PARAMETERS INFLUENCING AIR INTERFERENCE IN 4G WCDMA MOBILES

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Abstract: Air interference, high usability and global coverage are some of the research challenges associated with 4G mobile systems. In this paper we analyze the parameters influencing air interface in 4G WCDMA systems at the physical layer and Link layer. A system model is proposed to increase the coverage range without increasing the transmitter power but by enhancing the SNR at the receiver end.
Key words: Gain, multipath, Coverage area, WCDMA.

I. INTRODUCTION

Research in the wireless transceiver design is focused on providing expanded coverage capability without increasing power and price. One of the most desired features is "global roaming" where the wireless phone could be used anywhere across the world. This would have been a fairly practical objective if there was only one standard to deal with. There are numerous standards and frequency bands each having unique requirements and specifications. The task of designing a multi-format phone is equivalent to integrating several existing phones into a single one without compromising the power, form factor and price.
A major interest of the wireless system is to study and promote multiple antennas, at both transmitter and receiver, in wireless cellular systems. While such techniques are now being proposed for the emerging third generation (3G) physical layer as options, multiple antennas are likely to have a mandatory presence in forth generation (4G) communication systems. Multiple antenna wireless links are important because they improve link reliability through diversity and they increase potential data rate through multiplexing gain. It is anticipated that 4G wireless systems will provide high data rates, of the order of 20-100Mbps to mobile users. WCDMA is attractive to compensate for the significant frequency selectivity of the channel in outdoor, indoor and mixed indoor/outdoor environments. To provide these data rates in the limited bandwidth, multiple-input multiple-output (MIMO) wireless communication channels will be required. The paper is organized as follows. Section 2 presents the challenges, section 3 describes the system model, section 4 illustrates the results and the section 5 gives the conclusion.

II. CHALLENGES

Physical layer: At the physical layer, multiple-input multiple-output (MIMO) wireless links introduce new challenges in signal transmission and recovery. Specific statistical signal processing issues include synchronization (frame, symbol and frequency), channel estimation, equalization, interference mitigation and other receiver algorithms. Communication theoretic issues include space-time coding, efficient decoding, and communication in the presence of partial channel knowledge.

Link layer: The presence of multiple antennas introduces another parameter in wireless link management. Potential new designs include space-time link adaptation which trades off diversity for rate, hybrid ARQ protocols that

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work with space-time coding and iterative decoders and antenna centric power control.

Cellular system design: The potential for delivering multiple sub streams to a single user introduces a new design element in cellular systems. Transmissions from multiple base stations are used for macro-diversity in existing systems. In future MIMO cellular systems these transmissions can convey independent data streams to increase link throughput. Research issues in this case includes new aspects of hand-off due to the plurality of available antennas, dynamic space-time channel allocation, new models for cellular layout and selection of multiple access strategies (CDMA and its multi-carrier variants).

Channel modeling. Unlike channels in existing mobile systems, MIMO channels are much less understood. This is because MIMO channels also have a volume component thus new parameters such as channel rank can become significant. Research will focus on developing real-world models for broadband mobile MIMO systems as a function of antenna type, height, scattering environment, bandwidth, mobile speed, etc. that effectively model the variation of mobile MIMO channels over time.

III. SYSTEM MODEL

In order to increase SNR at the receiver various techniques may be utilized. Turbo coding, Diversity and RAKE receiver and Successive interference cancellation algorithm are used to enhance the quality of the signal at the receiving end. To incorporate the important features of the physical layer (channel estimation and equalization, interference mitigation), link layer (multiple antenna), cellular system design (hand off process) and channel modeling (Rayleigh and Racian channel) will be considered.

Channel Model

The channel is assumed to be Gaussian. We consider the Multipath channel here to show how the RAKE receiver works better than conventional receiver. The multipath channel is modeled as in the impulse response of the channel. It is a typical multipath channel with the first arriving component being dominant. Efficient and robust space-time-frequency codes, resource allocation and multi-user diversity will be necessary to develop wideband channel models in which the antenna spacing, pattern, and polarization will be considered. This will allow comparison of systems with different antenna architectures and will also allow for the inclusion of other effects such as mutual coupling. These benefits can be drawn from physical layer, link layer, cellular system design and channel modeling.

Fig. 1 represents the block schematic of the wireless system. Signals are transmitted from the transmitter using turbo codes. Encoding and interleaving is done there. The AWGN channel is used for the modeling purpose. RAKE receiver works on a main characteristic of PN codes used in spreading the signal. This characteristic is, when two PN codes are separated in time by one or more chip duration (bit of the PN sequence) their correlation is extremely low. Spread spectrum signal are wideband signals thus a typical waveform would experience frequency selective fading because its bandwidth is much larger than the coherence bandwidth of the channel. Using turbo equalizer, better SNR can be achieved at BER of 10^{-6}. SIC algorithm is used to minimize the interferences occurred during the wave propagation in the channel.

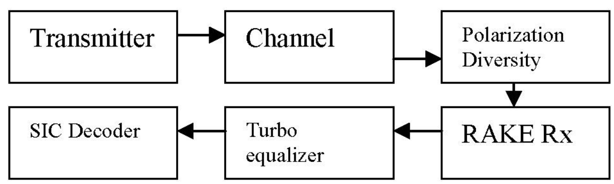

Fig. 1 Block schematic of a wireless communication system.

Polarization Diversity

Polarization of a radiated wave is defined as that property of a radiated electromagnetic wave describing the time varying direction and relative magnitude of the electric field vector. Polarization states are well defined for plane waves. Since mobile radio channels typically include multipath propagation, a new definition is needed for these channels. Here three increasingly general definitions are presented that are applicable to multipath channels. The horizontally and vertically polarized components of a plane wave are represented in phasor notation as follows, $E_H = E_1$, $E_V = E_2 e^{j\delta}$ where E_1 and E_2 are the amplitudes of the horizontal and vertical components, respectively and δ the

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phase of the vertically polarized part of the signal relative to the horizontally polarized part. This definition does not apply in a multipath channel. The received signal in a multipath channel can be represented as the superposition of M plane waves. In general, each of these plane waves can have a different absolute phase, angle of arrival and polarization state. The following representation is independent of antenna pattern (or assumes isotropic horizontally and vertically polarized patterns): where E_{1i} and E_{2i} are the horizontal and vertical components of the i^{th} plane wave, respectively, δ" is the phase of the horizontally polarized component and δ is the vertically polarized component relative to the horizontally polarized component.

$$E_H = \sum_{i=1}^{M} E_{1_i} e^{j\delta_i''}$$

$$E_V = \sum_{i=1}^{M} E_{2_i} e^{j(\delta_i''+\delta_i)}$$

The nature of the electromagnetic wave dictates that the polarization orthogonal to the obstacle surface is attenuated more than the polarization parallel to the surface. Considering that buildings are typical obstacles in the wireless channel, the signal energy received from the horizontal polarization is expected to be less than the signal energy received from the vertical polarization. The results are plotted in Fig.4. The results obtained confirm with the theoretical values for the P_e given by the derived expressions and also illustrated through simulation is the destructive effect of fading on the BER performance.

Implementing RAKE Fingers

The Rake receiver considered here is a 10-finger receiver, which is a standard consideration in typical CDMA system. Here each finger is considered to be like a conventional receiver with each offsetting the particular code for corresponding offset due to the phase change. Before a decision statistic is made the combing scheme is to be implemented. MRC was implemented assuming that we know the channel. The channel coefficients were used to weigh the decisions made by the individual fingers. For selection gain combining the dominant multipath component alone is weighed and the others are cancelled.

Figure 3 shows the plot of number of users Vs BER for 4, 8, 10, 16 finger Rake receiver with SNR=10dB fixed. For the symbol amount of Nd=500, spreading gain of P=64 and PN sequence of length N=50000 the number of users supported at BER of 0.1 increases from 20 for a 4 finger rake receiver to 38 for a 8 finger rake receiver and 48 for 10 finger rake receiver and 50 for 16 finger rake receiver which is a capacity increase of about 98% for a 8 finger rake receiver and 148% for 10 finger rake receiver and 150% for 16 finger rake receiver. As the number of finger increases the number users also increases and the performance gain also increases.

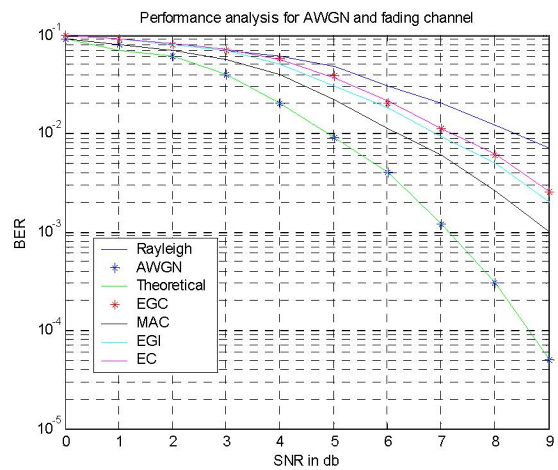

Fig.2. Performance analysis for AWGN and fading channels.

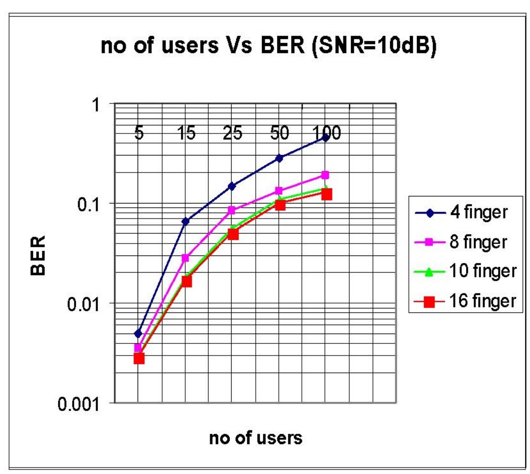

Fig 3. No of users Vs BER for different fingers of RAKE receiver.

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Turbo Equalizer

Turbo equalizer is employed in the presence of an ISI channel to counter the effects of ISI and minimize the bit error rate (BER). It was pioneered by C. Douillard *et al.* [4] as an application of the iterative decoding principle [3], [11], and turbo equalizer [16] are discussed.

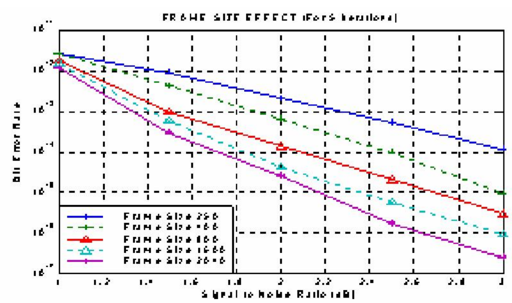
Table 1 shows the number of users supported at BER of 0.1 for different fingers and the capacity increase as compared to 4 finger rake receiver.

Rake Fingers	Number of users supported	Capacity increase compared to 4 finger
4	20	-
8	38	98%
10	48	148%
16	50	150%

IV. PERFORMANCE

The larger the frame size, bigger the S-window. Therefore, it will produce larger distance by using an inter-leaver. The correlation between the two adjacent bits will become smaller. Hence the decoder gives better performance. The simulation results verified this conclusion. However, since Turbo code is a block code, it causes time delay before getting the complete decoding output. Increasing the frame size also increases the delay time. Fig. 5 shows the BER's of Turbo code under static channel with the code rate=1/3, iteration=3, frame size L =1024 bits. When the code rate is decreased, more bits have to be punctured. The bandwidth requirement is also decreased. However, some information is lost. This means that the performance of the Turbo code will also degrade in general.

Fig. 4 shows the effects of the punctuation on BER. The higher the code rate the lower the BER. In the simulation, decode iteration=5, frame size=1024, uncorrelated AWGN environment applied. The three curves are corresponding to code rate=1/2, 1/3, and 1/4 respectively. The BER and FER curves of the *M*=8 BCJR algorithm are almost overlapping with those of the full BCJR which operates on the whole 16-state trellis. When *M*=4, the loss in performance is only 0.05 dB at a BER of 10^{-5}. For *M*=3, the loss is 0.25 dB at a BER of 10^{-4}. For *M*=2, the IED algorithm fails to evolve and does not provide any improvement in performance with iterations. As can be seen from these results for the above channel, we may use the *M*=4 BCJR equalizer with virtually no performance degradation or the *M*=3 BCJR equalizer with a very small loss in performance. This is an interesting result and suggests that the complexity of the BCJR equalizer can be reduced considerably without sacrificing its performance.



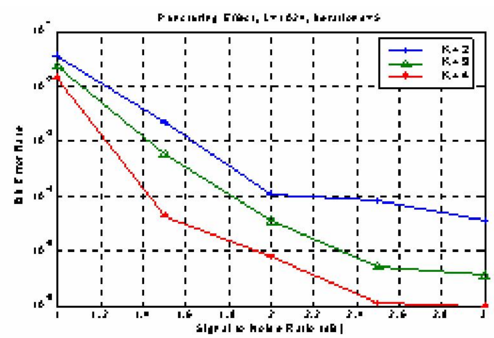


Fig. 4 Frame size effect and Effects of Puncturing on BER

There are no signs of an error floor at a BER of 10^{-5} and thus the performance may improve significantly as E_b/N_o increases. From the above results we observe for AWGN channel with a specification of BER 10^{-5}.

Analyzing the complete communication system model implemented in our work we observe that the Polarization diversity gives SNR of 8dB, Rake receiver gives SNR of 7.8dB and Turbo equalization gives SNR of 5.66dB. Hence the

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expected SNR of integrated result to be observed will be around 4.7dB.

V. CONCLUSION

In this paper, we analyze parameters influencing air interference in 4G WCDMA mobiles. At the physical layer channel estimation, equalization and interference mitigation parameters are analyzed. Using Turbo coding SNR has been improved by 4dB as compared to other coding systems. By utilizing MIMO systems the net signal magnitude is improved. This is established using multiple antennas with diversity polarization technique. Multipath fading is reduced by using 10 finger RAKE receivers. We observe increasing the RAKE fingers to 16 the design complexity increases, but there is a marginal improvement in the performance (0.2dB).

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