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Distributed Antenna Systems

In this issue

Increasing demand for seamless voice and data coverage is driving extensive wireless infrastructure. The service providers are expanding growth of their telecom infrastructure both in urban and rural areas in order to increase the coverage of their networks. The service providers have responded to growing demands for wireless data communication with the deployment of high speed data technologies. Provisioning of seamless voice and data coverage especially in indoor environment becomes a challenge for the service providers. Mobile signal reception in extremely dense urban areas becomes weak in many pockets. Steel and concrete structures in dense urban areas are barriers to macro network RF signal. To overcome this operator need to put more towers and also place towers closed to large complexes.

One of the methods to reduce the number of towers, increase capacity and reuse spectrum is to deploy Distributed Antenna System (DAS). A Distributed Antenna System (DAS) can be designed for use in both indoors or outdoors to facilitate provisioning of seamless wireless coverage. A distributed antenna system (DAS) is a network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure[1]. DAS splits the transmitted power between separated antenna elements. It distributes radio-frequency signals from a central location or head-end to remote antennas (Figure 1). This simplifies the network, improves coverage, capacity and aesthetics and reduces costs & power requirements. DAS supports dynamic resource allocation and facilitates better management of wireless resources and available spectrum, by closely aligning capacity to actual market requirements.

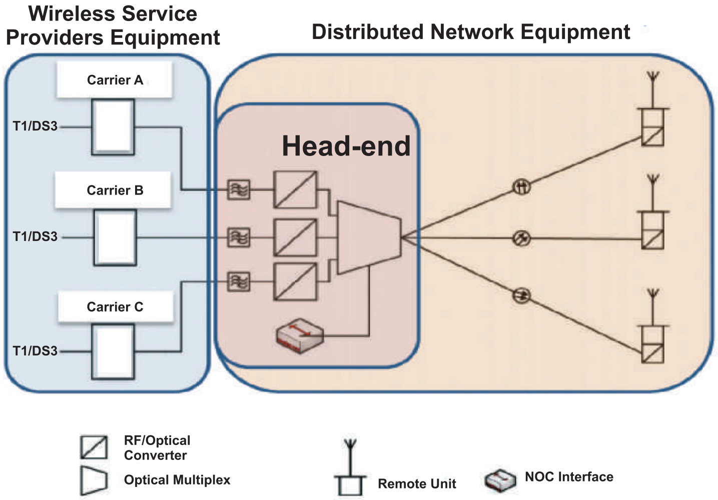

Figure 1: Distributed antennae system

Using this approach the overall power requirement is less as more localised antennas can be placed in the required coverage area, rather than having a single, larger antenna radiating more power for the wider coverage. This also helps in overcoming the shadowing and penetration losses because a line of sight link is available more frequently.

70% of cellular calls and 80% of data connections originate from indoors (Strategy Analytics)[2].The integration of optical technology in RF distributed antenna systems (DAS) provides an efficient indoor coverage system. An indoor DAS system distributes radio signals from one or more base stations and access points to any number of antennas located throughout the building. For an in-building network a single distribution backbone with a multi-band distributed antenna system can accommodate CDMA, TDMA, GSM, iDEN, LMR, DCS, GPRS and WiFi 802.11x, all in an interference-free environment[3].

DAS provides coverage in areas that cannot be effectively addressed with traditional sites. DAS is a scalable network that can meet future capacity requirements, or additional carriers, by adding additional nodes. It can be upgraded to improve capacity, coverage or to support future services without changing existing antenna systems. DAS can also respond to market dynamics, equipment architecture changes and new technologies. It is a network architecture that provides the ability to quickly incorporate new technologies. It facilitates better utilization of transmission infrastructure given aggregation from a central hub location.

DAS supports multiple systems of multiple operators in high traffic places such as airport terminals, subways, multi-storeyed buildings, etc. It such cases DAS involves infrastructure sharing that reduces the both CAPEX and OPEX and simplifies the operation and maintenance. In the absence of such infrastructure sharing separate infrastructure has to be rolled out by each operator. Wireless Service Providers (WSP) can realize a 15-40% reduction in both Capital and Operating Expenditures annually by migrating to a DAS architecture.

End user benefits of DAS include better coverage, better voice quality with fewer dropped calls, faster Internet access, longer battery life, seamless handoffs with the macro network. For service providers DAS provides increased coverage, a multi-carrier, multi-band, multi-technology solution, increased customer satisfaction, lower churn rate. It facilitates offloading of traffic from macro cells and facilitates efficient utilization of spectrum. DAS facilitates better management of available spectrum and wireless resources by closely aligning capacity to actual market requirements. It reduces interference through low radiation centers and lower output power. DAS provides better data throughput due to better signal strength and proximity of transmission points to user equipment.It provides better radio trunking efficiency by allowing larger areas such as the entire multi-storeyed building, to be served by a single cell. DAS implementation can also provide aesthetic look and reduction in radiation in addition to reduction of towers.

Wireless service providers are now using DAS to add additional capacity — not just coverage — to their network. Tablet and smart-phone customers are accessing more wireless content than ever before. Pole attachments, hub sites, rights-of-way issues and carrier agreements all have to be successfully managed to deploy DAS solutions. While femtocells mainly are used for residential, in-home deployments, and microcells and picocells only address the needs of one service provider and one or two technologies or frequencies, a DAS can address a multitude of frequencies, service providers and technologies[4].

DAS Architecture

For an indoor DAS network, remote antennas are strategically placed throughout a building and are connected with fiber to a single hub containing the wireless service provider's equipment. The indoor DAS solution provides building owners with a single system to address their wireless needs and provides wireless carriers with a system that allows them to tailor their RF signal to meet their specific coverage and capacity needs. An outdoor DAS network consists of a central hub location which links, via fiber, a system of strategically placed antenna locations (or nodes) to provide carriers with pinpoint coverage not provided by traditional coverage

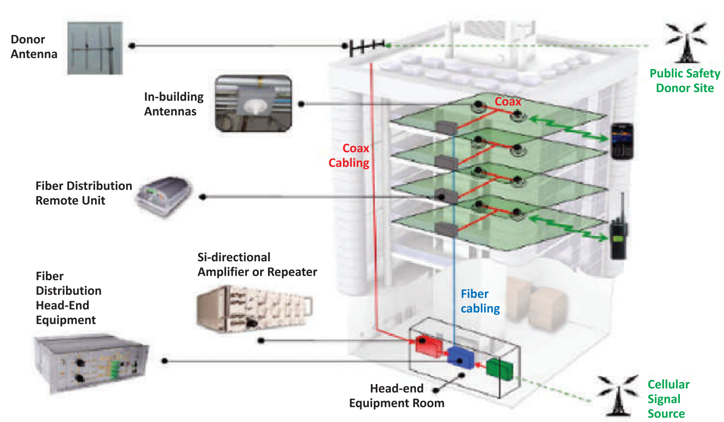

Figure 2: In-Building Distributive Antenna System

methods. In addition, antennas can be placed on street lights or utility poles or cleverly camouflaged as street signs, cacti, boulders or other objects[1]. A typical indoor & outdoor implementation are shown in figure 2 & 3 respectively.

Often times a DAS uses RF directional couplers and/or wireless amplifiers to split and amplify the wireless signal from the source out to the distributed antennas. In many cases a DAS may use a combination of low loss coaxial cabling as wellas fiber optic cabling supporting radio over fiber (RoF) technology to distribute the wireless signals to the antennas[6].

DAS typically uses a fiber optic backhaul, but the RF solutions also enable carriers to rapidly deploy DAS when the complexity of laying fiber is too high. The backhaul radio enables a high level of flexibility because it is a small-cell backhaul solution that expands capacity and coverage of macro cells. It is claimed that network operators can put their DAS anywhere they want and connect with a very low latency wireless link[7].

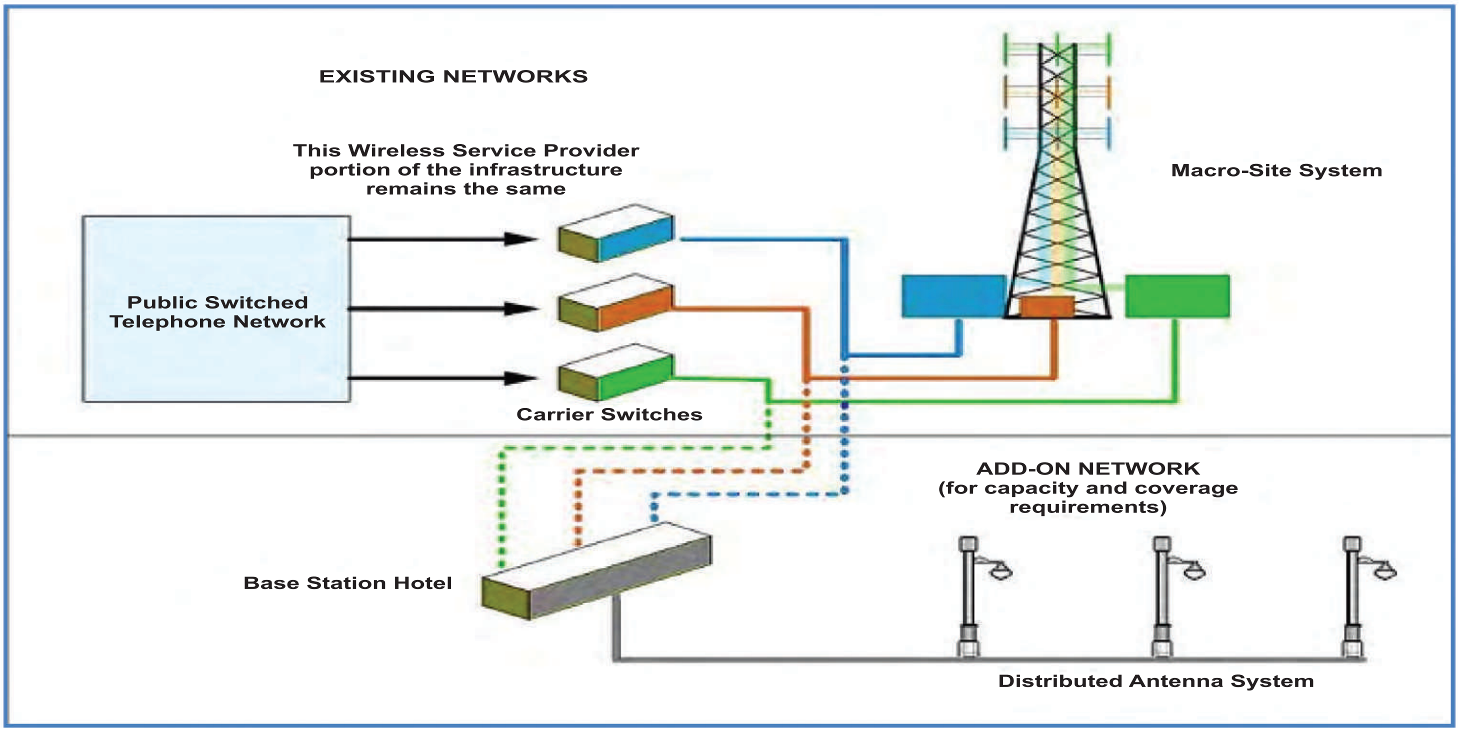

Figure 3: Typical outdoor DAS implementation

Types of DAS

The three different types of DAS usually considered are passive, active and hybrid DAS.

Passive DAS systems(Figure 4), uses different components to split the signal power between the antennas. These components are passive, i.e. they do not need external power supply[8].

1. Coaxial cables: Coaxial cables are used to split the signal and form the link between the different elements of the DAS. Their main disadvantage is high signal loss depending on the distance.

2. Splitters: This component equally splits the input signal into N output signals. It is used as an interconnection to split the signal between the different antennas.

3. Taps: Taps are similar to splitters, but are able to divide the input signal into two output signals with different ratios. They are used to adjust the power to allocate to different floors.

4. Attenuators: These simply attenuate the signal with the value of the attenuator. They are used to bring the signal to a lower level.

5. Filters: These are used to separate frequency bands, for example, a triplexer can separate the incoming signal into three output signals corresponding to the frequencies 900MHz, 1800MHz and 2100MHz.

6. Other components: Some other components can also be used to design indoor networks, for example, terminators are used to end a line, circulators to protect a port against reverse reflections due to a disconnected cable in the system, and couplers are used to combine signals from different incoming sources.

One variant of a passive DAS employs radiating coaxial cables instead of discrete antennas. The decision to use discrete antennas or radiating cables is usually based on factors such as building structure and installation constraints. Passive approach doesn't always provide the coverage and capacity needed. Many of the smaller less complex locations can be served with passive systems. The size of the area, complexity, and other factors determines the type of system required.

Active DAS systems (Figure 5) depend on power to transport the radio frequency between the service provider's equipment and all parts of the DAS. Different active elements are described below.

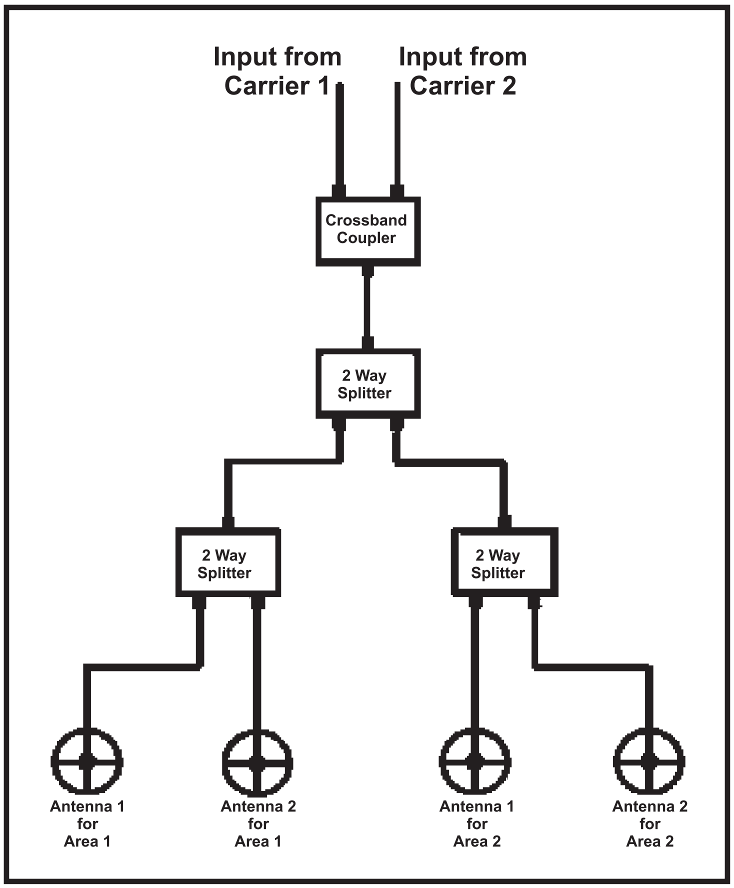

Figure 4: Passive DAS system

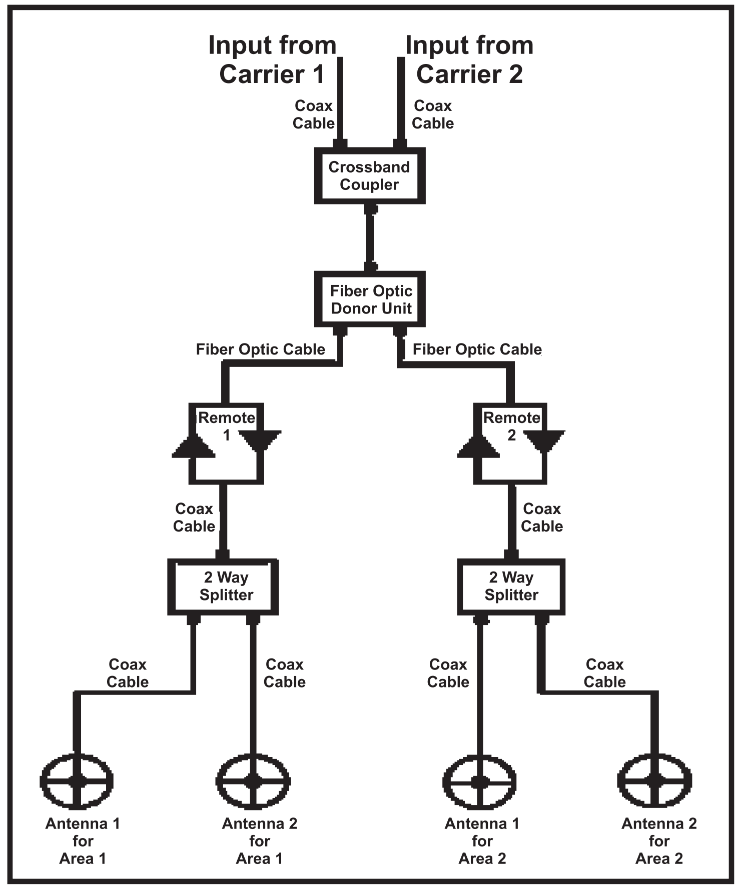

Figure 5: Active DAS system

- The master unit: The master unit (MU) can be connected to the base station or the repeater. It distributes the signal via the optical fibre to the different expansion units. The master unit is the intelligent part of the distributed antenna system that controls all the signals to deliver and adjust the signal levels thanks to internal amplifiers and converters.
- Remote unit: The RU is installed near the antenna to minimize the losses and is connected to the antenna. The RU converts the signal from the RU into downlink radio signal, and converts the uplink radio signal into signal to the EU.

Hybrid DAS combines active components, installed between the RF source and the floor, and usually coaxial cable for passive transmission across the last few meters on each floor. These systems offer some of the signal management and adaptation of the active system and some of the cost saving of the passive system. Figure 6 shows the architecture of a typical hybrid DAS solution [3].

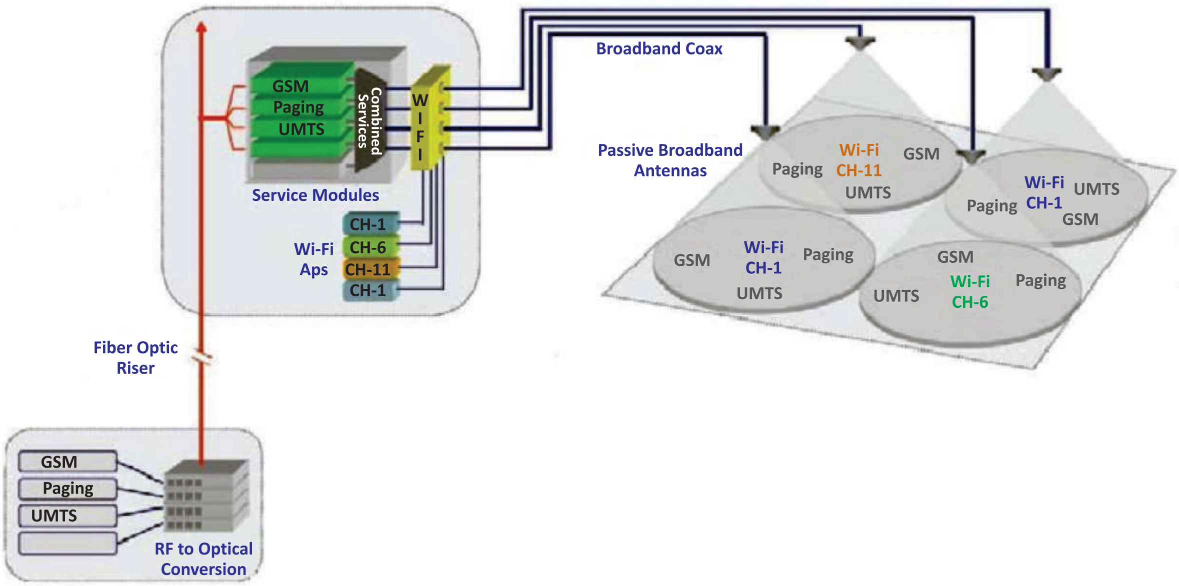

Figure 6: Architecture of a hybrid distributed antenna system

DAS Implementation

There are three prominent business models for DAS. Firstly the '**Carrier/operator pays (traditional model)'** wherein a service provider covers cost of all equipment, cabling, and installation. Another is '**Enterprise pays'** model wherein enterprise pays for all equipment, cabling, and installation (service provider provides RF source).

Lastly '**Neutral Host'** model in which the neutral host bears the burden of CAPEX and project organization.It is a system that can support multiple services and applications from multiple service providers – all sharing the same infrastructure. There are several licensed service providers and if each lay a separate cable and install separate DAS infrastructure, it will result in duplication of network and may create a condition much worse than the towers. This situation can be handled by mandating sharing of such infrastructure or neutral host model for expanding a wireless network footprint by adding coverage and capacity in hard to reach areas, resulting in increased quality without requiring customers to make the capital investment to build their own network system or manage additional infrastructure. The neutral host model results in focused ownership of the wireless assets that may add value throughout the life of the project. The neutral host gets revenue through leasing the system to the service providers.

Challenges

The roll-out of a distributed antenna system involves several important challenges. Firstly, as DAS is shared among the different operators more collaboration is needed among them especially regarding the financing model of the infrastructure.Generally, building owners prefer the cost to be borne by the wireless operator. However, other business models as described above are emerging nowadays, which share the burden and the reward of the rollout of the IBWS(In-Building Wireless Solutions) differently . The cost of these solutions is relatively high so the roll-out of these systems is limited to buildings beyond a minimum size. Furthermore, the costs are dominated by the installation costs so the roll-out of this solution is mainly focused on new buildings. Secondly, the integration of multiple communication systems involves a set of serious technical challenges. The integration of different radio systems with different link budgets forces to design the system according to the requirements of the most demanding system. Another challenge is to maintain a suitable intermodulation performance among systems with different output power and frequency bands. Moreover, the use of a common infrastructure has the drawback that if this infrastructure fails, all the systems will be affected. Therefore, the provision of several contingencies such as fail in the power supplies or the installation of redundant equipment is needed. This fact makes difficult the integration of the public safety systems in the shared DAS[9].

Regulatory Initiatives so far

In its recommendations on "Telecommunications Infrastructure policy recommendations" dated 12th April 2011 TRAI had recommended that Infrastructure Providers (IP-I) and telecom service providers should be mandated to share IBS/DAS system deployed in the buildings, complexes or streets to promote deployment of IBS/DAS. It was recommended to DOT to advise all ministries to provide, within next one year, In Building Solution (IBS)/Distributed Antenna System (DAS) solutions in all Central Government buildings including central PSU buildings, Airports and buildings falling under their jurisdiction & control. Also, all State Governments should be similarly advised to provide/mandate, within next one year, IBS/DAS solutions in all buildings including hospitals having more than 100 beds and shopping malls of more than 25000 square feet super built area. For outdoor coverage it was recommended that DAS should be mandated for deployment in 63 JNNURM cities within 18 months after completion of optical fibre network in these cities under the National Broadband Plan.

Recently issued National Telecom Policy 2012 (NTP 2012) mentions that ***use of In-Building Solutions (IBS) and Distributed Antenna Systems (DAS)*** *should be promoted through coordination with Ministry of Urban Development by aligning theNational Building Code as well as embedding requirements of IBS/DAS in the process of developmental planning and finalizationof master plans for rural and urban areas in consultation with the State Governments.*

Conclusion

As a promising technique for future wireless communications, the distributed antenna system has received considerable attention in recent years. It can significantly improve the system capacity, cell coverage and reduce power consumption in comparison with traditional towers & antenna systems, and thus it has become one of the key technologies in next generation mobile communication systems such as 3G-LTE (long term evolution) and IMT-advanced[10].

DAS system can support a wide variety of technologies and frequencies, including GSM, CDMA, WCDMA, HSPA, LTE and WiFi. As mobile operators seek to expand the capacity and reach of 4G networks around the world, it is claimed that DAS will be a critical part of their network.

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