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이동통신 시스템 성능 향상을 위한 다이버시티 알고리즘제안

이 명 호*

Propose Diversity Algorithm for Mobile Communication System Performance Improve

Myung-Ho Lee *

요 약

본 논문에서는 페이딩을 감소시키는 다이버시티 기법 알고리즘을 제안하였다. 무선채널에서 다중경로 때문에 페이딩이 발생하면 시스템 성능이 현저하게 감소한다. 본 연구에서 수신기는 탭 지연 수신기를 사용하였다. 변조방식은 QPSK와 OQPSK를 사용하였고, 부호율이 1/2, 1/3과 구속장이 11인 길쌈부호와 구속장이 6인 터보 코드를 사용하였다. 본 논문에서 제안된 다이버시티기법으로 순방향과 역방향 채널에서 페이딩지수를 변화시키면서 변조방식에 대한 평균에러확률을 비교분석하였다.

Abstract

In this paper, proposed diversity algorithm that decrease fading. In the wireless channel, if fading occurs due to the multipaths the performance of the system is apparently reduced. This study applied tap-delay receiver. It applied QPSK and OQPSK modulation methods and applied the convolutional codes, where the code rate is 1/2 and 1/3 and the constraint length is 11 and the turbo code where the constraint length is 6. The diversity algorithm proposed in this paper could be compared and analyzed the average error probability of modulation method variable of fading factor to uplink and downlink channels.

▸ Keyword : Diversity, Fading, CDMA, QPSK, OQPSK

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* 청주대학교 전자정보공학부 교수

Ⅰ. 서 론

DS/CDMA(Direct Sequence Code Division Multiple Access) is considered as the third generation of cellular mobile, indoor wireless and personal communication system.[1] CDMA offers attractive features such as frequecny reuse, soft hand-off, increased capacity, and multipath combating. In a CDMA system, several users simultaneously transmit information over a common channel using pre-assingned codes. The conventional single user detector consists of a bank of filters mathced to the spreading codes, One of the primary limitations on the performance of cellular communication systems is multiple access interference. Hence current research activities are focused on reducing this fading, including the use of antenna arrays at th base station. Antenna arrays can ve though of as spatial filters in the sense that they can be used to form a beam toward the desired user while spatially rejection the interferers outside the beam.[2] In the case of a DS-CDMA system employing Rake reception, the interference power is reduced considerably at the base station by performing temporal correlation of the signal received from all the users with the desited user`s spreading code. Multipath diversity combining is also achieved using a rake receiver. In a typical mobile environment, signals from users arrive at different angles to the base station and hence antenna arrays can be used to an advantage. In the extreme case, each multipath of a user amy arrive at a different angle, and this angle spread can be exploited using an antenna array. Thus, by combining an antenna array with rake reception in DS-CDMA, considerable performance gamin can be achieved.

In mobile radio systems, the transmitted signal is attenuated, reflected and refracted by many obstacles along the paths between the transmitter and the receiver. Early propagation experiments indicate the Nakagami-m distribution is one of the most versatile models to describing the fading statistics. The Nakagami-m distribution includes the Rayleigh distribution as s special case for m=1; it can also well approximate the Ricean fading when m>1, with one-to-one mapping between the fading parameter m and Ricean m-factor.

Although the error rate performance of many modulation schemes, e.g. BPSK, DPSK, QPSK, OQSPK, QAM has been extensively analyzed in the flat Nakagami fading channels, there are few papers devoted to the performance evaluation in frequency selective Nakagami fading. The BER of DS-CDMA system is derived in with an exponentially decaying power delay profile, and assuming identical fading parameters, The colsed form approximation to the BER is accurate for smally values of the power decay factors. Efthmoglou[3] extended the analysis to non-identical and non-integer fading parameters along different rake paths. The exact BER expression is represented by an infinite limit integral, with the integrand consisting of nested trigonometric function.

This study aims to find out the bit error probability of CDMA system in the mobile wireless channel as proposed in the new diversity algorithm. For this, this study assumes that it resolves the wireless channels into multipaths and the receiving signal has Rayleigh distribution. This paper is organized as follows. In Chapter II, it explains wireless channels. In Chapter III, it proposes the diversity algorithm to assess the performance of the system. In Chapter IV, it compares and analyzes the system performance of the CDMA method using rake receiver. Finally, it describes the conclusion in Chapter V.

II. Wireless Channel

2.1 DS-CDMA

The direct spread method causes the transmitting signals to be recognized as noise to other users but the receiver, making the data difficult to detect or extract. This method modulates the signals by spreading the data signal in the bandwidth using PN codes and modulates them again by spreading signals having wider bandwidth. There are two advantages of using the DS/CDMA methods[4]. First, it uses the simple spread method second, the error is random. In other words, as its interference is spread in the receiversof DS/CDMA system, the interference within the bandwidth seems to increase the level of the noise on the receiver[5]. However, the voice signals without error correction have larger tolerance level for burst error, so that the information data is easily corrected by Trellis error correction and Viterbi decoder.

2.2 Fading Channel

A slowly varying fading channel, whose parameters are unchanged over one bit duration, is assumed. Since Nakagami distribution is a versatile yet relatively simple statistical model and it is well suited to characteristic a radio mobile channel, we use a Nakami- m distributed to represent the amplitude of channel gains. By properly selecting the number of subcarriers, we assume that signals on each subcarrier experience flat fading. The fading amplitude $\alpha_{k,n}$ is a random variable obeying the Nakagami- m distribution having a PDF given by[9]

$$f_{\alpha_{k,n}}(\gamma) = \frac{2}{\Gamma(m)}\left(\frac{m}{\Omega}\right)^m \gamma^{2m-1} \exp\left(-\frac{m}{\Omega}\gamma^2\right) \quad \text{..... (1)}$$

Where $\Gamma(\bullet)$ is the gamma function, $\Omega = E[(\alpha_{k,n})^2]$ and m is the Nakagami- m fading parameter. When we think of the multipath fading of two different frequencies separated within a system bandwidth, in case wherethe interval of those two frequencies are small enough, those two waves pass almost in the same electromagnetic paths so that they have almost same amplitude and changes in phase. However, the bigger the interval between those two frequencies is, the smaller the level of the correlation between the patterns of the changes of those two frequencies becomes. This is because the changes of phases between two frequencies are different upon each path in the multipath environment. This phenomenon, which shows different fading according to the frequency, is called frequency selective fading. The bandwidth, which has small enough level of correlation of fading between two frequencies, is called Coherence Bandwidth. This coherence bandwidth is related to the delay spread. In the areas with large delay spread, the coherence bandwidth becomes smaller because the phases of signal received have large differences even though the interval between two frequencies is small. While in the area which has small delay spread, the bandwidth becomes larger.

In the mobile wireless communication system, multipaths are formed due to the reflection, refraction, and scattering of signals affected by buildings, man-made constructions, or natural environment. Likewise, it is difficult for the signals received from a mobile device to have line-of-sight waves from the sender. These waves are the sum of signals, which were scattered by disarranged obstacles, causing diminution and phases differences on each signal received. When there is no line-of-sight wave and only reflective waves exist, it is referred to as Rayleigh fading. Rayleigh fading has Rayleigh distribution and the equation of Rayleigh distribution is as follows[6].

$$p(r) = \frac{r}{\sigma^2}\exp\left(-\frac{r^2}{2\sigma_r^2}\right) \quad \text{..................... (1)}$$

III. BER of Diversity Technique

Rake receiver is the receiver used in the frequency selective fading channel having diversity effect. It receives the signals in a pace similar to that of collecting dried leaves with hooks, that adds a certain time delay, Doppler spectrum and AWGN applies average electric power of diminution upon the time delay on each tap of signals received through each different path. It sums up all the signals received and demodulates them[6].

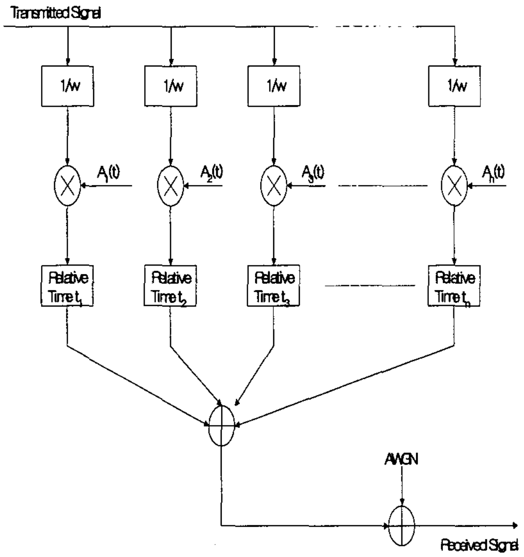

Fig 1. Rake Receiver
그림 1. 레이크 수신기

3.1 Signal Model

Figure2. is the DS/CDMA communication system model showing that K number of users exist[6][7][8].

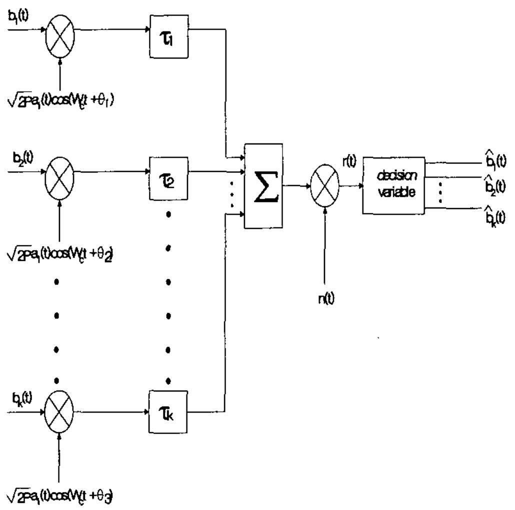

Fig 2. Receiver model
그림 2. 수신기 모델

The data signal of the users, $b_k(t)$, is a rectangle wave wand's sequence having +1 and −1 of values for T seconds of the section and displayed as follows.

$$b_k(t) = \sum_{l=-\infty}^{\infty} b_{k,l} P_T(t - lT) \qquad \cdots (2)$$

Here, the $b_{k,l}$ is the l^{th} data of k^{th} user. When $t = T$, the output of correlation receiver is displayed as follows.

$$Z_i = \sqrt{P/2}\left\{ b_{i,0}T + \sum_{\substack{k=1 \\ k\neq i}}^{K} [b_{k,-1}R_{k,i}(\tau_k) + b_{k,0}\hat{R}_{k,i}(\tau_k)]\cos\phi_k \right\} + \int_0^T n(t)a_i(t)\cos\omega_c(t)dt \qquad \cdots (3)$$

The Z_i distribution can be displayed as follows.

$$var\{Z_i\} = \frac{2PT^2}{12N^3}\left[\sum_{\substack{k=1 \\ k\neq i}}^{K} r_{k,i}\right] + \frac{1}{3}N_o T \qquad \cdots (4)$$

The average signal-to-noise ratio input in the receiver is as follows.

$$\gamma_c = \left[(6N^3)^{-1}\sum_{\substack{k=1 \\ k\neq i}}^{K}[2\mu_{k,i}(0) + \mu_{k,i}(1)] + \frac{N_0}{4E_b}\right]^{-1} \qquad \cdots (5)$$

In Equation (5), it was normalized when the value of K value was large,

$$(6N^3)^{-1}\sum_{\substack{k=1 \\ k\neq i}}^{K}[2u_{k,i}(0) + u_{k,i}(1)] = \frac{2(k-1)}{3N} \qquad \cdots (6)$$

and the average signal-to-noise ratio input in the receiver is displayed as follows.

$$\gamma_c = \left[\frac{2(k-1)}{3N} + \frac{N_0}{4E_b}\right] \qquad \cdots (7)$$

Here, k is the number of users, and N is the code sequence.

3.2 System Performance

It used a rake receiver and applied maximum synthesis method. In this case, the number of antennas was An. If there is L number of incidence signal paths, thetotal number of diversity of this system can be displayed as follows.

$$M = L_s \cdot L \quad (8)$$

If it is frequency selective slow fading channel, L is described as follows.

$$L = T_m \cdot W + 1 \quad (9)$$

The error probability of QPSK in the AWGN, P_e, can be displayed as follows[10].

$$p_e(\gamma) = \frac{1}{2} erfc(\sqrt{\gamma}) \quad (10)$$

The signal-to-noise ratio in cases where the diversity method was introduced in the multipath fading channel can be described as follows.

$$\gamma = M \cdot \gamma_c \quad (11)$$

Here, γ is the bit per signal-to-noise ratio and γ_c is the channel per signal-to-noise ratio. The bit per signal-to-noise ratio can be described as follows.

$$\gamma = (T_m \cdot W+1)\left[\frac{2(K-1)}{3N} + \frac{N_o}{4E_b}\right]^{-1} \quad (12)$$

The average error probability P_b when QPSK signal receives Rayleigh fading in the AWGN can be presented as follows.

$$P_b = \sum_0^{\infty}\left[(T_m \cdot W+1)\left(\frac{2(k-1)}{3N} + \frac{N_o}{4E_b}\right)^{-1}\left(\frac{1}{2}erfc(\sqrt{\gamma})\right)\right] \cdot \quad (13)$$

IV. Simulation

In this chapter, this study aims to compare and analyze the average error probability of DS-CDMA system. The study set the number of antenna as 9, and assumed that there are 500 users in a single set. For the channel distribution, it applied the Nagakami fading distribution and set the fading index as 1. The code rate was 1/2 and 1/3, and QPSK and OQPSK modulation methods were used. Table 1 display the results of the DS-CDMA system performance analysis applying QPSK and OQPSK modulation methods.

The uplink graph in Figure 3 applied a code rate of 1/2, diversity method, convolutional code and turbo code. The downlink graph applied a code rate of 1/3, diversity method, convolutional code, and turbo code. The Proposed graph applied the diversity algorithm proposed by this paper to the DS-CDMA system.

Figure 4 shows the average error probabilities upon each modulation method. When B_b/N_o is 25 dB, the average error probabilities.

Table 1. Comparison of QPSK of OQPSK(E_b/N_o=25dB)
표1. QPSK와 OQPSK비교(E_b/N_o=25dB)

	fading	Modulation	E_b/N_o
Uplink	m=1	QPSK	3.16×10^{-5}
		OQSPK	1.0×10^{-5}
	m=2	QPSK	6.3×10^{-6}
		OQSPK	3.16×10^{-6}
Downlink	m=1	QPSK	1×10^{-5}
		OQSPK	1.78×10^{-6}
	m=2	QPSK	1.0×10^{-6}
		OQPSK	5.01×10^{-7}

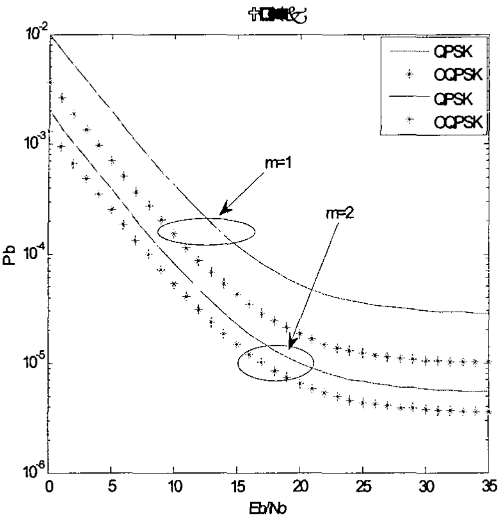

Fig 3. BER to Uplink
그림 3. 순방향 에서 비트에러확률

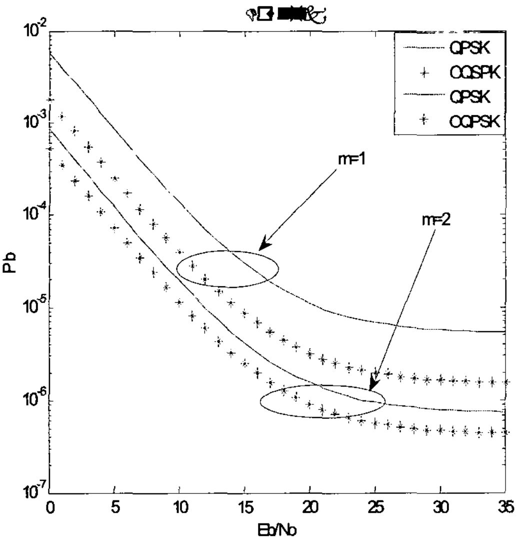

Fig 4. BER to Downlink
그림 4..역방향에서 비트에러확률

V. Conclusion

This study proposed a new diversity algorithm to reduce the average error probability. In Figure 3 where BER is 10^{-4}, it improved 5dB in the proposed algorithm compared to that in QPSK(m=1), and 5dB was an improvement over that of OQSPK. In Figure 4, where BER is 10^{-4}, it improved 6 dB in the proposed algorithm compared to that of QPSK, and about 3dB was an improvement over that of OQSPK. Therefore, these proved the superiority of the diversity algorithm proposed by this study. Comparing Figure 3 and Figure 4, the QPSK was 10^{-4} and OQPSK was 10^{-3} a finding again, that the diversity algorithm proposed in this study is more appropriate to the OQPSK modulation method. In this paper, The performance of the average error probability 2.5dB OQPSK mudulation more than QPSK modulation. I will be abel to forward research decrease with fading channels.

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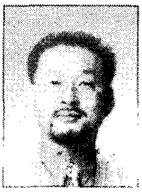

이 명 호

1979년 2월 : 광운대학교 전자통신과(공학사)
1981년 2월 : 연세대학교 전자공학과(공학석사)
1991년 2월 : 연세대학교 전자공학과(공학박사)
1984년 3월~ 현재 : 청주대학교 전자정보 공학부 교수
〈관심분야〉데이타통신