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Design of Effective Receiver in Hospital Wireless Network Using Turbo Code

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Abstract

In this paper, we considered the received signal of the wideband CDMA systems using turbo code in the multipath channel environments, and analyze the performance of the system. This study is to analyze the performance for the variable system bandwidth according to the number of branches of rake receiver by passing the received signal through a rake receiver with a turbo code in Rayleigh fading channel environments. For the design of receiver in wideband CDMA systems, we presented the efficient parameters for the number of iterative decoding and the number of branches of rake receiver.

Keywords*: W- CDMA, Turbo Code, Rake Receiver, QoS*

1. Introduction

The next generation mobile communications systems is discussed in order to transmit at high speed not only the traditional voice service but also data with the high quality like the Internet service or multimedia service. As the standard of HSDPA (: High Speed Downlink Packet Access) and HSUPA(: High Speed Uplink Packet Access) is completed, the wideband-CDMA system of UTRA TDD(: Time Division Duplex) or FDD(: Frequency Division Duplex) for IMT-2000 is considered as one of the most efficient radio access technology among various proposals for providing this service[1]. The spread bandwidth of this wideband-CDMA system is changed according to the change of data rate. Therefore, depending on the spreading bandwidths of systems, each CDMA system shows different multipath characteristics and performance. Over the last few years, many researchers controvert the dependence of the system performance over the different spread bandwidth [2-3]. Thus, in this paper, the received signal is statistically analyzed in order to design the efficient receiver about the channel bandwidth. And the performance is analyzed while differentiating the number of branches of the RAKE receiver with MRC based on this statistical received signal.

Moreover, in the mobile channel environment, it is applied to a system in the various techniques such as the diversity and channel coding so that the system performance can be improved. In the HSDPA, the HARQ scheme has been proposed as one of the possible techniques to enhance the system performance. The fast decoding occupies attention in the decoding schemes. If the decoding fails on the first attempt, the decoding is immediately stopped and retransmission is automatically requested. Therefore, in this paper, it makes a study of the inappropriate number of iterations of iterative decoding according to the number of branch of the RAKE receiver about the required performance in the wideband-CDMA using turbo code as channel coding.

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2. Hospital Wireless Network

2.1. Mobile IP Structure

Because must keep state that all computers always can communicate because subscriber terminals are connected to network in floating state Mobile IP method internet protocol in IETF Mobile IP recommendation RFC2002 refer to [3, 4].

Keep communication with different nodes continuously even if change links that Mobile IP is joined on the Internet to transfer node in figure 1. It is Mobile IP which is mobility offer plan of doing IP base so that necessary ashes connection may occur automatically without existent nodes and interaction having IP protocol using Internet Protocol Address continuously [4, 5, 6]. Agent that transfer node information of Mobile IP base is registered is HA. Agent that moves by other net leaving network with HA that transfer terminal registers own information and registers newly own position information is FA. Appeared by basic component groove network HA(: Home Agent) of Mobile IP, bract scale network and FA(: Foreign Agent), MN(: Mobile Node) and CN(: Correspondence Node)[7]. Because Mobile IP uses HA and FA, IP supports packet transmission between CN and transfer node. Packet transmission is made through tunneling between HA and FA[8]. It is method that make simulated tunnel between FA with HA and does so that pass data. HA has information for current position of transfer node after pass through registration process. HA is IP packet that grow to groove address of transfer node after [9]. In figure 2, process that attach new header that do HA's address in IP packet by beginning and CoA(: Correspondent of Address) by purpose is being capsule ration(Encapsulation). Through such being capsule ration process HA sauce address and new packet that do CoA to destination Address create [9, 10].

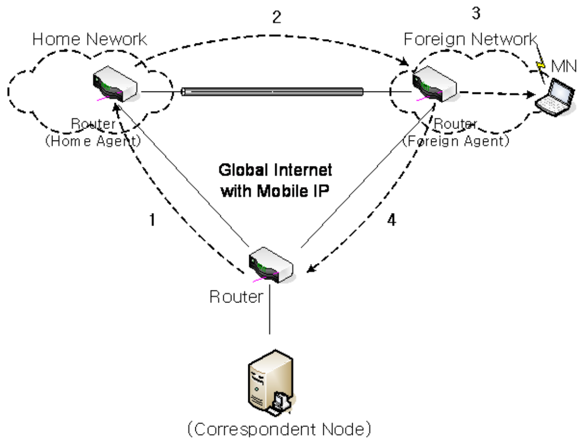


Figure 1. Architecture of Mobile IP

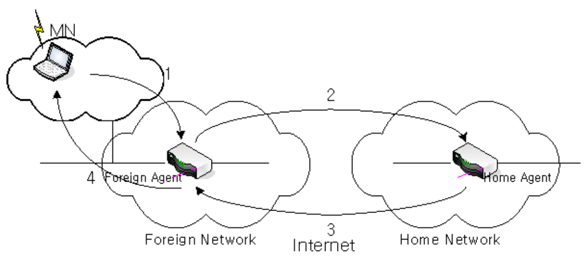


Figure 2. Process of Agent Registration

2.2. Cellular IP Mobility

Cellular IP suggests effective access with local mobility administration for transfer base radio station. Cellular IP is transfer node that is consisted of sun network of form of local in urbane scale. It is protocol that is optimized so that frequent mobility administration who produce whole terminal mobility by hand off by protocol that form supplementing Cellular IP protocol function may be suitable to necessary radio access network [11]. Cellular IP supports paging function or fast hand off function that do not offer from Mobile IP and passes packet based on IP protocol, and minimizes load which happen by signal and is kept to position information database information.

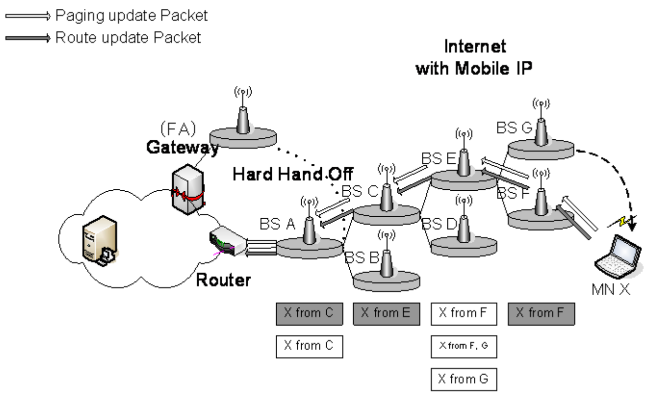


Figure 3. Process of Paging-update and Route-update Packet

Figure 3 shows update state of paging Cache when transfer node X moved from G cell to F cell. Paging packet to do Routing A from transfer node X that have been arrived recently via port that check its Cache and turns node C paging update packet find . Next, pass to all directions if A passes paging packet to C and C does not have some information for node. Paging packet that send by D is abolished automatically after time-out but because it knows that D is no node for own cell. On the other hand, E finds X that check its Cache and sends packet through F. Therefore, E passes paging packet to F and X. If transfer node receives paging packet, nodes that pass sending by router with paging update packet because create Routing update packet make Routing Caches form Mapping. When Routing update packets are carried on gateway, Routing Caches of all paths equip form, and normal packet transmission is achieved as temporary store packets are passed to transfer node on gateway.

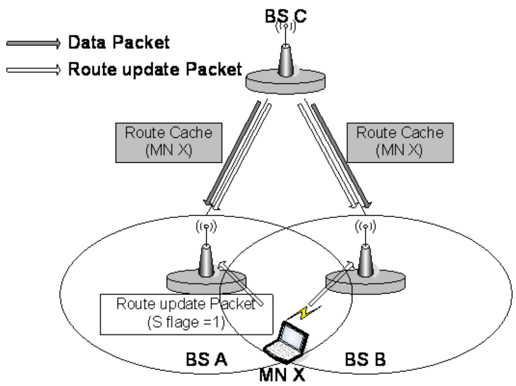


Figure 4. Soft Handoff of Cellular-IP

Figure 4 sent up to up-link establishing value of S flag of route update packet by 1 if arrive in the hand off point while transfer node exchanges and moves data packet from A cell to B cell by Cellular IP's soft hand off method. Base radio station in up-link records all base radio station information about B to be belonged forward with A that transfer node belongs to route Cache and sends data to both base radio station. Data packet that send route update packet at base radio station ago if it is uplink because transfer node establishes value of S flag by 0 after transfer to new base radio station is not been coming to time-out after given time and receives data packet from new base radio station. In so doing, transfer node can achieve fast and soft hand off receiving data packet without some damage or delay from all of the new base radio station and move base radio station hand off interval. If Cellular IP's soft hand off arrives in the new base radio station own data packet establish multiplex route by transmitting transmission and Routing update packet and accomplishes smooth hand off and cancellation is attained by Routing expiration sight by area secession of base radio station which path cancellation is receiving service present. Accomplish soft transmission by establishing multiplex route at current Cellular IP's soft hand off, but because do not terminate path, give strain to network with waste of system resource.

4. Analysis of Wideband-CDMA

In this paper, the JTC (: Joint Technical Committee) channel model is chosen as the wideband multipath channel model. The JTC channel impulse response is represented by the sum of delayed replicas for the impulse signal weighted by independent zero- mean, complex, Gaussian time- invariant processes for specific areas, as Equation(1)[4].

$$h(t) = \sum_{l=0}^{L-1} a_l \delta(t - t_l) e^{j\theta_l} \tag{1}$$

Where, α_l is a Rayleigh distributed random variable representing the envelope of a zero- mean complex Gaussian time- invariant process, t_l is the time delay, and θ_l is the phase of the process. That is shown in Figure 5.

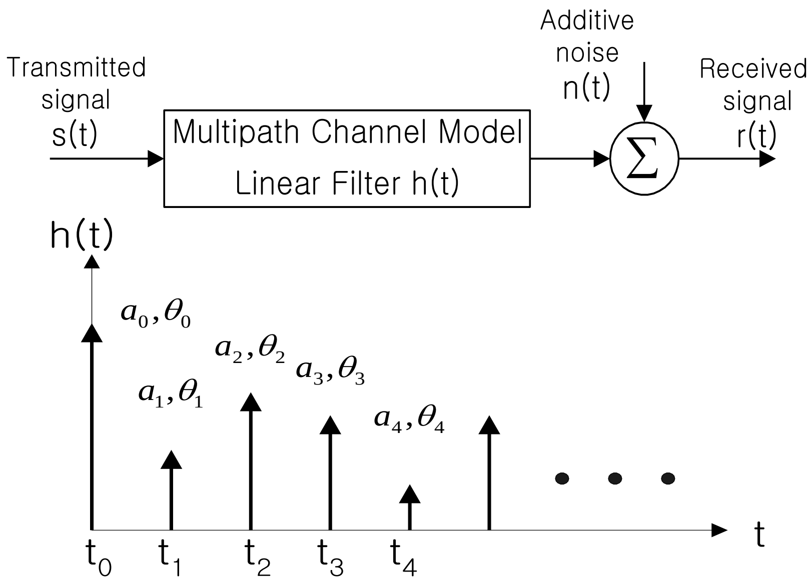


Figure 5. Wideband Multipath Channel Model

There is no difficulty in assuming that the phase θl of the various paths are mutually independent random variables which are uniformly distributed over (0, 2Π]. However, the statistics of path delay tl and path strength αl are not so obvious. In this paper, the path strength *αl* is assumed to be Rayleigh distribution. This kind of wideband multipath channel model can be used as a theoretical channel model for the analysis of mobile radio system whose bandwidth is less than or equal to that of a theoretical channel model. Thus we could not analyze wider bandwidth system based on narrower bandwidth channel model.

The reason is as following. The time resolution of multipath channel is limited by channel bandwidth. Narrower bandwidth channel model has longer time resolution whereas wider bandwidth channel model has shorter time resolution. In other words, even though there are more resolvable paths in a wider bandwidth channel, these can not be represented accurately on a narrower bandwidth channel model. In this paper, we assume the channel bandwidth is 10MHz, which is typical in many measurements. So we can analyze CDMA system whose bandwidth is less than or equal to 10MHz.

Let's assume the general situation for the analysis of W- CDMA signals. Total received signal is composed of *K* - DS waveforms, all of which are asynchronous one another. And coherent BPSK, perfect power control, and synchronization are assumed [5]. Then *k*- th transmitted signal is given by Equation (2).

$$s_k(t) = m_k(t)c_k(t)\exp(jw_o t) \tag{2}$$

Where $m_k(t)$and $c_k(t)$are the data and the spreading sequence of *k*- th user. Then total received signal *r(t)* can be represented by Equation (3),

$$r(t) = \sum_{k=0}^{K-1}\sum_{L=0}^{L-1} a_{k,l} m_k(t-\tau_{kl})c_k(t-\tau_{kl})\exp[i(w_0(t-\tau_{k,l})+\theta k,l)) + n(t) \tag{3}$$

where *K* is total number of users, *L* is total number of multipaths, and $n(t)$ is additive Gaussian noise.

The index $k=0$represents the signal from a desired user, whereas *k* = 1, 2,- - - , *K*- 1 stands for signals from undesired users. The index $l=0$represents the first arrived signal while $l=1$, 2,- - - , *L*- 1 stands for second, third, th multipath signal. And □$_{k,l}$ represents the delay time of *k*- th & *l*- th indexed signal, while $\theta_{k,l}$represents the phase shift of *k*- th & *l*- th indexed signal caused by impulse response. Time delay □$_{0,0}$ and phase shift □$_{0,0}$ can be set as a reference and assumed zero for analytical conveniece without loss of generality.

In Equation (3), *r(t)* can be grouped into three parts, multipath components from desired user $s_0(t)$, multipaht components from undesired user $s_i(t)$, and additive Gaussian noise $n(t)$.

$$\begin{aligned} r(t) &= \sum_{l=0}^{L-1} a_{0,l} m_o(t-\tau_0,l)c_0(t-\tau_0,l)\exp(j(w_0 t+\theta_{0,l})) \\ &\sum_{k=0}^{K-1}\sum_{L=0}^{L-1} a_{k,l} m_k(t-\tau_{kl})c_k(t-\tau_{kl})\exp[i(w_0(t-\tau_{k,l})+\theta k,l)) + n(t) \\ &= s_0(t) + s_i(t) + n(t) \end{aligned} \tag{4}$$

The output of a standard correlation receiver at *t* = *T* is given by Equation (4) [6].

$$\begin{aligned} z &= Re[\int_0^T 2r(t)c_0(t)\exp(-(w_0 t+\theta_j))dt] \\ &= Re[\int_0^T As_0(t)+s_i(t)+n(t))c_0(t)\exp(-(w_0 t+\theta_0))dt] \\ &\equiv S+I+N \end{aligned} \tag{5}$$

Where *S*, *I*, and *N* are correlator outputs corresponding to desired user, interference, and noise, respectively. If we assume the desired signal corresponds to transmitting a plus one, and further assume very small delay time compared to bit period $(\tau_{0,l} \ll T)$ so that we can ignore intersymbol interference, we have

$$S = \int_0^T \sum_{l=0}^{L-1} a_{0,l} m_0(t-\tau_{o,l}) c_0(t-\tau_{0,l}) c_0(t) \cos(\phi_{0,l}-\theta_0) dt$$
$$= \sum_{l=0}^{L-1} a_{0,l} \cos(\phi_{0,l}-\theta_0) \int_0^T c_0(t-\tau_{0,l}) c_0(t) dt \tag{6}$$

Where $\phi_{0,l} \Delta - w_0 \tau_{0,l} \theta_{0,l}$.

We denote the autocorrelation function of the spreading code,

$\int_0^T c_0(t-\tau_{0,l}) c_0(t) dt$ as $R_c(\tau_{0,l})$, and rewrite Equation(6).

$$S = \sum_{l=0}^{L-1} a_{0,l} \cos(\phi_{0,l}-\theta_0) R_c(\tau_{0,l})$$
$$= Re[(\sum_{l=0}^{L-1} a_{0,l} \exp(j\phi_{0,l}) R_c(\tau_{0,l})) \exp(-j\theta_0)]$$
$$= Re[|R| \exp(j(\theta' - \theta_0))] \tag{7}$$

If the phase of the receiver, θ_0 is adjusted to equal θ' for perfect synchronization then, S becomes

$$S = |R| = |\sum_{l=0}^{L-1} a_{0,l} \exp(j\phi_{0,l}) R_c(\tau_{0,l})| \tag{8}$$

If we make the standard Gaussian assumption for multiple access interference [2-3], we can have Equation (9).

$$Var[I] = (K-1) A^2 T^2 \frac{W[A_{k,l}^2]}{3G} \sum_{l=0}^{L-1} e^{-2\delta} \tag{9}$$

We employ a RAKE receiver with MRC(: Maximal Ratio Combining) diversity to use all multipath components. The general RAKE receiver is described in Figure 6.

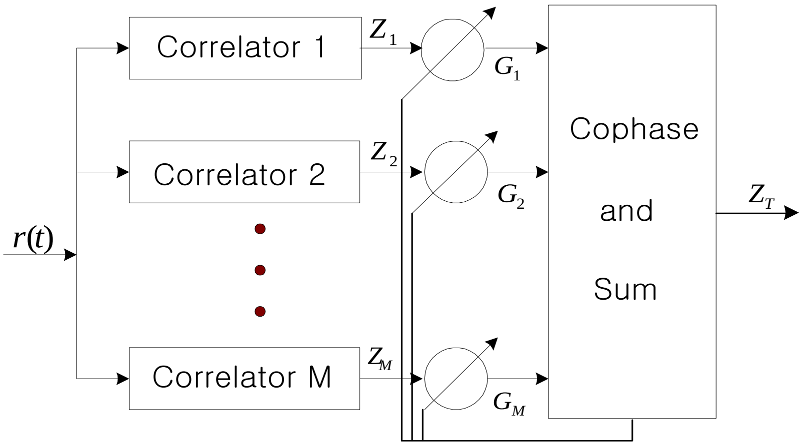


Figure 6. Rake Receiver

Then, after employing MRC diversity, the output of a receiver can be represented by Equation (10), and the statistics of S_T should be modified as Equation (11) [7].

$$\begin{aligned} Z_T &= G_1 Z_1 + G_2 Z_2 + \Lambda + G_M Z_M \\ &= S_T + I_T + N_T \end{aligned} \quad (10)$$

$$S_T = \sum_{i=1}^{M} G_i S_i \quad \text{- - - (11)}$$

Where, G_i is the gain of the ith branch, which is proportional to the ratio of the signal voltage to the noise power of the ith branch, and S_i is the signal component of the correlator output of that branch. Each S_i can be given by Equation (8) correspondingly. The statistics of I, and N should be modified as follows.

$$Var[I_T] = Var[I] \sum_{i=1}^{M} (G_i)^2 \quad (12)$$

$$Var[N_T] = Var[N] \sum_{i=1}^{M} (G_i)^2 \quad (13)$$

5. Simulations

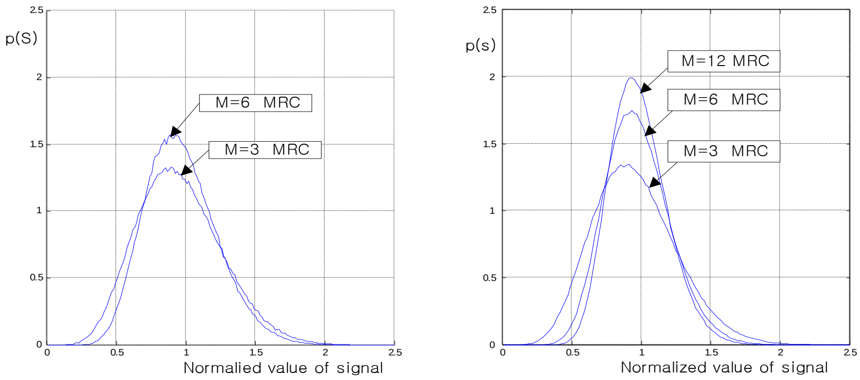
In this paper, we consider two different system bandwidths in heavy traffic urban area environments to design effective receiver in wideband CDMA systems using turbo code. Considered channel environments are assumed as maximal excess delay $\Delta = 2.3$[□sec] and slope $\delta = 0.2$, and considered system bandwidth is 10MHz. The parameters employed to analyze the performance are listed in Table 1.

Table 1. Parameters for Simulation

parameter	value
Maximal excess delay	Δ = 2.3μs
Decreasing slope	□ = 0.2
Constraint length	K = 4
Channel encoder	$G = (17, 11)_{octal}$
Coding rate	r = 1/3

Decoding algorithm	SOVA

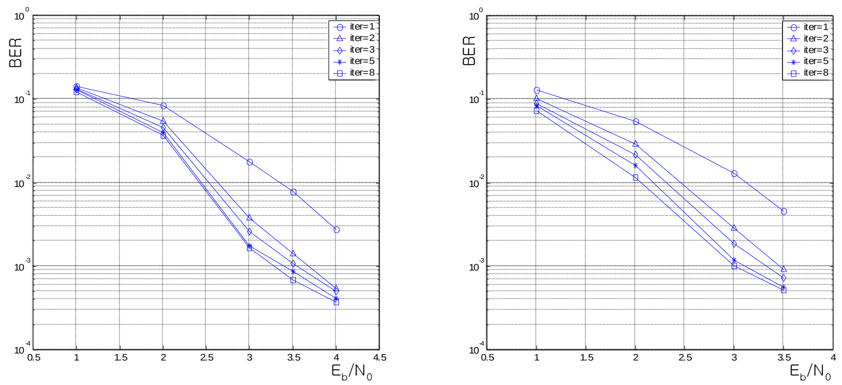
We generate the probability density functions, $p(S_T)$, of each CDMA signal over both system bandwidths by generating S_T numerically from Equation (8) and (11). Those are shown in Figure 7, where S_T is normalized to have unit power.



(a) 5MHz system bandwidth (b) 10MHz system bandwidth

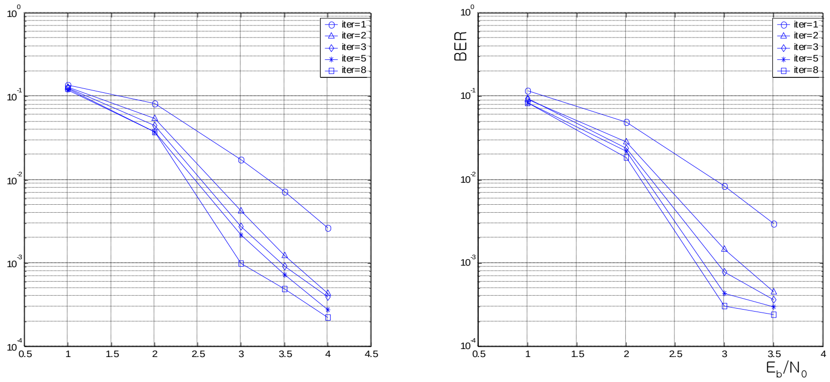
Figure 7. PDFs of Signal Statistics *S* for Different Bandwidth

This study is to analyze the performance according to the number of branches of RAKE receiver by passing the received signal through a RAKE receiver with a turbo code in Rayleigh fading channel environments. In this simulation, we use the internal interleaver size of turbo code is 192 bits, and maximum 8 times iteration for turbo code decoding. And SOVA (Soft- Output Viterbi Algorithm) for iterative decoding is used, because of low complexity and easy implementation. When turbo code is applied to each system whose number of branches of the RAKE receiver are M=3 and 6, the BER performance of 5MHz and 10MHz bandwidth system are illustrated in Figure 8 and Figure 9, respectively.



(a) Number of branches, M=3 (b) Number of branches, M=6

Figure 8. BER Performance of 5MHz Bandwidth Systems



(a) Number of branches, M=3 (b) Number of branches, M=6

Figure 9. BER Performance of 10MHz Bandwidth Systems

In Table 2, we present the required E_b/N_o for a BER of 10^{-3} according to the number of branches of RAKE receiver and the number of iterations for turbo code decoding.

Table 2. Required E_b/N_o at the BER of 10^{-3} (5MHz / 10HMz)

	# of Iteration=2	# of Iteration=3	# of Iteration=5	# of Iteration=8
M=3	3.68 / 3.60 dB)	3.55 / 3.45 dB)	3.40 / 3.35 dB)	3.28 / 3.00 dB)
M=6	3.46 / 3.17 dB)	3.34 / 2.98 dB)	3.12 / 2.79 dB)	3.00 / 2.71 dB)

6. Conclusion

In this paper, the system performance was analyzed through a computer simulation in order to design the efficient receiver of the wideband- CDMA system using turbo code over the wideband multipath channel environment. Firstly, we found the numerically generated statistics of the received W- CDMA signal, and illustrated the performance by applying this signal to the turbo code. In a simulation, PDF of the received signal was shown in case the number of branch of the RAKE receiver was 3, 6, and 12. This signal was applied to the turbo code and the performance was inquired into. The constraint length of the used turbo code was 4. The maximum number of iterations of the iterative decoding was limited within 8 times.

In case the bandwidth of 5MHz was used, it was confirmed as the simulation result to provide the good quality of voice service whenever the iterative decoding more than 2 times was performed, operating at less than 3.7dB of E_b/N_o. Moreover, in case the bandwidth of 10MHz was used, BER of 10^{-3} could be obtained with 3.5dB of E_b/N_o or less.

And the E_b/N_o value which is required in order to obtain BER of 10^{-3} according to the number of branch of the RAKE receiver and the number of iterations of iterative decoding organized as the table. As we can see in Table 2, it is shown that the same performance is achieved in case of eight times iterative decoding with M=6 in 5MHz system bandwidth, eight times iterative decoding with M=3 in 10MHz system bandwidth, and three times with M=6 in 10MHz as well at the BER of 10^{-3}. Also, the same performance is shown in the case of two times iterative decoding with M=6 in 5MHz system bandwidth, and three times with M=3 in 10MHz system bandwidth at the BER of 10^{-3}.

As seen in the simulation result, the system bandwidth, the number of branch of the RAKE receiver, constraint length of turbo code, and the number of iterations of iterative decoding affect the performance of the wideband- CDMA system. Therefore, it has to be design so that the actual system can be optimized in consideration of a relation between these parameters with bandwidth, cost and a delay time.

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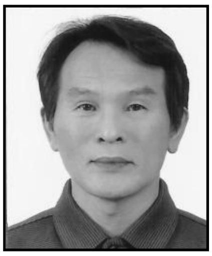

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