HetNetForum

HetNet Forum

Distributed Antenna Systems (DAS) and Small Cell Technologies Distinguished

Febuary 2013

Contents

Introduction[1]

The most familiar component of a cellular network is the cell tower and the antenna installations on other tall structures such as multi-story buildings and municipal water towers. These large cell sites, often referred to as "macro" cell sites, form the core of the macrocellular network, enabling wireless service providers to deliver voice, text, and broadband communications to today's 322 million U.S. wireless subscribers. Macrocell sites are effective for covering large geographic areas with relatively high capacity, because the antennas are typically mounted on tall towers or the rooftops of tall buildings and transmit radiofrequency (RF) signals at high power levels. They are also typically capable of hosting multiple wireless service providers. However, although a tower or building-mounted macrocell can be upgraded over time, coverage areas cannot typically be expanded.

Distributed Antenna System (DAS) Networks are being deployed to provide coverage in targeted locations, moving radios closer to the subscriber, and to provide additional call and data-handling capacity in areas with concentrated demands for wireless services.

Macrocell sites, DAS Networks and each of the various small cell technologies have unique characteristics and capacities that make them most suitable for deployment in specific environments and for resolving particular coverage and capacity challenges. The needs of the wireless service providers and their subscribers and the application of cost-benefit analyses dictate where and in what combinations the respective solutions will be deployed. Together the combination of the macrocellular network with DAS Networks and various small cell solutions has been termed the "heterogeneous network" or "HetNet". The purpose of this article is to promote awareness of DAS and other small cell technologies.

DAS Networks Defined

A DAS Network consists of three primary components: (i) a number of remote communications nodes (DAS Node(s)), each including at least one antenna for the transmission and reception of a wireless service provider's RF signals; (ii) a high capacity signal transport medium (typically fiber optic cable) connecting each DAS Node back to a central communications hub site; and (iii) radio transceivers or other head-end equipment located at the hub site that propagates and/or converts, processes or controls the communications signals transmitted and received through the DAS Nodes. Depending on the particular DAS Network architecture and the environment in which it is deployed, DAS Nodes may include equipment in addition to the antennas, *e.g.*, amplifiers, remote radio heads, signal converters and power supplies.

---

[1] This article is not meant to provide a rigid recipe for the uses of the various technologies discussed, nor is it intended to serve as a statement of any position on how or where the various network technologies and services fit within potential regulatory or legal frameworks. Further, these technologies continue to develop and mature. The figures related to number of simultaneous connections or coverage areas are meant as an approximation of the current state of technology at the time of this article's publication.

DAS Network can be deployed outdoors or within large buildings and partially enclosed structures, and a DAS Network can range from two to hundreds of DAS Nodes. Each DAS Node typically transmits RF signals at much lower power levels than is common for macrocell sites. Outdoor DAS Nodes are typically attached to utility poles or similar structures in the public rights of way (PROW) at heights that are relatively low and uniform, consistent with the smaller coverage area for each DAS Node.

DAS Networks are attractive solutions because they are scalable and flexible. Like macrocell sites, DAS Networks can be configured to support multiple wireless service providers deploying a variety of frequency bands and wireless service technologies in a small form-factor. While DAS Networks are often driven by the same radio transceiver equipment that is used with macrocell sites, DAS solutions enable these resources to be narrowly targeted to the areas where they are most needed and the capacity can be shifted to different parts of the DAS Network as subscriber locations and demands shift.

Distinguishing DAS Networks from Small Cells

Historically, the term "small cell" has been used to refer to microcells, picocells/metrocells, and femtocells. There are certain similarities between DAS Nodes and small cells that often give rise to some confusion. Like DAS Nodes, small cells transmit at signal power levels that are much lower than macrocells and are physically much smaller. In addition, small cells are typically mounted or installed in the PROW at low elevations when deployed outdoors.

However, DAS Networks and the various types of small cells differ greatly with respect to functionality, capacity, complexity, and cost, among other things. These network architectures and technologies are not interchangeable and each is suitable only for the particular purposes and deployment environments it is designed to address.

In contrast, small cell solutions are typically deployed piecemeal to provide coverage or enhance capacity in much smaller areas with a single wireless communications technology for a single wireless carrier. While each small cell installation is similar to a single DAS Node installation in that it requires a communications link back to the larger network, an electric power source, and location space, an appropriately configured small cell can generally be deployed to provide an immediate solution to a more isolated and smaller coverage or capacity challenge in a manner that requires much less upfront design work, planning and capital investment than DAS facilities.

Importantly, DAS Networks differ from small cell solutions because the distributed architecture of a DAS Network – including the design and configuration of the high capacity fiber optic network providing interconnectivity and the ability to operate large numbers of DAS Nodes from a central hub location – makes the typical DAS Network a much more robust, scalable, flexible and efficient solution to a range of capacity and coverage challenges than small cells. For example, a DAS Network can be deployed to simultaneously accommodate multiple wireless frequencies and technologies for two or more wireless service providers. A DAS Network can also be designed or relatively easily retrofitted to handle 2G, 3G and 4G commercial frequencies that operate in a range from 700 to 2500 MHz, as well as public safety UHF and VHF frequency bands (150 and 450 MHz band channels). A DAS Network can also be configured to support numerous Wi-Fi access points.

While a given DAS Network may involve as few as two DAS Nodes, the vast majority of outdoor DAS Networks and most indoor DAS systems deployed in large structures involve ten, fifty, or even more DAS Nodes. Outdoor DAS Networks cover areas ranging from several blocks, to whole neighborhoods, to entire cities. DAS Networks can require significant upfront capital investment because of the size and complexity of the network. Initial costs include installing, equipping, configuring and bringing power to multiple DAS Nodes and the extensive fiber optic cabling and other transport links that provide high capacity connectivity between each of the DAS Nodes and the radio transceivers or other head-end equipment at one or more hub site. It is this initial investment in careful network design and the construction of high-capacity network connectivity, as well as the significant investment in head-end and DAS Node equipment that makes DAS Networks such flexible and scalable solutions. But, it can take many years of use for a DAS Network to achieve profitability for the DAS providers and wireless service providers who bear the upfront costs.

Distributed Antenna System Networks

A DAS Network is used as a method of distributing RF signals from a central hub to specific areas with poor coverage or inadequate capacity and aggregating the return signals at the hub for interconnection with the larger telecommunications network. Three primary components are featured in each DAS Network solution:

1. A number of remote communications DAS Nodes, each including at least one antenna for the transmission and reception of a wireless service provider's RF signals. Depending on the particular DAS Network architecture and the environment in which it is deployed, DAS Nodes may include equipment in addition to the antennas, e.g., amplifiers, remote radio heads, signal converters and power supplies.
2. A high capacity signal transport medium (typically fiber optic cable) connecting each DAS Node back to a central communications hub site; and
3. Radio transceivers or other head-end equipment located at the hub site that propagates and/or converts, processes or controls the communications signals transmitted and received through the DAS Nodes.

Modern DAS solutions are typically configured as RF-to-optical-to-RF systems. That is, the head-end equipment converts RF signals generated by the wireless service provider's radio transceiver to optical signals that are transported via fiber optic cable to the DAS Nodes where the optical signal is converted back to RF in order to be transmitted via the remote antenna. Other configurations, typically used by Long Term Evolution (LTE) and WiMax operators, utilize an optical driver-to-fiber-to-RF system configuration. In this scenario optical output head-end equipment drives light along the fiber to remote sites where, for the first time, the signal becomes an RF signal. The transportation of the wireless service provider's signal, no matter the configuration, can stretch many feet or many miles depending on the system design and may span multiple municipalities or other local jurisdictions.

Use Cases

As more people adopt high-capacity wireless devices such as smartphones and tablets, DAS Networks are being deployed as an unobtrusive means to expand data throughput capacity and provide more uniform coverage. Since most DAS Networks are technology-agnostic, DAS Network deployments are attractive to wireless service providers that hold RF spectrum licenses across

multiple frequency bands and use multiple wireless technologies (as well as wireless service providers that anticipate upgrading to new technologies such as 4G LTE). A DAS Network may be deployed and owned by a single wireless service provider, a third-party neutral-host DAS Network service provider, an enterprise customer or a building or venue owner.

As noted above, DAS Networks are deployed both indoors and outdoors. Indoors, the technology is deployed in spaces where large numbers of people congregate, such as sports stadiums and arenas, convention centers, and healthcare facilities. Typically, these large, enclosed and RF-shielded spaces cannot be served effectively by existing macrocells located outside the structure. Outdoor DAS Networks are usually deployed in urban and suburban areas with medium to high capacity requirements. Increasingly, outdoor DAS Networks are deployed in targeted locations within an area that already has macrocell coverage to increase capacity. Some DAS Networks also support Wi-Fi, which can be used to off-load data traffic from capacity-constrained macrocells.

Characteristics of DAS Networks

Each outdoor DAS Node can be configured to support up to sixteen frequency bands, typically has a range of less than half a mile, and can support up to 300 simultaneous connections when driven by a full-scale radio transceiver such as those used for macrocells. In outdoor DAS Networks, the DAS Nodes are typically collocated in the PROW on existing infrastructure, such as utility poles and streetlights. Depending on the number of DAS Nodes and the capacity of the wireless carrier equipment interconnected to them by means of a given DAS Network, DAS architecture can be used to cover larger geographic areas and/or handle thousands of simultaneous user connections.

Like an outdoor system, indoor DAS Networks can support up to sixteen frequency bands and can support thousands of devices depending on the number of radio transceiver sectors allocated to the network. Though coverage will vary, current indoor DAS remotes typically support coverage areas of 5,000 to 25,000 square feet. Large buildings can have several DAS Nodes per floor.

Limitations

Because DAS Network installations can require significant upfront capital investment, especially when deployed outdoors, due primarily to the costs associated with designing, siting and installing multiple Nodes and miles of fiber optic cabling. The design of DAS Networks involves unique considerations that make the design and deployment of the network different from the traditional macrocellular engineering process. It is important that the design be performed by individuals that understand the differences.

Microcell Solutions

The term "microcell" is conventionally used to describe a single, outdoor, short-range radio transceiver. It is typically deployed to enhance existing macrocell coverage. Occasionally, microcells are installed indoors to improve coverage and capacity. Microcells can be installed on a utility pole or the side of a building.

Use Cases

Microcells and their smaller counterparts, picocells, are usually deployed to improve network coverage and capacity in a given area. Microcells can be used outdoors and indoors, often in high-traffic areas like public transportation spaces or a single city block with heavy cellular traffic. A microcell is physically bigger than a picocell, and has greater coverage and capacity capabilities which allows microcells to support more users than picocells.

Characteristics of Microcell Solutions

This solution can support up to 200 users and has a total range of up to two miles. Microcells require professional installation and maintenance.

Limitations

As a standalone device, microcells can support a single carrier with up to two frequencies on a single technology (either GSM, UMTS, or 3G/4G).

Picocell/Metrocell Solutions

The term picocell describes a small cell technology that can be used both indoors and outdoors. Indoors, picocells are generally used by a wireless service provider to increase capacity in a defined area. Outdoors, they can be used to fill gaps in coverage or increase capacity. The term "metrocell" is sometimes used to describe a picocell in a high-traffic urban area.

Use Cases

Picocells are smaller than a microcell, with a smaller equipment size, and lower transmit power. Picocell solutions are typically intended for installations in enterprise environments up to 30,000 square feet. Wireless service providers use them to fill coverage gaps in high-traffic environments like railway stations, subway platforms and bus terminals. Outdoor picocells are often mounted on the side of a building or in the PROW on utility poles, street light poles, traffic signal poles, etc. They are typically supported by fiber optic backhaul connections.

Indoor picocells provide small coverage areas to address coverage and/or capacity challenges. Deployments are regularly found in airports, hotels, corporate offices, and academic campuses. Their coverage area can be as small as thirty-three feet in an office setting. Picocells are generally owned by wireless service providers. They require professional installation and maintenance.

Characteristics of Picocell Solutions

Picocells are small. The picocell pictured above, from CommScope, measures 10.8 inches by 3.7 inches by 16.9 inches and weighs thirteen pounds. They can support up to eighty users, depending on the equipment installed. The industry is currently developing and launching multiple LTE-capable picocell solutions.

Limitations

Picocells only support a few frequencies and only one wireless service provider per unit. They typically cost more than femtocells and require professional installation and configuration. Like microcells, picocells are generally not interconnected like Nodes within a DAS Network. However, a single site may have multiple picocells deployed to solve a coverage or capacity issue.

Femtocell Solutions

Femtocells are small, fixed, standalone, low power cell sites designed to improve wireless reception inside a home or small office building. Femtocell solutions typically support two to six active connections in a residential setting and twenty or more in the business enterprise setting. A femtocell utilizes the subscriber's Internet service to connect to the wireless operator's core network.

Use Cases

There are several types of femtocells intended for different uses including residential, small businesses, and large businesses. For example, Verizon Wireless, AT&T and Sprint Nextel all offer femtocell solutions. It is important to note that a femtocell from one carrier will not support another carrier's device. Because of this, femtocells are usually deployed in homes or by small businesses without heavy customer traffic. For example, a femtocell may be a good solution to get better wireless coverage in a home-based business.

The end-user customer may pay a few hundred dollars for the femtocell solution, although in some cases the operator may offer the femtocell for free. In most cases, especially with residential femtocells, professional installation is not required.

Characteristics of Femtocell Solutions

Femtocells are small. AT&T's femtocell, pictured above, is 8.5 inches high by 6.3 inches deep by 1.5 inches wide at the top and 4 inches wide at the base. It weighs just over one pound. The maximum number of devices a femtocell can support ranges from 4 to over 20. The coverage range is typically up to 5,000 square feet for a residential femtocell. Verizon Wireless sells two femtocell devices – one intended for residential and another for small business customers. The residential device, which can connect six simultaneous voice calls (or four simultaneous EV-DO data calls), covers up to 5,000 square feet and costs around $250. The Network Extender for Business costs $400, can connect six simultaneous voice calls or eight simultaneous EV-DO data calls and covers an area up to 7,500 square feet. Network Extenders can be linked to cover up to 10,000 square feet.

Limitations

Femtocells currently only support a single technology from a single wireless service provider. Supporting a single technology means separate units are required for 3G and 4G support, even from a single carrier. Femtocells can generally hand-off an RF source to the macrocellular network but

cannot hand-in the RF signal from the macrocellular network to the femtocell. In this way, the technology acts as a one-way broadcast and not a seamless and adaptable part of the network. The subscriber supplies the power and backhaul to the wireless network through a subscription wired broadband connection. In most cases the subscriber must register which phone numbers are allowed access to the wireless provider's network via the femtocell.

Wi-Fi Solutions

Wi-Fi technology allows electronic devices to exchange data over a computer network wirelessly using unlicensed radio frequency spectrum. Devices such as personal computers, video game consoles, smartphones, tablets, and TVs can use Wi-Fi to access the Internet via wireless access points, also called "hotspots". Hotspots have a range of about 20-200 feet indoors. A Wi-Fi hotspot can contain one or more access points (APs) that deliver the connectivity to a specific network. In this instance, however, it is describing each AP as a hotspot, when in fact all the AP's within a single coverage area are part of a single hotspot, much like each DAS Node of a DAS is part of the whole.

Use Cases

Wi-Fi connectivity is prevalent throughout the United States on a wide variety of devices and in a plethora of venues. People install wireless routers in their homes so they can remain connected to their home network and the Internet from room to room. Wi-Fi service is also available in many retail chains and independent businesses, as well as in public spaces at Wi-Fi hotspots set up either commercially or free of charge. Organizations and businesses, such as airports, hotels, and restaurants, often provide free-use hotspots to attract customers. Enthusiasts or jurisdictions who wish to provide service or promote business in selected areas sometimes also provide free Wi-Fi access.

Characteristics of Wi-Fi Solutions

Unlike the other technologies listed in this document, Wi-Fi uses unlicensed radio spectrum in the 2.5 and 5 GHz bands. Wi-Fi is based on the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards. Wi-Fi enables cheaper deployment of local area networks (LAN) because it reduces the need to run wires for cabled connections. To date, Wi-Fi has largely been a consumer-oriented technology not requiring professional installation and coordination. However, in large enterprise deployments (multistory buildings, entertainment venues and convention centers) RF engineers often aid in installation.

Limitations

Wi-Fi is only available when hotspots provide consumer access. Wi-Fi can ride on top of the wired element of a DAS. However, the caveat is that the Wi-Fi RF coverage range from a shared antenna is smaller than voice services due to its higher frequencies, so the antennas need to be closer to provide seamless Wi-Fi coverage, which translates into more antenna and reduced voice power levels to minimize the overlap.