Smart Antenna

Presented by:-

J.Madhavi latha
09FH1A0409
III-II ECE
Jn.madhavi09@gmail.com
K.Geetha Rupa Spandana
09FH1A0406
III-II ECE

DR.K.V.Subba Reddy Institute Of Technology, dupadu, Kurnool
ABSTRACT:-
One of the developing areas of communications is “Smart Antenna” systems. This paper deals with the principle and working of smart antennas and the elegance of their applications in various fields such as 4G telephony system, best suitability of multi carrier modulations such as OFDMA etc. This paper mainly concentrates on use of smart antennas in mobile communications that enhances the capabilities of the mobile and cellular system such a faster bit rate, multi use interference space division multiplexing (SDMA), increase in range, Multi path Mitigation, reduction of errors due to multi path fading and with one great advantage that is a very high security. The signal that is been transmitted by a smart antenna cannot tracked or received any other antenna thus ensuring a very high security of the data transmitted. This paper also deals the required algorithms that are need for the beam forming in the antenna patters. The applications of smart antennas such as in WI-FI transmitter, Discrete Multi Tone modulation (DMT), OFDMA and TD-SCDMA is already in real world use is also incorporated in this paper.

INTRODUCTION:
What is a smart antenna?

A smart antenna is an array of antenna elements connected to a digital signal processor. Such a configuration dramatically enhances the capacity of a wireless link through a combination of diversity gain, array gain, and interference suppression. Increased capacity translates to higher data rates for a given number of users or more users for a given data rate per user.

![Diagram of Smart Antenna](image)

Multipath paths of propagation are created by reflections and scattering. Also, interference signals such as that produced by the microwave oven in the picture, are superimposed on the desired signals. Measurements suggest that each path is really a bundle or cluster of paths, resulting from surface roughness or irregularities. The random gain of the bundle is called Multipath fading.

Principle of working:-
The smart antenna works as follows. Each antenna element "sees" each propagation path differently, enabling the collection of elements to distinguish individual paths to within a certain resolution. As a consequence, smart antenna transmitters can encode independent streams of data onto different paths or linear combinations of paths, thereby increasing the data rate, or they can encode data redundantly onto paths that fade independently to protect the receiver from catastrophic signal fades, thereby providing diversity gain. A smart antenna receiver can decode the data from a smart antenna transmitter this is the highest-performing configuration or it can simply provide array gain or diversity gain to the desired signals transmitted from conventional transmitters and suppress the interference. No manual placement of antennas is required. The smart antenna electronically adapts to the environment by looking for pilot tones or beacons or by recovering certain characteristics (such as a known alphabet or constant envelope) that the transmitted signal is known to have. The smart antenna can also separate the signals from multiple users who are separated in space (i.e. by distance) but who use the same radio channel (i.e. center frequency, time-slot, and/or code); this application is called Space-division multiple access (SDMA).

BEAM FORMING BASICS
Beam forming is the term used to describe the application of weights to the inputs of an array of antennas to focus the reception of the antenna array in a certain direction, called the look direction or the main lobe. More importantly, other signals of the same carrier frequency from other directions can be rejected. These effects are all achieved electronically and no physical movement of the receiving antennas is necessary. In addition, multiple beam formers focused in different directions can share a single antenna array: one set of antennas can service multiple calls of the same carrier. It is no coincidence that the number of elements in the above diagram equals the number of incoming signals. A beam former of $L$ antenna elements is capable of accepting one signal and reliably rejecting $L-1$ signals. A greater number of interfering signals will diminish the performance of the beam former. Beam forming presents several advantages to antenna design. Firstly, space division multiple access (SDMA) is achieved since a beamformer can steer its look direction towards a certain signal. Other signals from different directions can reuse the same carrier frequency.

Secondly, because the beamformer is focused in a particular direction, the antenna sensitivity can be increased for a better signal to noise ratio, especially when receiving weak signals. Thirdly, signal interference is reduced due to the rejection of undesired signals. For the uplink case of transmitting from the antenna array to a mobile telephone, system interference is reduced since the signal is only transmitted in the look direction. A digital beamformer is one that operates in the digital domain. Traditionally, beam formers were implemented in analog; the weights were determined and applied to the antenna inputs via analog circuitry. With digital beam forming, the antenna signals are individually translated from Radio Frequencies (RF) to Intermediate Frequencies (IF), digitized and then down-converted to base-band I and Q components. A beam forming algorithm implemented on one or more digital signal processors then processes the I and Q components to determine a set of weights for the input signals. The input signals are then multiplied by the weights and summed to output the signal of interest (SOI).

One of the foremost advantages offered by the software radio technology is flexibility. Because beam forming is implemented in software, it is possible to investigate a wide range of beam forming algorithms without the need to modify the system hardware for every algorithm.
Consequently, researchers can focus their efforts on improving the performance of the beam forming algorithms rather than on designing new hardware, which can be a very expensive and time consuming process. A complete description of the RLS algorithm can be found in . This algorithm was chosen for its fast convergence rate and ability to process the input signal before demodulation. While the first reason is important especially when the environment is changing rapidly, the later reason decreases the algorithm dependency on a specific air interface.

*Applications in Mobile Communications:*

Aspace-timeprocessors (‘smart’antennas) is capable of forming transmit/receive beams towards the mobile of interest. At the same time it is possible to place spatial nulls in the direction of unwanted interferences. This capability can be used to improve the performance of a mobile communication system

*Increased antenna gain*

The ‘smart’ antenna is capable of transmit and receive beams. Therefore, the ‘smart’antenna has a higher gain than a conventional omni-directional antenna. The higher gain can be used to either increase the effective coverage, or to increase the receiver sensitivity, which in turn can be exploited to reduce transmit power and electromagnetic radiation in the network.

**Decreased inter-symbol-interference (ISI)**

Multipath propagation in mobile radio environments leads to ISI. Using transmit and receive beams that are directed towards the mobile of interest reduces the amount of Multipath and ISI.

**Decreased co-channel-interference (CCI)**

'Smart' antenna transmitters emit less interference by only sending RF power in the desired directions. Furthermore, 'smart' antenna receivers can reject interference by looking only in the direction of the desired source. Consequently ‘smart’ antennas are capable of decreasing CCI. A significantly reduced CCI can be taken advantage of by Spatial Division Multiple Access (SDMA) or . The same frequency band can be re-used in more cells, i.e., the so called frequency re-use distance can be decreased. This technique is called Channel Re-use via Spatial Separation.

Several mobiles can share the same frequency within a cell. Multiple signals arriving at the base station can be separated by the base station receiver as long as their angular separation is bigger than the transmit / receive beam widths . The beams that are hatched identically use the same frequency band. This technique is called Channel Re-use via Angular Separation.
Spatial Structure Methods:

As mentioned before, spatial structure methods exploit the information in the steering vector $\mathbf{a}(\theta)$. The spatial structure is used to estimate the direction of arrivals (DOAs) of the signals impinging on the sensor array. The estimated directions of arrivals are then used to determine the weights in the pattern forming network. This is called beam forming. Spatial structure methods only exploit spatial structure and training signals and the temporal structure of the signals is ignored. In the following an overview will be given about the three main spatial structure methods, namely conventional beam forming methods, maximum likelihood estimation and the so-called subspace-based methods. For simplicity, the vector channel model used here (and everywhere in the array processing literature for spatial structure methods) is a spatial-only vector channel.

$$\mathbf{x}(t) = \mathbf{A}(\theta) \mathbf{s}(t) + \mathbf{n}(t),$$

$$\mathbf{A}(\theta) = [\mathbf{a}(\theta_1), \ldots, \mathbf{a}(\theta_L)].$$

Note, that knowledge about the number of impinging Multipath signals is assumed in the models that make use of spatial structure.

Future applications are based on “Bearer Services”:

Real-time applications like voice, video conferencing or other multimedia applications require minimum delay during the transmission and generate symmetric traffic. This type of communication is nowadays carried via circuit switching systems. For non real-time applications like e-mail, Internet and Intranet access timing constraints are less strict. In addition, the generated traffic is asymmetric. This type of communication is relayed via packet switched systems. Future pattern of use will show a mix of real-time and non real-time services at the same time and same user terminal. Based on the TDD principle, with adaptive switching point between uplink and downlink, TD-SCDMA is equally adept at handling both symmetric and asymmetric traffic. Wireless Multi Media requires high data rates. With data rates of up to 2 Mbit/s TD-SCDMA offers sufficient data throughput to handle the traffic for Multi Media and Internet applications. With their inherent flexibility in asymmetry traffic and data rate TD-SCDMA-based systems offer 3G services in a very efficient way. Although it is optimally suited for Mobile Internet and Multi Media applications, TD-SCDMA covers all application scenarios: voice and data services, packet and circuit switched transmissions for symmetric and asymmetric traffic, pico, micro and macro coverage for pedestrian and high mobility users.

In order to further improve the system robustness against interference, TD-SCDMA base stations are equipped with smart antennas, which use a beam-forming concept. Using omni directional antennas, the emitted radio power is distributed over the whole cell. As a consequence, mutual inter cell interference is generated in all adjacent cells using the same RF carrier. On the other hand, smart antennas direct transmission and reception of signals to and from the specific terminals, improving the sensitivity of the base station receivers, increasing the transmitted power received by the terminals and minimizing inter and intra cell interference.

REAL TIME SMART ANTENNAS:
CONCLUSION: For visit
In conclusion to this paper “Smart Antenna” systems are the antennas with intelligence and the radiation pattern can be varied without being mechanically changed. With appropriate adaptive algorithms such as Recursive Least Square Algorithm (RLS) the beam forming can be obtained. As the system uses a DSP processor the signals can be processed digitally and the performance is with a high data rate transmission and good reduction of mutual signal interference.

ACKNOWLEDGEMENTS:

We thank Prof M.Ravindra Reddy , Head of the department Electronics and Communications Engineering, Sir C.R.Reddy College of Engineering, Eluru. For guiding us in preparing this paper.