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September 2, 2011

Delivered by Email, RESS and Courier

Kirsten Walli
Board Secretary
Ontario Energy Board
P. O. Box 2319
2300 Yonge Street
Toronto, Ontario
M4P 1E4

Dear Ms. Walli:

Re: Board File No. EB-2011-0120
Canadian Distributed Antenna Systems Coalition
Canadian Electricity Association – Interrogatories of CANDAS

Pursuant to Procedural Order No. 2, dated August 26, 2011, please find attached the intervenor evidence of the Canadian Electricity Association (the CEA) in the EB-2011-0120 proceeding. This evidence is also being filed in support of Toronto Hydro-Electric System Limited's (THESL) notice of motion for a Decision and Order of the Ontario Energy Board (the Board) pursuant to Subsection 29(1) of the *Ontario Energy Board Act, 1998*, filed September 2, 2011.

Yours very truly,

Goodmans LLP

Robert Malcolmson
Counsel to Canadian Electricity Association

Encls.

cc. Helen Newland, Fraser Milner Casgrain LLP (By email and courier)
Michael Schafler, Fraser Milner Casgrain LLP (By email and courier)
Interested Parties (By email)
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INDUSTRY REPORT

Outdoor Distributed Antenna Systems and their role in the Wireless Industry

Executive Summary

Outdoor Distributed Antenna Systems (ODAS) of the type discussed by CANDAS are but one of a new set of tools intended to supplement capacity and coverage requirements for wireless communications. The wireless industry already uses a range of technologies and antennae installation solutions, and newer, smaller and more flexible solutions are gaining traction. ODAS may become a complement to more traditional wireless technologies, in part because of their flexibility of design and because key components, including antennas, can be located at a broad range of sites. Manufacturers understand that new antenna systems (including ODAS and others) must be flexible in terms of where they are placed and how they interact with core network components.

This report provides an overview of the wireless industry, and specifically the historical and current deployments of wireless networks using macro cells and microcells and how ODAS fits into this landscape. Because ODAS is but one of numerous new technologies at the disposal of the wireless network operators, ODAS is described in relation to other options used to "fill in" high-traffic and other difficult coverage areas.

At the core of this report is an analysis of the difference between wireline attachments and wireless attachments to “Joint Utility Poles”. Utility Poles’ historical use and the practical question of attachment of ODAS systems on utility poles is also reviewed from several perspectives, including engineering, safety, and practicality. This industry landscape culminates in a series of questions about the role of utility poles, attachment rights and ODAS.

Our analyses and conclusions are informed by extensive practical experience in the wireless industry.

Our main findings may be summarized as follows:

1. ODAS is but one of many technologies that is (and will) be used by wireless provides as they add capacity to existing networks.

2. It is highly unlikely that ODAS will evolve as a full substitute for traditional transmission engineering found today in the form of macro and multiple micro-site technologies. Instead, ODAS and multiple other technologies (e.g., Wi-Fi, pico-, femto-) will be used to "fill in" areas of high demand and/or unique terrain characteristics.

3. Wireless providers and network builders have multiple attachment alternatives when designing wireless networks, including those relying primarily upon ODAS. Manufacturers are aware of, and build to, the need for substantial flexibility in placing today's wireless hardware. Buildings, street furniture, stand-alone poles and other aesthetically designed apparatus exist, and are currently in use, to support ODAS and other wireless hardware.

4. Wireless facilities associated with ODAS networks are fundamentally different from traditional wireline facilities that are mounted on utility poles. It is not essential that utility poles be available as attachment options in the design and construction of wireless networks, including those that rely upon ODAS. Numerous other siting options are available.

1. About LCC International, Inc.

LCC, the largest independent telecom services company in the world with local presence in over 50 countries, is a recognized leader in providing consulting and network services to the telecommunications industry.

A pioneer in the industry since 1983, LCC has performed technical services for the largest wireless operators in North and South America, Europe, The Middle East, Africa and Asia. The Company has worked with all major access technologies (including LTE, WiMAX, HSPA, EV-DO, CDMA, EDGE and GSM) and has participated in the success of some of the largest and most sophisticated wireless systems in the world. We bring local knowledge and global capabilities to our customers, offering innovative solutions, insight into cutting-edge developments and delivering solutions that increase business efficiencies. Our service offering includes consulting, design, deployment, performance and operations and maintenance services and training through the world-renowned Wireless Institute.

Over the past twenty-seven years of operation, LCC has continually expanded its capabilities and adjusted its service offerings to best suit the needs of the industry. LCC has been involved in the design and optimization of networks utilizing virtually every major transport technology ranging from traditional microwave and leased line to advanced technologies. Our desire is to take this knowledge, experience and skill, and apply it to the greatest benefit for our clients in the design, deployment, optimization and operations of their existing and future networks. Having started at the very inception of the mobile wireless industry, LCC has been fortunate to be intimately involved with - and in many cases leading - new technology at virtually every step of the way.

LCC's Enterprise Mobility Solutions Group provides operators and enterprise clients many services to address skyrocketing mobile data demands. By providing increased capacity with various solutions including indoor and outdoor Distributed Antenna Systems (DAS), data off-loading and mobility services are using both licensed radio and unlicensed (Wi-Fi) radio service solutions. In addition, LCC's Land Mobile Radio Group provides in depth engineering, network, and project management services to support Public Safety and Land Mobile Radio (LMR) solutions.

With the need to bolster coverage and increase capacity, wireless carriers and enterprise Chief Information Officers (CIO's) are looking at various technology solutions to support the ever increasing demand for bandwidth .

LCC's Enterprise technology experience includes;

- Passive Distributed Antenna Systems
- Active Distributed Antenna Systems
- WiFi – 802.11a/b/g/n & Mesh
- Public Safety Land Mobile Radios
- Bridging – point-to-multi-point

Each solution plays a role in meeting our clients demand to get the wireless signal closer to where the actual users are.

2. Wireless Industry Overview:

How has the construction of mobile communications networks evolved, what are the key drivers, and how has the industry responded with new technologies?

From the inception of mobile communications systems, stand-alone cell towers have been the dominant way to illuminate service areas with radio signals. These installations are typically 50 feet or more above the ground, and are spaced a mile or more apart, and to the technical community the regions created by each of these antenna locations is called a macrocell. When a mobile user moves from one location to another, their signal is handed off from one cell to the next, to ensure the best coverage, capacity and quality of service. Yet, the wireless industry is at a turning point.

The confluence of end-user demand and proliferation of devices with advanced media capabilities is putting pressure on traditional macrocell deployment and its ability to provide necessary capacity and coverage in areas of high use. Growth in wireless devices is widely recognized to be exponential, in terms of both adoption rates and device capabilities. But the recent emergence of widescreen devices, such as tablet computers and advanced multimedia smartphones, has brought another dimension to traffic growth forecasts for the coming years.

Wireless Carriers are therefore being forced to (i) develop smaller cell sites to increase the reuse of available spectrum; and (ii) deploy alternative wireless strategies such as using unlicensed Wi-Fi to reduce the strain on capacity.

These smaller cells are called microcells, and are typically situated on rooftops and sides of buildings, . They may be spaced as little as a few hundred feet apart and at heights of less than 30 feet of elevation above ground level.

Not surprisingly, increases in demands for capacity and the need for more focused use of available spectrum has spurred innovation in the miniaturization of electronic components and the use of new types of antenna systems to provide higher levels of capacity, coverage and quality.

In the US, the cumulative capital expenditures on these types of systems has reached over $ 300Bn, and continues to grow at approximately 8 to 10% per year (i.e. about $ 25Bn per year).

3. Introduction to Macrocells, Microcells and DAS systems

How does a service provider transmit a signal (connection) to an end subscriber?

Over the past two decades, cellular networks have evolved from relying almost exclusively on large cells (called macrocells) where an antenna is spaced a mile or more apart to a point where they now include smaller cells (called microcells and picocell) where the coverage may be as little as a few hundred feet.

Various methods exist today which fall into several broad categories: Macro, Micro, Pico and Femto cells. There is no authoritative delineation between these categories, as these terms generally reflect relative coverage area of one group of technologies when compared to another.

- Macro Sites have a footprint which typically includes Cellular Towers & Rooftops, and cover “miles”.

- Micro Sites can cover “blocks” or buildings and Pico Cell coverage generally ranges from a few floors of large building to a diameter of several hundred meters in an outdoor setting.

- Femto cells have traditionally been used for short-range applications typically inside homes, apartment buildings, and enterprise locations, though newer "metro-femto" cells are being introduced that provide outdoor coverage of up to 300-600 meters.

Historically, the predominant deployment method for wireless networks has been by the use of dedicated cellular towers and rooftops of buildings, water towers, and various other facilities, where real-estate for equipment, power facilities, room for an antenna at a suitable height above the ground, as well as a safe area for maintenance, and connection to the conventional telephone network can all be installed.

In the competitive world of mobile operators, operators typically deploy a variety of locations, primarily tower locations, and in more urban settings rooftop locations. Each carrier will build their network to suit to the coverage and traffic needs of their customers. Deployment examples and pictures will demonstrate the antenna siting market is alive with ingenuity as it relates to mounting methods that do not involve Utility Poles. These techniques continue to be used, and will be used in most markets – these include macrocells, microcells, as will be described in this report.

The most critical factors for the deployment of an antenna site for wireless communication is what the industry terms “coverage and capacity”. Coverage is best engineered with the right height and type of antenna to illuminate the desired coverage area, taking into account the physics of radio propagation, including terrain, buildings, other obstacles, and environmental factors such as foliage and weather.

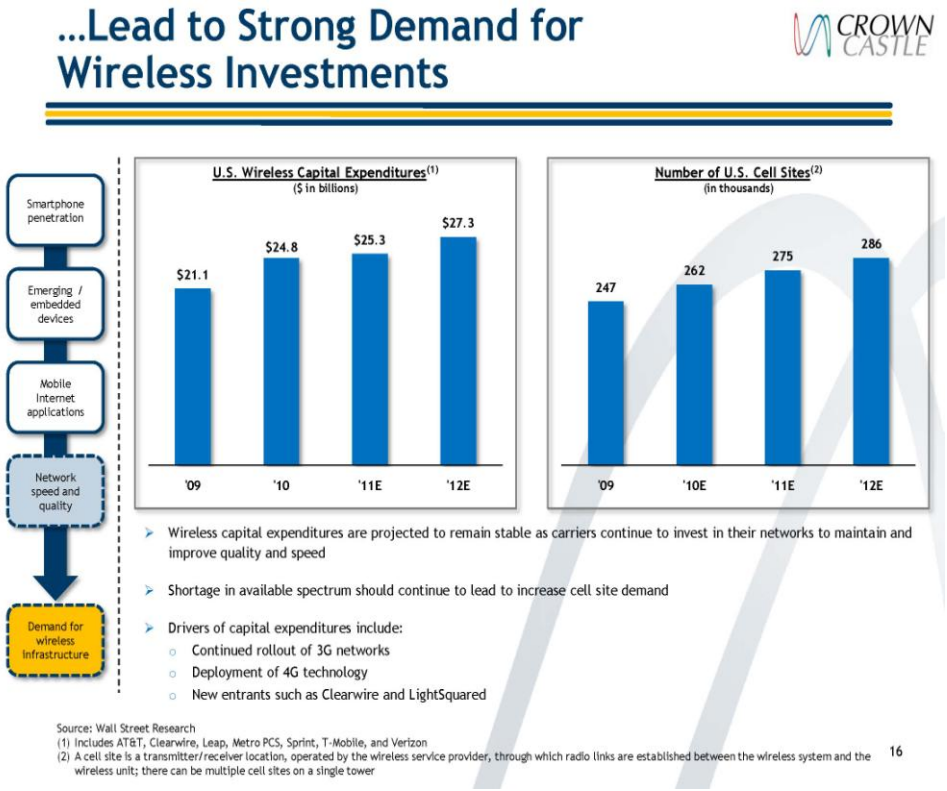
Today in the U.S. the vast amount of mobile communications traffic is transmitted via Macro and Micro sites. There are an estimated 275,000 macro and micro cell sites in the US. Since the typical range of a cell site is about a mile radius, the actual area covered by these two solutions represents most of the cellular infrastructure in the US.

Network operators typically choose a mix of macro and micro and increasingly pico cells, to provide high quality capacity and coverage, and to ensure that they can support the increasing bandwidth requirements of smartphones, tablets and mobile computing devices.

The principal drivers for this portfolio of different types of antenna installations have been variations in traffic density and terrain effects.

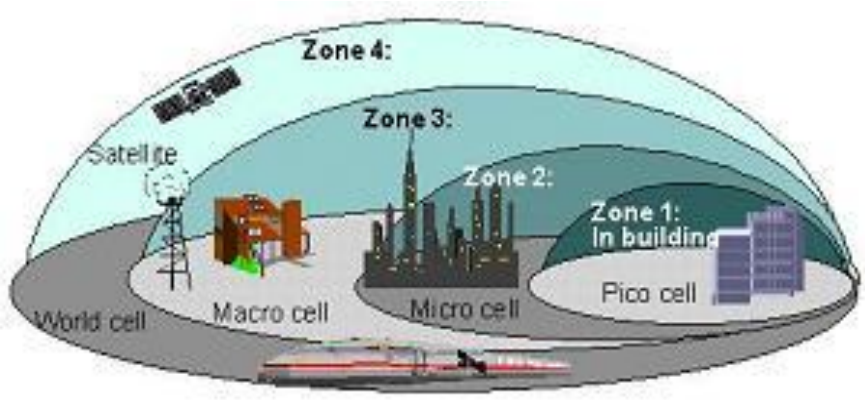
One technology that has emerged in this drive toward smaller, more focused antenna sites, is ODAS. ODAS uses a distributed set of small antennas fed by one radio transmitter. This use of a single transmitter sharing multiple antennas is somewhat unique, in that more conventional systems assign a single transmitter to each antenna. Industry estimates are that approximately 10,000 ODAS systems (representing less than 0.1% of the geographic coverage area of macro and microcells) have been deployed in certain select regions in the US.

This illustrates that Outdoor DAS is a small, but emerging segment of the market. However, it is important to note that ODAS is by no means a substitute for traditional cellular network planning and deployments for mobile communications. Nor is ODAS the only technology intended to supplement more traditional macro-site technologies. Indeed, with an installed base of approximately 275,000 macro and micro cell sites cell antennas throughout the U.S., it is evident that ODAS will never function as a replacement or substitute for macro cell technology in the foreseeable future. Rather, ODAS and other emerging technologies will likely function in conjunction with macro cell sites to provide “in-fill” coverage and capacity in select areas.



In addition to ODAS, there are a wide range of other emerging technologies such as adaptive antennas, ultra-miniaturized micro- and pico-cellular products, and the use of WiFi networks to complement cellular networks to accommodate the bandwidth requirements of mobile customers. All of these technologies can be, and are currently, utilized by wireless carriers to achieve the same network coverage/capacity improvements that an ODAS system offers.

In order to illustrate graphically the progression of these wireless technologies, below are graphical descriptions of the terms used in this section:

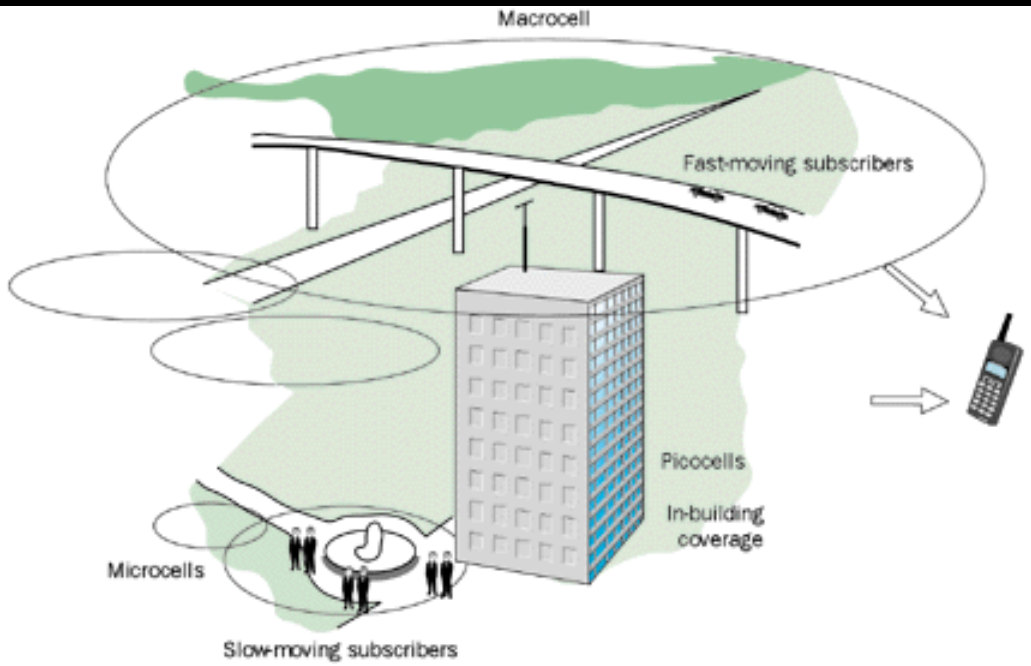


In the cellular standards industry, macrocells are described as locations where the radio base station equipment is connected to antennas on a tower or rooftop or a fixed structure in a single location, with typical cell range (of coverage) of 0.5 to 10 miles.

Most cellular systems have been built with these types of installations. Since wireless operators have limited licensed spectrum, and increasing demands for bandwidth consumption, the number of such macrocells deployed a decade ago has increased by a factor of ten or more. In parallel, the industry has made leaps in terms of technology, to handle higher capacity transmission technologies in the very same spectrum (for example, in the progression from 2G to 3G to 4G mobile systems).

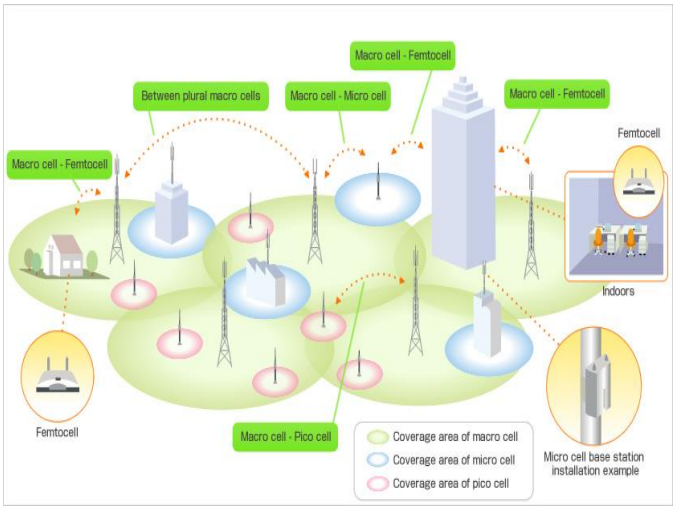
Due to miniaturization of electronics, the industry has also developed Microcells: miniaturized versions of the equipment used to generate radio signals for macrocells, with physical size and shape that do not require a dedicated cell tower or rooftop, and can be deployed on light poles, sides of buildings and even disguised as street furniture, and have a cell coverage range of 0.5 miles down to a few hundred feet.

Pico cells have been used for in-building coverage (typically in businesses and factories or large multi-tenant facilities) and are now being used outdoors, as well. Femto cells (including metro femto cells) have been released as products that can be installed in a single home to provide high quality cell coverage indoors.



From a city-wide perspective, combinations of macro, micro and pico cells are used to adapt to the coverage and capacity requirements of wireless customers.

The skill of each network operator is to utilize available antenna sites of all types (such as towers, buildings etc) and combine the range of solutions to provide what is often described as a “hierarchical” cell structure. In a particular geographic area, each network operator will have developed and implemented their own “rf (radio frequency) plan”, based on the number of customers, traffic requirements, and the engineering of traffic and available facilities, based on the wide variety of network infrastructure products (macro, micro, pico and femto) from different manufacturers.



In addition, as shown above, these networks are designed with the ability to hand over a voice call or internet or video communications from one cell to another, so the consumer receives high quality service on their phone, smartphone or other mobile device, whether they are at work, study or play.

4. Outdoor Distributed Antenna Systems

Distributed Antenna Systems (DAS) are a complementary tool for providing high quality coverage and capacity in the portfolio of antenna systems for wireless communications service providers. DAS can be deployed indoors or outdoors.

The emerging technology of Outdoor DAS is one of numerous technologies used by network operators to provide wireless services. There are many novel and unique aspects to DAS technology that are captured in this report and their relevance to the question of attachment rights to Utility Poles.

ODAS is just one of multiple solutions that have emerged to improve the coverage and capacity of wireless networks in outdoor locations (i.e. on streets, neighbourhoods, etc.).

A technology called Indoor Distributed Antenna Systems also exists, which provides a unique way of improving the coverage and capacity of wireless networks indoors (in places such as schools, hospitals, shopping centers, etc.). These systems are not the subject of this report, as they do not rely on any outdoor installations, and in particular, have no requirement for attachment rights to Utility Poles, but for completeness, are described later in this report

DAS is the name given to a network of spatially separated antenna nodes connected to a common source of radio frequency signals that provides wireless service within a geographic area or structure.

(Pictures from Crown Castle)

ODAS has been proposed as an additional tool for the deployment of cellular antennas which are typically installed on towers, buildings and other structures such as water towers. The DAS acts like a radio tower, with special adaptations to transmit and receive signals in a localized area. Instead of broadcasting radio signals to cover a broad geographic area from antennas mounted on a tower or building rooftop, DAS converts radio signals to light using lasers and carries the signals to remote locations using fiber optic cable. Outdoor DAS systems are often used to fill “holes” in coverage and capacity from macro and micro cells.

These outdoor DAS deployments are typically done in selected geographic areas. In fact, it is difficult to deploy DAS uniformly in most geographic areas as the primary or dominant technology.

One can envision the macro and micro coverage as an “umbrella” coverage, and ODAS and other similar technologies as a “filler” where the capacity and coverage requirements and local terrain mandate a specialized solution.

In an ODAS configuration, equipment at the remote locations converts the light signal back to radio, amplifies it, and transmits it through an antenna system. In marketing terms, this feature is called a “Neutral Host” capability. This is relatively unique, as traditionally, different cellular operators may share the same cell tower, but not the same antennas and electronics and power. The term “neutral host” means the system provides access for all wireless carriers over common equipment. Phones, PDAs, and wireless modems communicate with the underground antennas to complete phone calls and data sessions.

One additional feature of a well-designed DAS solution is that the antennas can transmit not only one frequency band, but potentially support multiple frequency bands. For example, a single DAS system can be fed with signals from several competing mobile communications service providers. This neutral host capability creates an opportunity for the first installer of a DAS system to generate revenue from subsequent wireless operators seeking to use the equipment initially installed by the “first mover”. In the case of a telecom attachment on a utility pole, different operators can deploy fiber on the same pole, since the space and attachment process is well established.

5. Other emerging wireless technologies

In addition to ODAS, where, as described above, a radio frequency signal is used to feed the distributed antenna, and the signal is transmitted over the air at various nodes on the ODAS, there are many other technical solutions which are also emerging.

As wireless operators upgrade from 2G to 3G and 4G networks, the inherent capacity, coverage, traffic handling, types of service and spectral efficiency are already on an accelerated trend. Also, as operators continue to acquire additional radio spectrum (their most precious asset), they continue to invest in their networks and services.

Advanced Radio Technology

Two examples of advances in mobile communications systems have various trade names such as Liquid Radio (from Nokia Siemens Networks) and Light Radio (from Alcatel Lucent). These technologies differ from ODAS, but can achieve the same purpose: to fill-in coverage and capacity as a supplement to conventional macro and micro cells.

These innovations are based on the use of software-defined radios (where traditional hardware components are superseded by advanced signal processors, software algorithms and miniaturised electronics). Certain implementations have shrunk the electronics that would have fit, a decade ago, into a coat closet, now to the volume of a small toaster.

These miniaturised devices have the ability to integrate the antennas into the box, so they can be installed as one attachment on buildings, towers and utility poles easily as “plug and play” components of a network that may already have deployed macro cells and micro cells. These products have the advantage of small size and power consumption, so they can be installed on towers, rooftops, water towers, on the sides of buildings of various types of poles, including utility poles, light poles and even “street furniture”.

Because of their size and shape, these products are small and unobtrusive. However, due to their advanced design, they have the coverage and range of a micro cell or even a small macro cell.

Adaptive Antenna Systems

In addition, instead of using an antenna with a fixed radiation pattern at a macro cell or microcell, “smart” antenna technologies (also called adaptive antennas) have been deployed commercially. For these, the antenna pattern adapts to the instantaneous traffic conditions by use of advanced digital signal processing and “beam-steering” to deposit radio energy only in the directions required (and doesn’t waste radio energy where there are no users).

The smart antenna technology can be applied to any wireless system, and have shown dramatic improvement in “spectral efficiency” (i.e. the measure of how much bandwidth can be sustained in a particular amount of radio spectrum) and coverage.

Wi-Fi

Wi-Fi which is the brand name for an unlicensed 802.11 specification, allows for users to connect to their local area network. Shipments of electronic products with embedded wireless local area networking technology (WLAN) will surpass 1 billion units for the first time ever in 2011 and then rise to more than 2 billion in 2015, according to iSuppli. Wi-Fi has become a very economical approach for network operators to off-load capacity constraints from their networks.

MetroPCS may be offloading at least 20% of its traffic to Wi-Fi
August 26, 2011 — 6:27am ET | By Sue Marek

*An executive at the Wi-Fi connectivity firm iPass said her company's research indicates that MetroPCS may be offloading as much as **20 percent of its cellular traffic onto Wi-Fi networks**. During an interview with FierceWireless, iPass CTO Barbara Nelson said some operators are unwilling to offload traffic to Wi-Fi unless they own the network, while others, such as MetroPCS, are offloading a significant amount of traffic to Wi-Fi now. "Although they are not broadcasting it, we estimate 20 percent of MetroPCS' traffic is offloaded to Wi-Fi," Nelson said. MetroPCS would not confirm the iPass statistic. However spokesman Drew Crowell said the firm is "encouraged by what we are seeing with traffic offloaded to Wi-Fi."*

In December, MetroPCS announced that its new Android-powered smartphones would automatically link to Wi-Fi hotspots. Specifically, the company said that the Huawei Ascent and LG Optimus M devices would be preloaded with Devicescape and Boingo clients, which can link customers' smartphones to Wi-Fi hotspots without users having to search, log in or instigate the connection.

Heterogeneous Networks

The industry is also moving very rapidly into new areas, such as “heterogeneous networks” where a mobile phone may be on a cellular network, but can seamlessly transition to a low-power WiFi network, to improve battery life and to maximize bandwidth availability

Most major network operators have announced plans to use WiFi technology (with short range, and typically mounted on the sides of buildings or other fixed structures) to “offload” the traffic from the conventional macro cell and micro cell networks.

WiFi technology uses “unlicensed spectrum”, so the barrier to entry for network operators to deploy these heterogeneous networks is lower than having to purchase new radio spectrum. Also, most portable devices (including e-readers and tablet devices and gaming devices) have WiFi connectivity.

In this way, the operator can support a wide variety of services using technologies that would not have been contemplated as part of a cellular network even a few years ago.

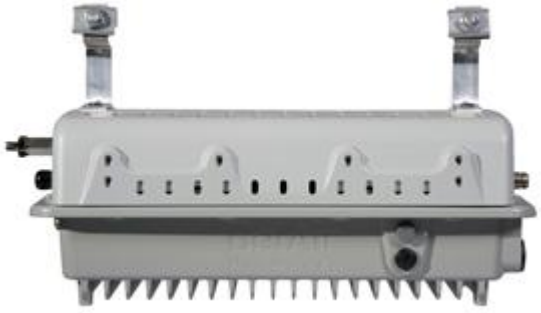
WiFi radio products are also very small and can be mounted by way of a single attachment not only on poles and sides of buildings, but even on the cable strand between two utility poles.

One additional existing product used by wireless operators, especially those who already have deployed a cable network in a particular neighborhood, is a technology called Strand Mounted WiFi network. In this case, there is no requirement to do any new attachments to a utility pole, since the wireless equipment is built to mount directly on the cable, away from the utility pole.
Below is the product description and photographs of one specific product that was purpose-built for this market.

Mounting Strand Mount Picocell

The BelAir100SP Strand Picocell is a compact wireless base station that leverages available broadband infrastructure enabling mobile carriers and cable operators to deliver mobile broadband internet via both licensed and unlicensed wireless spectrum. The BelAir100SP solves the problem of how to mount, power and backhaul small cell base stations. Now, large scale and small cell deployments can cost-effectively address mobile network congestion in areas of high user concentration.

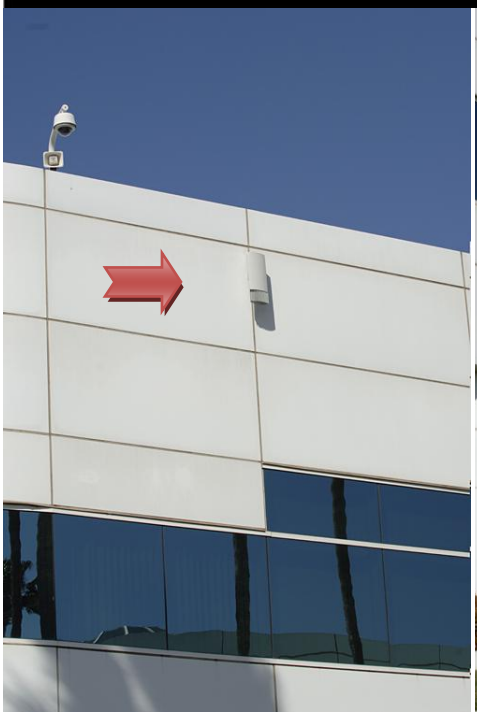
The BelAir100SP is designed to be mounted on existing cable infrastructure, with both power and backhaul provided by the broadband hybrid fiber coax (HFC) plant. Available in a range of mounting options, the BelAir100SP can be deployed from cable plant installed on poles, in cabinets and pedestals and even underground. The modular design of the BelAir100SP currently supports a range of licensed 3G radios, with a migration to LTE, along
with dual 802.11n Wi-Fi radios.

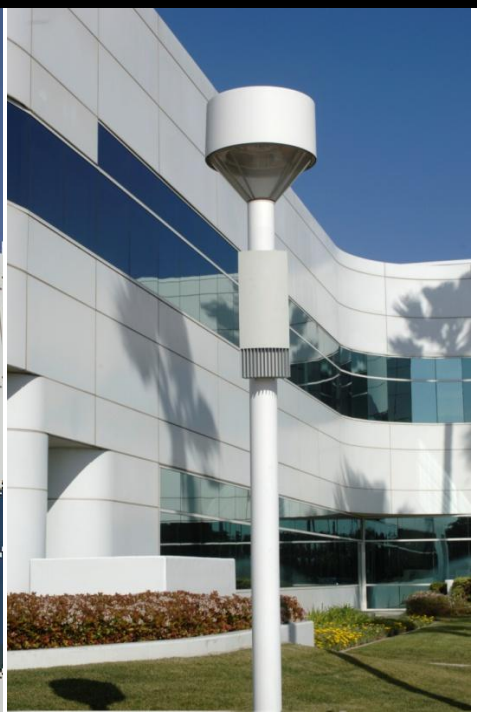


Another manufacturer has developed a product with a very small size that can also be mounted in very flexible locations.

The Powerwave Picocell family, which includes an outdoor pico cell, was first introduced in February, 2011. Both models are among the highest capacity pico cells, supporting up to 100 active outdoor users and 32 active indoor users, and up to 1,000 registered users. They support all 4G frequency bands in the 700MHz to 2.7 GHz range and feature a 2x2 MIMO antenna for additional capacity. They also feature an optional concurrent dual-band 2.4GHz and 5.8GHz 802.11a/b/g/n Wi-Fi radio that makes them a single system for all carrier and enterprise wireless needs.

Shown in the pictures below are Powerwave pico cell installations on the side of a building, and on a private light pole in a parking lot.





Summary:

Most cellular operators use combinations of all of these cellular and wireless technologies to provide mobile communications services. As will be described below, ODAS is but one component in the portfolio of tools available to any network operator.

6. Indoor DAS: an emerging solution to in-building coverage

It is important to distinguish outdoor and indoor DAS.

The use of DAS for indoor coverage is attractive and is gaining broad industry acceptance, since it is very difficult to build macro or micro cells inside buildings to provide excellent indoor coverage. It is better engineering practice to illuminate an indoor location with low power distributed antenna systems which can snake through a factory, mall or educational institution.

Indoor DAS is a growth area since some 70 - 80% of mobile traffic originates from inside buildings for the wireless industry, as the mobile carphone has been superseded by the smartphone and personal communications device, where consumers and enterprises expect high quality coverage where people live, work and play.

Implementations of indoor DAS were described as early as 1987 at AT&T Bell Laboratories to provide improved coverage and capacity of wireless signals inside buildings.

These research results showed better coverage than from traditional cellular systems which often lack good coverage inside buildings due to poor penetration of radio signals through walls and windows. In this way, the combination of outdoor cellular networks and indoor DAS provided high quality coverage.

Carriers need to service their subscribers where they are, thus in-building DAS systems are much more important to solving the capacity constraints and have few substitute approaches compared to ODAS.

7. The Outdoor DAS Market: a nascent business

The DAS market is, and will be for the foreseeable future, a complementary technology. There are no precise figures on how large it is.

The Wireless Infrastructure Association, PCIA, is the trade association representing the companies that make up the wireless telecommunications infrastructure industry. Members include the carriers, infrastructure providers and professional services firms that own and manage more than 125,000 telecommunications facilities throughout the world. The PCIA does not keep track of exact figures (in contrast to macro and micro cells, which are tracked accurately by the CTIA industry body)because it is difficult to track the differences between indoor and outdoor DAS systems.

It is currently estimated there are roughly 10,000 ODAS nodes, or site deployments, in the US.

According to Brian Regan of the PCIA, the number of DAS nodes in operation could double to 20,000 by the end of 2012, and estimated a total of 150,000 by 2017. Cumulative capital expenditure for DAS was estimated to reach over $ 15Bn by 2017.

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8. Attachment to Utility Poles

Utility poles require contiguous connections between the generation of power and the distribution of that power via lines to homes, businesses, hospitals, factories, etc. Engineering factors such as weight, safety and maintenance to support a reliable power distribution system has created a well known set of operating and maintenance guidelines.

This same capability (i.e. a network of utility poles to which telecom wire, coaxial cable, or fiber is attached) is also of value to cable and wireline telecom companies who want to also create a contiguous network of connectivity from where they connect to cable video programming, or the Internet, or telephone switches to homes, businesses, public buildings, etc.

The most prevalent is the use of utility poles for telephone and cable TV lines. More recently, they have also been used for very high speed transmission of telephony, internet and video signals over optical fiber.

In all of these cases, the size, weight, power requirements and process of installation and maintenance is well understood, and there have been established guidelines on the safe and secure installation of these attachments on the same pole, as illustrated below.

A typical joint pole supports three facilities: electric power, cable television, and wireline telephone. Some joint poles also support all manner of other devices: streetlights, signs, traffic signals, seasonal decorations, fire and police call boxes, antennas, municipal communications systems, OPGW (optical ground wire) fire- and police-alarm signal wiring.

The following definition of Joint Pole is an expanded version of the definition found in Newton's Telecom Dictionary, 18th Edition (New York: CMP Books, 2002, p. 410; reprinted by permission of Harry Newton).

This figure illustrates the typical allocation of space on joint utility poles in the US; the allocation is similar in Canada except that cable television and telephone are sometimes lashed to the same supporting strand. Starting at the top and working down, facilities on the pole are allocated into three spaces: Supply Space, Safety Zone Space, and Communications Space.

The Communications Space contains telephone, cable television (CATV), and other communications cables. Communications cables are insulated; however they may be enclosed in metal shields. For safety reasons, all exposed metallic surfaces must be bonded to each other and to the MGN.

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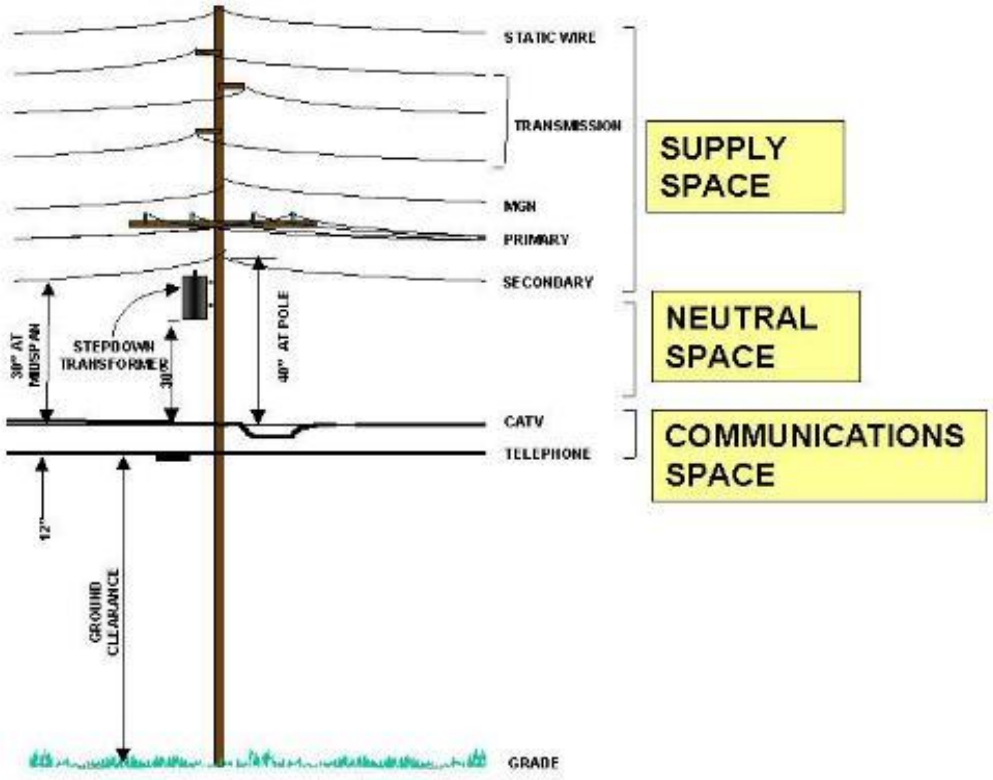


Typical communications cables include:

- Telephone: telephone cables supported by steel strand. Each telephone cable contains several individual copper wire pairs; a large cable may contain as many as several hundred pairs. The strand is placed under tension to prevent excessive sag; typical strand tension is a few hundred pounds, although a strand supporting a large multipart cable may be tensioned as high as 1000 pounds.
- Cable TV: CATV coaxial cable and equipment supported by steel strand. An expansion loop at each pole absorbs expansion and contraction caused by temperature variations. The strand is placed under tension to prevent excessive sag; the typical strand tension is a few hundred pounds.
- Other: just about any other type of communications circuits. Among the more common are fire- and police-alarm wiring, traffic-signal control wiring, and closed-circuit audio or video communications circuits. Depending on purpose and age, these circuits may utilize open-wire conductors, twisted-pair cables (similar to telephone networks), coaxial cables (similar to CATV networks), or fiber optic cables.

Moreover, since telecom and cable attachment rights only require safe and secure attachment to the existing poles (i.e. no further engineering or design effort, which as will be shown below differs for wireless attachments) the development of Joint Utility Poles is well established (both in terms of business processes and charging rates) for wireline networks, and there is a space allocated called “communication space” on utility poles for that specific purpose. Even though ODAS is also a communications technology, it does not have the same requirements for attachment of coaxial cable, copper wire or optical fiber.

9. Outdoor DAS: different from other Utility Pole attachments

Unlike conventional wireless systems, ODAS is a network of spatially separated antenna sites called "nodes" connected to a common source that provides wireless service within a geographic area or structure. The DAS antennae are typically mounted 20-40 feet above the ground

The idea is to split the transmitted radio frequency signal from a single central hub site among several of these distributed antenna sites, separated in the neighborhood space so as to provide coverage over the desired coverage area instead of using a single antenna at the same location as the central hub site. Thus, a single antenna radiates at high power. The concept is similar to wiring a house with loudspeakers for each room rather than having a single stereo system in one room.

Before exploring utility pole usage, it is useful to define the physical components of ODAS, and which of these are the subject of attachment rights (i.e. devices that would have to be attached to a utility pole or other structure to make ODAS operational):

- a host base station with a wireline connection to the distributed antenna system
- distribution poles upon which DAS equipment can be installed
- a fiber optic network (typically an existing system) to carry the signals from the base station to the antennas
- shared antennas and control boxes
- neutral host for different wireless service providers
- lightening protection box
- connection to a power supply
- battery-powered back-up supply in the event of a distribution line loss of service

In a filing with the US FCC, dated August 2010, the Coalition of Concerned Utilities laid out a number of concerns regarding the use of ODAS and utility pole attachment. This filing focused on the various practical issues that a utility company must manage to allow ODAS on utility poles. Below, this report summarized the issues and quotes the specific text (in *italics*) to illustrate that ODAS attachments are fundamentally different from conventional attachments on utility poles.

Wireless Attachments and Safety:

> *Wireless attachments in general are more complicated and technical, raising numerous additional operational and safety concerns than those associated with wire attachments. Unlike standard wireline attachments, wireless antennas come in all shapes, sizes, power levels and RF emissions, depending on a carrier's needs at a particular location. Wireless devices emit radio frequency energy that is subject to maximum permitted exposure regulations for workers and the public.*

Wireless Antennas and Equipment:

> *Wireless antennas also require the installation of a variety of accessory equipment on poles, such as cabinets, electric distribution panels, work receptacles, electric meters, work lights and wires running the entire length of the pole to connect the cabinet to the antenna.*

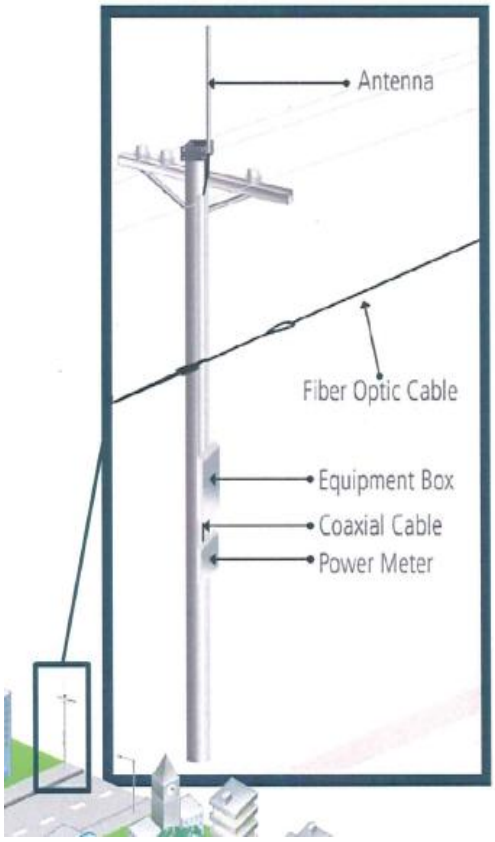
Wireless Antennas and Space:

Wireless antennas themselves take up much more space than standard wireline attachments. Plus, while the communications space on poles is often similar from one pole to the next, many wireless companies wish to attach to pole tops, in the area designated for electric facilities known as the electric supply space.

Wireless has other alternatives:

The PSC recognized, for example, that unlike wireline attachers, wireless companies need not rely solely on utility poles to reach their customers:

> *Unlike telephone, cable and power facilities, which may only be attached to utility poles, wireless attachers have other options for attaching their facilities, such as buildings, existing towers, and newly constructed towers.*



Wireless and Additional Safety Concerns:

The New York PSC also recognized that wireless attachments raise additional safety concerns:

> *Since wireless attachments usually involve placing facilities above the power area of the pole, special attention must be given to safety because such facilities could fall over onto power lines in high wind conditions or in heavy wet snow conditions resulting in power outages. While National Grid allows wireless attachments, it has comprehensive safety standards and requirements for such attachments and reserves the right to refuse to put wireless attachments on its poles or increase the height of poles to accommodate wireless attachments*

Wireless requires more careful analysis:

Installing wireless antennas on pole tops above energized electric facilities raises a host of safety, reliability and engineering concerns and requires much more careful analysis than placing wireline attachments in the designated communications space. Pole top attachments require workers to pass through and work above energized lines. During installation and afterward, the antennas and other equipment could fall onto energized electric facilities.

Distributed Antennas and environmental concerns:

Distributed antenna companies sometimes find themselves delayed in obtaining permits to use municipal rights-of-way because they seek to place their not-so-attractive antennas with unknown radiofrequency emissions in close proximity to residences and the general public. Such routine municipal reviews and permitting processes render any imposed utility make-ready

schedules meaningless in the context of wireless attachments.

Wireless installations are non-standard:

> *Wireless antenna installations are anything but standard and must be assessed on a case by-case basis. Utility pole owners in general do not yet have enough experience with wireless attachments to satisfy their own questions as to safety, reliability and overall impact on the electric distribution system.*

The consistent theme that emerges from this filing is that wireless attachments are different from wireline telecom attachments in the areas of safety, equipment, space and environmental concerns. The Coalition's filing also highlighted that wireless systems have alternatives to attachment to utility poles, and that they tend to be non-standard and require more analysis, compared to conventional attachments.

Practical Examples of Outdoor DAS Deployments.

The figure above shows a typical attachment for ODAS on a utility pole. The amount of space required is significantly more than merely attaching a CATV or Telco Strand of wire. Specifically, these illustrations show an antenna structure and an equipment box containing wireless equipment which is specific to an Outdoor DAS installation, and quite unlike the conventional facilities that are attached to Utility Poles.

10. Practical Considerations and Concerns for the Attachment of Outdoor DAS on Utility Poles

These descriptions show that an outdoor DAS is a nascent technology for deployment on utility poles. Thus, there are several practical considerations that such a new technology poses. These considerations demonstrate that using legacy methods for engineering, space allocation, cost and price of attachment cannot be arbitrarily applied to a novel solution.

a) Do the rules and guidelines for attachment (location on the "Spaces" on a utility pole, power requirements for the equipment, location of an antenna on the pole, different requirements for maintenance of active electronics versus a piece of cable or optical fiber etc.) apply to a device containing active electronics, power and antennas, rather than other communications attachments such as telephone lines, fiber or cable?

b) Should the pricing of attachment rights be the same as that of other legacy technologies (the pricing method for current attachments is well established, as opposed to the methodology to be used for a solution that has yet to be widely deployed, and its associated costs to the utility are unknown)?

c) What are the implications of giving attachment rights to one entity, and if that right either restricts or prevents other entities from gaining similar rights, what are the implications for access to the DAS systems for a future wireless communications provider who wants to use DAS as one of the various technologies (macro cells, micro cells, indoor DAS, ODAS and pico cells) to provide capacity and coverage for high speed Internet or video services?

d) What other new services may be deployed on utility poles, and what demands may be made on these services: for example, public safety (i.e. emergency alert and first-responder communications services), or the increasing pressure from regulators as a result of natural and man-made disasters for continuity of communications in a disaster scenario?

e) What other new services may be deployed on utility poles: for example, with the increasing focus on smartgrid technologies for meter reading, management of power distribution and generation, and integration of home security into the smartgrid networks, what are the implications on space and engineering requirements for utility poles for these solutions?

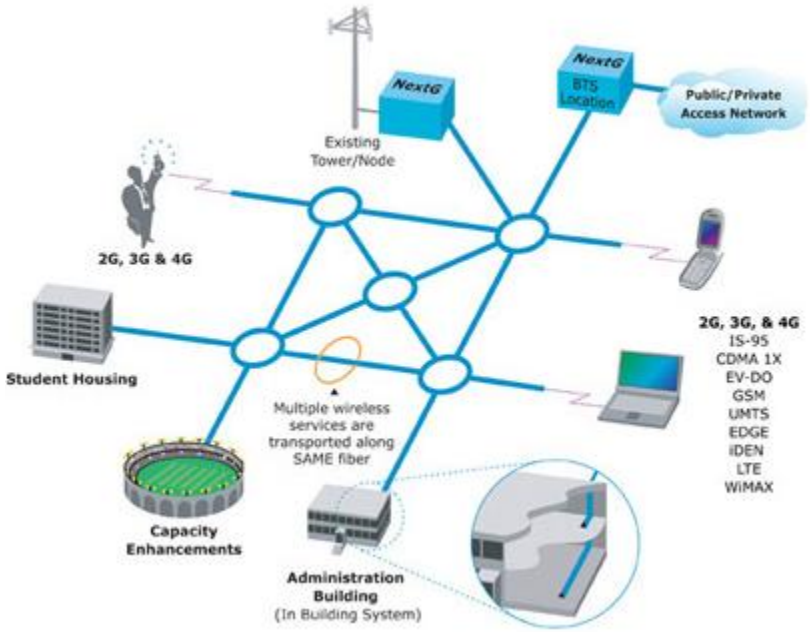
f) What is the competitive implication of the "Neutral Host" capability of a DAS system, which may give a "first-mover" advantage to the DAS operator, to the exclusion of other competitive solutions, and in particular how should that be factored into the pricing model for attachment to a utility pole?

11. Outdoor DAS Case Study: San Diego State University

In this section we describe the outdoor DAS network that has been put in place at San Diego State University. ODAS transmits a wireless signal the same way as an in-building system. The DAS includes nodes that are strategically placed on existing utility poles, street lights, traffic signals and other structures every half mile within the coverage area.

The nodes connect to a hub via fiber optic cable. The hub contains American Tower's head-end equipment and the service provider's Base Transceiver Station (BTS)."

NextG Networks' DAS-Network solution was chosen to provide improved cellular coverage and capacity for San Diego State University. Instead of using additional cell towers, NextG is using unobtrusive equipment using DAS to meet the needs of the University and cellular carriers. NextG strategically places small, low power antennas on approved buildings and lampposts in such a manner as to make them virtually unnoticeable.



12. Outdoor DAS Case Study: Use of purpose-built Cactus structures

DAS systems have been deployed in many different locations . Wireless network deployment companies have used their imagination and been sensitive to environmental and aesthetic considerations.

One illustration is the case of Paradise Valley, Arizona, where ODAS was approved for installation and the vast majority of the DAS equipment was deployed on purpose-built structures, which were disguised as cactus for aesthetic reasons. This is one of several installations where a commercial deployment found a way to deploy DAS without the use of utility pole attachments.

13. Outdoor DAS Case Study: Use of structures other than Utility Pole Attachments

LCC builds and assists its clients in building wireless infrastructure around the world, including ODAS, and has direct experience with designing wireless equipment to be attached to numerous and varied locations other than utility poles. Below we have included some pictorial representations of these other alternatives with which we are familiar. Simply put, while utility poles may be one potential avenue for deployment of these types of systems (including ODAS), they are not essential to a successful deployment.

Buildings, in many circumstances, represent an ideal attachment location given quick access to power and adequate space for the placement of supporting hardware. Further, buildings of any size in metropolitan areas are often pre-lit with fiber optic cables which can provide necessary backhaul services. Even when fiber isn't available, many newer technologies can rely upon a more standardized broadband connection for that purpose. The picture to the left below represents the installation of an ADC Systems wireless antenna and supporting equipment on the side of a commercial building. The picture to the right represents similar equipment attached to the structure of a sports stadium.

In some circumstances, no building is even required. ADC, the same manufacturer represented in the picture above, produces a terrestrial antenna that can be placed at ground level in some circumstances. That technology is demonstrated in the following picture:

Stand alone structures such as sole purpose poles and other street furniture are also used regularly to place (and often "hide") necessary antenna and radio equipment. The pictures below are taken from Extenet's own website related to its deployment of ODAS in Las Vegas, Nevada.


Encore

14. Alternative Antenna Site Deployments:

The number of alternative site locations is constrained only by the creativity of the designer and the willingness of the market to allow for wireless attachments. Below we identify numerous antenna locations that rely neither on buildings, utility poles or street furniture, but instead, use existing or replacement commercial signage:

Likewise, it is important to note that buildings provide numerous ways to hide wireless antenna equipment that could never be accomplished via attachments on utility poles. For example, see the antenna attachments in the pictures which follow that have been effectively hidden by creative architecture:


E*TRADE
FINANCIAL


Drugs
JUL 24 2002


Can you see me?
77.9
77.9
Car Wash
Optimax

Flagpole acts as antenna location

Fake tree in center acts as location for antennas

Photo above: Sequoyah Community Church, with four cell-phone antenna panels

A number of churches have opted to host cell antennas. Churches often provide some distance from concerned neighbors. They have high roofs, crosses or bell towers where antennas can be hidden inside on an upper facade.

Communities that staunchly oppose the development of cellular communication sites often petition their zoning board of appeal to force carriers to propose and build cellphone towers that blend into their surroundings or are virtually undetectable. Carriers could save a lot of money on zoning legal expenses by proposing camouflage cellular sites . Concealed cell towers when deployed and integrated properly blend in with their surroundings and are often difficult or impossible to detect. The photo to the right provides a great example of a camouflaged cell site.

The photo to the right is a great application of a cellular antenna concealment on a typical building that can usually be found on a Municipal Building, Library, or Courthouse. The cellular antennas are concealed within the cupola facade, and are completely undetectable. The use of an existing high-elevation structure reduces the need to build an additional tower in the coverage area. When cellular antennas are deployed on municipal property, the revenue generated can provide decades of revenue for community initiatives.

Municipalities who require the use of disguised cell towers by the carriers in return for a streamlined zoning review process can ultimately save huge costs involved with fighting carriers in the courts and prevent wireless sprawl in their communities, allowing for proper wireless expansion.

There is no way to know that this church steeple is a cellphone antenna location. As more cellular sites will be constructed throughout the US, municipalities that have created wireless ordinances favoring the use of concealed antenna cellular technology can prevent the obstruction of their view-sheds with a camouflage cell tower solution such as this cellular steeple replacement.
Cost of construction is paid by the carrier, not the property owner. Carriers can justify the expense of a customized concealed antenna deployment by the time and money saved in zoning and fighting the municipality in court.

A hidden cell tower such as this disguised church bell tower are a win/win solution for any community concerned with the aesthetics of having a traditional cell tower built in or near their community. The problem that many municipalities have is that their municipal cell tower ordinances are non-specific, non-existent or poorly written. Towns and cities that embrace wireless technologies and are willing to work with the cellular carriers instead of constantly fighting them will find that the carriers are willing to incur the additional cost of concealing a cellular tower.

Images courtesy of **STEALTH® Concealment Solutions, Inc.,** a leading designer and fabricator of Cellular Antenna Concealment Systems custom engineered for Municipal and Church Wireless Communication Sites.

See also:
http://weburbanist.com/2010/03/26/faux-ny-towers-cleverly-concealed-cellular-sites/?ref=search

15. Conclusion

At the core of this report is the difference between wireline attachments and wireless attachments to "Joint Utility Poles" i.e. poles that are installed by a utility, but attachment rights are also offered to other entities (i.e. telecom and cable companies). This report has shown not only that there are fundamental differences, but also that there are numerous alternatives for the deployment of ODAS systems, illustrated by practical examples, than the use of attachment rights to utility poles.

As is evidenced from the examples detailed throughout this report, DAS is only one of many technology alternatives to alleviate the increase in consumer demand for mobile data. As the wireless industry matures with more sophisticated roaming support for carriers, the need for ODAS as it exists today, becomes less important. Joe Madden, principal analyst at Mobile Experts L.L.C., said , "Without a doubt outdoor DAS solutions are more expensive to deploy than a traditional rollout." If a carrier is looking at option A as a DAS deployment or option B as something akin to a remote antenna or traditional cell site, option A will cost more.

In summary, we demonstrate that:

1. ODAS is but one of many technologies that is (and will) be used by wireless provides as they add capacity to existing networks.

2. It is highly unlikely that ODAS will evolve as a substitute to traditional transmission engineering found today in the form of macro and multiple micro-site technologies. Instead, ODAS and multiple other technologies (e.g., Wi-Fi, pico-, femto-) will be used to "fill in" in areas of high demand and/or unique terrain characteristics.

3. Wireless providers and network builders have multiple attachment alternatives when designing wireless networks, including those relying primarily upon ODAS. Manufacturers are aware of, and build to, the need for substantial flexibility in placing today's wireless hardware. Buildings, street furniture, stand-alone poles and other aesthetically designed apparatus exist, and are currently in use, to support ODAS and other wireless hardware.

4. It is not essential that utility poles be available as attachment options in the design and construction of wireless networks, including those that rely upon ODAS.

16. About the Authors

DR. NITIN J. SHAH

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Executive Summary

Leadership roles in product management, business development, marketing and technology innovation. Recognized for skills in strategic planning, technology & product roadmaps: analysis of ecosystems, competitive threats and economics. Experience in start-ups, multi-national corporations and strategic consulting. Track record of innovation and commercialization of communications and software products.

- Successful management of business and technical organizations, with versatility and resilience to learn, adapt and react in a dynamic environment while focused on defined goals.
- Record of anticipating market and technology trends and threats, and reacting with innovations and building personal and organizational competence to meet customer requirements.
- Record of taking concepts through all phases of market requirements to prototype to commercial introduction including partnerships and customer contracts in mobile and digital advertising.
- Strong focus on learning about industry and ecosystems to perform risk assessment, identification of gaps, making resource allocations to ensure efficient and realistic product and project delivery.
- Clear and articulate in both business and technology communications which was instrumental in closing executive-level contracts with major service providers.

Product Management - Business Development - Strategic Planning
Product and Technology Roadmaps - Consumer Privacy - Intellectual Property
Broadband Wireless – Digital Advertising – Mobile Advertising

Significant Accomplishments

- Innovative privacy-compliant platform to deliver hyper-local targeting and audience intelligence and metrics to ad networks and publishers, and new online ad revenues to service providers: attracted word-class advisors and commercial partners (Cisco and Juniper, ISPs and advertisers).
- Career record of critical decisions in the mobile products and services industry to improve competitiveness, cost and performance, using market requirements, product management, strategic planning, technical analyses and triage on priorities.

Professional Experience

Broadband Mobile Wireless Innovations **2004 to 2007 and 2010 to present**

Solo consulting and decision services to executives responsible for strategy in major service providers and vendors with a target of $ Bn+ new revenues in business opportunities

Founder:

- Identified suitable partner with network & spectrum for a mobile operator's entry into North America, analyzed service and network economics and led RFQ for network deployment.
- Developed network, value-added service and product roadmap for spectrum holders in US and Europe: comparative analysis of WiFi, WiMAX, 3G, LTE for video and advertising.

- Delivered revenue risk/opportunity analysis of licensed and unlicensed spectrum and accurate cost estimate of upcoming 700 MHz spectrum auctions for a broadband service provider.

Feeva Technology, Inc. **2007 to 2010**

Software start-up with a privacy-compliant platform for hyper-local targeted advertising, generating new revenues from existing assets for mobile and broadband service providers.

Founder and CEO:

Invited to become co-founder by original founders and angel to lead and grow the start-up company.

- Closed investment of $ 10M, built the organization (from 3 to 20+ people), and attracted three world-class Strategic Advisors in the area of telecoms, privacy and advertising.
- Developed the architecture and IP (20+ patent applications), revenues of over $ 2M, won support of major ISPs in US and Europe, contracts with leading ad networks and exchanges.
- Led strategy, product management and business development resulting in partnerships with
  Cisco Systems, Juniper Networks and Microsoft, and acceptance by privacy bodies (FTC), and development of a cloud-based platform for real-time metrics and targeting.

RHK, Inc. **2003 to 2004**

Leading strategy and technology consulting, and telecommunications market research firm.

Group Head, Wireless Advisory Services:

Recruited by executive founder to jump-start a new wireless consulting and market research practice.

- Consulted on wireless strategy, risks, opportunities, spectrum for WiFi, WiMAX, and 3G.
- Clients included US, Asian and European telecoms carriers, network infrastructure, technology and IC manufacturers, content and applications providers, and financial investors.
- Market analysis of wireless alternatives (WiFi, 3G, LTE, WiMAX etc) for major network operators

ArrayComm, Inc. **2000 to 2003**

Industry leader in "smart antenna" technology for wireless networks.

Chief Strategy Officer and General Manager:

Recruited from Bell Labs by the founders to establish a new division for iBURST: industry's first commercial all-IP mobile broadband system manufactured by Kyocera for emerging markets.

- Led product management, marketing, partnerships (Sony, Kyocera, and Mitsubishi) and IP portfolio (from 12 to over 100 patents) and standardization in IEEE 802.20/ATIS.
- Purchased nationwide 1.9 GHz 3G spectrum and founded Personal Broadband Australia a wholesale broadband wireless network with Vodafone and Ozemail, and led a similar business partnership for nationwide licensed spectrum from FCC Auction 46 in the US.

Bell Labs/Lucent Technologies **1990 to 2000**

Leading manufacturer of network infrastructure for 2G, 3G and 4G mobile networks.

Vice President, Wireless Internet:

Held progressive leadership roles from Supervisor to Director of Wireless Core Technology to Vice President of Wireless Data Networking and Chief Wireless Architect in the Office of the CTO.

- Responsible for strategy, technology and product roadmaps, R&D and product team of over 350 staff in six global locations and budget of $ 35M, generating over 360 patents in 6 years.
- Managed portfolio of technology development in software architecture, digital speech coding, software radio, CDMA baseband IC, GSM base station, 3G core and radio access standards.
- Resulted in cost reduction and performance enhancement and were the launch-pad for the first 3G networks, an open applications platform for mobile Internet.
- Deployed in-building and distributed antenna systems and fiber-connected base stations
- Sponsored for an Executive MBA Program, Leadership Continuity Program, promoted as one of the youngest Vice Presidents at Lucent Technologies to lead mobile Internet initiatives.

Prior experience

Quantum-engineering of compound semiconductors for US Air Force, US Army and DARPA funded R&D (Program budgets over $ 20M): as lead scientist and program manager, achieved the goal of building the fastest transistors and optoelectronic switches in the world.

Education

University of Pittsburgh Executive MBA Joseph M. Katz Graduate School of Business (incomplete)
University of Cambridge PhD, Microelectronics and Physics
University of Cambridge BA, MA, Natural Sciences: Materials Science, Physics, and Mathematics

Industry

Named Wireless Week's Top 50 Newsmakers (2000)
Served as one of the 30 industry experts on the FCC's Technological Advisory Council (2001 to 2003)
Featured as “The Thinker” in Wireless Review (2004)

Products and Platforms

Bell Labs/Lucent Technologies:

Wireless Data Server (software platform for mobile Internet services) for US carrier trials.
WaveAccess/XWD (fixed broadband wireless for Internet access) first deployed in Argentina.
PlanR (distributed objected-oriented software platform for mobility management and IP services).
CDMA network trials with Cox, Sprint PCS and KDDI (first CDMA trials).
W-CDMA network product and trials with NTT DoCoMo (first 3G RAN and core networks).
GSM BTS (“cube”), fiber microcell, CDMA algorithms and baseband IC, EVRC speech coder.

Press and Media

Feeva:

Partnerships with Cisco Systems, Juniper Networks and Microsoft.
Marketing video http://www.youtube.com/watch?v=IPXCNEm5QBE.
Microsoft BizSpark *One* Start-up of the Day interview; AdExchanger interview.

RHK:

Analysis on broadband wireless in leading news, financial & trade publications.

ArrayComm:

iBURST product, Personal Broadband services and DEMOgod Award.
Partnerships with Sony, Vodafone Australia, Kyocera, Hanaro, LGE, TSMC.
FCC Auction 46 nationwide spectrum license.

Bell Labs:

Responsible for the Global Wireless Conference series for Bell Labs/Lucent’s customers.
Mobile Communications and Mobile Data Services in the Bell Labs Technical Journal.
Over 100 publications and presentations in technical and trade journals and conferences.

Patents

Twelve issued patents and over ten patent applications in process. Most recent issued patents: "Directed Media Based On User Preferences" for digital media and audience intelligence (2009) and "Method and apparatus for disabling the RF functionality of a multi-function wireless communication device while maintaining local functionality" (2007)

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Professional Experience

LCC International ***2011- Present***
Vice President, Enterprise Mobility Solutions
Responsible for leading the Enterprise Mobility Solutions Business Unit. Enterprise Mobility Solutions provides operators and enterprise clients solutions to address the skyrocketing mobile data demands. Services include the design and deployment of Distributed Antenna Systems (DAS); data off-loading and mobility services using both licensed radio (Cellular) and unlicensed (Wi-Fi) technologies. In addition, LCC's Land Mobile Radio Group provides in depth engineering, network, and project management services to support Public Safety and Land Mobile Radio (LMR) solutions.

Edgecon Consulting ***2010 - 2011***
Managing Partner
Business Development support several clients with respect to Wireless In-Building technologies – Wi-Fi, DAS and LMR. business development strategy as it relates to the wireless and telecom industries. Led team to prepare and submit, and subsequent award of $17M NTIA BTOP grant for client.

Feeva Technology, Inc. **2008 – 2010**
Vice President, Strategic Alliances and Partnerships
Feeva Technology specializes in cutting-edge online advertising solutions for marketers and publishers. Feeva has created a patented software platform to allow advertisers to more accurately target online audiences based geo-demographics.

- Defined, negotiated and closed deals with business partners essential to Feeva's ecosystem
  - Service providers (Fixed and Mobile/domestic and international)
  - Media companies
  - Network Equipment Vendors
  - Data providers.
- Led Sales partnership program with Network Equipment Vendors
- Created, and executed the Go-to- Market Strategy for Feeva Inc.
- "Evangelize" Feeva solution across industry segments with Senior Level Executives.
- Responsible for driving ad strategy/execution and all publisher/agency/ad network relationships
- Acquired strong knowledge of interworkings of the digital marketing (display) industry
- Member of IAB Sales Executive Council

Integral Wireless Solutions, Inc. Charlotte, NC **2004 – 2008**
Executive Vice President Business Development
IWS provided system integration, design, and commissioning of wireless applications and networks.

- Negotiated master service partnership agreements with Motorola, Verizon, AT&T, Cincinnati Bell and Avaya
- Subject matter expert in Wireless technologies including Wi-Fi, WiMAX, In-Door & Outdoor DAS systems, Public Safety, and Mobile applications
- Created and Delivered New Service Offerings
  - Mobile Applications, Location Tracking, In-Building System Design
- Responsible for Investor Relations including the preparation and presentation of road show materials and the Company's private placement memorandum for prospective investors
- Direct report to CEO

WPCS International, Inc Denville, NJ **2002–2004**
President, InvisiNet Subsidiary
Executive Vice President Business Development & Investor Relations
WPCS International Incorporated provides design-build engineering services for specialty communication systems and wireless infrastructure. This included site design, structured cabling, product integration, network security, technical support, product integration and project management. The company has a diverse customer base that includes corporations, government entities and educational institutions. WPCS was created through a "roll-up" acquisition strategy in which InvisiNet was the first
company acquired***.***

- Led the InvisiNet subsidiary, which included full P&L responsibility
- Merger and Acquisitions experience
  - Responsible for strategic direction and identification of acquisition candidates
  - Led due diligence efforts on numerous M&A targets
  - Led the deployment of hundreds of wireless network deployments for enterprise and government customers. Outdoor DAS, Wi-Fi

InvisiNet, Inc. Morristown, NJ (acquired by WPCS, Int'l) **2000–2002**
Founder/ CEO
InvisiNet Inc. was a project engineering company that focused on the implementation of Wi-Fi networks and fixed wireless deployment. InvisiNet provided a wide range of wireless communications services including project management, site design, product integration, infrastructure deployment, wireless network security and technical support.

- Created Business Plan, Secured angel financing to create InvisiNet
- Developed vision and go-to market strategy
- Hired key executives to management team
- Recalibrated the company's market penetration post 9/11.
  - opened new markets, including homeland security/public safety

- Negotiated and completed the sale of the Company to WPCS
- Return on investment was over 300% in 2 years

AT&T / Lucent Technologies Whippany, NJ **1989–2000**
Director WaveLAN (Wireless LAN) Business Unit
North America ***Parsippany, NJ***

- Grew revenue from $16M to over $120M in 5 years
- Complete P&L responsibility for business unit
- Manage all aspects for Wireless LAN business unit
- Managed team of 35
- Created indirect channel program including recruiting, training and supporting of over 250 Value-Add Resellers
- Negotiated key distribution agreements
- Negotiated all major sales contract
- Provided strategic direction for product development
- Represented Lucent on WECA committee to name “Wi-Fi™”

CFO, Wireless Communications Division ***Utrecht, The Netherlands*** **1994–1996**

- CFO responsibility for wholly own International subsidiary
- Implemented proper internal controls and financial discipline
- Managed all reporting and forecasting for Wireless LAN business unit
- Managed team of 15 Dutch nationals
- Supported Negotiations for all major sales and supplier contracts worldwide

Various positions within AT&T’s CFO and Product Management organizations.

Education

St. Bonaventure University, Olean, NY - BA, Finance, 1989
Fairleigh Dickinson University, Madison, NJ - MBA, Finance, 1992