MARKET MONITOR RESEARCH SERIES

Advantage Business Media

Designing Distributed Antenna Systems (DAS)

Considerations, challenges, and what to expect when designing and deploying DAS.

PRESENTED BY:

WDD WIRELESS DESIGN & DEVELOPMENT

SPONSORED BY:

api technologies corp.

Anritsu envision : ensure

Table of Contents

Introduction 3

Defining DAS 4

Rapid Industry Expansion 5

DAS Design Considerations 6

DAS Design Challenges 9

Weighing the Systems 11

Coordinating with Mobile Carriers 12

WiFi Over DAS 13

The Push For DAS 14

Introduction

According to Pew Research Center, 72% of cell owners experience dropped calls at least occasionally. Some 32% of cell owners say they encounter this problem at least a few times a week or more frequently. In addition, 77% of cell Internet users say they experience less than desirable download speeds. Of those cell Internet users, 46% face slow download speeds weekly or more frequently.

In today's always-connected world, people are accessing the Internet in many different locations throughout the day, and usually via a mobile device. Wireless Service Providers (WSPs) are helping enable the shift in usage habits by employing new technologies to address the considerable network traffic growth with the use of a Distributed Antenna System (DAS). As with most new technologies, significant considerations and challenges must be examined during the design process.

This research report analyzes data collected from design engineers in order to fully understand the issues and challenges engineers face when designing and deploying DAS.

In this report, we delve into the necessary considerations and sometimes unavoidable challenges that arise when designing DAS, as well as potential solutions. When and where is a DAS necessary, and why? What should engineers consider when designing a custom DAS for a particular market segment? What challenges should engineers expect to face when deploying DAS?

Research Methodology

In November 2015, survey questionnaires were emailed to a subscriber list containing approximately 47,000 contacts. As an incentive, respondents were entered into a drawing to win a video drone. The survey was officially closed with a total of 582 survey responses.

Of the total responses, 179 indicated that they were involved in the design and/or deployment of Distributed Antenna Systems. This survey focuses solely on those 179 participants.

Defining DAS

Distributed Antenna Systems are networks of spatially separated antenna nodes that improve wireless coverage in otherwise poor coverage areas, such as high-density indoor or outdoor venues or in areas where geography obstructs wireless signals. DAS antennas are connected to a central controller, which is connected to a wireless carrier's base station. This provides voice and data services to mobile devices much like the cell site in a cellular network.

To break it down even further, DAS connects a system of hubs and remote antennas, which distribute wireless signals to connected DAS multi-band, multi-technology radio heads. Service providers locate base stations to provide cellular signal at the head-end. The main hub within the system actually takes the signal, digitizes it, and then distributes it to other hubs and radio heads via a high-bandwidth fiber optic network. The radio converts the signals from digital to RF and RF to digital at the antenna, and the signals can then, as stated above, be used for cellular service, public safety radio frequencies, and WiFi.

DAS can be deployed indoors (an iDAS) or outdoors (an oDAS), however, Distrbuted Antenna Systems aren't a one-size-fits-all solution. Due to the unique nature of each venue, no single, cookie cutter system can be constructed, making a DAS a complex and expensive system to implement despite an ever-increasing consumer demand.

Rapid Industry Expansion

The past 10 years have brought rapid expansion across the wireless and telecom industries, particularly major growth since the dependence on smartphones for personal and business use. The need to connect, communicate, and share caused WSPs to allocate significant sums of money to both improve networks and purchase additional spectrum.

Consumers rely on devices as well as robust coverage in order to communicate anytime, anywhere. In order to meet these continued demands, to satisfy customers, and to compete in the market, WSPs must research and employ solutions in order to successfully improve networks.

KEY POINT

Networks that were initially designed with voice services in mind are now expected to support rising data demands. A domino effect occurs when the network operators cannot sustain the large amounts of data being shared; higher spectrum frequency bands are used to attempt to accommodate the mass data, and the customer is left disconnected and dissatisfied. The higher frequency used negatively affects the Federal Communications Commission (FCC) and prevents wireless signals from propagating, especially inside of buildings. And, as mentioned above, dropped or lost calls, unsent message errors, and apps and websites that won't load are becoming more problematic at public venues as the number of wireless users on a network increases with the number of devices being used. As consumers use devices at the same time in a confined area, the network experiences an exceptionally high level of demand for network service in a concentrated timeframe.

In order to meet these continued demands, to satisfy customers, and to compete in the market, WSPs must research and employ solutions in order to successfully improve networks.

This increased use of mobile telecommunications devices will continue, and in the case of extremely dense venues, such as stadiums or exhibit halls, the increased users will inevitably induce significant strain on the network. This is where Distributed Antenna Systems come into play to meet the quality of service and future growth needs of wireless networks. Essentially, the idea is to split the transmitter power among multiple antenna segments to provide maximum coverage, while reducing power and improving network reliability. This is done by replacing a single antenna with a group of much lower power antennas to cover the same area.

DAS Design Considerations

As with any RF system, the placement of DAS starts with an RF analysis and design, along with expected characteristics relating to performance outcome.

Efficient Signal Propagation

Forty-one percent of industry engineers believe that efficient signal propagation is one of the most important considerations when designing DAS for a specific venue or space. Signal propagation refers to the radio signal transmitting from one place to another, presumably from the station's antenna to the receiver's antenna. In order to be successful, designers must take a look at the full scope of ways in which wireless signals are propagated. For instance, cell towers carry antennas for one or more macrocells, and, with multiple carriers, these towers are comprised of layers of antenna arrays. Frequently included, in addition to macrocells, are microcells, which add higher volume in areas with a large number of mobile wireless device users. The decision to include any or all of these specific technologies is wholly up to the engineer but should be considered early on in the design process.

Performance Factors

The design stage of a DAS is one of the most important, as operators give high priority to designs that are future-proofed, meaning they address concerns that are not necessarily an issue today, but may become an issue in the future. High performance depends greatly on maximizing the desired factors, while minimizing the undesired factors such as interference and noise – key factors that must be addressed to achieve the best performance.

DAS networks are prone to interference problems, which are generated by signals in other circuits or in the same circuit. Distributing antennas throughout a building or venue brings them closer to the sources of interference, such as cash registers, ID card readers, two-way wireless communications systems, and other electronic devices that may hinder DAS. Typically large, indoor facilities experience poor coverage simply because buildings act somewhat like an RF shield. This is commonly due to fortified construction, highly tinted windows, lack of coverage in below grade floors, and the like. High rise buildings, which typically extend more than 15 floors, experience high levels of RF interference from cell towers degrading service, and lower/below-grade floors are often shadowed from towers.

Additional causes are the building is blocked from the tower by other buildings, the WSP network cell site tower is too far away or new technologies are being broadcasted on higher frequencies. However, even when you design with interference issues in mind, there are still unpredictable sources of co-channel interference that can obstruct DAS and greatly affect network performance, reduce capacity, and disrupt network coverage.

KEY POINT

Noise is, by definition, the random fluctuations in electrical signals and can be due to interference, temperature, impurities, etc. Noise is generated by electronic devices, and sources can range from thermal radiation from the earth and sky, cosmic background radiation, and random thermal processes in the receiving system.

> As an industry, a solution is needed to address the service impact as a result of Near-Far, and engineers must weigh the options and potential solutions early on in the design stage to procure maximum coverage and efficiency.

Ideally, you would remove all sources of interference in order to obtain great performance, however this is simply not realistic. A more practical approach is to identify all potential sources of interference. In the event that the source cannot be completely removed, or furthermore, if the source cannot be identified, automatic detection and mitigation will ensure that the DAS network will not be compromised.

Addressing Near-Far

When designing a DAS, 64% of industry engineers said they are addressing Near-Far in the design stage. Near-Far describes performance reduction when a mobile device is operating within a DAS coverage area but is being serviced by a distant macrocell tower. Near-Far affects users on the DAS, as well as those in the DAS coverage who are not actually on the DAS. When users on the DAS are affected, this is known as uplink Near-Far. When those not on the DAS are affected, it is known as downlink Near-Far.

Kirby Yap, DAS Field Application Engineer at CommScope, further expands upon Near-Far. "Near-Far is a situation where there is performance degradation because a mobile device is in a network but the macro tower is serving that mobile. In this case, the DAS coverage is not enough to overcome the macro/outside signal. In this situation, the mobile tends to transmit at higher power since it is communicating with the macro network. This can degrade the DAS system, causing performance issues."

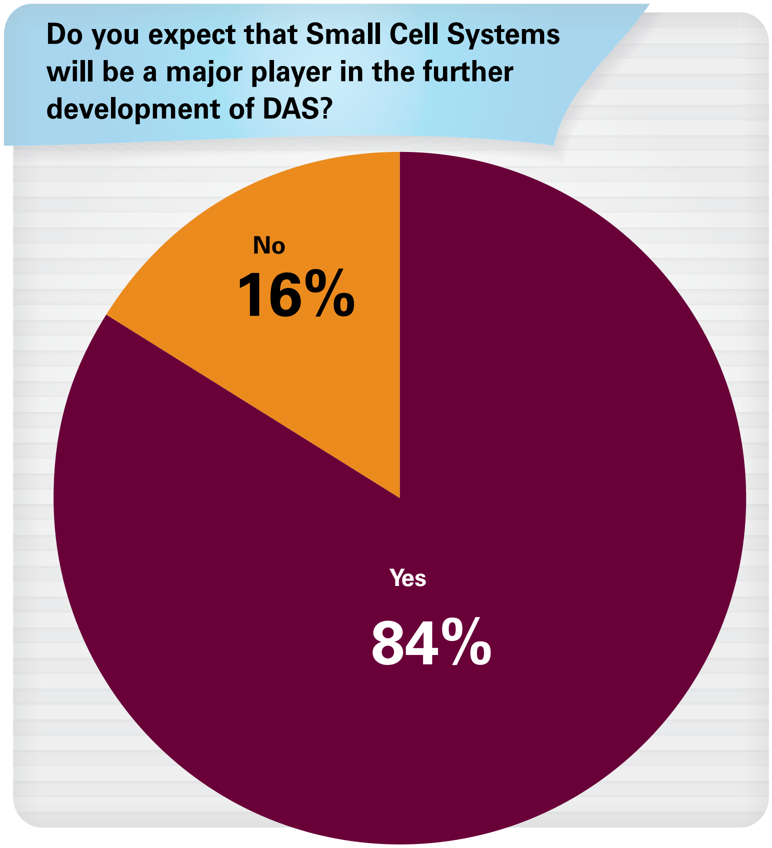
Typically, DAS designs are not able to mitigate the impact of Near-Far. Furthermore, if it is not addressed when designing a DAS, users will experience significantly degraded performance after deployment. As an industry, a solution is needed to address the service impact as a result of Near-Far, and engineers must weigh the options and potential solutions early on in the design stage to procure maximum coverage and efficiency.

Yap suggests, "When designing a DAS, we should take into account the amount of macro/outside signal bleeding into the building, and make sure to overcome it with enough DAS signal so the mobile device will stay on the DAS instead of connecting to the macro or switching back and forth between the two systems."

Integrating Small Cells

Small cells can function alone, as can DAS, but 84% of engineers expect small cell systems will be a major player in the further development of DAS. Rich Grimes, the COO of InSite Wireless' DAS and Small Cells Division, has witnessed small cells successfully complement DAS in highly trafficked venues.

"Small cells will play a greater role in the development of wireless coverage and capacity at various venues, as a complement to DAS. DAS is the optimal solution for high-density wireless capacity traffic venues, like transit, stadiums, entertainment venues, and large convention centers. However, small cells provide a complementary solution at venues where outer coverage areas do not have the dense capacity traffic, whereas small cells are more capital efficient," says Grimes.



Small cells are comprised of a fiber optic transport network and multiple wireless access points, much like DAS. Unlike DAS, however, a fiber optic transponder (BIU) bridging the base station RF signals to fiber is not necessary. Small cells are either attached to the base transceiver station (BTS) baseband unit, or to the wireless core using a 3G gateway or an evolved packet core (EPC). When they are attached to the baseband unit (BBU), they employ the common public radio interface (CPRI). When they attach to the core using a 3G gateway or EPC, they utilize Ethernet. Depending on the network architecture, small cells either appear as a single cell site sector (CPRI-connected small cells), or as a pico cell site. The actual configuration selection is completely dependant on the application and the design engineers' preferences.

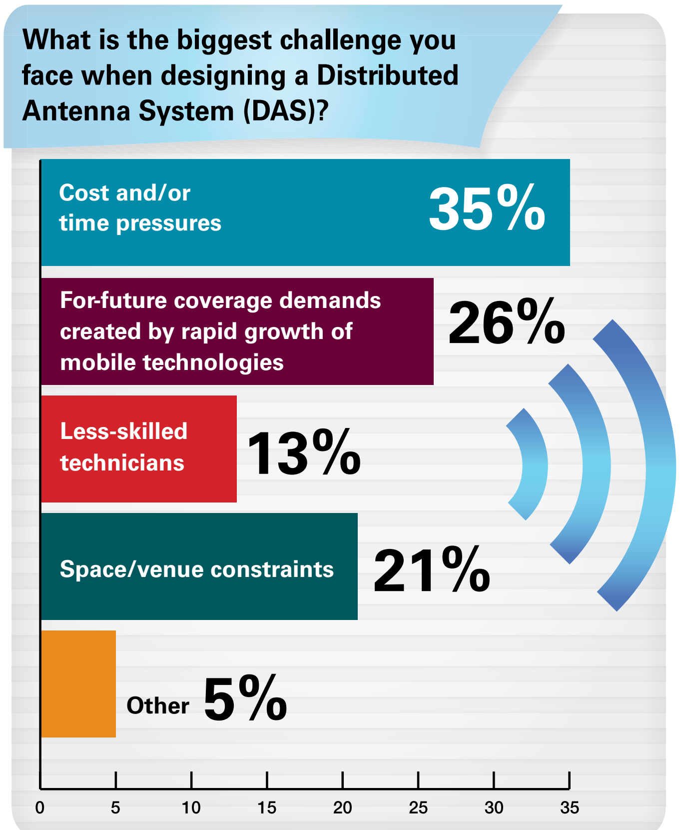
Small cells offer exceptional coverage and target very similar applications as DAS, however there can be significant architecture and design differences between them depending upon the situation. And, although they can be designed to support many bands and any of the common technologies (including 2G, 3G, and 4G), in the past they've been largely focused on only one mobile operator's specific network requirements. More recently there has been a shift, however, as more engineers have been designing small cells in order to support requirements for multi-operator core networks (MOCN) or multi-public land mobile networks (multiPLMN), whereas two or more providers share a mobile network operating on common bands. Design engineers are now able to join the two systems together to create a more effective solution.

Yap agrees. “Providing ubiquitous coverage and capacity in a variety of venues of different sizes will continue to require a variety of solutions. The outdoor macro network, DAS, and small cells all likely have a role to play. The evolution of small cells and DAS will be an important part of bringing indoor wireless to the next wave of buildings.”

DAS Design Challenges

Cost and/or Time Pressures

DAS design costs depend on variables such as frequency range—particularly, if a system will need to integrate Very High Frequency (VHF), Ultra High Frequency (UHF), and/or 700 to 800 MHz public safety. VHF/UHF (consisting of ranges 30 to 300 MHz and 300 MHz to 3 GHz, respectively) are more complex and will therefore be more expensive. Alternatively, the 700 to 800 range is typically the easiest to construct and will cost less. A majority of DAS utilize fiber optics to transmit signals, requiring custom cabling, installation, and equipment that will drive up material costs and deployment time, which already requires a minimum of six months from carrier permission to final installation. Fortunately, however, as DAS becomes more prominent, particularly in many of the largest venues across North America, new trends, such as integrating converged infrastructure, centralized headends, and multi-purpose antennas, are beginning to bring overall system costs down.



For-Future Coverage Demands

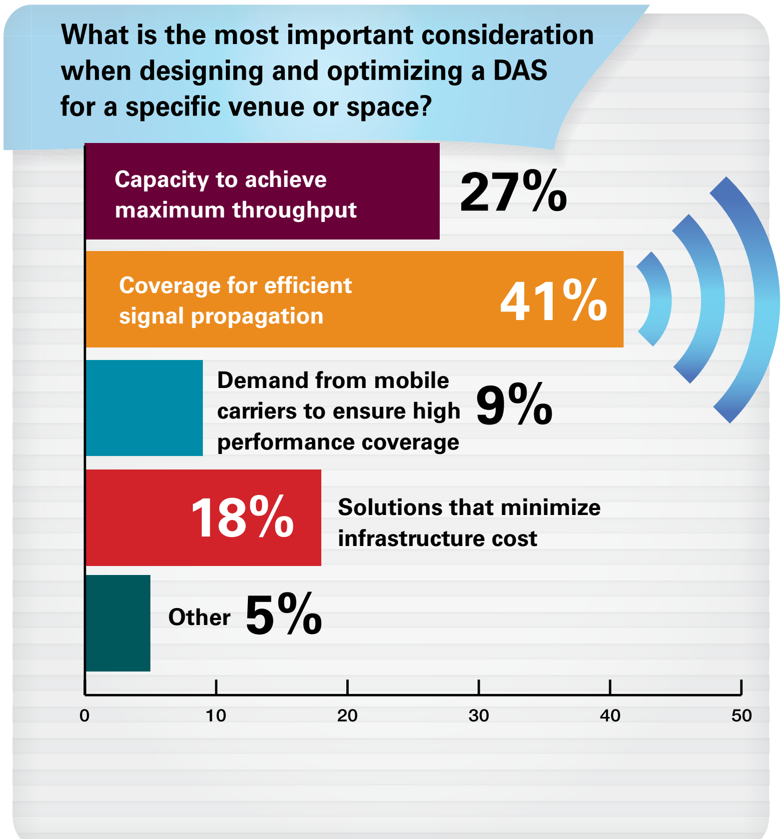
To account for for-future coverage demands, it is important for the WSP to share its roadmap of growth with the DAS designer, whether this includes plans to acquire new spectrum or projecting future traffic usage based on current subscriber data. Steps can (and should) be taken to ensure that DAS will support future traffic and frequency requirements, as already, traffic demand on wireless networks is increasing with the mainstream adoption of smartphones and tablets. To ensure long-term system performance, DAS should be designed with a flexible architecture, permitting the easy addition of more channels and frequencies. This can be accomplished by allowing for MIMO transmission (which mayinclude laying the groundwork for extra antennas, coaxial cable, fiber, and composite cable into DAS infrastructure, thereby reducing future expansion costs), incorporating multi-band equipment, and providing a core architecture that can be expanded on with modular electronic components.

Space/Venue Constraints

DAS design and installation will depend on the combination of physical variables related to the space or venue. Some considerations include: what materials were used in the interior and exterior construction of the space or venue; if the space encompasses underground floors, such as a parking garage; the possibility that RF signals may be present on upper floors or near exterior boundaries, reducing the need for in-building coverage; and the role of aesthetics, which may preclude the installation of visible hardware. Additionally, the layout of a particular space will inform the location of the head-end booster and where cables will need to run between floors.

All things considered, DAS for a specific venue requires the highest level of design, business, legal, and project management expertise. “A company/team that has experience in the design complexity of accommodating each WSP design and technology solution requirements will achieve for each the most optimal coverage and capacity objectives that is scalable to accommodate added frequencies,” says Grimes.

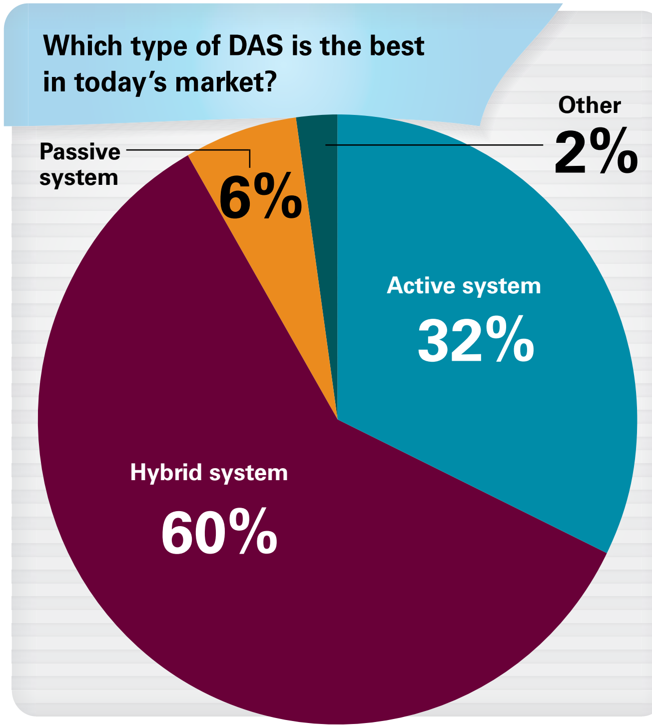
In short, Distributed Antenna Systems enable WSPs to provide sufficient coverage, while still considering aesthetic demands and zoning requirements. DAS provides access to coverage where traditional systems have been unsuccessful due to other barriers, providing consumers with enough coverage, while not being overly obtrusive.



Weighing the Systems

There are three types of DAS designs to consider: passive, active, and hybrid. Passive DAS is best utilized in smaller areas, or for iDAS specifically, in buildings without a large amount of metal, masonry or concrete to block the RF signals. Small, passive DAS are simply repeaters for signals to or from an outside antenna. A passive system uses coax cabling to distribute the signals. It is the smallest, simplest solution from a design aspect, and is often the least expensive to employ.

Active DAS is a solution best utilized in larger spaces, and in those with more barrier materials that could potentially block the RF signals from traveling through an interior space. Active DAS uses fiber optic cabling, which actually changes the RF signals into light for distribution, and then back into usable signals upon arrival at the desired locations. Sixty-five percent of engineers employ advanced fiber technologies in their Das Design. The most significant solution offered by advanced fiber technologies, and the most successful, is the all-digital transport of RF signals. It is imperative to consider employing advanced fiber technologies in your DAS, as some can actually increase coverage and capacity.



Yap says, "A true digital RF DAS solution has many advantages over analog DAS. The ability to sub-band and only send the particular blocks of spectrum to the remote end is important. This helps maximize fiber utilization and improves performance. As the industry moves more toward a software defined network (Cloud RAN), a digital architecture is the only way to achieve true C-RAN."

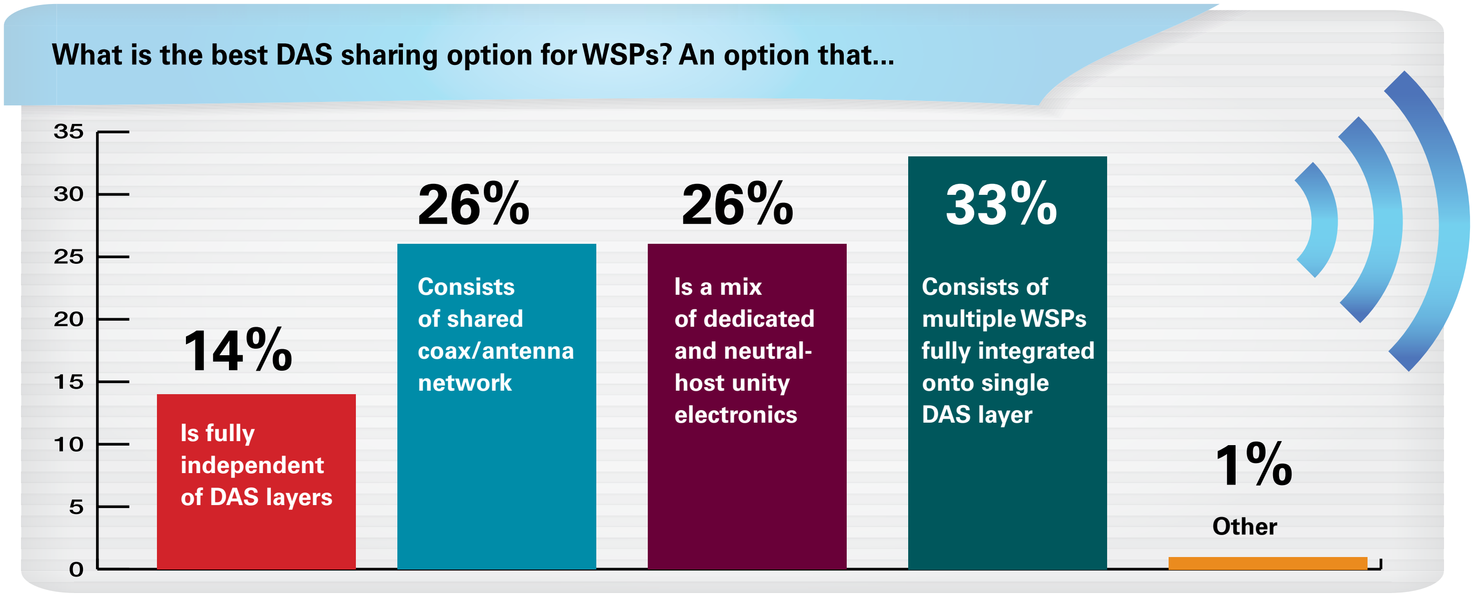
One drawback when designing active vs. passive, however, is that active systems require much more maintenance. Hybrid systems, on the other hand, combine a passive design (coax) with an active design (fiber optics) in order to distribute signals. Hybrid systems notoriously have lower signal loss than passive systems, however are still subjected to signal loss since the antennas are connected via coaxial cables. A hybrid design employs a single passive DAS, which is extended to several additional passive systems using RF amplifiers. Because the design foundations and components are the same as a passive design, the hybrid solution design time and installation deployment are minimal. In fact, of the three designs, 59% of engineers specified that they believe a hybrid system is the best in today's market.

Coordinating with Mobile Carriers

Involving mobile carriers in the design process is imperative. Being able to effectively collaborate with them on things such as negotiating, coordinating, scheduling, securing, design approval, testing the systems, etc., is an essential piece of the pie. It is not advisable to build a DAS without some input from the carriers, considering they will be less willing to pay to be on the towers companies' system if they had zero strategic input from the start of the project. Most mobile carriers want to invest in something they know firsthand is flexible, expandable, and maybe more importantly, future-proofed.

Yap says, "Planning is the most critical part of any successful DAS deployment. Often, the carriers are the ones taking the lead, but more recently, private enterprises are exploring deploying their own networks, a trend which we expect to continue. Since the DAS ultimately needs to link into the carrier network, carrier involvement is an important part of the planning process."

According to our industry engineers, when it comes to WSPs sharing options, it's pretty clear that not all are in agreement. Thirty-three percent of DAS engineers say the best sharing option for WSPs consist of multiple providers fully integrated onto a single DAS layer. Twenty-six percent say the best is a mix of dedicated and neutral-host unity electronics, though another 26% say the best option consists of shared coax and antenna networks. Grimes agrees with the latter.



"The most efficient option for WSPs in key strategic high wireless traffic areas is to have a neutral host system wherein multiple carriers with multiple technologies can be delivered through a shared fiber backbone and supporting nodes. Otherwise, you lose the efficiency of space by having redundant single dedicated systems for each WSP," says Grimes.

The remaining 14% believe that the best option is actually not to share at all, but rather to remain fully independent of DAS layers.

Yap believes the best option depends on the needs of the building owners and suggests that the right wireless solution is best determined on a case-by-case basis. "A DAS system that is a full neutral host system supporting multiple WSPs is a valuable proposition for many scenarios. Large public venues often require multi-operator support to meet the needs of a diversity of subscribers. There are cost and deployment efficiencies with multi-operator systems. Other scenarios do involve single operator systems or perhaps parallel small cell systems to support two operators. The needs of the building owners, subscribers, and networks operators are important criteria for determining the right wireless solution," says Yap.

WiFi Over DAS

The option to deploy WiFi over DAS is possible, however there are challenges and design and deployment implications that should be considered during the planning process. A WiFi over DAS solution must meet all of the requirements of any 802.11 installation, however the features may not work as designed when deployed this way.

Yap says, "The ratio of DAS remotes to WiFi are not 1-to-1 so having the ability to transport anyone's WiFi is important, but having it integrated is more costly and in many cases would not meet the WiFi design requirements if it were integrated."

Each design should be individually observed to determine if WiFi is an appropriate integration onto the DAS, and site surveys should be performed to ensure proper network operation and support of 802.11 specifications before deploying. A WiFi over DAS technology requires thorough planning and design, as well as 802.11 WLAN and RF expertise. Solutions for supporting 802.11n MIMO are available, however reduced MIMO support will affect overall performance of the WLAN. In order to avoid this, designers should verify in advance that their WLAN network performance will not be compromised.

The Push For DAS

Yap says, “Fundamentally, providing good wireless service indoors is about keeping customers happy. Subscribers expect high quality service wherever they are, even indoors, which happens to be where about 80% of data sessions begin or terminate. Venues require dedicated systems such as a DAS because concrete walls, energy efficient windows, and other factors block wireless signals from outside. Plus, today’s wireless users consume large amounts of bandwidth, so providing enough network capacity for them is equally important.”

Despite the risks, the importance of a successful wireless solution is driving the push towards employing DAS. According to research firm Mobile Experts, in 2013 alone US spending on DAS technologies was up 30% from previous years. This number will only continue to climb. With that said, in 2011 Gartner predicted that 80% of newly installed wireless networks would be obsolete in 2015 due to a lack of proper planning. This statistic alone is why it is so important to review the full scope of work in order to avoid the most common mistakes, such as failing to effectively communicate, failing to consider post-deployment approvals, maintenance, and support, neglecting to weigh the systems, neglecting to future-proof the system, failing to collaborate with the WSPs early in the process, and so on.

Designing and deploying DAS can be intimidating for even the most seasoned experts. However, in some cases it’s imperative, as customers are relying heavily on devices and effective coverage to communicate anytime, anywhere. In order to meet consumer demands and compete in the market, solutions like DAS are necessary.

KEY POINT

Despite the risks, the importance of a successful wireless solution is driving the push towards employing DAS. According to research firm Mobile Experts, in 2013 alone US spending on DAS technologies was up 30% from previous years.

Market Monitor Research Series:

Advantage Business Media's Market Monitor Research Series presents fresh research and analysis on compelling and timely industry topics. "Designing Distributed Antenna Systems (DAS)" was prepared by *Wireless Design & Development* Editor in Chief Janine Mooney. The data presented in this report is based on the results of a survey of *Wireless Design & Development* subscribers, comprised of corporate management, design/development, research and development, and manufacturing/production engineering professionals.

About the Author:

Janine E. Mooney is the Editor in Chief of *Wireless Design & Development* magazine. She manages all aspects print and digital, from content creation to trade show coverage, social media, and promoting brand awareness. Janine enjoys covering a variety of topics including, but not limited to Wearable Electronics and Smart Homes. She co-hosts *Wireless Design & Development's* weekly news show "The HotSpot," and has moderated panels discussing topics from STEM Education to Connectivity Testing for the Internet of Things (IoT).

About *Wireless Design & Development*:

*Wireless Design & Development i*s the leading technical and information resource for wireless design and technology professionals. Serving readers since 1991, *Wireless Design & Development* brings the latest new products and applications knowledge to those involved in the wireless industry design community. *Wireless Design & Development* reaches qualified professionals that are the primary decision-makers in their market segments, be it communication systems and equipment, industrial manufacturing/processing, telecommunication systems and equipment, or automotive electronics.

About Advantage Business Media:

Advantage Business Media (www.advantagemedia.com) is a data-driven marketing solutions company leveraging content, technology, and business intelligence to match its audience's job performance needs with its clients' solutions. With a diversified portfolio of highly focused websites, e-newsletters, print publications, specialized directories, vertical search databases, conferences, ancillary media vehicles, and associated web-based services, Advantage serves more than one million industry professionals in the manufacturing, science, and design engineering markets.
For more information visit www.advantagemedia.com.