Low Handover Latency for WiBro Network

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Abstract : IEEE 802.16 WirelessMAN aiming to broadband wireless access (BWA) is evolving to 4G mobile communication system through the standardization of IEEE 802.16e supporting mobility on existing fixed WirelessMAN system. It is necessary for handover to provide seamless data service while MS (Mobile Station) moves to another BS (Base Station). Because the performance of handover affects packet loss or delay of any communications, it must consider low latency handover mechanism in packet based network. In this paper, we describes handover scheme of IEEE 802.16e with the cell edge interference problem and shows the way to solve the problem in frequency reuse one deployment. Our scheme reduces the handover latency and packet loss probability.

Keywords: Handover, WirelessMAN, BWA, IEEE 802.16

I. INTRODUCTION

The rapid growth in demand for high data rate service in wireless communications has created a demand for broadband wireless access. IEEE P802.16-REVd/D5-2004 defines the WirelessMAN air interface specification for wireless metropolitan area networks (MANs) [1]. This standard describes physical and MAC (Medium Access Control) layer operations of broadband wireless access systems which support high speed multimedia services. IEEE 802.16e-2005 was released, and this system can support MS moving at vehicular speeds. It is expecting that the 802.16e broadband wireless mobile system based on OFDMA technology would be one of high technologies in 3.5G or 4G communication worlds beyond the widely deployed 3G communication with CDMA technology.

Since the IEEE 802.16e system is based on OFDMA physical structure, an MS basically conducts hard handover and the great part of standard describes the hard handover operation. Also, IEEE P802.16e describes MDHO (Macro Diversity Handover) and FBSS (Fast BS Switching) operations. An MS involving MDHO or FBSS is registered to several BSs of Active Set at the same time. In MDHO operation, two or more BSs are transmitting and receiving the same MAC/PHY PDUs to/from the MS at the same time interval. In FBSS operation, the MS is only transmitting/receiving data to/from Anchor BS at any given frame. However, in this paper, we will only discuss hard handover operation for real-time service.

According to the IEEE 802.16e handover operation, an MS in the handover process should complete the network re-entry process for the new BS to receive the data continuously. If the MS moves to another cell and performs handover, the data packets for the MS will be delayed and the service might be disrupted for some time. For non real-time service such as E-mail or FTP, the service user does not care about the packet transmission delay seriously. However, the delay sensitive application, such as VoIP or video streaming service, should be delivered under the delay of 20 to 25ms at network link, typically. The network re-entry processing time during the handover might be much larger than required delivering time for real-time packets. If the transmission delay of real-time packets is over the play time delay, those packets will be discarded and packet loss probability is increased. In this case, the 802.16e system could not provide good quality service and seamless handover for the real-time service. In this paper, we propose low handover latency scheme for downlink real-time service reducing packet transmission delay and packet loss probability during the handover.

The reminder of this paper is organized as follows. Section II gives brief handover procedure description of the IEEE 802.16e. Section III introduces low handover latency scheme and the performance analysis and simulation are given. Finally, we present the conclusion in Section IV.

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II. HANDOVER PROCESS OF IEEE 802.16e

Network topology acquisition is carried out before HO Request. Then, the actual HO process including HO decision, initiation, ranging and network re-entry process is performed.

A. Network Topology Acquisition

A BS periodically broadcasts the network topology information using MOB_NBR-ADV messages, which includes channel information of neighbor BS. In case that DCD/UCD information of neighbor BS is changed serving BS obtains that information from EMS (Element Management System) and it is available to facilitate MS synchronization with neighbor BS without monitoring DCD/UCD transmission from neighbor BS. MS is able to scan neighbor BS and selects several neighbor BS as a candidate BS for HO decision. During MS scanning process to another FA, incoming data to MS is buffered by serving BS. It is optional association procedure performed during MS scanning interval and non-contention based ranging is conducted between MS and target BS.

B. Handover Process

When MS migrates from serving BS to target BS HO process is performed as follows. MS scans neighbor BS with information obtained from network topology acquisition stage to measure the signal strength periodically. As a result of scanning with Trigger value and

Trigger averaging duration, MS triggers handover to serving BS with MOB_MSHO-REQ message. Then, serving BS and neighbor BS exchange the handover information of MS to negotiate handover capability through backbone network and select one target BS. The serving BS transmits MOB_BSHO-RSP to MS trying to handover. When target BS is decided, MS sends MOB_HO-IND message to serving BS. Then, MS releases the connection with serving BS and conducts network re-entry process to makes a new connection with target BS.

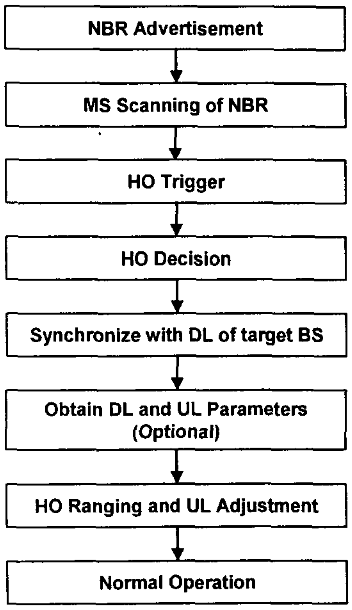

Fig.1 Handover Process

MS may synchronize DL of target BS and obtain DL and UL parameters. If MS had previously received MOB_NBR-ADV message including target BSID, Physical Frequency, DCD and UCD, this process is shortened. MS chooses randomly a ranging code from the Handover Ranging domain of target BS and transmits it in the contention-based ranging interval of target BS. After target BS successfully receives ranging code and sends RNG-RSP message with ranging status "success", it will provide UL allocation of adequate size for MS to transmit RNG-REQ message with MS MAC Address. If target BS obtains MS context information from serving BS, MS can skip Network entry process from negotiating basic capabilities as specified by HO Process Optimization. Fig. 1, 2 shows overall handover procedure of IEEE 802.16.

III. LOW HO LATENCY SCHEME

A. Traffic Model

Voice calls should be generated according to a Poisson process assuming mean call duration of 120 seconds for speech. There are several types of voice model for VoIP. VoIP without silence suppression model generates packet constantly every 20 ms with activity 1. There is an option that the packet can be compressed.

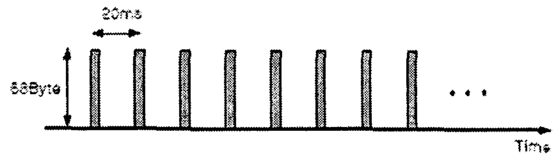

Fig.2 VoIP without silence suppression

VoIP with silence suppression model can be described with ON-OFF model with activity factor 0.35. ON and OFF duration are exponentially distributed. Packet is generated every 20 ms and packet size is different according to the ON/OFF state.

VoIP with variable rate model can generate several sizes of packet which is generated every 20 ms. At the steady state, voice traffic generated with 29% full rate, 60% eighth rate, 4% half rate, and 7% quarter rate and these rates which is shown in table.1 are determined every 20ms.

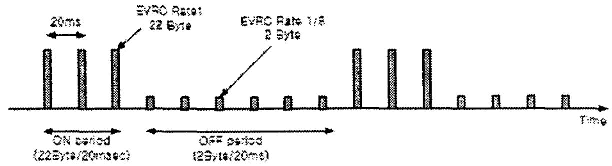

Fig.3 VoIP without silence suppression

Data block type	Compressed (Bits/20ms)	Uncompressed (Bits/20ms)
Full rate	171	266
Half rate	80	124
Quarter rate	40	54
Eighth rate	16	20

Table.1 Voice Traffic Rate

B. Performance Analysis and Simulation

In this paper, we defines FRF (Frequency Reuse Facto) = 1 means that all the sectors has the available subchannels over same frequencies, while a BS with FRF=3 has the sector using the subchannels over different frequencies, that is, each sector can use 1/3 of the available subchannels. At FRF=1, all the sector can use all the available subchannels, but adjacent sectors become interferer. In case of the system with FRF=3, adjacent interfering sectors reduce to 1/3, but the available subchannels are also limited.

In WiBro system, a BS can use subchannels for traffic in a fully-usage manner (FRF=1) or a partially-usage manner (FRF=3). Since a BS with FRF=1 can use all the subchannels to maximize spectral efficiency, higher average sector throughput can be obtained than FRF=3. However, due to heavy co-channel interference in frequency reuse one deployment, higher interference from other cell can cause degradation of handover performance. To reduce handover latency and packet loss ratio for real-time downlink services, we propose a low handover latency scheme that the flexible subchannel reuse is facilitated by subchannel segmentation and permutation zone. The slot of the frame for downlink and uplink is reserved for handover users, which are in chance of having bad condition and giving much contribution to interferences. That reserve slots are operated in FRF=3 manner, that is, a BS uses one-thirds of the subchannels in the reserve slot.

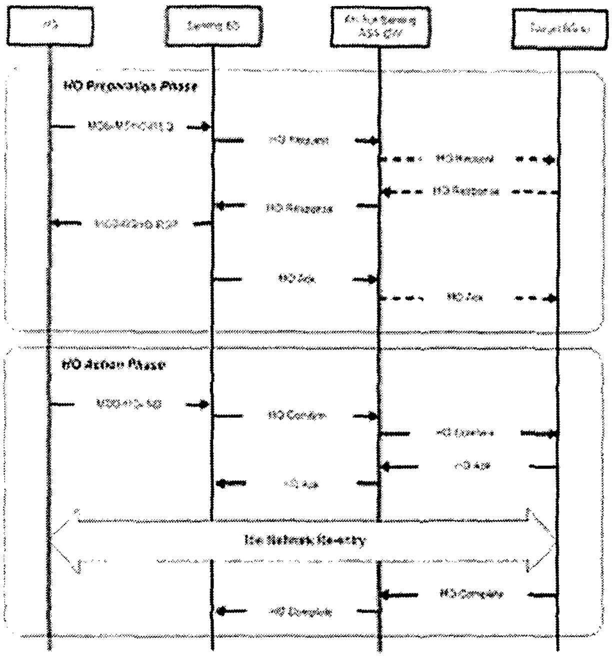

Fig.4 MS-Initiated Handover Process

For the users near a serving BS with good channel condition, all the subchannels are allocated. The average CINR of the preamble determines which users are moved to reserved slot as shown in Fig. 5. The user receiving average CINR below the CINR criterion is allocated to reserved slot while the users over that criterion remain other slots and use all the subchannels. Handover performance considering a latency is evaluated for FRF =1 and FRF =3 as shown in Table 2. In order to evaluate the handover-specific performance, it is assumed that one user per sector is serviced. When handover latency is considered, that is, after the handover criterion is met, the serving cell for the handover user is immediately changed to target cell. The average sector throughput for FRF = 1 is much higher than that for FRF = 3.

Fig.6 shows the distribution of the latency for FRF=1 and FRF=3. The latency of FRF=3 is much shorter than that of FRF=1. There are 80% users of FRF=3 within the latency of 150ms, while just 30% users of FRF=1 have the latency of same time.

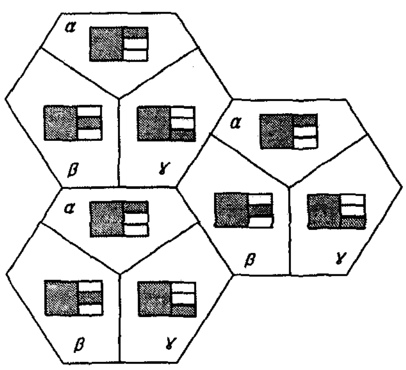

Fig.5. Reserve Slot Usage

To provide seamless data service it is necessary to perform data buffering in Anchor ASN-GW. This function buffers the data packets from the network and maintains the state information related to bearer for MS during handover. Anchor ASN-GW starts to buffer DL data packet when MS releases channel with serving BS by MOB-HO-IND and it receives HO Confirm message from serving BS. After MS completes network re-entry process with target BS and Anchor ASN-GW gets HO Complete message from target BS, it forwards DL data packet to MS.

	FRF = 1	FRF = 3
Throughput at Handover	1.55 Mbps	1.79 Mbps

Table.2 Throughput comparison between FRF =1 and FRF =3

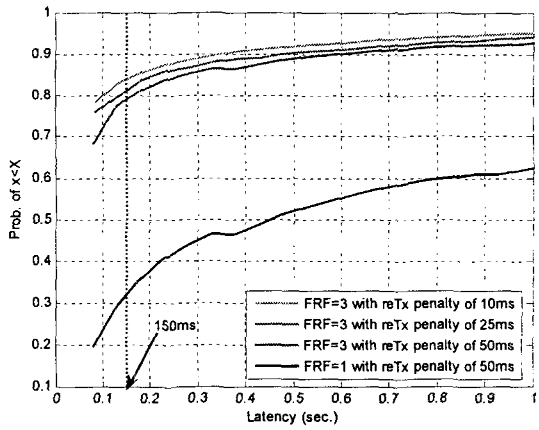

Fig.6 Distribution of Handover latency

IV. CONCLUSION

In order to improve the handover performance, the scheme of allocating the users in bad channel condition to the reserved slot is introduced. Considering handover latency, the system with FRF=3 is expected to get better performance in terms of handover latency and packet loss ratio. If it is assumed that the criterion for the handover drop is the maximum latency of 150 ms, about 80% of users in the system with FRF=3 can be successfully moved to target cell without dropping data service.

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