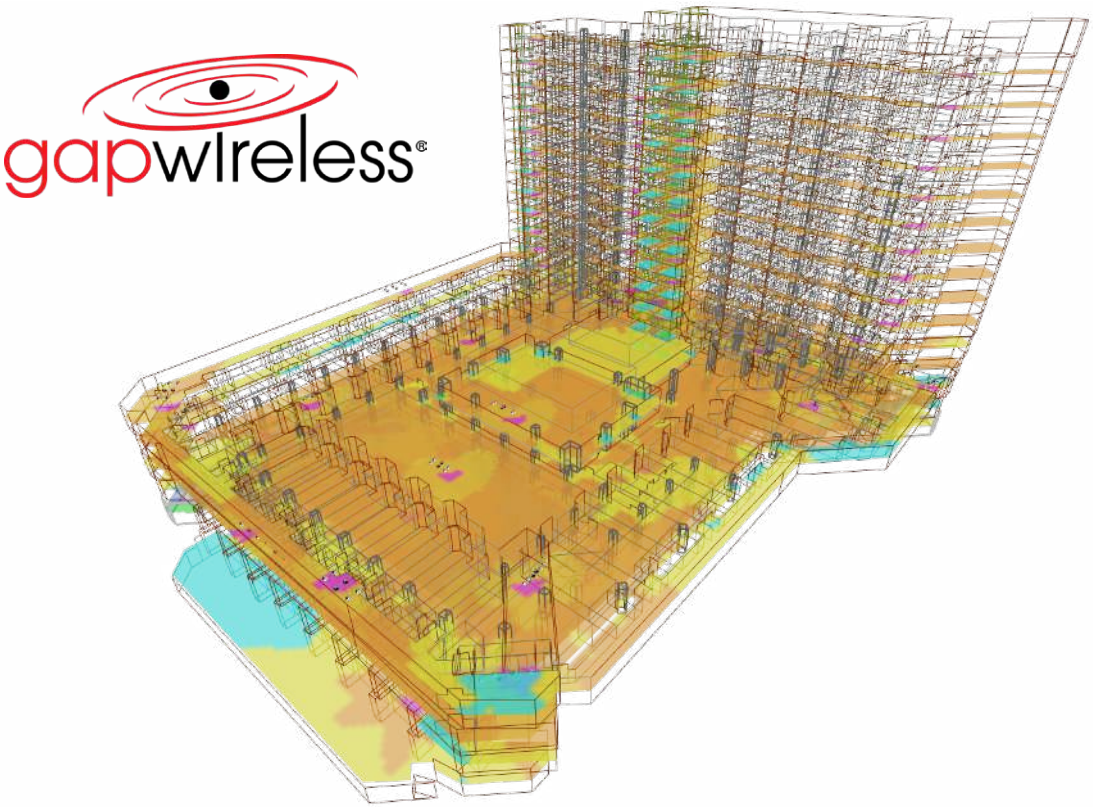
In-Building Wireless Report

Wireless connectivity has never been as crucial to as many people as it is today. In a new world shaped by social distancing, wireless capabilities have transcended convenience and become the primary fabric of human interaction.

As recently as 2016, ABI Research reported that more than 80 percent of mobile data traffic occurs inside buildings. Buildings, by their nature, provide a physical barrier to wireless communication. Dropped calls, poor signals, and slow downloads all result when RF signals are obstructed by building materials like concrete walls and low emission windows. In the worst case scenario, parts of a building may become wireless dead zones. There is also the question of capacity—buildings may be home to many more users than can be supported by a given cell tower.

In-building wireless (IBW) solutions serve to address these concerns. IBW solutions can ensure that networks deliver on Quality of Service (QoS) agreements and that Quality of Experience (QoE) expectations are met by building occupants. These solutions range from minimal passive signal routing that ensure coverage to sophisticated digital distributed antenna systems that add additional cellular capacity. There is no one-size-fits-all IBW solution—the correct approach is dependent on the nature of the building and the scope of wireless services required.

In this report, we'll examine different IBW solutions available today, the challenges that come with them, and the emerging technologies that are changing the landscape of IBW.



Distributed Antenna Systems

One of the most common approaches to In-Building Wireless is the Distributed Antenna System, or DAS. In the context of buildings, this is sometimes referred to as indoor DAS or iDAS.

The principle behind a DAS is simple. By placing antennas strategically throughout a building—e.g., one in each room— cellular signals can be distributed where they're needed. The signals can originate outside the building, in which case an external antenna receives and sends the signals to internal antennas, or the signals can come from an on-site base transceiver station (BTS) provided by a carrier. In effect, a DAS can increase cellular capacity for a building and allow wireless signals to clearly reach end-user devices.

There are many considerations when planning a DAS. For instance, will it need to support multiple cellular carriers? What sources of interference will need to be mitigated? Will the system need to respond to changing user behaviour? How will it be installed and how much will it cost? Several types of DAS architectures address these differing needs.

Passive DAS

The simplest type of DAS is called a passive DAS. Such systems are best-suited for smaller buildings without complex or changing requirements. A passive DAS receives cellular signals from an external antenna and sends them through a low-loss coaxial cable to a bi-directional amplifier (BDA). From the BDA, the signal is sent over coaxial cables to multi-band antennas throughout the building, being directed with passive components such as splitters and couplers.

Passive DAS systems can be an economic choice for IBW, but design complexity increases with the number of carriers that must be supported. Installation of coaxial cables throughout the building can be difficult, and passive DAS systems are particularly susceptible to passive intermodulation (PIM) interference.

Active DAS

As cellular technology has evolved, a much more common approach to IBW is what's called an active DAS. Such a system is similar to a passive DAS, but, as its name suggests, an active DAS employs active RF components. Though this results in a more complex system with higher power consumption, it allows much more control over the signal distribution. An active DAS is configured with a head-end unit that receives multiple RF signals and distributes them to remote radio units throughout a building. These remote radio units re-broadcast the RF signal through either integrated or external antennas.

Active DAS systems use single mode (SM) or multi-mode (MM) fibre optic cables between the head-end unit and remote radio units, a transmission medium which is both easier to install and less lossy than the coaxial cables used in passive DAS systems. This enables longer fiber optic cable lengths in an active DAS compared to coaxial cable lengths in a passive DAS. In an active DAS, the fiber optic cables feed into the remote radio units, which serve as the RF source for the antennas and can be placed close to them regardless of the length of the fiber optic cable. In a passive DAS, the antennas are necessarily separated from the RF source by the entire length of the coaxial cable. This allows an active DAS to encompass much greater distances within a building (or campus) than a passive DAS. The use of fiber optic cables also means active DAS systems have less potential exposure to PIM, though care must still be taken to guard against PIM in the passive RF components before the head-end unit as well as around the antennas.

Active DAS systems have a higher cost than passive DAS systems, as they require more equipment and more space to implement. However, they provide more flexibility as well. The signals sent to each antenna can be tuned band-by-band to ensure optimal coverage across the spectrum. With active gain elements and low-loss fiber optic cables, active DAS systems are also a better fit for larger buildings.

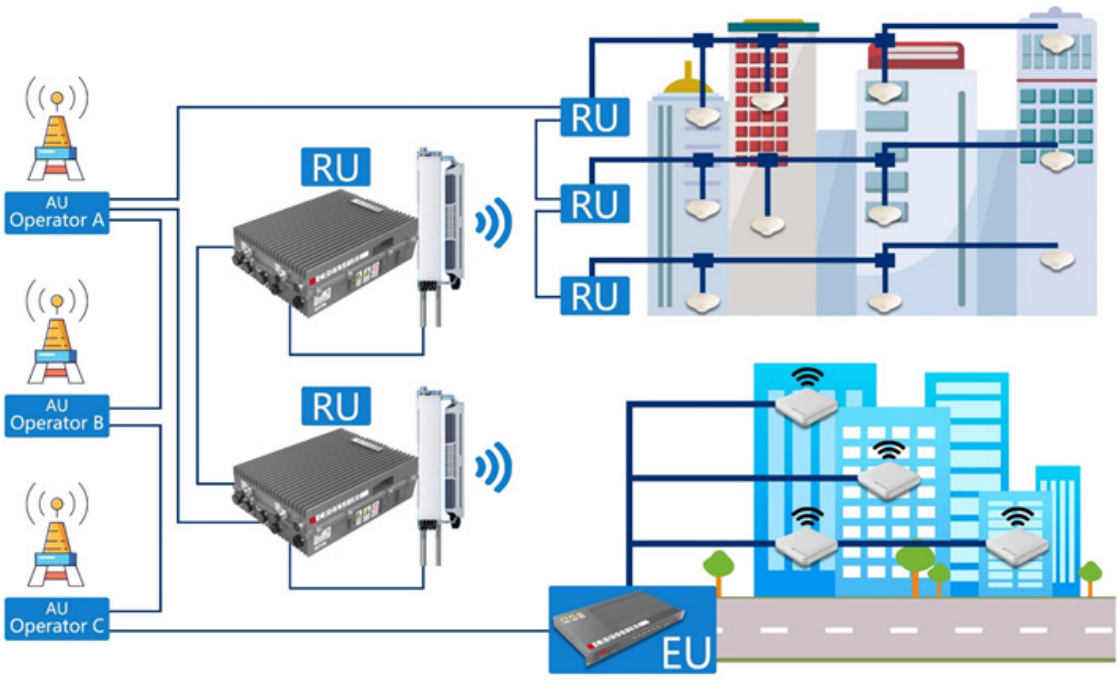
Hybrid DAS

There is an approach between active and passive DAS called, fittingly, hybrid DAS. A hybrid DAS employs active components, including head-end units and remote radio units, in the same way as an active DAS. However, the remote radio units distribute signals passively throughout a particular zone of coverage in the same fashion as a passive DAS, routing RF signals via splitters and similar components to several multi-band antennas. This saves on capital expenditure, as fewer remote radio units and less fiber optic cable are required than in an active DAS. However, each remote radio unit must provide a high enough power to support its zone of coverage.

Digital DAS

A variant of active (or hybrid) DAS that uses digital instead of analog signals is called a digital DAS. The configuration of a digital DAS is similar to an active DAS, with RF signals being conditioned and routed through a head-end unit over fiber optic cables to multi-band remote radio units and antennas throughout the building. However, whereas an active DAS distributes analog optical signals over the fiber optic cables, a digital DAS head-end unit converts the analog RF signals into digital optical signals. These signals can be sent directly to a remote radio unit, but additionally flexibility can be achieved by sending them to components called expansion units. These convert the optical signals into electrical signals and route them as necessary to different remote radio units, which can be determined in software. Older digital DAS products used Ethernet cables between expansion units and remote radio units, but modern systems like the Sunwave Solutions CrossFire 2.0 DAS use a hybrid fiber/power cable all the way to the end node. Digital DAS systems support Common Public Radio Interface (CPRI) or other communication protocols.

One key advantage of a digital DAS is that signals can be addressed to specific remote radio units. This allows building operators to dynamically adjust coverage throughout their facility, for example switching signals from one zone to another based on the time of day. Another advantage is that digital signals have a much better signal to noise ratio (SNR) than the modulated analog signals on the fiber optic cables, making them more resilient to losses. For this reason, it may be possible to reuse existing fiber optic cables in a building rather than installing dedicated cables. A hybrid fiber/power cable can bring power directly to a remote radio unit. For example, the Sunwave CrossFire N2RU nano power remote unit supports 8 bands with a power output of 20 dBm per band. If even higher powers are needed, such as in tunnels, digital DAS systems can also use high power remote radio units powered with a local supply. PIM is largely alleviated in a digital DAS, though sources of interference around the antennas still must be considered.



Distributed Small Cells

An emerging architecture for IBW is distributed small cells (DSC), often shortened to small cell. In contrast to a DAS, which contains a centralized source with a single backhaul connection to the operator network, a small cell system consists of a network of individual nodes that each must have a separate power supply and backhaul connection. Depending on their coverage and capacity, small cells can be further categorized as metrocells, nanocells, picocells, and femtocells in descending order of power.

Small cells have both pros and cons. They can often be deployed quickly and with lower cost than a DAS, but they are much less flexible. Small cells typically only support a single carrier and only one or two bands, whereas a DAS can support multiple carriers and bands. Small cells may not be an adaptable solution if the needs of a building change. To accommodate the individual backhaul links, some small cells (generally femtocells) need reliable high-speed internet, though other cells (generally nano and picocells) employ a dedicated backhaul to the carrier.



Approaching IBW Design

As we mentioned earlier, there is no single correct approach to in-building wireless solutions; what's best for one facility may be a poor fit for another. We'll now take a closer look at some of the challenges and trade-offs that must be balanced in any IBW solution.

Compatibility

Ultimately, an IBW solution will succeed or fail based on the experiences of the end users. Thus, it is crucial to consider these end users when planning a system. For example, an office worker using a smartphone will have a much different user experience requirement than a first responder using a 2-way radio. With an ever-growing number of wireless standards and multiple operators to consider, it is necessary to ensure support for as many current and future mobile technologies as possible. For example, 5G is steadily rolling out and will become ubiquitous within the next several years. While users will expect support for this latest standard, an IBW solution must not neglect older but common standards such as LTE and 3G. It's also important to recognize that 5G will in time be supplanted by 6G, which will give way to 7G, and so on. It is therefore vital to plan ahead and ensure that future technologies can be supported without completely overhauling IBW equipment or architecture.

Total Cost of Ownership

The total cost of ownership, or TCO, is one of the most important variables to consider when planning an IBW solution. More expense does not necessarily mean better experience. If you have a small to medium sized building that doesn't need to support many operators and that won't change much over time, a small cell system or passive DAS can provide a perfectly suitable solution for the lowest cost. On the other hand, if your facility is large or spread out and will need to dynamically adapt to changing user behaviour, a more expensive digital DAS system may be warranted. For an accurate picture of the TCO, you must consider the cost of all equipment (head-end units, remote radio units, cooling equipment, cabling, etc.) as well as all installation and operating costs (electricity, fiber leases, IP backhaul, real estate and roof access, etc.). Systems like the CrossFire 2.0 digital DAS platform reduce TCO with features including extremely low power consumption and hybrid fiber/power cabling to simplify installation

Interference

It is important to understand and mitigate all sources of interference that your IBW solution may experience. A common source of noise is PIM, which can arise in passive RF components. As discussed, the prevalence of PIM decreases from a passive DAS (most susceptible) to an active DAS (less susceptible) to a digital DAS (least susceptible) but must always be considered in a design, so make sure you look for components with low PIM. Besides PIM, there may be RF interference originating from outside your building. This is most common in dense urban areas with a lot of wireless traffic. To combat such problems, RF insulation may be necessary.

Choosing the Right Antennas

While a DAS can distribute RF signals throughout a building, the last stop before the end device is the antennas. In active and digital DAS architectures, some remote radio units have integrated multi-band antennas, but it can often be advantageous to use external antennas. In this way, specific antennas can be chosen based on the setting and application they serve, such as wireless carrier, public safety, or both. Where an omnidirectional antenna may be useful in some circumstances, a directional antenna may make more sense in others. Choosing the correct antenna and placing it properly is a flexible way to tune your IBW performance (and aesthetic).

Finding the Right Partner

As we have seen throughout this report, in-building wireless solutions provide a way to ensure sufficient wireless coverage and capacity for a given building. However, there are a variety of IBW solutions and architectures, each with advantages and trade-offs. For a quick and inexpensive way to add capacity, distributed small cells are an increasingly popular approach. For a complex facility with many users of different needs, a sophisticated digital DAS may be the only tenable solution. When partnering with IBW system and component providers, communicate the specific needs of your building. Providers like Sunwave Solutions offer a wide portfolio of IBW technology to help you implement the right solution.



Sunwave Solutions

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