Performance Comparison of Diversity Techniques in MIMO Wireless Communication

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ABSTRACT
The goal for next generation of mobile communication system is to perfectly consistent integrate a broad variety of communication services like high-speed data, video and voice signals,multimedia traffic . In the paper, we have analyzed various diversity techniques to find out the optimum scheme for use. Diversity is a technique used to combat multipath fading and is used two or more receiving antennas. Severe attenuation in a multipath wireless environment makes it extremely difficult for the receiver to find out the transmitted signal except the receiver is provided with some form of diversity, i.e., some less-attenuated reproduction of the broadcasted signal is offered to the receiver. Results of simulation are attached.

General Terms
Wireless Communication, Transmission

Keywords
Diversity Schemes, Selection Diversity and Maximal Ratio Combining

1. INTRODUCTION
Wireless communications is playing a vital role in engineering from last few years not only from a scientific point of view, where the progress has been exceedingly, but also in terms of market size and impact on society. In several countries the wireless industry is controlling the complete economy. Working way of life, and even more usually the ways we all communicate, have been altered by the option of talking ‘‘anywhere, anytime’’[1].

For a long time, cellular telephony is the biggest market segment use wireless communications and has had the maximum impact on everyday lives. To cope with a recent trend of increasing demand in mobile communication, system considerations of digital cellular radio systems have been intensively pursued so far where time division multiple access techniques is often used. These systems are composed of some base stations (BSs), and a number of mobile stations (MSs), and a transmission channel is provided according to demand of each cell [2].

In current time, wireless computer networks have also led to a considerable change in running habits and human resources answering emails in a coffee shop has become an everyday incidence. But besides these widely publicized cases, also a large number of less obvious applications have been developed, and are starting to change our lives. Wireless sensor networks monitor manufacturers; provides the wireless links which is the substitute of cables between computers and keyboards; and wireless positioning systems monitor the location of vehicles that have goods recognized by wireless RF (Radio Frequency) tags. This kind of new applications causes the technical challenges for the wireless engineers to become bigger with every day [3].

The goal for next generation of mobile communication system is to steady combine a broad range of communication services like video, high-speed data, multimedia traffic in addition to voice signals. Diversity is a technique used to balance for fading channel destruction, for this two or more receiving antennas are implemented. The evolving 3G common air interfaces also use transmit diversity, where base stations may transmit multiple replicas of the signal on spatially separated antennas or frequencies. So we can say that diversity improves the quality of a wireless communications link without altering the common air interface and without increasing the transmitted power or bandwidth.

While equalization is used to contradict the effects of time spreading, diversity is usually engaged to condense the depth and distance end to end of the fades skilled by a receiver in a local area, which are due to motion. Diversity techniques are often affianced on both base station as well as mobile receivers. The most common diversity technique is called *spatial diversity*, whereby multiple antennas are deliberately spaced and associated to a common receiving system. Though one antenna distinguishes a signal void, one of the new antennas may fine make out a signal crest, and the recipient is capable to go for the antenna by way of the most excellent signal at any time. Generally, only *0.4* λ spacing is needed to obtain uncorrelated fading between two antennas when they receive energy from all directions. Other diversity techniques include *antenna polarization diversity, frequency diversity, and time diversity*. CDMA systems make use of a RAKE receiver, which provides link improvement through time diversity [4].

Diversity is a powerful communication receiver technique that provides wireless link improvement at relatively low cost. Unlike equalization, diversity requires no training overhead since a training sequence is not required by the transmitter.

Diversity develops the arbitrary nature of radio propagation by decision independent (or at least highly uncorrelated) signal paths for communication. In virtually all applications, diversity decisions are made by the receiver, and are unknown to the transmitter. There are two types of fading - small scale and large scale fading. Small-scale fades are differentiated by bottomless and fast amplitude variations, which happen as the mobile move about distances of just a small amount of wavelengths. These fades are basis by various mirror images from the atmosphere in the vicinity of the mobile. For narrowband signals small-scale fading typically results in a Rayleigh fading distribution of signal strength over small distances. In order to prevent deep fades from occurring, microscopic diversity techniques can exploit the rapidly changing signals. (This is called antenna diversity of space diversity)[5]. Large-scale fading is sourced by shadowing due to deviations in both the territory report and the nature of the atmosphere. In deeply shadowed conditions, the received signal strength at a mobile can drop well below that of free space. Large scale fading was shown to be log-normally distributed with a standard deviation of about 10dB in urban environments. By selecting a base station which is not gloomed when furthers are the mobile can progress significantly the standard signal-to-noise ratio on the frontward link. That is called macroscopic diversity, since the mobile is taking advantage of large separations (the macro system differences) between the serving base stations [6].

In telecommunications, a diversity technique pass on to a way for improving the consistency of significance signal by utilizing two or more message channels with special type of characteristics. Diversity plays a significant role in struggle fading and co-channel interference and avoiding fault ruptures. It is based on the information that entity channels experience special levels of fading and intrusion. A same signal which has many versions may be broadcasted and/or received and mutual at the receiver. On the other hand, the different parts of the message are transmitted over different channels with redundant forward error correction code. Diversity techniques could utilize the multipath transmission, ensuing in a diversity gain, regularly considered in decibels. Figure1[7] shows multiple antenna space diversity

Fig-1:.Earthly microwave broadcasting scheme with two antenna arrangements constructed for space-diversity[1]

2. TYPES OF DIVERSITY SCHEMES

Frequency diversity is implemented by transmitting information on more than one carried frequency. The logical basis behind this technique is that frequencies are separated by more than the consistency bandwidth of the channel will be parallel and will consequently not know-how the same fades. Time diversity reputedly transmits information at time spacing that go above the consistency time of the channel, so that multiple replication of the signal will be received with fading free conditions, in that way providing for diversity. One recent implementation of time diversity involves the *RAKE receiver is used for spread spectrum CDMA*, where the multiple channels provide redundancy in the transmitted message. Antenna diversity is a communication technique that carries the signal information while transmitted beside different propagation paths. This can be accomplished by using various receiver antennas (diversity response) and/or by using several broadcasting antennas (transmit diversity).

Although the antennas are not other than one fourth of the wavelength distant, a great deal of the possible antenna gain is recognized. A diversity merging circuit mix or picks the signals on or after the receiver antennas to be an enhanced quality signal.

A. *Types of Antenna/Space Diversity*

(i) Transmit Diversity.

(ii) Receiver Diversity.

(iii) Multiple Input and Multiple Output (MIMIO).

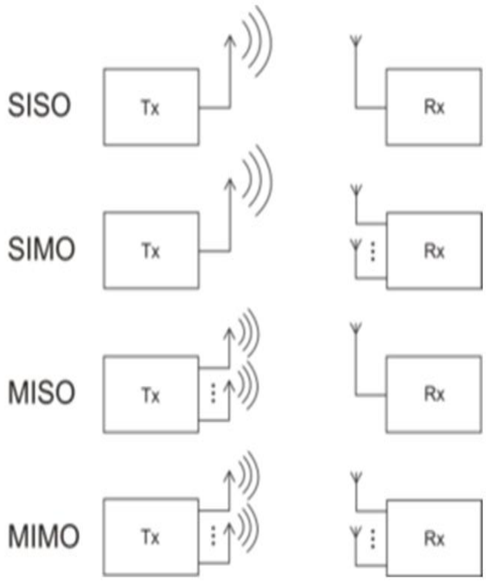

Fig-2: Understanding of SISO, SIMO, MISO and MIMO

Transmit diversity is a type of radio communication which use the signals that is created by two or more free sources so as to have been modulated with the same information-accepting signals and that may possibly vary in its transmission characteristics at any known instant. It is also known, as *MISO* system Receiver Diversity is radio communication using a single transmitted signal that is received by two or more independent antennas that have been separated by more than coherence separation. It is also known as *SIMO* system. It may help to beat the *circuit* failures, effects of *fading and* outages. As soon as using transmission and reception diversity technique, the improvement of received signal depends lying on the autonomy of the fading (self) characteristics of the signal in addition to circuit failures and outages.

Multiple Input and Multiple Output (MIMO) use multiple antennas at both ends i.e. transmitter and receiver to enhance communication performance. It is same as smart antenna and the position of the skill of smart antenna technology. We use MIMO technology to show attention in wireless communications, because without increase bandwidth and power we can improve data throughput and signal strength. It is done by diversity (reduced fading). Because these properties of MIMO is a current research area.Figure2[8] shows concept of SISO, SIMO, MISO and MIMO.

B. Space diversity reception methods

We can divide Space diversity reception methods into three categories

1. Selection diversity.
2. Maximum ratio combining.
3. Equal gain diversity.

3. SELECTION DIVERSITY

Selection diversity is the simplest diversity technique, which is analyzed in this section. Figure3 shows block diagram for space diversity. In this diversity technique gains of m number of branches are adjusted to achieve same SNR to each branch, for these Demodulators are used. At receiving end maximum instantaneous SNR is connected to the demodulator. The antenna signals itself might be sampled and the most accurate sample is sent to a single demodulator. In practice, the branch with the largest (S+N)/N is used, since it is difficult to measure SNR alone.

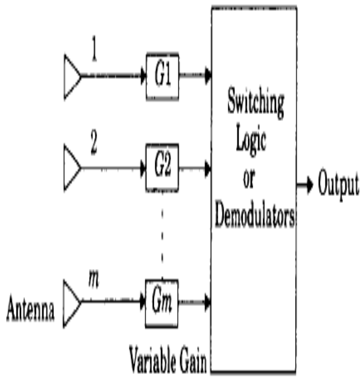

Fig -3: Generalized block diagram for space diversity

4. MAXIMAL RATIO COMBINING

In this method first proposed by Kahn, the signals starting from every one of the M branches are prejudiced according to their entity signal voltage to noise power ratios of M branches and then summed. Here, the individual signals of M branches must be co phased before being summed (unlike selection diversity) which usually needs an entity receiver and phasing circuit for each antenna component. Maximal ratio combining is shown in figure4 which generates output SNR equal to the sum of the individual SNRs.

So the advantage of Maximal ratio combining is to generating an output with desired SNR when nothing of the individual signals itself acceptable.

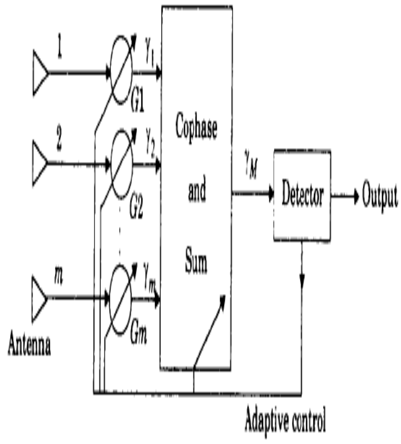

Fig-4: Maximal ratio combiner

5. EQUAL OR LIKE GAIN COMBINING

In several cases, it is not easy to provide for the variable controlling potential requisite for true maximal ratio combining. In few situations, the branch values are all set to unity, but each branch's signals are co-phased to offer equal gain combining diversity. This allows the receiver to take advantage of signals that are concurrently received on each branch.

In figure5 on the i_{th}receive antenna, received symbol y_i is divided at the receiver to perform equalization by the a priori known phase of h_i. The channel h_i is corresponding to polar shape as $|h_i|e^{j\theta_i}$. The decoded representation is the sum of the phase remunerated channel from all the receive antennas.

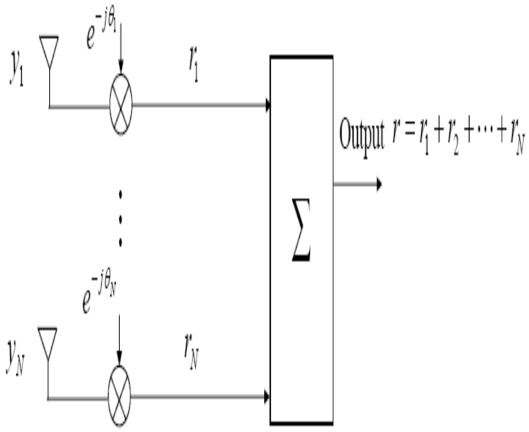

Fig-5: Equal gain combiner

6. SIMULATION RESULTS

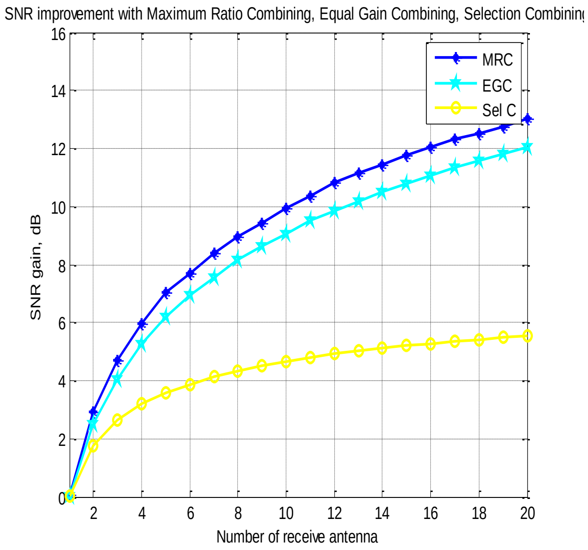

Fig-6: Graph between receiving antenna and SNR gain

Figure 6 shows the graph between receiving antenna and SNR gain.

7. CONCLUSION

We can observe that with the increase in no of receiver antennas, the SNR gain increases. When there are 10 antennas, the SNR gain is 10 dB for MRC, the SNR gain is 9 dB for EGC, and the SNR gain is 4.5 dB for Selection combining. Hence we can conclude that for the same number of receiver antennas, the value of SNR is maximum for Maximal Ratio Combiner. The above plot shows the comparison of output curve between SNR and No. Of receiver antenna's of MIMO system using Maximal Ratio Combiner scheme, Equal Gain Combining, Selection Combining

8. REFERENCES

[1] T. S. Rappapot, Wireless Communications: Principles and Practice Prentice Hall, 1996

[2] A. Hottinen et al., "Industrial embrace of smart antennas MIMO," IEEE Wireless Commun, Mag., August 2006.

[3] Z. Liu, G. B. Giannakis, S. Zhou, B. Muquet, "Space-time coding for boradband wireless communications", Wireless Communications and Mobile Computing, vol. 1, no. 1. pp. 35-53, Jan. 2001.

[4] V. Tarokh, N. Seshadri, A. R. Calderbank, "Combined Array Processing and Space-Time Coding", IEEE Trans. Inform. Theory, vol. 45, no. 5, pp. 1121 - 1128, May 1999.

[5] J. H. Winters, "On the capacity of radio communication systems with diversity in a Rayleigh fading situation", IEEE Journal on elected Areas in Communications, pp. 871-878, June 1987.

[6] I.E. Telatar, "Capacity of Multi-Antenna Gaussian Channels", AT&T Bell Labs, 1995.

[7] File: Space diversity.gif, From Wikipedia, http://en.wikipedia.org/wiki/File:Space_diversity.gif

[8] Single-input single-output system, Available at Wikipedia: http://en.wikipedia.org/wiki/Single-input_single-output_system