UMTS SMART ANTENNA DESIGN AND IMPLEMENTATION

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Abstract. *Adaptive type smart antennas does not usually operate on the deployed UMTS systems, although UTRA-UMTS preview their operation and they also could improve capacity specially in a multiservice environment. This paper describes the implementation of a simplified version of an adaptive antenna, that can be applied to standard Node-Bs, both in the up and down links..*

1. Introduction. The smart antenna concept is wide in the sense that under this idea are included several kind of arrays. Phased arrays, switched multibeam antennas and adaptive array antennas are usually included in the same smart antenna concept with the only condition of some automatic control depending on the incoming signals. Grate advantages have been reported for the smart antenna implementation in base stations for mobile telephone communications. But this kind of antenna has not been applied extensively to that systems.

If we compare capabilities of phased arrays, switched beam arrays and adaptive arrays, the last show advantages from the others. Adaptive arrays not only can improve antenna gain in the user direction but it can also cancel interferences inside the angular range of control. That ability suppose to rise the carrier to interference ratio (C/I) for each user. For CDMA systems an increase of cell or sector capacity is obtained for those places where a smart antenna is placed as base station. This capacity increment is grater as interference level from high bit rate users becomes important in the cell.

Adaptive antenna systems can be implemented with time or space reference algorithm. In time reference adaptive arrays, time series from the input signal at each array element are processed to form the array vector of weights. The array factor implemented for each user allows a C/I increment in order to improve Eb/No by means of received signal autocorrelation. This strategy is proper for CDMA signal due to a time reference must be obtained applying the user code. In space reference adaptive arrays, interference directions are computed so array weights are defined.

This paper details a practical implementation of an smart antenna with an adaptive beam for a 3er generation mobile communication system based on W-CDMA, that is to say, those called UMTS [1]. What is more, the implementation is being done requiring an easy deployment over any base station none specifically developed to be used with an smart antenna.

Channel	witth S-CPICH	without S-CPICH
P-CCPCH	No	No
SCH	No	No
S-CCPCH	No	No
DPCH	Yes	Yes
PICH	No	No
PDSCH(DPCH)	Yes	Yes
AICH	No	No
CSICH	No	No
PRACH	Yes	Yes

Table 1. Relationship between smart antennas and physical channels

2. UMTS and Smart Antennas. UMTS system has been designed to work with adaptive antennas both in up-link and down-link. Two kinds of adaptive antennas has been previewed depending on the secondary common pilot channel (S-CPICH) is shaped or not. Adaptive algorithm may be applied using dedicated pilot symbols. Besides in case of transmission by diversity the diversity pilot should be also considered. The previous table show what physical channels are attained by the adaptive antenna [2]. Our implementation does not shapes-CPICH, but needs to attend the access procedure in CPCH channel to obtain user codes.

3. Smart Antenna Architecture. The implemented architecture [4] of our smart antenna can be shown in Figure 1. At down-link, Node-B signal is down-converted from RF to IF, demodulated, shaped (with a set of different weights for each user) and finally up-converted to RF. At up-link an equivalent process is performed but with a common weights for all the users. This architecture performs a total interference cancellation in the down-link but only a partial cancellation of only cell external interference for the up-link.

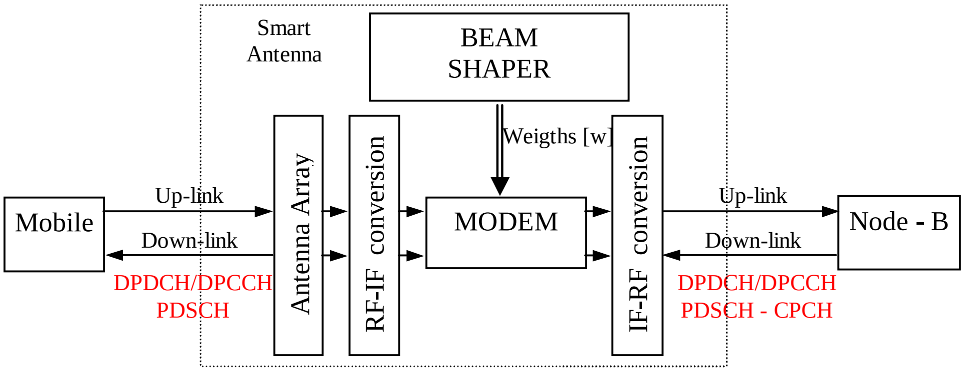

Figure 1. Implementation architecture of our smart antenna to be deployed with an standard Node-B.

4. Antenna and RF/FI section Specifications. The implemented prototype produces a 120º sector coverage and it is built with an array of four standard sectored antennas for mobile telephony in UMTS band. Figure 2 shows the general scheme of the transmitter. The combiner allows the usage of several block frequencies. The receiver is a dual scheme. Basic the prototype specifications are described in Table 2.

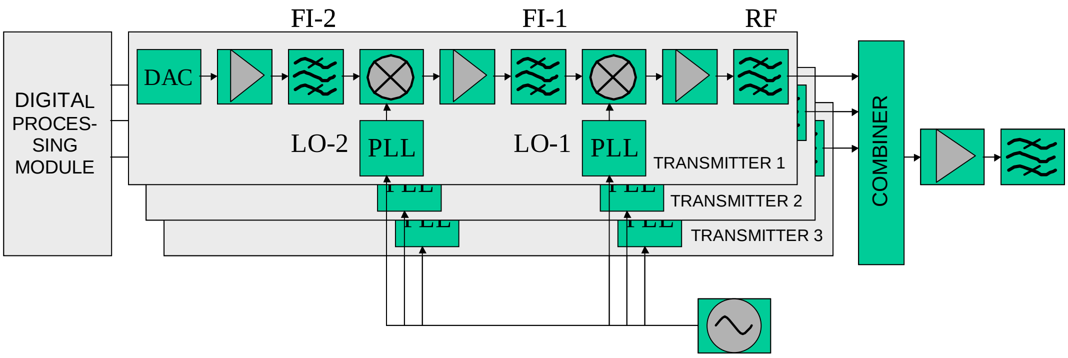

Figure 2. General block scheme of RF-IF stages of transmitter antenna

Transmisión Band	2110 - 2170 MHz
Reception Band	1970 - 2030 MHz
Carrier separation	4.6 to 5.6 MHz
Minimum step between carrier values	200 KHz
Sensibility	-112 dBm
Maximum power of each sectored antenna	1 w

Table 2. Basic specifications of transmitter/receiver section.

5. MODEM and Shaper. The shaper has been implemented by means of a despread reference at bit and rate level. A block description of shaping process is shown in Figure 3. The spread factor of control channel is 256, so a control symbol is produced each 256 chips.
An estimation of computational load for the computations done in modem + shaper are summarised in Table 3 and Table 4 for up-link and down-link respectively.

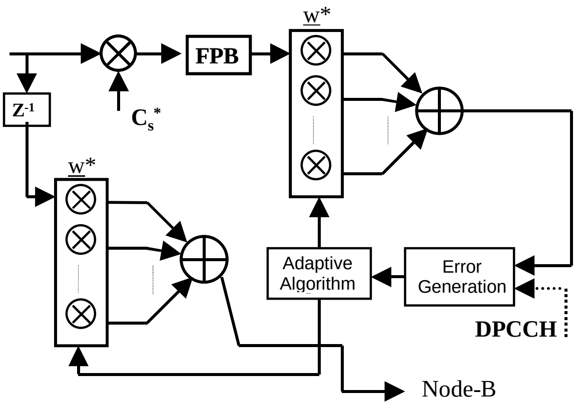

Figure 3. Adaptive process with despread reference signal (Cs*: conjugated of user scrambling code).

Processes	Flops
RRC filtering (25 taps, 4 samples/chip)	7680004
Beam shaping	3993600
Control channel demodulation	4 x 311105
LMS	26667
Total real time processes	11673604 ≈ 11,7 Mflops
Total delayed time processes	1271087 ≈ 1,3 Mflops
Total	12.944.691 ≈ 13 Mflops

Table 3. Computational load. Up-link, 4 array elements, 1 frame (2560 bits, 38400 chips), 1 user

Processes	Flops
RRC filtering (25 taps, 4 samples/chip)	7680004
Beam shaping	3993600
Descrambling	2085896
1 control channel demodulation	73382400
Control channel demodulation	311105
Data channel demodulation	4*311105
LMS	26667
Total real time processes	87453005≈ 87,1 Mflops
Total delayed time processes	1271087 ≈ 1,3 Mflops
Total	88.724.092≈87.5 Mflops

Table 4. Computational load. Up-link, 4 array elements, 1 frame (2560 bits, 38400 chips), 1 user

6. Conclusions. The work here presented justify the feasibility of a realistic implementation of an smart antenna, of adaptive type, applied to an UMTS mobile system and built under the requirement to be compatible with an standard Node B.

7. References.

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8. Acknowledgments. The authors wish to thank to DYCTEL the support to the development of ADAM project.