論文内容の要旨

論文題目

Random Access Process in Broadband Wireless Access Systems

(広帯域無線通信システムにおけるランダムアクセス方式に関する研究)

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Rapid changes and improvements of recent mobile and network technologies have been realizing ubiquitous network services. Even though the present wireless access technologies already provide wireless data communication services, there still exists the request for the high-speed wireless data transmission. To satisfy this request, researches on broadband wireless access technologies are ongoing. Broadband wireless access systems include various technologies such as random access process, radio resource management, interference cancelation, power control, and so on. Among them, this dissertation focuses on the random access process because it is one of the fundamental technologies for the initialization of the broadband wireless access systems.

Random access process in the broadband wireless access systems refers to the contention-based random access, and provides functions of the initial network entry, the bandwidth request, and the network entry during handover. The procedure of random access process in the broadband wireless access systems is conducted as follows. First, the base station (BS) periodically broadcasts the necessary information for random access process such as the location of random access channel. Second, multiple mobile stations (MSs) simultaneously transmit randomly chosen random access code to the BS. Third, the BS carries out the multiuser resolution process to identify transmitted random access codes. If BS successfully identifies random access codes, it allocates some resources to each MS and notifies this information to MSs. Fourth, each MS transmits the detailed information to the BS using the allocated channel. Random access process in the broadband wireless access systems have following two key features. First, it is performed by the code-based multiple

random access. Polling or CSMA-CA based random access scheme cannot be adopted because the number of MSs in typical broadband wireless access systems such as WiMAX and LTE systems is significantly large. Second, random access signals experience the multipath fading channel environment due to the relatively large cell size. This dissertation analyzes the performance of random access process in the broadband wireless access systems considering above stated two features.

In the mean time, the interference problem in the relay-deployed network, which is caused by the unbalanced transmit power between the BS and the relay station (RS), should be taken into account as well. Hence, this dissertation also scrutinizes the interference problem of random access process in the relay-deployed network and provides a novel transmit power control algorithm. Followings are detailed descriptions of this dissertation.

This dissertation provides the mathematical modeling of random access process in the broadband wireless access systems and derives the probability density function of received random access signals. Using the characteristics of random access signal and the central limit theorem, received random access signals are modeled into Rayleigh random variable. By this modeling, the coarse performance analysis of random access process is feasible, which is considerable beneficial for the initial system design.

This dissertation also provides the finite performance analysis of random access process in the broadband wireless access systems. For the thorough performance analysis, four performance evaluation metrics are defined: 1) the probability of detection success, which refers to the probability for a MS to succeed random access process, 2) the probability of detection miss, which refers to the probability that the transmitted random access code is not detected, 3) the probability of detection false alarm, which refers to the probability that not transmitted random access code is detected as the transmitted code, 4) the average necessary random access success time, which refers to the average necessary time for a MS to succeed random access process including retransmission, random backoff, and penalty time. Based on above defined evaluation metrics, the performance analysis of random access process in the broadband wireless access systems is conducted with various system parameters including the number of MSs and SNR under various channel environments. Moreover, the comparison between the localized FDMA and the interleaved FDMA, which are two different mapping methods of single-carrier FDMA systems, is provided. The localized FDMA is determined to show better performance for the random access process.

This dissertation reveals the interference problem of random access signals in the relay-deployed network. Since the existing random access transmit power control algorithm is based on the compensation of the distance-based path loss between the BS and the MS, it cannot be directly applied to the relay-deployed network. When the existing transmit power control algorithm is adopted, the transmit power of random access signal between the RS and the MS is set to relatively lower than the transmit power of random access signal between the BS and the MS. It is derived from the fact that the distance between the RS and the MS is relatively shorter than that of the BS and the MS. Therefore, the random access signal between the BS and the MS may cause the interference to the random access signal between the RS and the MS. As the number of RSs is increased, this interference problem

becomes more severe. This dissertation provides the probability and the amount of the interference problem in terms of the number of RSs, the number of MSs, and the location of RSs, which validates that the interference problem degrades the performance of random access process significantly.

To overcome above stated interference problem, this dissertation proposes a novel random access transmit power control algorithm for the relay-deployed broadband wireless access systems. The proposed algorithm is based on the random access transmit power boosting. The transmit power of the random access signal within the RS coverage is properly enhanced considering the location and the coverage of the RS. Moreover, the transmit power control is conducted through RS's broadcast message setting for the backward compatibility, which means that the modification of the MS is not necessary. The performance evaluation of the random access process in the relay-deployed network is also conducted based on the previously defined four metrics. Results of the performance analysis show that the above stated interference problem is efficiently overcome by the proposed random access transmit power control algorithm.

Achievement of this dissertation will provide benefit as a guideline for the design of broadband wireless access systems.