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A Study on Role of Smart Antennas in Mobile Communication

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Abstract: The global acceptance of cellular technology or personal communication service raised the wireless communication beyond all the expectations. But this led to the shortage of the number of radio frequencies that can be utilized thereby increasing the cost of few remaining licenses to use these frequencies to manifold. With emerging techniques that provided voice, data and multimedia facilities in an extensive range, space was the final frontiers. Spatial division is the only promising multiple access technique that is successful in providing capacity, coverage and quality. For many years, antennas were most neglected part in mobile communication. But with the need of spatial division, advancement of antenna led to the evolution of smart antenna. The goal of this paper is to study what is smart antenna, what makes it smart and efficient from Omni directional antenna and how its implementation made the communication system more efficient.

Keywords: Adaptive Array Antenna; Delay Spread; Fading; SDMA; Smart antenna; Switched Beam Antenna.

I. INTRODUCTION

Increase in global demand of data, voice and video has led to some major changes in infrastructure. Coaxial cable, power line and fiber optics all have certain limitations in terms of cost and bandwidth. a real sense of communication is a "last mile" connection which provides a worldwide network, requires both cost and bandwidth. if we view this constraint from a technical point, the information transmission requires resources in the form of power and bandwidth. In wired communication, the transmission is set up independently over each link and in fiber optics, the useful information or energy is confined to a small region in space making the system more reliable and efficient. But same is not true in the wireless communication; reliability is achieved on the cost of wastage of energy. Transmission over short distances in space requires a large amount of space, from which a small portion is received by the intended user and rest behaves as a interference to the other potential users of the system. The range is defined by the amount of power that can be transmitted and the capacity is given by the available spectrum. For a given amount of power and a fixed amount of bandwidth, the resulted capacity i.e. bits/sec/hz/unit area, really per unit volume) is finite that can be made available to user by operators to any given locations. Specifically two problems had to be overcome in such systems: spectral efficiency or ways to increase the capacity at lower cost while maintaining the quality in the area where demand is high and coverage or ways to increase the coverage area where demand is less so that the infrastructure and maintenance costs decreases. [1].

With the emerging new network. The many advancements in past few years came into picture like improved air interface, modulation schemes, deployment of smaller radio cells with combinations of different cell types in hierarchical architectures and advanced signal processing but none of them was able to fully utilize the multiplicity of spatial channel that arises because each mobile occupies a unique place in the space. This approach of utilizing space as a domain to separate the spectrally and temporally overlapping signals from different mobile users was termed as space division multiple access (SDMA). it is a hybrid multiple access technique enhancing the FDMA, TDMA and CDMA schemes. SDMA allows multiple users within the same radio cells to use same frequency and time slot. The full exploitation of this technique in mobile communication was done through smart antennas. smart antenna can be defined as array of antenna system that adjust itself to the change in environment i.e. it changes its antenna pattern dynamically to adjust with the noise, interference in the channel and mitigate multipath fading effects on the signal of interest. In contrast to simple RF antenna, it uses digital signal processors, general purpose processors and software signal processing algorithms to achieve optimum transmitted or received radiation patter. In true sense, an antenna is not itself smart. The combination of antenna array with digital signal processing capabilities to transmit and receive, make the whole antenna system smart in terms of adaptability and spatial selection. The benefits of smart antenna are as follows:

1. Integration – a approach that can fit into the hierarchical tradition cellular system. it is basically a more enhanced technology according to the needs of today's network. In case of adaptive array, less hardware is used as compared to switched beam but requires new system instead of traditional.
2. Range/ Coverage - low prices for consumer, low infrastructure cost and more uniform area with the same power level.
3. Interference Suppression – Switched beam suppress the

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interference coming away from the active beam's centre. Since the beams are fixed, the interference rejection causes the reduction in the gain of the desired signal in the interferer's direction. In adaptive antenna, infinite number of narrow focused beam are transmitted which decreases the interference in neighboring user.

4. SDMA – Technology used behind the smart antenna is SDMA. This technique allows the adaptive steering of the beam towards the desired user and nulls towards the interference by appropriate tracking the mobile station. It makes the frequency reuse scheme more efficient as compared to the traditional hexagonal cell technique. It is a pollution friendly technology as the power transmitted reduces due to more directional energy, as well as the size of power amplifier reduces. With the deployment of algorithms, interference reduces as the spatial processing maximize the usage of multiple antenna to combine signal in space with going beyond the limit of one user-one beam technology which assumes one correct direction of transmission towards a user.

5. Adaptive Beam forming and Algorithms – One of the most important feature offered by this software processing reducing hardware is flexibility. Today researchers focus on enhancement or updating of algorithm rather than for going towards new hardware which is costly and time consuming. According to the need of air interface, environment, new algorithms are formulated without any modification in hardware [1, 2]

II. TYPES OF SMART ANTENNA

The different types of smart antenna deployed according to the level of intelligence are as follows:

1. Switched Beam Antennas: it is deployed at base Station having multiple directive antennas or predefined beam of an array. It switches between one beam to another on the basis of received signal power. The output is sampled to give the best reception beam. It is an enhanced approach towards the cellular sectorization in which each sectorized cell has three 120o macro sectors. These macro sectors are further divided into micro sectors, these sectors will have fixed beam pattern and it is selected according to the weighted sum of the combined antenna array. These beam have highest sensitivity at centre and lower near the periphery. The selected beam is moved in different direction by changing the phase of the current for reception of maximum desired signal. When the mobile station enters a macro sector, a fixed micro sector beam pattern is choosed according to the best reception and the antenna system monitors regularly the signal strength to other fixed beams. In comparison to Omni directional, the switched beam increases the range of abse station to about 20-200%. There some limitations like:

As the user moves toward the periphery, the signal strength decreases rapidly before it comes under the other fixed beam pattern.

It cannot distinguish between interference signal and user signal. If the noise signal is present at the center of the beam and user at the periphery, noise signal would be enhanced similar to user signal thus degrading the strength of desired user signal.

2. Dynamically Phased Array: In contrast to switched beam antenna, this type of smart antenna does not utilize predetermined and fixed beam. It checks the user signal by tracking through a Direction of Arrival (DoA) algorithm. In case of fixed beam, as the signal crosses the mid of beam and reaches periphery, the signal strength decreases and gain reduces while intra cell handover.

3. Adaptive Antenna Array: This type of smart antenna is considered to be smartest of all. An adaptive antenna array is a set of array elements that changes their radiation pattern according to the changes in environment. These variations are updated regularly so that it has maximum gain in the direction of desired user and minimum towards channel noise and interference in order to improve SNR of s desired signal. This procedure is also known as "adaptive beam forming" or "digital beam forming". They are further classified into forms: (i) Phased Array – in this array, only phase of the current is changed according to the weights. (ii). Adaptive Array antenna: it is a strict sense array in which both the amplitude and phase of the current change to produce a beam in desired direction to maximize SNR. With the use of sophisticated algorithms, the adaptive antenna array distinguish between the interference, multipath and desired signal. This helps to move the beam towards the desired signal and nulls towards the interference according to calculation of Direction of Arrival by the algorithm. Another advantage of adaptive antenna that makes it more efficient than switched beam is its ability to create spectrum. Through the technique of accurately differentiating between desired user, interference signal and multipath, the adaptive array makes it possible to use the channel within the same cell users. Capacity enhances by decreasing intra cell and inter cell frequency reuse pattern. In switched beam, the beam moves only for desired signal and not in response to the interfering signal. As when the interfering signal approaches near the centre of beam, it get identical processing degrading the overall communication. But in adaptive array, it is able to distinguish between the desired user and interfering signal. It will hand over any two channel user whether they are intra cell or inter cell before they get too close and interfere with each other [1,2].

III. COMPARISON OF SMART ANTENNA

Antenna is a type of transducer that converts the electrical energy into a electromagnetic waves for transmission purposes to the outside world and in reverse collect the RF energy from the outside world for reception. Antennas are most neglected part in mobile communication. But the goal is to study why smart antenna replaced a single omnidirectional antenna at base station.

1. Omni directional Antenna: - Earlier when no specific knowledge about user was available or needed, the single dipole antenna radiates and receives the RF energy well in all directions. But the amount of energy reaching the desired user is small as compared to the transmitted energy due to unfocused scattering of signals. the only method of improving the overall signal broadcast system is by boosting the power level of signals. if the signal miss the intended user, it will behave as an interference to the other

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users. in this approach, there was no strategy to reject signals interfering with several users, adversely affecting the spectral efficiency, limiting frequency reuse. but these limitations gained attention in the role of antenna system in mobile communication.

2. Directional Antenna and Sectorized Systems: A single antenna can be used to have directional transmission and reception by deploying sectorized antenna system. This approach uses same traditional cellular area by dividing them into sectors and each sector is covered using directional antenna from same base station. Each sector can be treated as an independent cell. This system increases the range as compared to Omni directional antenna due to focused power and it is commonly referred to as antenna element gain. Sectorized Antenna system increase the possible reuse of a frequency channel in such cellular system by decreasing the interference across the original cell. Adjacent sectors use different frequency to reduce co-channel interference, by increasing handoff between sectors. This technique stills lag behind in overcoming the major disadvantage of filtering the unwanted interference from adjacent cells [1].

The major problems encountered in wireless communication that limits the performance are : **Multipath Fading-** due to multiple signals reaching the receiver antenna, the overall amplitude and phase vary in antenna location, direction and polarization as well as the with the time of the received signal. **Delay Spread-** it is the difference in propagation delay among the multiple paths. When this factor exceeds the ten percent of symbol duration, it results in inter symbol interference thus limiting the maximum data rate. The reduction in average output SNR ratio for a given BER with fading is termed as diversity gain. **Co-channel interference-** the number of available frequency channels are subdivided into channel set and each channel set is allocated to cell for transmission and reception using frequency reuse technique. Due to improper spacing and increase in the capacity of each cell, co channel interference increases with the decrease in channel set. In TDMA systems, the co channel interference is mainly from one or two user. On the other hand, in CDMA system the co channel interference occurs both within the cell and from adjacent cells. Diversity gain can be decreased in three different ways: Spatial Diversity – the antennas are spaced far enough to provide lower diversity gain. The angular spread or the angle at which the antenna receives the signal decides the spacing between them. In case of mobile handset and indoor base station angular spread is 360o, therefore spacing of quarter wavelength proves to be an efficient whereas for outdoor base station, the angular spread is very low therefore 10-20 wavelength spacing is required, making the size of the antenna array an issue.

Polarization Diversity – Two orthogonal polarizations are used. These orthogonal polarization have low correlation and the horizontal polarization can be 6-10 dB lower than the vertical polarization thereby diversity gain. Angle Diversity – the signal is arrived at the main lobe having same angular spread therefore other adjacent lobes can be used to receive weaker signal thereby decreasing the diversity gain. Diversity can be utilized for increasing the overall strength of the received signal by using: Switched Diversity – Any one of the antenna is in favorable location at a moment to receive the highest possible signal power.

Diversity combining: This approach first corrects the phase error of two received signals and then adds the power of two signals to give maximum possible gain. In maximal ratio combining systems output of all the antennas are combined to maximize the ratio of combined received signal energy to noise. These diversity systems helps in the conditions were fading is the dominant factor for degradation of signals, it has no effect on the interference. For avoiding interference, along with these diversity systems to reduce fad in next link was developed in the antenna system and that camed with the evolution of smart antennas [1].

IV. COMPONENTS OF SMART ANTENNA

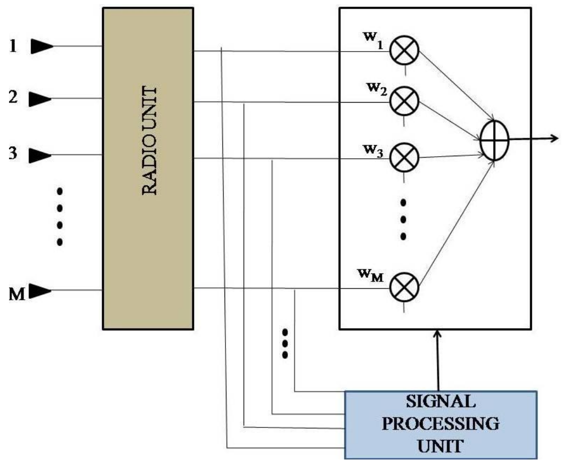

Fig.1. Smart Antenna Receiver

Smart antenna receiver is mainly divided into four units – antenna array, radio unit, beam forming unit and a signal processing unit. Antenna array has a set of antenna element. The signals received from these elements are combined and then send to rest of the units for further processing. Generally the number of elements is kept low to avoid any complexity. Different types of array geometries are employed for covering different areas- **Uniform linear array and Circular array** are mainly used for beam forming inn the horizontal plane (azimuth). Uniform linear array has an element spacing of about Δx and perform beam forming in azimuth angle within an angular spread. Circular array has a bird view with an element spacing of $\Delta\phi = 2\pi/M$ and can perform beam forming in all the azimuth angles without any transcends on angular spread. **2- Dimensional and 3- Dimensional grid array** are desirable for indoor or dense urban environments. It can perform beam forming in the directions, azimuth and elevation angles. 2-D grid has an element spacing of Δx in horizontal and Δy in vertical plane. 3-D cubic structure has element spacing of Δx, Δy and Δz.

Radio unit consists of down conversion unit and Analog to digital convertors each for one of the M element in an antenna array.

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In signal processing unit, each incoming signal from M element of the array is multiplied by the weights W_1……….W_M. The weights are calculated depending upon the employment of switched beam or adaptive array antenna system. Theoretically we can completely nullify the interference sources but practically due to multipath propagation, it is not possible to complete remove but can be decreased. These weights will decide the radiation pattern in the uplink. If the Switched Beam is used, then all the weights vectors are examined and one of them is selected giving the strongest received signal level. If adaptive smart antenna is used, the beam is directed towards the strongest signal to achieve maximum gain. Therefore first Direction of Arrival is calculated and then the weights are calculated accordingly.

When the beam forming is done digitally, the beam forming and signal processing parts are integrated in the same unit. For maximization of SIR (for AA), the optimum weight vector W_{opt} can be calculated using number of algorithms [1].

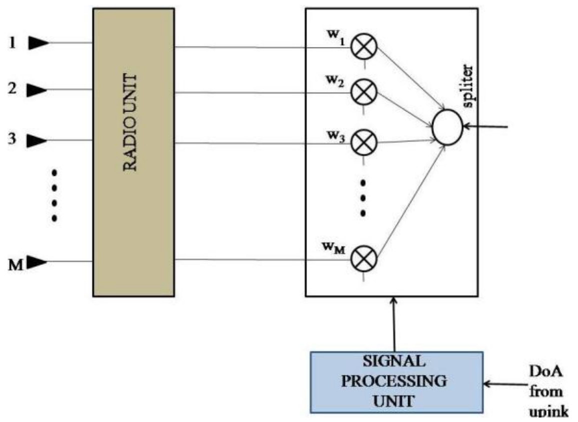

Fig.2. Smart Antenna Transmitter

In transmitter, the incoming signal is first spilted into M branches which are weighted by the complex weights W_1, W_2……….W_M in the beam forming units. The weights that decide the radiation pattern in downlink is calculated by signal processing unit. The radio unit consists of up convertor chains and digital to analog convertor. Practically antennas and digital signal processing is similar as on receiver. The main difference between uplink and downlink is no availability of spatial channel response on downlink. In TDD system, the same carrier frequency only separated in time is utilized by the base station and mobile. Thus the weights utilized on uplink are deployed on downlink, if the channel is not changed i.e. if user does not moves in high speed. In FDP, the channel response depends on frequency; the optimal weights are not same. As optimum beam forming is typical on downlink, the technique utilized is the geometrical approach of estimating the DoA. This technique is based on the concept of directional reciprocity i.e. it is assumed that the direction of received signal on uplink is the direction in which signal will be transmitted on downlink. Thus the DoA is estimated from which the main part of the user signal is received. This direction is utilized on downlink for calculation of weight so that the radiation pattern is directed towards the desired user similar to the phased array systems. For reducing the interference, zeros are positioned towards the other users as the base station as base station interference is observed by mobile station and interference for mobile station is observed by base station. For sub-optimum system, we can average the uplink channel over a period of time to choose the downlink direction.

Fundamentals of Antenna Array: An antenna array has been equipped with the sensors whose output is directed towards the weighting network or a beam forming network. Due to antenna reciprocity, the antenna array can be utilized as a transmitter or receiver. There are many assumptions for analyzing an antenna array:

1. All signal component received on the antenna array are composed of finite number of plane waves. These component results both from the direct and multipath propagation.
2. The transmitter and objects that causes multipath propagation are present in the far field of antenna array.
3. In order to avoid any difference in the amplitude of signal received by the two elements of antenna array, the sensors are placed closely.
4. Each sensor is assumed to have the identical radiation pattern and the same orientation.
5. The coupling between the antenna elements in array is assumed to be negligible.

Array Geometry And Element Spacing : If the inter element spacing in the antenna array is greater than $\lambda/2$ then the problem of grating lobes come into picture that degrades performance and if this spacing is less than $\lambda/2$, coupling effects are seen. Thus the element spacing of $\lambda/2$ is preferred [1].

V. THEORETICAL MODEL FOR AN ANTENNA ARRAY

The most preferred geometry for antenna array is liner and circular geometry since later has some flaws related to symmetry of radiation pattern about axis along the end fire, thus the former is considered to be most used array with uniformly spaced sensors. The array has an reference element at the origin and the element has co ordinates (x_m , y_m , z_m). The signal experiences a phase shift as it travels across the array. The phase shift between the signal received at the reference point and signal received at the element m is given as:-

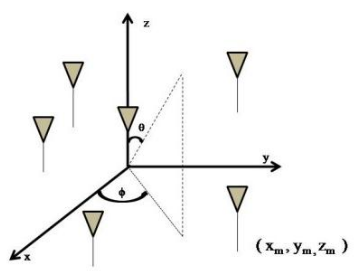

Fig.3. Coordinates of Smart Antenna

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$$\Delta\gamma_m = \gamma_{m(t)} - \gamma_1(t) = -\beta x_m \cos\phi \sin\theta - \beta y_m \sin\phi \cos\theta - \beta z_m \cos\theta \qquad \text{equation: I}$$

Where $\beta = 2\pi/\lambda$ is the propagation constant

This relation is valid for narrowband signal in which modulated signal bandwidth is much less than carrier frequency bandwidth. The assumption of narrowband signal allows us to assume that the signal present at different element differ only in phase shift introduced by the extra distance travelled but not due to the modulation during this time. It is assumed that the reference plane lie at z = 0. A wave received at antenna array may be considered to come along horizon or with $\theta = 90^o$, as the distance between transmitting and receiving antenna is larger than the heights of both the antenna. From eq 1, it is clear that with variation in height (z_m), the phase shift between the reference element and element m does not change. Therefore, we may consider x and y offsets from the reference element.

Consider a transmitted narrowband signal in complex envelope representation:-

$$\mu_m(t) = A_m(t)\, e^{j\gamma_m(t)} \qquad \text{equation II}$$

where $A_m(t)$ is amplitude and $\gamma_m(t)$ is phase of the signal.

The vector combining thses signals is called data or the illumination factor.

$$\mu(t) = [\ \mu_1(t), \mu_2(t) \text{ -- -- -- -- } \mu_M(t)\ ] \qquad \text{equation III}$$

A complex quantity $a_m(\phi)$ is defined as a ratio between signal received at the element m of the array and the signal received at the reference element when a plane wave is incident and it is given by :-

$$a_m(\phi) = e^{-j\beta(x_m\cos\phi + y_m\sin\phi)} \qquad \text{equation IV}$$

If a single wave is incident then

$$\mu_m(t) = \mu_1(t)\, a_m(\phi) \qquad \text{equation V}$$

A single plane wave travelling at an angle ϕ towards the antenna array, the response of antenna array is called steering vector given by:-

$$a(\phi) = \begin{matrix} 1 \\ a2(\emptyset) \\ am(\emptyset) \end{matrix} = \begin{matrix} 1 \\ e^{-j\beta(x2\cos\phi + y2\sin\phi)} \\ e^{e-j\beta(xm\cos\phi + ym\sin\phi)} \end{matrix} \qquad \text{equation VI}$$

The collection of the steering vector for all angle for a given frequency is called array manifold. It must be measured carefully to accurately set the array for direction finding experiments. For narrowband adaptive beam forming, each element output is multiplied by a complex weight w_i^* by changing the phase and amplitude relation between the branches and it is summed up to given relation:-

$$v(t) = \mu_1(t) \sum_{m=1}^{M} e^{-j\beta(x_m\cos\phi + y_m\sin\phi)}\, w_m^* \qquad \text{Equation VII}$$

$$= [\ w_1^*, w_2^*, \ldots\ldots, w_M^*] \begin{matrix} 1 \\ e^{-j\beta(x_2\cos\phi + y_2\sin\phi)} \\ \vdots \\ e^{-j\beta(x_m\cos\phi + y_m\sin\phi)} \end{matrix} = w^H u(t)$$

The response of the array with the weighting network is called array factor:-

$$AF(\phi) = v(\phi)/\max v(\phi) = w^H a(\phi) \text{ ----- equation VIII}$$

The weighting network can be fixed or varying. In adaptive array, the weights are deployed to maximize the SINR ratio at the output of antenna array. Hence, the weighting network is similar to the finite impulse response (FIR) filter, by replacing time samples with spatial samples. Thus the weighting network is also known as spatial filter [1].

VI. ADAPTION OF ADAPTIVE PROCESSING METHODS IN TDMA AND CDMA:-

Digital processing in TDMA makes this technology efficient and applicable. In TDMA, the channel is allotted to user periodically after a fixed interval of time. In this technology information from user is send and then stopped for fixed time interval, this condition is possible only through a digital transmitter that can store its bits and then transmitted at a speed higher than that at which they are generated.

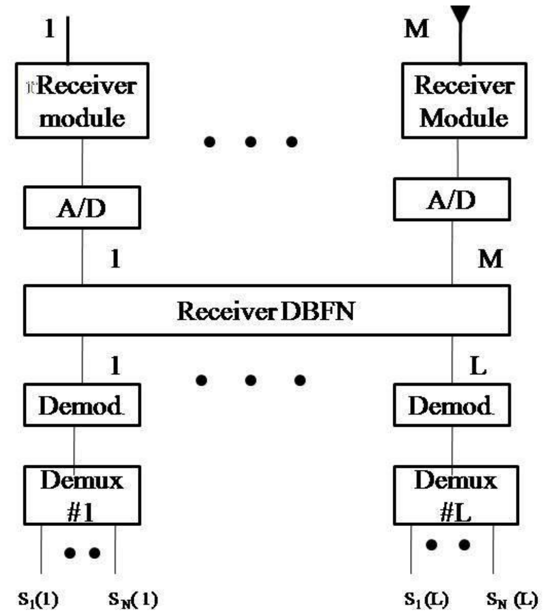

Fig.4. Reverse Link DBF configuration for a TDMA system

The DBF configuration using TDMA in reverse or forward link consists of six main units: An M-element antenna array, M receiver (transmitter) modules, M ADCs (DACs), An RDBF (TDBF) network, L digital demodulators (modulators), L digital demultiplexers (multiplexers). In the reverse link, the beam forming method is applied to the received signals by M antenna elements to generate the output of L reverse link beam. Each beam output is then demodulated and demultiplexed to give N message signals. Thus the number of users that can communicate or use network at a time can be upto N*L. in forward link, these N*L message signal are grouped into L groups. This N message bit in each group is time multiplexed. A particular digital modulation scheme is then applied to the multiplexed signal. The L modulated signal is send as a forward beam through proper digital beam forming methods. These digital output of the beam forming methods is converted into analog for transmission.

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The digital beam forming method should process the signals sequentially that is in frame by frame manner. In forward link,with the frame t_1, the digital beam forming method will generate L beams for L message signals { $s_1(1)$, $s_1(2)$,……, $s_l(L)$ } similarly for t_2 frame another L beams are generated { $s_2(1)$, $s_2(2)$, ..., $s_2(L)$}. T he digital beam forming network should be fast, so that the processing time used by the network t_p should not be larger than the TDMA frame time. Thus instead of using very fast digital beam forming network, a bank of digital beam forming network can be used parallely at a low speed. This technique requires additional hardware such as buffer and software for synchronization control [1].

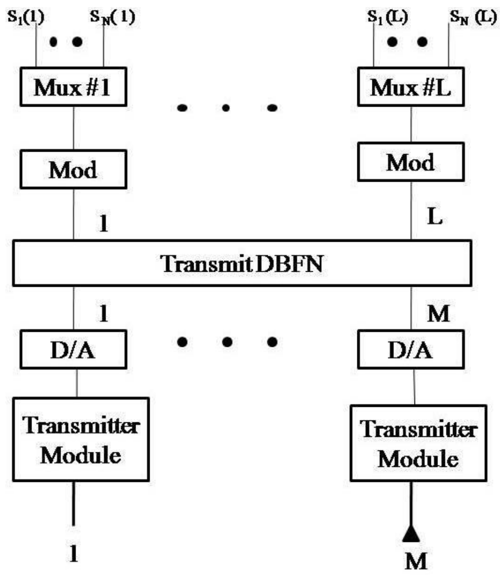

Fig.5. Forward Link DBF configuration for A TDMA system

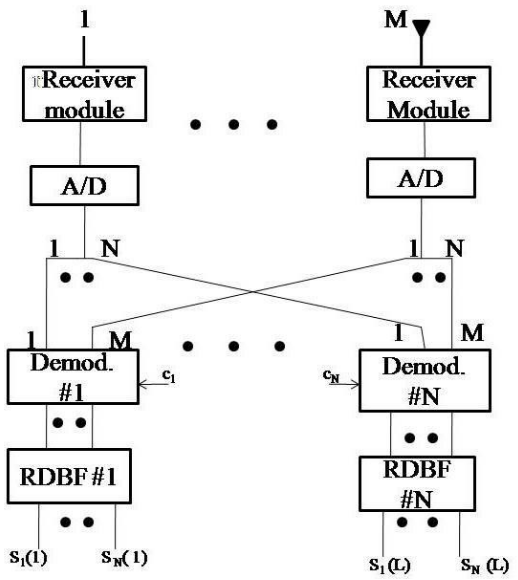

Fig.6. Reverse Link DBF configuration for a CDMA system

The beam forming discussed in TDMA system, were for narrowband signals. In this system, the phase shift required by each weight depends on the differential propagation distance between each antenna element and the wavelength of signal. The phase shift depends both on frequency and the desired beam direction, while the weights only adjust the desired beam direction. Therefore weights are most accurate only at center frequency. But in wideband, the phase shift depend on the frequency such that for lower frequency signal components have less phase and for higher frequency signal components have higher phase shift as they travel the same length. In order to have flat frequency response within the signal bandwidth, these variation in phase shift according to the different frequency components is necessary to add. The device that allows each element to have a phase response that varies with frequency resulting in flat frequency response is known as tapped delay line. Such wideband array is also called space time receivers. An important case of wideband array is the spatial processing CDMA rake receiver. In CDMA, multiples users share same frequency and time slot. The DS-CDMA utilizes a spreading code technology that operates at a chip rate P times greater than the data rate. P lies in the range of 100 to 1000. The DS-CDMA has large channel bandwidth that incorporates multiple user. The spreading code can be defined as a complex waveform with large time-bandwidth product that is approximately equal to P while in TDMA, this product is approximately one. The user codes can be orthogonal or quasi orthogonal. If we use orthogonal spreading code, then the interference between the users and noise is reduced, example of orthogonal code is Walsh code. If we use quasi orthogonal codes or orthogonal codes with multipath, the interference between users takes place and interference limited signal is received. This Multiple Access Interference from other user is reduced using the processing gain P during the detection process.

The Digital Beam Forming implementation of CDMA is different from TDMA, as in CDMA beam forming takes place along the entire band while in TDMA beam forming takes place in frame by frame basis. Thus the DBF configuration depends on type of CDMA utilized i.e. synchronous or asynchronous CDMA. In case of synchronous CDMA, the data bit duration of each user signal is time aligned at the base station. The main components used in synchronous CDMA in reverse (forward) link are: An M-element antenna array, M receiver (transmitter) modules, M ADCs, (DACs), N digital demodulator (modulator) banks, each of which consist of samplers and correlator, N RDBF (TDBF) networks. In the reverse link, the mobile user signals require a beam forming networks using an identical code. If each beam forming network produces L beam outputs, then the number of simultaneously operating users are N*L. In the forward link, the N*L messages that are to be transmitted are arranged in N groups. The beam forming is applied to L messages in each group, then the output are spread using a particular code. This code multiplexed signal is converted into analog for transmission. In this type of CDMA, the beam forming networks operates at the bit rate and demodulation and modulation is necessarily linear and coherent to preserve the phase information required for beam informing.

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But in asynchronous CDMA, the configuration is different as the receive beam forming network is placed before demodulators and the transmit beam forming network is placed after modulators. The demodulators and modulators may be coherent or non coherent and linear and non linear [1].

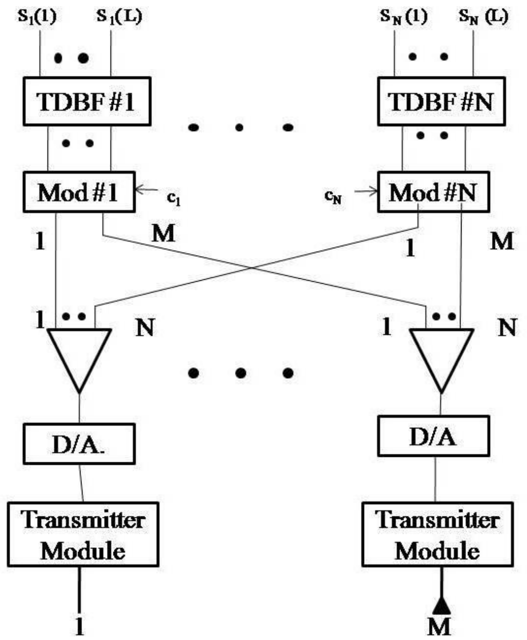

Fig.7. Forward Link DBF configuration for a CDMA system

VII. SMART ANTENNA ON MOBILE HANDSETS

Till now we assumed that smart antenna is present only at the base station, not in the mobile. The objective of smart antenna is to increase the signal to interference and noise ratio of the received signal by maximizing the signal strength and reducing the effects of multipath fading, interference and noise. Smart antenna beam changes according to the environment. It enhances system performance by increasing the signal strength, by controlling the directivity and using the optimum weights using algorithms for beam forming. Due to cost, size and available power, the smart antennas were preferred more at base station than mobile. But the demands of upcoming third generation systems raised the need of smart antenna in mobile. Advantages of adaptive antenna array in mobile are : reduces multipath fading, interference signals are suppressed, enhances call reliability, lowers the specific absorption rate, mitigation against dead zones (vi) increased data rates and spectral efficiency. Two types of adaptive antenna are developed for mobile:

(i) The Quadrifilar Helix Antenna: - it consists of four twisted wires in a form of helix. It allows receiving signal in a weak network areas like inside the building. Enhances performance with the minimizing the risk of radiation to human. The signal is produced using a torch beam that will use a narrow beam travelling towards the nearest base station or satellites instead of Omni directional radiation. It reduces the required transmit power by a factor of 10, depending on the configuration of building and trees around the user. It increases the life of battery.

(ii). Solid State Antenna: - Surface mounted to motherboard. It is approximated one tenth size of conventional copper antenna. The antenna is highly directive (not to multi beam or switched beam) due to which battery life increases as the handset point in the direction of base station. It also minimizes the heath issue by radiating radio waves away from the body; Antenna avoids detuning by the proximity of the user [1].

VIII. CONCLUSION

Smart Antenna are the most promising technique for using the space as a domain to increase coverage, capacity and signal strength. It suppresses the interference by operating highly directive beams towards the desired user. Many algorithms are deployed along with the digital processing technique to enhance the system performance. With the utilization of smart antenna still many challenges has to be faced like in power consumption, size and diversity. Spatial diversity is difficult on a small handset. Researchers have calculated that 50% power in the handset is utilized by RF electronics. Therefore multiple antennas in handset increases cost, power and decreases the battery life

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