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Considerations for an In-Building Distributed Antenna System

John.Whatley | Sr. RF Engineer | American Tower | for HetNet Forum

Integrating Wireless Technologies into a DAS Design

Businesses are finding a growing demand to provide a wide variety of wireless technologies in the indoor space today. Wireless cellular customers depend on the mobility of their devices wherever they go. There is a need to implement a Distributed Antenna System (DAS) with the breadth of design requirements that allow it to carry a wide range of technologies and to do it well. Venue owners and wireless carriers wish to provide their customers and occupants with a satisfying wireless user experience. The DAS may have to provide services for a range of cellular frequencies and technologies.

In addition, regulatory movement dictates that public-safety communication service is a gating item to building occupancy covering the indoor area, including both public and back-of-house areas. The DAS can provide a broadcast mechanism for reaching public-safety personnel throughout a building, and can be done with an economy of scale when combined with commercial cellular services. Public safety can be broadcast across a range of frequencies that the DAS may provide. Building owners often demand Wi-Fi service as well, from small offices to large venues such as airports and convention centers. This paper discusses the pros and cons of levels of integration that can be accomplished with Wi-Fi and a DAS.

Designing a Neutral Host DAS

Requirements – the Integration of Technologies on a DAS

Today's DAS design should consider the perspective of integrating multiple wireless services that meet performance standards demanded by the wireless provider and building owner. The design must also consider the economies of scale of sharing DAS resources among carriers. DAS vendors have advanced their equipment to meet a wider range of frequency bands and higher power outputs to address these high standards. Here are some sample key performance indicators for DAS design.

Sharing the DAS

Figuring out how to share DAS resources among multiple wireless service providers (WSPs) is an important facet of designing and operating a neutral-host DAS. Sharing DAS resources can occur on various levels, from completely independent use of separate DAS equipment for each WSP to fully integrated usage on the same equipment. Depending on the carrier, the preference can be for either dedicated or shared equipment. A DAS can be designed to accommodate either architecture or a combination of both. For the shared neutral-host architecture, the challenge is how to design it to meet quality of service and growth needs of each participant while sharing resources. If a first WSP commissions its services with a DAS, the continued level of performance must be addressed when an anticipated second or third WSP is added.

The following sections describe some guidelines and safeguards for sharing DAS equipment. First a table is presented that lists some options for DAS sharing at various levels of functional integration.

DAS Sharing Pros and Cons

DAS Sharing Option	Advantage	Disadvantage
Fully independent of DAS Layers	Full flexibility to design each system to optimal configuration, easier to debug, ownership is well defined	Cannot take advantage of common synergies, multiplied number of cable and antennas, highest cost, integrator must be careful about inter-system interference
Shared coax/antenna network	Reduce cable install costs by running fewer cables, fewer antennas in ceiling	Differing topologies may limit common cabling paths
Mix of dedicated and neutral-host remote unit electronics	Allows both neutral-host capability and WSP-dedicated equipment	Higher cost than fully integrated neutral-host DAS
Multiple WSPs fully integrated onto single DAS layer	Most cost savings, least amount of equipment	Power sharing of RF transmitting hardware may be unfair or changing, interference from unintended signal mixing

Today's DAS Equipment is Better Able to Handle Multi-Wireless Service Provider/ Multi-band/Multi-technology

Fortunately today's top-tier DAS equipment is built by design to be able to handle a wide range of frequency bands and technologies, allowing for broader use by WSPs with modern 3G and 4G wideband channels. Modern DAS systems may be built in layers or with modules that allow multiple WSPs and their channels/carriers to ride on them. Equipment often has built-in band filtering and power management to allow a diversity of signals to coexist on a DAS without any hindrance to performance. They are designed to better avoid interference issues from multiple bands transmitted that would often plague older-generation DAS systems.

Converged Cellular, PCS, Public Safety and Wi-Fi

An interesting aspect of ownership is integration of Wi-Fi and cellular services within a building. Large venues such as airports need wide-ranging Wi-Fi coverage (802.11a/b/g/n), and the DAS integrator may opt to design this functionality into the overall system design. Many are now questioning whether the Wi-Fi network should be integrated into the DAS infrastructure at some level, or should it be installed on a discrete basis. If Wi-Fi service is designed to be integrated, then the question becomes who will take ownership of Wi-Fi issues. While 2.4 GHz signals could be supported to meet the link budget, a 5 GHz (802.11a) amplification will need to occur either at the antenna element or access point. As WLANs are increasingly issued for mission- and life-critical applications, additional hardware allows for multiple points of failure. Support of MIMO is highly questionable for 802.11n. In potential support of MIMO, multiple coaxial runs are needed, which makes costs much higher than a discrete DAS design and a discrete WLAN design. The WLAN manufacturer will not provide warranty support for access points integrated with the DAS. Real Time Location-based Services will not operate as intended.

Here are some Wi-Fi/DAS integration options.

Wi-Fi Integration Options

Wi-Fi Integration Option	Advantage	Disadvantage
Fully independent of DAS	Wi-Fi operates as intended by the WLAN provider. WLAN manufacturer provides warranty support. All capabilities of the WLAN (i.e., MIMO, 802.11a, Real Time Location-based Services) operate as intended	None
Uses only DAS cable paths	Reduce cable install costs by running DAS and Wi-Fi cabling at same time	Differing topologies may limit common cabling paths
Integrated with DAS Coax/Cable	Reduces cabling and antennas	DAS antenna topology may not support Wi-Fi MIMO scheme
Fully integrated with DAS	Access points could be co-located in the wiring closet and could be combined onto a common coaxial infrastructure	Amplification will need to occur either at the antenna element or access point. Additional hardware allows for multiple points of failure and added costs.

Long-term System Performance

Although no one can protect a DAS from eventual obsolescence, there are some steps to provide flexibility for meeting new traffic and frequency requirements.

1) Build the DAS with **the knowledge of the WSP's roadmap** for future growth. The DAS designer should understand the future needs of the WSP. Limiting the design with only today's traffic in mind is risky to system performance.
2) Provide **a flexible architecture** that permits easy addition of more channels and frequencies on existing or expanded DAS equipment. Understand potential WSP providers and customer demands within the building facility.
3) Where feasible, it is a good idea to use **call generators/probes** to provide an independent view of RF key performance indicators that can assess accessibility and retainability of the throughput signal, etc. This can also aid in providing early warning of any RF degradation, and in some cases, could help distinguish DAS from RAN problems, as well as troubleshoot in conjunction with head-end Management Information Base (MIB) data.
4) In order to mitigate uplink noise rise from for high-density, peak-traffic scenarios, it is a good idea to ensure RAN sectors feeding the DAS are set to **high-capacity parameters**; invoke traffic throttling on these RAN sectors, keep the soft handover from the DAS to the macro-cellular network outside the venue, and whenever possible, allow automatic authentication of subscriber devices onto the Wi-Fi network for offload.

Understanding the WSP's Frequency/Traffic Demand Projection Plan

If the WSP can share its roadmap with a DAS provider, it will help ensure adequate DAS capacity over time. Traffic demand on wireless networks is really ratcheting up with equipment like Apple Inc.'s iPad and iPhone, Google Inc.'s Android operating system, and other smartphones, tablets and emerging devices. Further, the majority of wireless traffic occurs indoors. How does a DAS provider account for these changes? This is not an easy task, but here are some items to consider:

- *Expanded or shifted frequency band licensing and use* – the WSP may be acquiring new spectrum or planning to use spectrum it owns but has in reserve. The WSPs should share that information with the DAS designer.
- *Available RF traffic channels* – as macro outdoor wireless traffic increases, additional channels are often commissioned per sector to meet demands. These may be available for indoor use too.
- *WSP traffic growth predictions* – the WSP looks at subscriber and usage data for indoor venues and projects traffic usage and number of channels required to meet subscriber traffic over some foreseeable period of time. What will traffic look like on the DAS three years from now?

The DAS designer can use all of that information to determine how to best design the DAS. The following table lists typical traffic demands that a carrier may expect a DAS to carry.

DAS Traffic Demands Example

Venue Name	DAS Coverage Area (sq. ft.)	Peak Attendees	Three Year Voice Erlangs	Three Year Data Erlangs	Required # of Sector Carriers	Required Number of DAS Zones/Sectors
Entertainment Venue	2,500,000					
Convention Center		50,000	450	700	47	10
Coliseum		15,000	150	200	14	3
Casino		10,000	100	175	12	3
Hotel & Other Areas		5,000	50	80	6	2

One consideration in the design of a DAS that will handle this capacity is to build a DAS that will accommodate the number of sectors the WSP desires to broadcast on it. This is done by dividing the venue's coverage area into DAS Zones, allowing each WSP sector to cover one or more zones with a WSP sector. The DAS can provide capacity for both low- and high-use WSPs alike. This allows the DAS to accommodate the worst-case number of sectors, meeting the traffic demands of each WSP.

Flexible DAS Equipment

Over time the DAS equipment manufacturers have designed increased bandwidth into their products. The DAS designer can use these products to provide a flexible design. This can be done either by building in the capability up front with multi-band equipment, or by providing a core architecture that can be easily expanded with modular electronic components.

Provision for a flexible architecture should also include allowing for MIMO transmission. Although there is debate over how much MIMO helps with data speeds in an in-building venue, there is at present enough demand by certain carriers where a DAS integrator must seriously consider provisioning for it. It may be cheaper to provision up front, such as pulling a higher cable-quantity bundle and installing two or more antennas versus one at each antenna node location. DAS OEMs have several schemes for implementing MIMO.

Careful planning, flexible architecture and DAS partitioning should all be factored together when formulating a strategy for growth. This path should also be designed to protect the interests of incumbent DAS users while providing for future needs.

Lessons Learned

In summary, some lessons learned from this case study are as follows:

1) Pre-plan for system growth – expect growth!
2) Know the limits of the DAS and do not exceed them.
3) Provide a way to re-engineer or expand the DAS to provide design flexibility.
4) Design each DAS network with inter-dependencies of other networks in mind. Performance of one DAS should not degrade the performance of another.
5) Use quality components that meet design specification and have a large MTBF (mean time between failures).
6) Employ skilled contractors that will assemble and install cabling and components in a reliable manner and will verify and warrant system performance.

Taking heed to these guidelines will go a long way toward designing a DAS that meets both current and future requirements while maintaining strong system performance.

If you'd like to learn more about Considerations For An In-building Distributed Antenna System, a complete report is available through the HetNet Forum. Contact Tracy.Ford@pcia.com to request the report.

About the author: John B. Whatley is Senior RF Engineer, DAS Network Operations, at American Tower. As a senior RF engineer, John provides analysis and design of in-building DAS networks. John analyzes system requirements, writes technical proposals, sets design standards, develops design tools, designs systems, verifies performance, and helps lab test new DAS products. He trains younger RF engineers and participates in the HetNetForum, part of PCIA – The Wireless Infrastructure Association.