CSAWireless

Additional antenna technology for 3G network optimisation

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The last two years have seen continuing delays in the roll-out of many 3-G networks. Antenna manufacturers have taken advantage of this delay to provide additional technology in the form of remotely-controlled elevation pattern tilt, which is increasingly seen by operators as providing an essential tool for W-CDMA network optimisation. The increasingly tough planning regime in many countries is extending the demand for multi-band antennas

This report describes the application of these techniques, and the world-wide move to interface standardisation which will facilitate the rapid introduction of remote tilt control technology.

Antenna beam tilt

In order to maximise the capacity provided by a mobile network, the area of coverage of individual base stations is carefully controlled. When the network is being rolled out, base stations are placed relatively far apart; the objective is to get a signal laid down over as wide an area as possible at least cost. To do this the radiation of the base station antennas is directed almost horizontally – like the main beam of a car's headlights.

Once traffic begins to build up the network operator must ensure that sufficient capacity is provided within each cell to support the user traffic demand. In 2G systems this is achieved by adding additional radio carriers (each supporting 8 more voice channels) and by adding additional base stations between existing ones. When new stations are added the required range of coverage drops and the antennas are down-tilted – like a car's headlights on dipped beam. Simply reducing the radiated power doesn't provide an adequate solution, because coverage is impaired in any shadowed or in-building areas inside the wanted area. Dipping the beam improves coverage within the cell, while limiting the spread of signals outside the cell. The technique is known as *beamtilt.*

In a W-CDMA 3G system the situation is similar, but the operator is likely to have only 2 or 3 carriers available. The greatest possible efforts must be made to maximise the throughput on these carriers. CDMA systems reuse the same RF

carrier frequencies in adjacent cells; individual user circuits are differentiated by the spreading-code sequences which are unique to each circuit. As a mobile user moves location, signals will be received by adjacent base stations, or by other sectors of the original base station. While 2G systems hand-off the user from one sector (or base station) to another in a single operation, CDMA systems use a variety of 'soft' handoff procedures, during which signals received by other sectors or base stations are all used to maintain the user's channel performance. The user appreciates the more constant optimum channel performance obtained by this procedure, but an unwanted result for the network operator is that a single mobile requires capacity resources in more than one sector/base station.

Optimisation of a CDMA system requires that sectors overlap sufficiently to ensure trouble-free handoff, but if they overlap too much, a large number of mobiles may consume capacity at multiple base stations. The result will be that inadequate total network capacity is available to support the traffic demand. The control of antenna beamtilt in a 2G system is a tool to obtain closer frequency re-use, while in a 3G CDMA system it directly influences the capacity of the network.

Variable-tilt technology

The use of beamtilt for coverage control has been common since the beginnings of mobile radio, but until recently the usual technique has been to provide a fixed beamtilt by the choice of the lengths of transmission lines (coaxial or microstrip) inside an antenna. While there is some cost associated with the provision of adjustable tilt, a number of features of today's environment make its adoption increasingly attractive.

- 3G networks will probably grow more slowly than previous networks; the traffic patterns they will be required to support will probably change while the networks are being rolled out.
- Capacity will always be at a premium; it will always be necessary to operate a network close to its capacity optimum.
- Higher QoS objectives are specified for 3G networks. Customers who subscribe to premium services will expect very high standards of circuit availablity.
- More and more base stations use shared infrastructure; physical access to antennas is becoming more difficult as more users are accommodated on antenna structures.

Antenna designers have responded to this changing environment by creating antennas with adjustable tilt, incorporating a number of variable phase shifters into the feed system of the antennas. In the simplest realisation the beamtilt angle is controlled by a knob on the antenna. However this leaves a situation in which a rigger must climb up to the antenna to adjust it, perhaps requiring close-by

antennas to be de-powered while the operation is carried out. The antenna will be inaccessible in bad weather, and a rigger usually needs someone else to be on site for safety reasons. Access to many on-building sites often requires the permission of the landlord, and perhaps the attendance of his representative. All this makes adjustment expensive.

A much more attractive solution is to attach a drive unit to the antenna and provide an interface by which the antenna can be controlled remotely. CSA Wireless has new products available to meet this market demand.

A standard interface

The specification of an antenna control interface is relatively straightforward, but it was clear that the market for these products would be impeded if every antenna manufacturer created products using different and incompatible interfaces. Network operators responded enthusiastically to the author's proposal that a standard interface could be agreed. The result has been the creation of the Antenna Interface Standards Group (AISG), currently chaired by the author, which has brought manufacturers together from all over the world to create a standard for the control of antennas and other tower-mounted devices such as TMAs. The standard (AISG1) provides common hardware interfaces and a software toolbox that can be used to provide a variety of added-value user benefits. It allows operators to specify products which can be supplied by a variety of vendors, and provides a common path for future evolutionary growth in functionality. Options are provided in the standard for the direct connection of an antenna drive unit to the base station using a multi-core cable, or for sharing a single coaxial cable to a TMA, carrying power, data and RF signals.

Control options

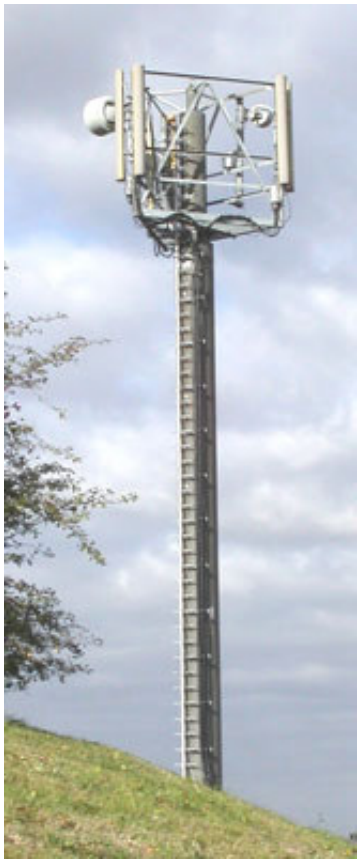
Using these new products a network operator now has a number of options for antenna tilt control:

- *Install antennas with full control facilities extended to the network control centre*. This provides the highest level of system benefits, with options of the co-ordinated control of antennas at groups of base stations. Adjustments can be made whenever required, perhaps by dynamic interaction with traffic demands. A local controller will be required to interconnect the antenna control interface (AISG1) to the protocol used within the base station, so the antenna will share the control infrastructure of the other equipment.
- *Install antennas with basic extended control facilities*. Using GSM modems or alternative connection methods the antenna tilt can be adjusted and system status monitored with no need for a site visit.

- *Install antennas with control cables, but no remote control facility.* Antenna tilt can be adjusted by a visiting technician, with no requirement to use a rigger.
- *Install antennas with hand-knob tilt adjustment.* This is clearly the lowest-cost solution, while providing a future upgrade path to the options above. Inventory is minimised (no need to purchase antennas with alternative tilts) and off-air time for adjustment is reduced. However, site access is still needed and riggers must still wait for the wind to die down!

It may be expected that these options will coexist during the early rollout of 3G systems, while the operators assess the technical effectiveness and cost pay-back of these new systems. It may well be justified to apply the highest level of remote control at busy city-centre sites. In low-traffic rural locations a much simpler system may be all that is needed, but the ability of a fully-equipped system to respond rapidly to a radical change in traffic patterns – a local sporting event or major news story – will always be an appealing feature.

Multiple-band antennas



The expansion of mobile radio services has required very large numbers of base station sites and in many countries the public have reacted ambivalently to their construction. They are critical of networks with poor coverage, but they respond negatively to proposals for new base stations, or even for new antennas at existing base stations.

To address this situation, CSA Wireless has directed substantial development effort to the creation of a variety of multi-band antenna solutions. These products allow an operator to substitute an existing single-band antenna with one which provides service on two or even three frequency bands with an antenna which generally comparable in external dimensions with the previous single-band device, and maintains the performance of the existing revenue-generating network. The new multi-band antenna may optionally include the adjustable-tilt facilities described above one or more of the operating bands. A further benefit to the appearance of a base station is that antennas of this type can be mounted with a single mechanical beamtilt (typically zero) and the antennas are not seen to have the unsightly higgledy-piggledy appearance that draws attention to many of today's shared sites.

CSA's role

CSA Wireless migrated from the defence and professional broadcast market at the beginning of the 1990's and is a major player in world markets with manufacturing facilities in Europe and the United States. The author's innovations in the use of microstrip technology for base station antennas have been widely emulated and micro-strip antennas now account for a large proportion of the worldwide antenna market.

While the slow rollout of 3G services has disappointed many people in the industry, CSA has taken full advantage of the available time to extend its product range and create new products to serve this dynamic and ever-changing market.

Figure 1 (Page 4): Space-diversity antennas for 1800MHz

Figure 2 (This page): A similar installation retrofitted with dual-band antennas providing the same performance as before at 1800MHz and similar performance on the UMTS band.

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