DIVERSITY RECEPTION TECHNIQUE FOR QOS IMPROVEMENT

Sunil J Wagh*

Dr. U.V. Kulkarni**

Dr. S. Qamar***

Abstract:

The diversity is used to provide the receiver with several replicas of the same signal. The diversity techniques like selection diversity, equal gain diversity and maximum ratio combining diversity have been discussed to improve the quality of service parameters in CDMA communication network.

Key Words- Qos, Network, Diversity, CDMA, Gain

* Computer Science Department, MGM College of Engineering& Technology, Noida (U.P),*India.*

** Computer Science Department, SGGS Institute of Engineering& Technology, Nanded, India.

*** Computer Science Department, Salaman Bin Abdul Aziz University, Wadi-addawassir, KSA.

1.1 Introduction:

The diversity combining is the technique applied to combine the multiple received signals of a diversity reception device into a single improved signal. The signals are combined at the receiver by using diversity combiner. The diversity is a well known technique for improving performance in CDMA mobile communications Network and soft handoff is a technique to improve Quality of service in soft handoff region using macro diversity combining technique. Diversity paths carry the same information but experience independent fading. By appropriately combining these paths, the effect of excessively deep fades in the received signal can be reduced. The diversity paths can be obtained in two ways. Thus, there are two types of diversity.

(i) External diversity- by deliberately generating them using techniques such as space, time or frequency diversity. This is known as external diversity.

(ii) Internal Diversity- by exploiting the multipath nature of the channel. This is known as inherent or internal diversity.

1.2 Diversity paths

A mobile station (MS) may experience a significant loss of the transmitted signal if there is a large obstruction (such as hill or building), which shadows its communication link. This type of fading is known as long-term fading. To combat this type of fading, macroscopic diversity is used. A simple method is to use several base stations (BS) located in several strategic positions to ensure that there at least is one clear communication link between the MS and the BS at any time. More often occurring in a mobile radio communication environment is the phenomenon called short term or fast fading. Methods for counteracting this fading type are called microscopic diversity. This term is used because the diversity paths in the fast fading environment are separated by intervals equivalent to a delay varying from a fraction to several wavelengths. In order to effectively use either macroscopic or microscopic diversity in combating slow or fast fading we need several uncorrelated diversity paths. There are three different techniques for generating the uncorrelated diversity paths that will be briefly discussed in this section.

(a) Space diversity

This technique involves transmitting and/or receiving the same information using several well-separated antennas. It is widely used in a variety of microwave communication systems. In space diversity the antennas can be separated vertically or horizontally either in the base station or in the mobile station. [3 , 4]

(b) Frequency diversity

The same information is transmitted using two or more carrier frequencies in frequency diversity. This method is economical in terms of antennas but requires more bandwidth. In order to obtain frequency diversity paths that fade independently, the separation between the carrier frequencies should be greater than several times the coherence bandwidth [1].

The coherence bandwidth (B_c) can be defined [1], as the frequency separation for which the magnitude of the normalized complex correlation coefficient between the signals (diversity paths) drops below a certain value. Yacoub [4] assumed this correlation value as 0.5. The coherence bandwidth is inversely proportional to the multipath delay spread of the channel.

(c) Time Diversity

Different time slots are used to transmit the same information in time diversity. In the case of sending repetitive data through the multipath channel the inter transmission time is an important factor in ensuring the received signals experience independent fading. This time interval ($\square_s$) should be greater than the reciprocal of the baseband fade rate [1] or in other words the time interval must exceed the coherence time ($\square_c$) of the channel [9]. Note that the coherence time is not directly related to the coherence bandwidth but inversely proportional to the doppler shift (f_d).

$$\square_s \square \; 1/(2\pi f_d) \qquad (1.1)$$

where $f_d = v/\square$. where v is the speed of the MS and. is the wavelength. For example, in an

environment where a MS moving with a speed of 60 km/h and operating at a carrier frequency of 900 MHz, a time interval of 10 ms between the independent diversity paths is required.

1.3 Internal diversity and resolvable paths

In a sufficiently wideband transmission system like CDMA system, a multipath signal can be viewed as creating a series of diversity paths. Resolving the number of paths and their parameters will be discussed in this section. This diversity technique is called multipath diversity in some references [7,8]. The inherent diversity paths in the multipath fading envelope are called internal diversity paths. The number of resolvable paths, L, is related to the coherence bandwidth, Bc, and also to the bandwidth of the signal. The relationship between the multipath delay spread □ T and the transmitted pulse duration, Tc, defines the behaviour of the channel. If □ T □Tc, the channel is a frequency selective channel while if □ T □ Tc the channel is a frequency nonselective channel. In a frequency selective channel there can be several (say L) trains of pulses with duration T_c in the multipath delay spread of the channel. In other words, there will be L diversity paths. Thus the maximum number of resolvable independent diversity paths that can be obtained is as in [1]

L□ (□ T/ T_c)+1 (1.2)

The Rake receiver is capable of extracting diversity paths received from the multipath propagation environment. Typical values of mean delay spread can be several □ s in urban areas and fraction of □ s in suburban areas [5]. The Qualcomm CDMA system uses a chip rate of 1.2288 MHz or Tc = 0.81□ s. In an urban area with delay spread of 5 □ s, the Rake receiver is capable of resolving up to 6 diversity paths. However this process requires the amplitude and the phase of the diversity paths to be estimated on a continuous basis. In practice, relatively good estimates can be obtained if the channel fading is sufficiently slow or in other words the coherence time of the channel, $□_c$ is much greater than the data symbol period, Ts i.e. ($□_c$ / Ts) □100 [8]. From equation (2.2) we may conclude that the longer the time delay spread of the channel, the more diversity paths can be obtained. It is seen that the diversity combiner performance will not improve much for L > 3. On the other hand the longer the value of □ T, the longer the required waiting time before sending the next pulse if intersymbol interference is to be avoided. This causes the signaling rate to be reduced.

1.4 Diversity combining Methods

The diversity combiner combines the signals in constructive manners to those signals, which are obtained through diversity paths. There are two main issues in reviewing the properties of alternative diversity combiners. The first is related to where the combining process takes place in the system and the second is how to combine the diversity paths. We will briefly review where the combining process takes place before focusing on the combining method. (1) Predetection and (2) Post detection.

There are two locations where diversity paths can be combined in a diversity receiver. If the combining process occurs after the Intermediate Frequency (IF) stage and before the detection process then it is called a predetection combiner. On the other hand, in the post detection combiner, each diversity path is combined in the base band stage. The main differences between these two basic types of diversity combiners are described [6] in terms of the detector used in the system and the extra circuitry required, such as a co phasing circuit. If a nonlinear detector (e.g. a square-law detector) is used, the predetection combiner performs better than the post detection combiner. Parson[6] stated that in case where two identical paths are combined, predetection may have a 3 dB signal to noise ratio gain over post detection. On the other hand, predetection requires complicated co phasing circuitry before combining all the paths. The co phasing circuit is not necessary in the post detection method since combining occurs at base band.

There are two main types of diversity combiner, the switch combiner and the gain combiner. Examples of the switch combiner are the scan diversity combiner and the selection diversity combiner. Examples of the gain combiner are the equal gain combiner and the maximal ratio combiner. A linear combiner is most often used in practical applications. The output of a linear combiner for L diversity paths can be expressed as-

$$r(t) = \sum_{K=1}^{L} a_k r_k(t) \qquad (1.3)$$

Where a_k is the weight assigned to the signal component in the k-th diversity path respectively. The choice of a_k, as seen later will define the type of combiner. To compare the signal to noise ratio and bit error rate performance of three commonly used diversity combiners (selection, equal gain and maximal ratio combiner) several assumptions are made, we summaries some assumptions as in [3] for the diversity combiner inputs.

- The noise in each path is independent of the signal, and additive.
- The signals are locally coherent. This implies that the fade rate is very slow in Comparison to the lowest modulation frequency present in the signal.
- The noise components are locally incoherent (i.e. uncorrelated) with zero
- means and the local mean square values (noise powers) are slowly varying or constant.
- The local rms values of the signals are statistically independent.

Table 1.1 Comparison of Diversity Schemes

Type of diversity	Properties	Mathematical model	Remark
Selection diversity Combining (SDC)	The diversity path having the strongest signal is selected	SNR is maximized by single chosen path, other path gain is zero.	Probability of error decreases with SNR, incremental benefit decreases as the number of paths increases
Equal gain Combining (EGC)	All signal are equally weighted and combined combined	SNR is maximized by combining all the path signal with equal weights	The Probability of error of EGC performs better than the SDC and is only about 1 dB worse than the MRC
Maximum ratio Combining (MRC)	Signals weights are unequal, SNR is maximized	SNR is maximized by combining all the path signal with unequal weights	The SNR at the output of MRC is better than can be achieved with any other linear combiner, Probability of error performance is best.

Conclusion:

The diversity is used to provide the receiver with several replicas of the same signal. The diversity techniques has been used to improve the performance of the radio channel without any increase in the transmitted power.

The diversity Combining MRC outperforms the Selection Combining. The equal gain combining (EGC) performs very close to the MRC. Unlike the MRC, the estimate of the channel gain is not required in EGC. Among different combining techniques MRC has the best performance and the highest complexity. The SC has the lowest performance and the least complexity.

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