THE SUMMARY OF Ph. D. DISSERTATION

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Title

Studies on High-Quality Signal Transmission Technologies in W-CDMA

Abstract

Recently, the demand for mobile communication services in Japan is rapidly increasing. The number of subscribers of mobile cellular services exceeded 7.8 millions (60% of populations) which is larger than that for wired communication services.

The major services provided in the current mobile communication systems are voice and voice-band low-rate data transmission services. However, because of the enormous increase of the Internet users in the fixed networks, the demand for mobile-multimedia services, such as moving image transmission and high-speed data download from the Internet, is increasing in addition to the voice transmission service. Therefore, it is expected that wireless access system, which realizes high-capacity, high-speed and high-quality signal transmission, must be constructed in order to flexibly support the mobile-multimedia services. Then, the third generation (3G) mobile communications system called IMT-2000 (International Mobile Telecommunications 2000) is extensively investigated. In the IMT-2000, there are following requirements; higher capacity more than those of the current mobile communication systems, high-data rate signal transmission up to 2 Mbits/sec (bps), high-quality signal transmission comparable to the fixed networks, and world-wide standard system to enable global roaming. W-CDMA (wideband direct sequence code division multiple access) system is adopted as one of the wireless access standard in the IMT-2000. The commercial services of W-CDMA were launched in October 2001. Wireless access technologies of the W-CDMA for achieving the high-quality transmission are discussed in order to flexibly support the mobile-multimedia services. The enhanced technology for increasing the system capacity is also discussed.

Section 1 shows the background and the objective of this research, and summary of this paper.

In section 2, highly accurate path search algorithm for correlator based Rake receiver for W-CDMA is proposed. The proposed algorithm discards the noisy or noise-only path from the Rake combining and selects the paths having sufficiently large SINRs by setting the path-selection threshold on the measured power delay profile. From the laboratory and field experimental results, the proposed Rake receiver based on the proposed path search algorithm with antenna diversity reception and fast transmission power control (TPC) can accurately select the paths having sufficiently large SINR and the average bit error rate (BER)

performance is improved.

In section 3, two highly accurate Rake combining algorithms for matched filter based Rake receiver for W-CDMA and broadband DS-CDMA systems are proposed. The first algorithm searches multipaths to be Rake combined by setting two path-selection thresholds on the measured power delay profile. The first threshold is to select the paths that provide largest SINRs. However, as the total received signal power decreases, some of the selected paths become noisy. Therefore, the second threshold discards the noisy or noise-only paths from the paths selected by the first threshold. The second algorithm combines the matched filter outputs with adaptively controlled weights that are updated based on a modified least mean squared error (LMS) algorithm. From the computer simulation results, it is verified that the first algorithm can accurately select the paths having sufficiently large SINR irrespective of the propagation model. It is also verified that the second algorithm can equivalently select the desired paths by adaptively controlled weights.

In section 4, the open loop type transmit diversity and closed loop type transmit diversity are investigated by laboratory and field experiments. STTD (Space Time Transmit Diversity) for open loop type and two schemes of PTD (Phase-control Transmit Diversity) and STD (Selection Transmit Diversity) based on a FBI (feedback information) bit sent via the reverse link for closed loop type are investigated The laboratory experimental results clarify that the received timing difference of transmitted signals from two antennas should be smaller than approximately 1/4 chip duration in order to restrict the loss of transmission power to within 0.3 dB. It is also clarified, by field experiment, that the performance is in-sensitive to the fading correlation between two transmit antennas with the antenna arrangements for commercial system (antenna separation of approximately 1.5-7.5m). Furthermore, the field experimental results show that STTD is effective in the channel without fast TPC (such as common control channel) and closed loop type transmit diversity is effecting in the channel with fast TPC (such as dedicated physical channel).

In section 5, weight generation algorithm for adaptive antenna array beam forming (AAA-BF) coupled with transmit diversity is proposed. Average block error rate (BLER) performances of conventional AAA-BF and AAA-BF coupled with transmit diversity in a multipath fading channel in the W-CDMA forward link are investigated by computer simulation. The computer simulation results show that the required transmit power for achieving BLER 10^{-2} using AAA-BF coupled with transmit diversity is decreased by approximately 1 dB compared to that of AAA-BF assuming the identical number of total antennas when the multipath interference (MPI) is small. However, it is also found that in an interference-limited channel (thus when MPI is large), AAA-BF employing all antennas accommodates a larger capacity compared to AAA-BF coupled with transmit diversity because of sufficient interference suppression effect due to a much narrower beam width despite the absence of the antenna diversity effect. It is also elucidated in a multi-cell model that AAA-BF employing all antennas can accommodate approximately 1.4 times more users compared to the case with AAA-BF coupled with transmit diversity, when the total number of antennas is 8.

Finally, section 7 concludes the results of the research in the paper.