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Multiple Antenna & Diversity: Smart Antennas

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Abstract- In communication systems, we have to increase the reliability of the communication operation between transmitter and receiver while maintaining a high spectral efficiency. The ultimate solution relies in the use of diversity, which can be viewed as a form of redundancy [1]. Multiple-input multiple-output systems include a variety of techniques capable of not only increasing the reliability of the communication but also impressively boost the channel capacity. In addition, smart antenna system can increase the link quality and lead to appreciable interference reduction. Smart antenna technology is one of the most vital developments in mobile communication. The signal that is been transmitted by a smart antenna cannot be tracked or received by any other antenna thus ensuring a very high security of the data transmitted.

Index Terms- Adaptive antenna array, Diversity techniques, MIMO, Smart antennas, Spatial diversity

I. Introduction

Multiple antenna technology proposed for communication is an important means to improve the performance of wireless systems. In a system with multiple transmit and receive antennas (MIMO channel), the spectral efficiency is much higher than that of the conventional single antenna channels. Smart antenna technique can significantly increase the data rate and improve the quality of wireless transmission, which is limited by interference, local scattering and multipath propagation. A smart antenna is an array of elements connected to a digital signal processor. Smart antenna was discovered in early 1990s when well developed adaptive antenna arrays originated from Radar system. Recently, smart antenna technique has been proposed as a promising solution to the future generations of wireless communication systems and broadband wireless access networks.

II. MIMO Diversity

Diversity schemes provide two or more inputs at the receiver such that the fading phenomena among these inputs are uncorrelated. There are many diversity techniques that can be applied to communication systems – time diversity, frequency diversity and spatial diversity or any combination of these three diversities. [2] In time diversity, the same information-bearing signal is transmitted in different time slots where a good gain can be achieved when the duration between the two slots, in which the same symbol is transmitted, is greater than the coherence time of the channel as per fig.1

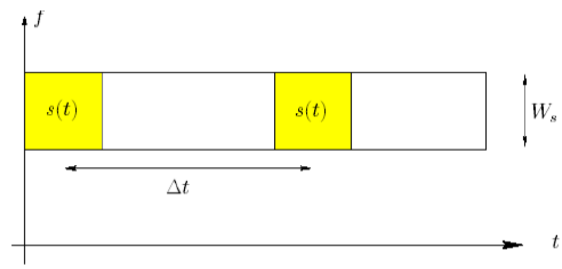

Fig.1: Time diversity

In frequency diversity, the same information-bearing signal is transmitted on different subcarriers where a good diversity gain can be achieved when the separation between subcarriers is greater then the coherence bandwidth as per fig.2.

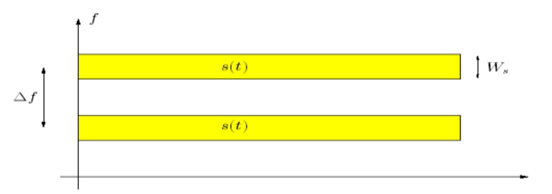

Fig.2: Frequency diversity

In spatial diversity, the same information-bearing signal is transmitted or received via different antennas where the maximum gain can be achieved when the fading occurring in the channel is independent. In receiver space diversity, M different antennas are used at the receiver to obtain independent fading signals as in fig.3.

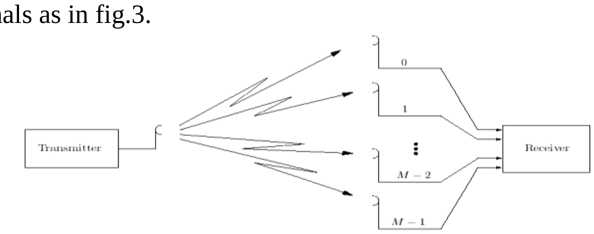

Fig.3: Space diversity in receiver

In transmitter space diversity, M different antennas are used at the transmitter to obtain uncorrelated fading signals at the receiver as in fig.4.

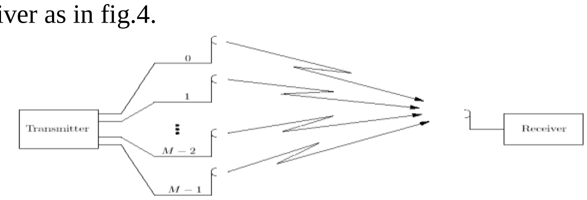

Fig.4: Space diversity in transmitter.

III. SMART ANTENNAS

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 result, smart antenna transmitters can encode independent streams of data onto different paths or linear combinations of paths, thereby, increasing the data rate and providing diversity gain.[3] No manual placement of antennas is required. The smart antenna electronically adapts to the environment. Smart antenna system can be categorized into three main groups – Phased antenna array system, switched beam systems and adaptive antenna array system. Phased antenna array is a group of antennas in which the relative phases of the respective signals feeding the antennas are varied in such a way that the effective radiation pattern of the array is reinforced in a desired direction and suppressed in undesired directions. [4] In switched beam approach, the sector coverage is achieved by multiple predetermined fixed beam patterns with the greater gain placed in the centre of a beam. [4] In practice, switched beam system can simply replace conventional sector antennas without requiring significant modifications to the radio base station antenna interface or the baseband algorithms implemented at the receiver. Fig 6 illustrates the produced antenna pattern with 4 antennas.

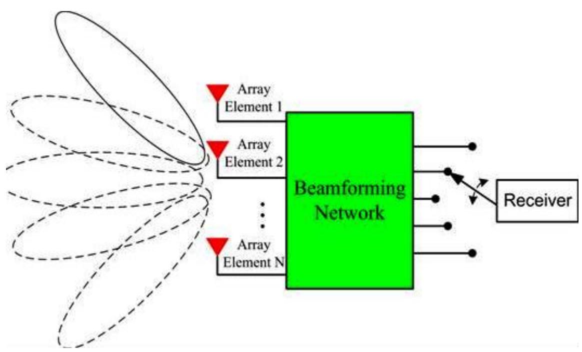

Fig.5: Functional block diagram of switched beam antenna.

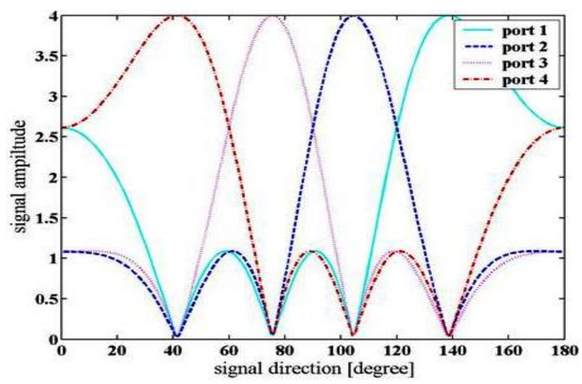

Fig.6: Functional block diagram of switched beam system.

Adaptive antenna array beam forming techniques have been employed to remove unwanted noise and jamming from the output, mainly in military applications. With powerful digital signal processing hardware at the base-band, algorithms could control antenna beam patterns adaptively to the real signal environment, forming beams towards the desired signals while forming nulls to co-channel interferers. Thus the system performance is optimized in terms of link quality and system capacity. [5] Adaptive antenna array can be utilized in the transmitter side, which is known as transmit beamforming as in fig.7 or in the receiver side, which is called receive beamforming.

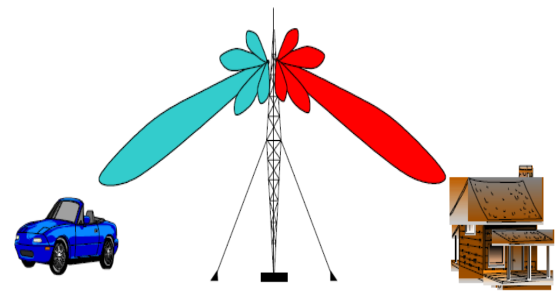

Fig.7. Illustration of transmit beamforming.

Multipath propagation in mobile radio environment leads to inter-symbol interference. Using transmit and receive beams that are directed towards the mobile of interest reduces the amount of multipath and inter-symbol interference. [6]

IV. CONCLUSION

This paper introduced the multi antenna technologies which can be considered as one of the most vivid area of research. Diversity techniques are used to improve the performance of the radio channel without any increase in the transmitted power. The use of multiple antenna system increases link reliability, increases channel capacity and reduces interference in both uplink and downlink. Further, smart antenna techniques are introduced which are intelligent devices whose radiation pattern can be varied without being mechanically changed. General conclusions about how best to upgrade a network are not easily made because every operator has a unique set of constraints such as what frequencies are available, what interfaces pre-exist and what network, antenna and user equipment has been previously deployed. Even so, the wide variety of antenna types and processing techniques makes impressive improvements in the capacity and coverage of emerging 4G networks.

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