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In this issue

Advanced Antenna Systems

Even as the wireless networks move up the generation ladder, operators continue to have difficulties in keeping up with the increased network demand on capacity coming from high-speed devices and applications. Experts are apprehensive that switching from 3G to 4G might not provide enough capabilities to accommodate the expected rise in traffic as millions of more people get connected to the Internet with their smart-phones, iPads, tablets, and computing devices such as laptops and netbooks. The service providers are trying to look ahead and prepare for what could be a meteoric rise in mobile video demand. Traditionally, service providers have added more network capacity by deploying new radio carriers, building new cell sites, adding sectors and technological upgradation. While some of these methods may not always be practical because of limited spectrum or cost considerations, advanced antenna systems have been suggested and deployed as an efficient means to meet the rapidly increasing traffic volume. This issue of Technology digest discusses the importance of various advanced antenna schemes for improving the capacity and coverage of the emerging generations of wireless networks. The concept of advanced antennas for radio base stations is not well defined but, in general, can be taken to mean any antenna or strongly antenna-related solution more sophisticated than that of a conventional three-sector base station[3].

Advanced antenna systems may take the following forms:

- Receiver diversity
- Transmit diversity
- Fixed multi-beam
- Multiple Input Multiple Output (MIMO) multistream transmission
- Adaptive beamforming with linear array antenna

Receiver Diversity and Optimal Combining: Base station receiver diversity is widely used in all 2nd and 3rd generation cellular mobile systems including GSM, UMTS and CDMA using cross-polarized antennas. The combining solution can be Maximum Ratio Combining (MRC) or Interference Rejection Combining (IRC). MRC is the optimal solution when the interference is spatially white Gaussian, while IRC is optimal in case of dominant interferers.

Transmit diversity – open and closed loop: Base station transmit diversity can be utilized to enhance the downlink coverage and capacity. The transmit diversity can be based on an open loop or closed loop approach. The closed loop

[Source:Gartner]

Top Mobile Application of 2012

1. Mobile Advertising

2. Mobile Payments

3.Mobile Health

4.Mobile Music

5. Mobile Browsing

6. Location Based Services

approach uses feedback from the terminal to optimize the downlink transmission to that terminal.

Fixed Multibeam: As an alternative to increasing the number of sites or cells per site as the means to enhance capacity in cellular networks, multibeam array antennas may be introduced. Fixed multibeam systems are characterized by the use of a set of fixed azimuth beams in each cell for transmission and reception. Each beam in the set has predefined properties such as pointing direction and beam shape and covers only part of the cell.

Multiple Input Multiple Output (MIMO): MIMO uses atleast two transmit antennas at the base station and two receive antennas at the terminals. It may use space time coding or diversity transmission or spatial multiplexing/dual stream transmission. Spatial multiplexing transmits two parallel data streams to double the data rate. Downlink MIMO can utilize the same cross-polarized antenna that is used for receive diversity. MIMO in the uplink faces the problem that two power amplifiers would be needed in the terminal, increasing the cost, size and power consumption of the devices.

Adaptive beamforming with linear array: Adaptive beamforming has been an area of research for all radio systems for their capability of boosting the radio coverage and capacity. Adaptive beamforming is known as antenna array signal processing, where every antenna element is separated from its nearest element by half of the transmit signal wavelength. Weights are assigned to the signal passing through each antenna element make it possible to point the resultant signal into a narrow beam towards the terminal. The downlink beam direction is determined based on the uplink received signal using direction-of-arrival estimates(DOA). Antennas with smart DOA estimation are also known as smart antennas. In case of systems using OFDMA, uplink signal cannot be used directly to control downlink beamforming. Uplink sounding zone where the terminal sends a known signal covering the whole bandwidth can be used. The ideal capacity gain from adaptive beamforming with N antennas is N times capacity, however, in practice it may be less than that. Adaptive beamforming is illustrated in the figure below.

Figure: Adaptive beamforming

Types of Advanced Antenna Systems

1. Antennas for MIMO

MIMO is a multiple antenna technology that uses advanced signal processing techniques to increase capacity in a radio link; it employs multiple transmit and receive channels and antennas with different data streams sent over each antenna. MIMO antenna systems are a magic ingredient in the quest for broadband wireless systems with higher capacity, performance and reliability. MIMO technology exploits multi-path to provide higher data throughput, and simultaneous increase in range and reliability all without consuming extra radio frequency. MIMO technology achieves a multifold user throughput gain and multiple aggregated capacity increase compared to current 3G macro-cellular networks. Because of these properties, MIMO has become an important part of modern wireless communication standards such as HSPA+, IEEE 802.11n (WiFi), 4G, 3GPP LTE and WiMAX.

With MIMO technologies and higher order modulation, HSPA+ can deliver 42 Mbit/s peak bit rate in the downlink and 11 Mbit/s in the uplink over a 5 MHz channel. In LTE Peak data rates of up to 300 Mbps (4x4 MIMO) and up to 150 Mbps (2x2 MIMO) in the downlink and up to 75 Mbps in the uplink are specified.

Types of MIMO antenna systems

SU-MIMO
When the data rate is to be increased for a single User Equipment (UE), this is called Single User MIMO (SU-MIMO)

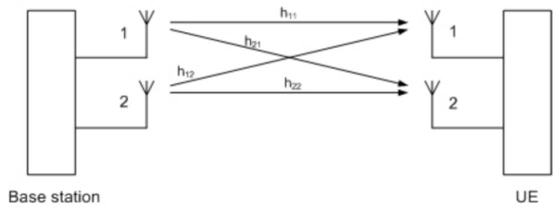

Figure: Single User MIMI

MU-MIMO: Multi-user MIMO (MU-MIMO) is exploits the availability of multiple independent radio terminals in order to enhance the communication capabilities of each individual terminal by using more sophisticated signal processing. MU-MIMO can be seen as the extended concept of space-division multiple access (SDMA) which allows a terminal to transmit (or receive) signal to (or from) multiple users in the same band simultaneously.

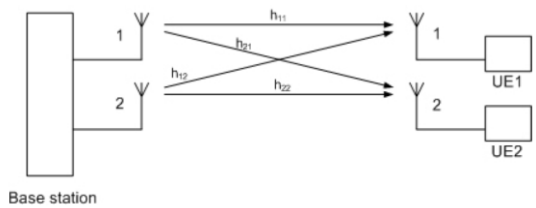

Figure: Multi User MIMI

CO-MIMO: CO-MIMO, also known as Network MIMO (Net-MIMO), or Ad-hoc MIMO, utilizes distributed antennas which belong to other users, while conventional MIMO, i.e., single-user MIMO, only employs antennas belonging to the local terminal. CO-MIMO improves the performance of a wireless network by introducing multiple antenna advantages, such as diversity, multiplexing and beamforming. Strategies such as autonomous interference cognition, node cooperation, and network coding with dirty paper coding (DPC) have been suggested as solutions to optimize wireless network capacity. CO-MIMO is a technique useful for future cellular networks.

Hex-MIMO: A technology for a variety of 4G applications, Hex-MIMO is a configuration that uses compact, lightweight antenna arrays to provide six sectors per cell site versus the typical three, delivering valuable capacity and coverage gains in urban hot-spot deployments. As shown in the diagram below, a Hex-MIMO configuration essentially partitions each sector of a conventional tri-sector antenna area into two, achieving six-sector (or hex-sector) coverage around the cell site. Hex-MIMO employs two carefully shaped fixed dual-polar beams within a sector, each of which carries two-branch MIMO. Depending on the scenario, a Hex-MIMO solution can offer downlink and uplink capacities in excess of 2.5 times that of conventional deployments.

Obsolete Technology: The big losers
Adapted from PC World that has classified the old tech friends, that we used for years, as deceased, on life support or seriously ill.

1. **Hearing the Sound of a Modem Connecting:** Sounds of 56k modem! So grating and yet gratifying! Status: ***Nearly deceased***.
2. **Storing Data on a Floppy Disk:** The mighty 1.44MB standard seems so puny by today's file-size standards. Status: ***Nearly deceased.***
3. **Booting Up to a C:\ Prompt:** The blinking DOS prompt will always be fondly remembered! Status: ***Nearly deceased***.
4. **Sitting in Front of a CRT Monitor:** ***On life support***.
5. **Checking Your Answering Machine**: Most people are now using dial-in voicemail instead of these: *Status:* ***Seriously ill***.
6. **Removing the Perforated Leader Strips From Continuous-Feed Paper Printouts:** The dot matrix printer will be remembered for its frequent paper jams; for its slow, noisy operation; and for the thin strips of perforated paper that you had to tear. Status: ***Nearly deceased***.
7. **Dialing on a Rotary Phone:** The old model built to withstand thermonuclear attack, will they ever become rare! Status***: Nearly deceased***.
8. **Putting in a Videotape to Watch a Movie:** VHS gave us hours of videotape-watching enjoyment--and almost as many hours of trying to adjust the tracking knob to get a steady picture. Status: ***On life support.***
9. **Using Carbon Copy Paper:** With even low-end printers now able to scan, copy, and possibly make toast, you don't see old-fashioned carbon copy paper too often. Status: ***Nearly deceased.***
10. **Using Proper Grammar and Punctuation:** txting and iming has made proper grammar seems kinda old skoo, dont u thnk? Status: ***On life support***

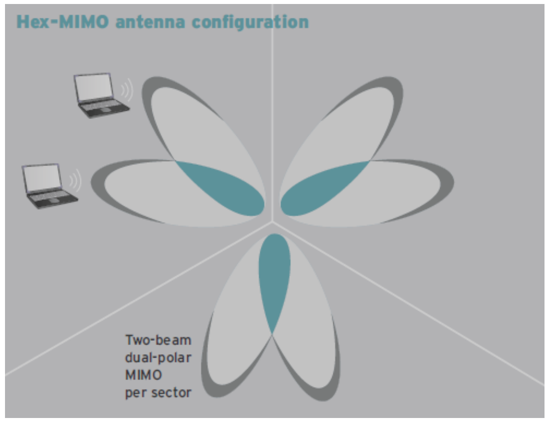

Figure: Hex-MIMO Antenna Configuration

Closed-loop and Open-loop MIMO: For multiple transmit antennas, the channel becomes more complicated, and there is interference between different transmitted streams. In closed-loop MIMO the BTS transmitter utilizes channel information to enable simple spatial diversity or beam-forming techniques that increase the system's effective SNR and potentially simplify the receiver architecture. In the case of open-loop MIMO the transmitter has no channel knowledge, the receiver is alone in exploiting MIMO capacity, which usually means that a complicated algorithm is required.

2. Fixed multi-beam array antennas

To address the need of increasing capacity in high-density macro-cell sites, fixed multi-beam antennas can provide an effective solution. The fixed twin-beam antenna has many advantages over the conventional approach of using two discrete antennas for sector splitting. Three antenna enclosures provide six sectors of coverage resulting in reduced tower loading and favorable aesthetic appearance. The reduced antenna count minimizes cap-ex and op-ex costs. Enhances network capacity-six sectors with three antenna faces, increases flexibility in network optimization with RET, maximizes spectrum use, makes it 2x2 MIMO ready. The figure below shows the patters of a typical 65-degree sector, two 33-degree and a twin beam antenna.

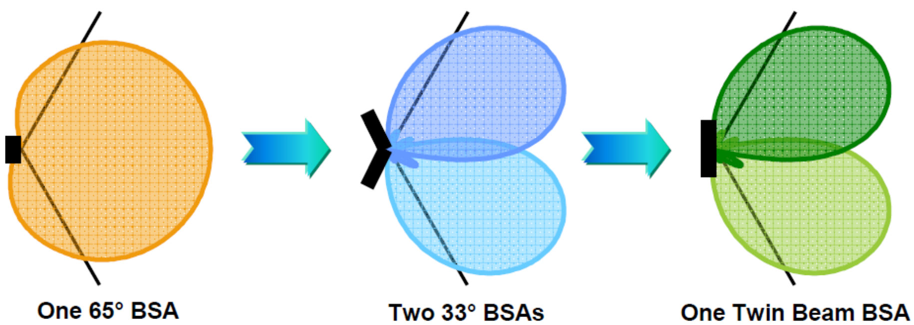

Figure: Comparison of single beam, two beam and twin-beam antennae

3. Adaptive beam antennas

The basic architecture of an adaptive beam-forming antenna consists of multiple columns of radiating elements that are driven by separate transceiver networks. It consists of planar array of multiple columns of radiators. External DSP controls the horizontal antenna pattern. A unique beam tracks each mobile. Increased S/N generates capacity improvements.

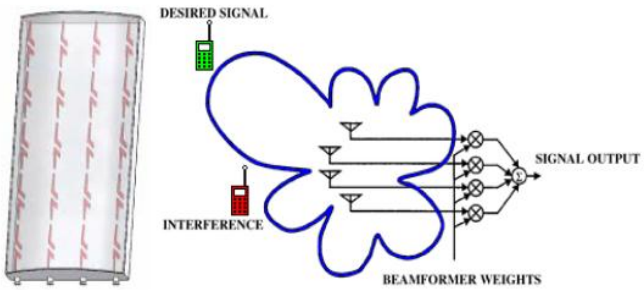

Figure: Adaptive beam antenna

Figure below shows typical planar array architectures that are currently deployed in wireless networks. There has been a significant trend to migrate towards dual-polarized arrays as the resulting physical size of the antenna has been reduced by 50 percent as compared to a vertically polarized array. The separation between the columns for a beamforming array is of the order of 0.5 wavelengths. Increasing spacing results in degradation in the beamforming characteristics under various scanning conditions. Unfortunately, however, adaptive array antenna is not effective in the presence of multiple propagation paths because it inevitably nullify the delayed desired signal components, even though they bear the desired user's transmitted information.

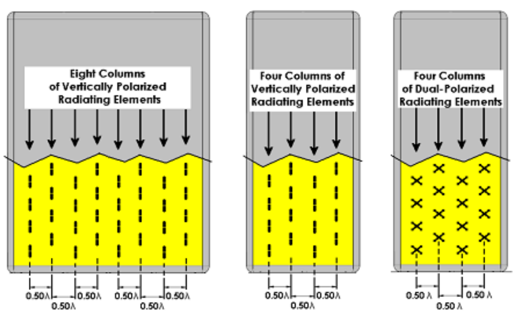

Figure: Multicolumn planar array architecture

Free Space Optical Communication

Free Space Optics (FSO) is a re-emerging technology using modulated optical beams to establish short, medium or long haul wireless data transmission. It is also known as Optical Wireless or Laser Communication. Free Space Optical communication links transmit information by lasers through atmospheric channels. Operating with a high carrier frequency of 300 THz, FSO offers high bandwidth links with data rates of several Gigabits per second which are likely to reach 40 Gbps in near future. As a matter of fact, FSO is the only wireless technology able to grant bandwidth of several Gigabits per second.

Its advantages make FSO interesting for *applications* in airborne, satellite and undersea communication. It can be used for the first/last mile in dense urban areas, high-speed LAN-to-LAN links, chip-to-chip connections, permanent connections between buildings, temporary mobile links and in situations where a physical connection is not a practicable solution and high bandwidth is required. Furthermore FSO can be used as an alternative or upgrade add-on to existing wireless technologies. A further advantage FSO and fiber equipment can be combined, without intermediate conversion, as both air and fiber material have good transmittance at the established wavelengths, namely 850 nm and 1550 nm.

Among the *disadvantages* are atmospheric effects on the distance and the availability of the FSO links. The outage will depend on the link length and on the persistence of adverse weather conditions. While light to moderate rain (5mm/hr) may only cause attenuation of approx. 3 dB/km. Tropical rains of 100 mm/hr would result in higher attenuations of about 30 dB/km. Scintillations and air turbulences may also affect the performance. Air cells with different temperatures, randomly distributed along the link, cause focusing and defocusing of the beam due to changes in the refractive index. Performance is also affected by problems affecting visibility e.g. sand, dust, birds flying through the beam cause momentary link losses. The sun itself acts as a noise source, which may completely overdrive the receivers if they are directly exposed to sunlight.

Besides commercially available opaque systems, where the optical signal is terminated to an electronic receiver and subsequently sent through the atmosphere by means of a dedicated laser, a new configuration, known as fully transparent, is in research stage. It is expected that the bandwidth achievable in these systems would be comparable to that given by optical fibers.

There is also the obvious frequency dependence of the antenna size on frequency. Figure 17 shows the relative physical sizes of antennas at operating frequency ranges of 850 MHz and 2500 MHz. Each of the antennas shown has an approximate elevation beam width of 6.5 degrees to provide a relative comparison

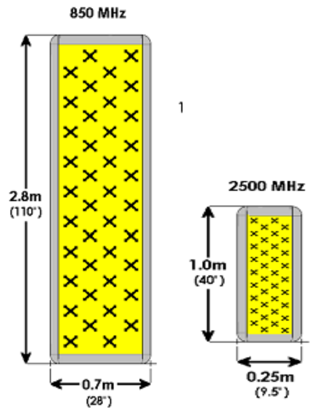

Figure: Typical and relative antenna sizes at different frequencies

Smart Antenna Technology: The term smart antennas generally refers to any antenna array joint with signal processing, which can adjust or adapt its own beam pattern in order to emphasize signals of interest and to minimize interfering signals. Smart Antennas can modify their radiation pattern by means of an internal feedback control while the antenna system is operating. In beamforming, each user's signal is multiplied with complex weights that adjust the magnitude and phase of the signal to and from each antenna. With this each user's signal is transmitted and received by the basestation only in the direction of that particular user. Modern smart antennas systems take advantage of digital signal processing at the base band frequency instead of doing it at RF stage. Smart antennas have alternatively been labeled through the years as adaptive arrays or digital beam forming arrays.

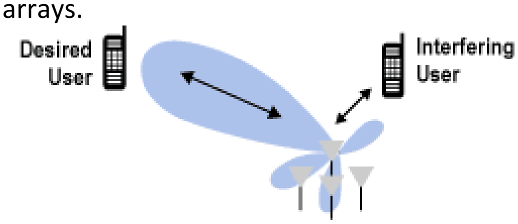

Figure: Beamforming by smart antenna system

Switched and Adaptive Beamforming: Smart antennas can be switched beam or adaptive. If the complex weights are selected from a library of weights that form beams in specific, predetermined directions, the process is called switched beamforming. On the other hand, if the weights are computed and adaptively updated in real time, the process is called adaptive beamforming. Through adaptive beamforming, the basestation can form narrower beams towards the desired user and nulls towards interfering users, considerably improving the signal-to-interference-plus-noise ratio.

4. Reconfigurable beam antennas

Reconfigurability is the capacity to change an individual radiators fundamental operating characteristics through electrical, mechanical or other means. Reconfigurable beam antennas are capable of making real-time adjustments to changing traffic patterns. Reconfigurable beam antennas can dynamically load balance capacity across all sectors of a site cluster by tilting the beam, changing the horizontal azimuth direction of the beam. Reconfigurable beam antennas extend the range of remote beam changes from a single dimension for elevation beam steering (Remote Electrical Tilt, RET) to multiple dimensions. These antennas include the possibility to change the boresight or azimuth direction (panning), as well as the beam width of the antenna (fanning) remotely. RET(1-way) antenna optimises C/I (Ec/Io) performance in a network. RAS(Remote Antenna Azimuth or 2-way) adds beam panning or horizontal beam scanning which improves C/I (Ec/Io), cell overlap performance and coverage. Offered traffic can be shifted more effectively between the individual cells. This resulted in better load balancing and higher cell utilization. RAB(Remote Antenna Beam width or 3 way) adds beam fanning or horizontal beam width adjustment to RAS. It gives further improvement over RAS in all performance indicators.

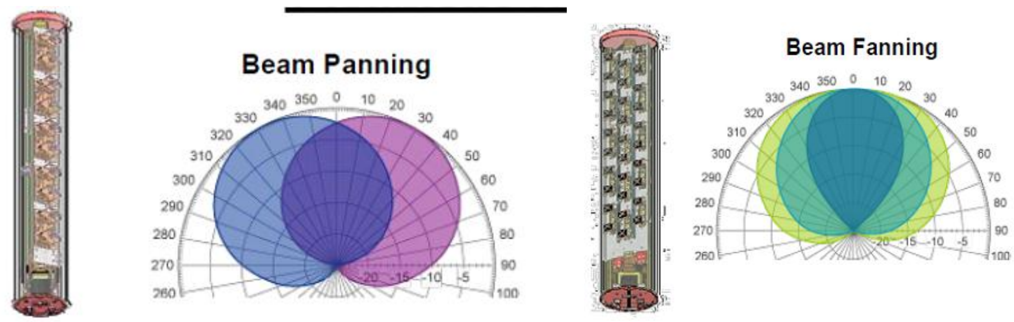

Figure: Reconfigurable Beam Antenna

A reconfigurable beam antenna with three degrees of freedom utilizes a multi-column design that generates superior pattern shaping and more enhanced roll-off than a standard 90 degree antenna. A reconfigurable beam antenna essentially combines the advantages of both a 65 degree and 90 degree antenna into one superior pattern. It has the wide coverage of a 90 degree antenna with the roll-off of a 65 degree antenna. The result is less interference, wider coverage area, improved SNR, better network quality, and higher data rates, even when the three-way reconfigurable beam antenna is used statically (i.e. not adjusted routinely). When combined with the agility to change the tilt, azimuth direction and beamwidth in a matter of a few minutes with no costs, three-way reconfigurable beam antennas are the key solution for superior, cost efficient data networks.

5. Active antenna arrays

Active antenna systems(AAS) are radio embedded base station antennas. It has functionality of a remote radio head integrated and distributed into the antenna. It has the same size as a standard passive BSA with standard azimuth beam. Another critical benefit of an AAS is the unique ability to electronically tilt elevation beams by having independent base band control of the phase and amplitude on each element. This supports multi-mode systems where different carriers in the same frequency band, with different air interfaces, may require different orientations. For example, LTE may be down-tilted differently than the legacy carriers. A most general approach to Digital Signal Processing(DSP) controlled smart antennas that permits both the typical horizontal beamforming and vertical beamforming, is made possible by active antenna arrays as shown in the figure below. This technology has the added benefit of eliminating power losses in the RF feeder cables, much like Remote Radio Heads. With the radios integrated directly into the radome housing, and with replacement of a small number of large amplifiers with many small amplifiers, the heat is spread over the larger antenna structure as opposed to the smaller RRH or amplifier shelf, permitting larger total RF transmit powers without the use of fans or other active cooling. Rx/Tx feeds each element directly. Loss of transceiver does not cause a complete failure of the sector – graceful degradation with self-healing. Input to BSA is via fiber and CPRI(Common Public Radio Interface**)** or OSBAI(Open Base Station Architecture Initiative) radio interface standard.

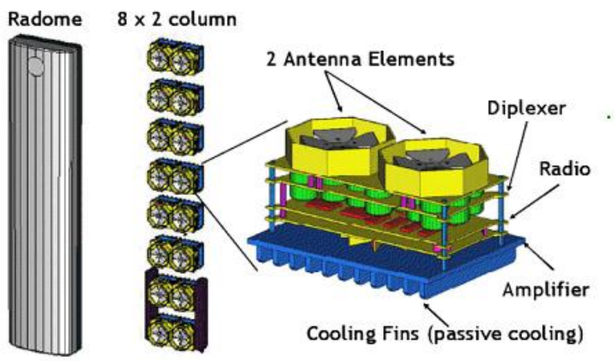

Figure: Active Antenna Array

By integrating the remote radio head functionality into the antenna, the aesthetics of the site can be improved, windload reduced, and potentially, some leasing costs avoided as shown in the figure below.

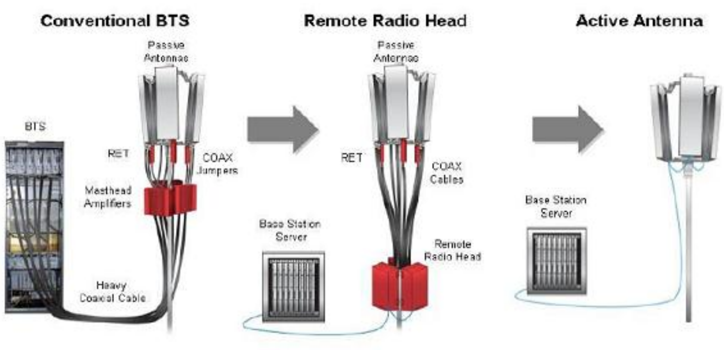

Figure: Radio and antenna integration

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