Handover Ranging Power Adjustment Using Uplink Channel Information in IEEE 802.16e/m

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This letter proposes a handover ranging power adjustment scheme to improve handover performance. Incorrect ranging power can degrade handover performance due to the increased handover latency; therefore, the proposed scheme exploits the uplink channel information to adjust the uplink handover ranging power. Simulation results demonstrate that the proposed scheme reduces call outage probability by 33% compared to that of the conventional scheme. It also improves the number of users who satisfy the system requirements for handover interruption time.

Keywords: Handover, ranging power, uplink, IEEE 802.16e.

I. Introduction

The handover ranging process is the first step for a mobile station (MS) to connect with a new base station (BS) during handover. The MS acquires new connection identification information from the target base station, and the MS also adjusts the transmission power and timing offset of the target BS using the downlink channel quality. Therefore, the handover ranging process is an important part of the handover process. However, the ranging process based on the downlink channel quality may have high failure probability because the first ranging message is an uplink message, and most MSs that execute the handover process have low uplink channel quality. If a ranging message is dropped due to the lack of transmission power during the process, then it leads to an increase in the handover latency for the retransmission of the ranging message. On the other hand, uplink interference can increase when the uplink transmission power is too high, and as a result, handover outage can occur. Therefore, uplink transmission power adjustment is critical for improving handover performance.

The IEEE 802.16e standard defines orthogonal frequency division multiplexing access/time division duplex (OFDMA/TDD) and frequency division duplex (FDD) modes as multiple-access technologies [1]. In an FDD system, the uplink and downlink channels are asymmetric because the uplink and downlink frequencies are different. In an OFDMA/TDD system, although the uplink and downlink use the same frequency, uplink and downlink channels can be asymmetric. The distribution of mobile users in adjacent cells has a major impact on the uplink channel quality, whereas the distribution of BSs is a major factor for the downlink channel quality. However, most conventional handover schemes only consider downlink channel quality [1]-[3]. Some studies consider the uplink channel quality, although there are overheads incurred in measuring uplink channel quality [4], [5]. However, these studies do not fully utilize the uplink channel information since they consider uplink channel quality only as a handover execution criterion. Therefore, this letter proposes an uplink power adaptation scheme for handover ranging messages. It is based on a handover scheme that considers the uplink and downlink channel quality to reduce handover outage in the IEEE 802.16e/m system.

II. Handover Ranging Adjustment Scheme

The IEEE 802.16e standard defines the transmission power of a ranging message as

$$P_{\mathrm{TX\_IR\_MAX}} = EIRxP_{\mathrm{IR,max}} + BS\_EIRP - RSS, \qquad (1)$$

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where $EIRxP_{IR,max}$, BS_EIRP, and RSS are the maximum equivalent isotropic received power at the BS, the equivalent isotropic radiated power of the BS, and the received signal strength, respectively [1]. This conventional power adjustment algorithm has two weaknesses. First, the transmission power of a ranging message is calculated based on the downlink channel quality, even though the handover ranging message uses the uplink channel. Second, the interference power is not considered when calculating the transmission power. The interference power is a very important factor in the packet error rate in the OFDMA system. The reason is that users in neighbor cells can use the same frequency, and this affects the signal-to-interference-and-noise ratio (SINR). Therefore, handover ranging messages with inadequate power can be dropped, which may cause an additional retransmission delay of the handover ranging message during the handover process. As a result, the probability of handover outage increases.

The proposed scheme uses two factors to calculate the uplink handover ranging power. The first factor is the acceptable target power level of the MS at the target BS, and the second factor is the power attenuation information between the MS and the target BS. We define $EIRxP_{HR,min}$ for the acceptable target power level as the minimum equivalent isotropic received power for handover ranging at the BS. Moreover, for the uplink power attenuation information, we also use existing parameters, such as RSS_{BS}, $p_{interference}$, and p_{noise} in the standard [1]. These denote the received signal strength at the BS, the uplink interference power level, and the noise power level, respectively. To implement the proposed algorithm, we exploit the existing messages in the IEEE 802.16e system. As shown in Fig. 1, the parameters in bold face are added to the existing handover messages of the IEEE 802.16e standard [1]. Neighbor BSs measure RSS_{BS}, $p_{interference}$, and p_{noise} of the MS during the scanning process. Then, the serving BS gathers these uplink channel quality factors through an *HO-pre-notification-response* message from the neighbor BSs, and it forwards these parameters and $EIRxP_{HR,min}$ to the MS in a *MOB_BSHO-RSP* message. The MS calculates the uplink transmission power of the handover ranging message P_{TX_HR} as

$$P_{TX\_HR}(\mathrm{dB}) = EIRxP_{HR,min} + MS\_EIRP - 10\log(RSS_{BS}/10 - p_{interference} - p_{noise}), \qquad (2)$$

where MS_EIRP denotes the effective isotropic radiated power level of the MS in the decibel scale. Here, $p_{interference}$ and p_{noise} are expressed in the linear scale. The MS recognizes the uplink channel quality, and it adjusts the handover ranging power to compensate for the signal degradation, interference, and noise to reduce the drop rate of the handover ranging message. In addition, the proposed scheme reduces the uplink interference caused by the handover ranging message to the neighbor BSs because P_{TX_HR} is based on the minimum acceptable power level. Accordingly, the proposed scheme can reduce the service interruption time.

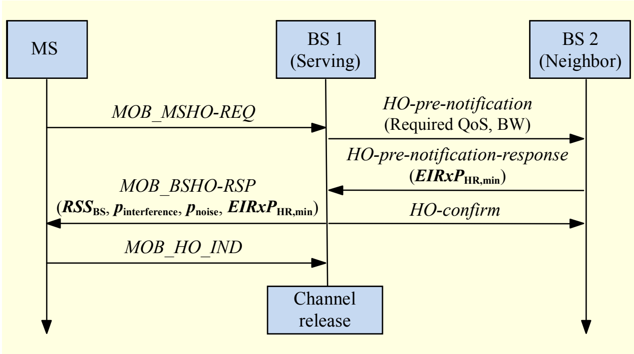

Fig. 1. Message flow of handover process.

III. Simulation Results

To evaluate the performance of the proposed handover scheme, we built a simulator using OPNET. We considered the path loss and large-scale fading of the channel mode because fast fading effects are eliminated due to the averaged SINR. We also generated interference from 37 cells which wrap around the serving cell. For uplink interferences, the dummy MSs were randomly distributed over each cell. To mitigate the ping-pong effect, we calculated the moving average of the measured SINR and used the averaged SINR for the handover initiation and decision thresholds. We measured the handover outage probability and the service interruption time during handover. The handover outage probability is the ratio of the number of handover outages to the number of handover trials. The handover outage is defined as the downlink or uplink signal level being lower than the outage threshold for 30 sequential frames, which means that the service interruption time exceeds 150 ms during the handover process. WiMAX limits the system requirement of the service interruption time to 150 ms for seamless communication [6]. The service interruption time is defined as the time during which the MS cannot exchange data packets with any BS.

Figure 2 describes the results of the handover outage probability in respect to the outage thresholds. The conventional handover scheme uses only the downlink channel information for the handover process. The hybrid handover scheme exploits both the downlink and uplink channel information. The hybrid handover scheme has a lower handover outage probability than the conventional scheme. This means that channel asymmetry exists in the IEEE 802.16e system, and the conventional scheme cannot avoid uplink

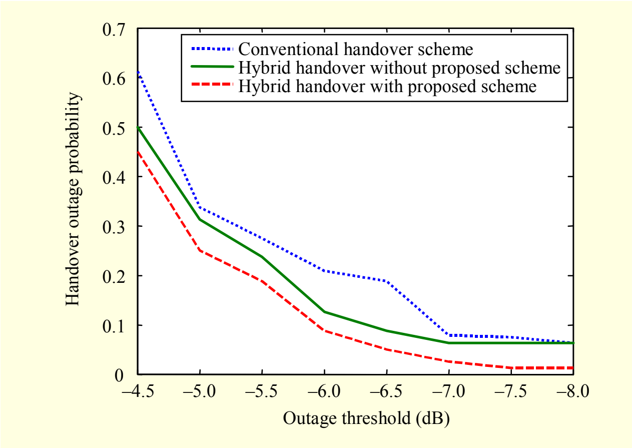

Fig. 2. Handover outage probability.

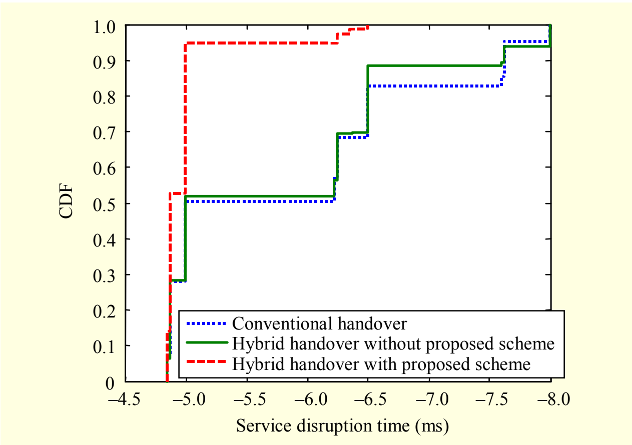

Fig. 3. Service interruption time.

signal outage when the uplink channel quality is poor, although the downlink channel quality is acceptable. However, the hybrid scheme copes with both uplink and downlink signal degradation. The hybrid handover that includes the proposed ranging power adjustment scheme shows the best performance because it prevents both signal outages and timeout outages. The hybrid handover scheme selects the target BS with good channel quality for both uplink and downlink transmission. Moreover, the proposed scheme reduces the number of retransmissions of handover ranging messages by adjusting the ranging power based on the uplink channel quality. Thus, the proposed scheme prevents handover outages caused by exceeding the allowed service interruption time. As a result, the proposed scheme improves handover outage performance by 12% compared to the conventional scheme and 4% compared to the normal hybrid handover scheme.

Figure 3 shows the cumulative distribution function of service interruption time during handover. In the conventional scheme, 83% of the users experienced service interruption time within the 150 ms limit within the given conditions. Some users experienced 180 ms of service interruption time. The increased service interruption time was caused by retransmission of the handover ranging messages. Retransmissions occurred due to the lack of transmission power for handover ranging. A handover ranging message is an uplink message, but the conventional scheme adjusts the handover ranging power based on the downlink channel quality. The hybrid handover scheme satisfies 89% of users within the 150 ms limit. Although the hybrid handover scheme adjusts the handover ranging power based on the downlink channel quality, it chooses the target BS with good uplink channel quality. Thus, there are fewer retransmissions of ranging messages than in the conventional scheme. The proposed hybrid handover scheme allows 100% of users to experience less than 150 ms of service interruption time because it appropriately adjusts the handover ranging power based on the uplink channel quality. Thus, only 6% of users experience handover ranging message retransmission. In all other cases, handover ranging was completed without retransmission.

IV. Conclusion

This letter proposed a novel handover ranging power adjustment scheme that considers the uplink channel information in an asymmetric channel environment. The simulation results verified that the proposed scheme reduces the total handover outage probability by 33% compared to the conventional scheme. The proposed scheme improves handover QoS, while meeting the service requirement of service interruption time. Consequently, the proposed handover scheme can improve the handover performance of IEEE 802.16e/m systems and next generation systems based on OFDMA.

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