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Advance Features and Mobility Management of Mobile WiMAX

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Abstract: Mobile WiMAX comes with an advantage of full mobility support and higher capacity compared to the Fixed WiMAX (802.16d 2004). This leads to a tremendous change in the field of Wireless Communications. There are many handover mechanisms in mobile WiMAX which reduces the handover latency for specifying that, including an advance layer 3 handoff schemes for mobile WiMAX based Wireless mesh Network. Hence in this handover scheme, the handover latency should be very low which reduces the chance of packet losses when compared to the conventional layer 3 handover scheme. The main aim of this paper is to give an overall view about Mobile WiMAX and its applications and also to explain one of the handover schemes for Mobile WiMAX.

Keywords: ARQ, FEC, Handover latency, WiMAX, QoX, WMN.

1. INTRODUCTION

Throughout the years we are seeing a large number of developments in the field of wireless communication technology. Due to its higher volume of requirements and capacity, leads it to the step of fifth generation in the field of cellular technology. Introduction to WiMAX is also a great development in the field of wireless communication technology.

WiMAX, Worldwide Interoperability for Microwave Access is a family of wireless communication standards. Basically it is a telecommunication technology based on IEEE 802.16 standards that will provides the wireless data transmission in different ways such as in mobile type access or in fixed way. There are many challenges facing in the field of WiMAX, some of them are cost, flexibility and privacy. Generally Mobile WiMAX is the combination of features of a fixed and mobile wireless application with higher performance and better flexibility. Major factors that considered in the mobile applications are Handover and Power management. WiMAX is having an efficient power operation mode to handle the power management factor. There are many handoff mechanisms in Mobile WiMAX, which reduces the handover latency. The handover mechanism in mobile WiMAX should perform in such a way that the Mobile Station (MS) switches between the two consecutive Base Station (BS) in a vehicular speed without causing any interruption in the connections.

In this paper, explained about advance layer 3 handoff techniques for mobile WiMAX based Wireless Mesh Network (WMN), which constitutes to a less handover latency. The layer 3 handover in mobile WiMAX can be either MIP based or PMIP based handover. The handover latency in PMIP is less when compared to MIP based one, as the number of handover message is less. In section II provide the overview about Mobile WiMAX and its applications. In section III explains about Wireless Mesh Networks and we conclude in Section IV with the lessons we learned from the analysis of WiMAX and handoff techniques based on Wireless Mesh Network (WMN)

2. MOBILE WiMAX

Mobile WiMAX is a new technology rooted on the IEEE 802.16e standard, published in 2006, with the first commercial service commenced in 2007 [1]. Basically Mobile WiMAX is the combination of fixed and mobile wireless application features with higher performance and better flexibility. WiMAX a wireless broadband solution that offers a rich set of features with a lot of flexibility in terms of deployment options and potential service offering [2]. WiMAX has been increasingly called the technology of the future [3]. A basic mobile WiMAX cloud is shown in figure 1. The important factors that affect the mobile applications are power management and hand off mechanism. Mobile WiMAX is equipped with novel technological tools, such as orthogonal frequency division

multiplexing (OFDMA), time division duplexing (TDD), multi-input multi-output (MIMO), adaptive modulation and coding (AMC), Internet protocol (IP), security, and others, which are combined together to offer high-rate, low-cost, wide-area, secured mobile multimedia services[1]. The first mobile wireless system that adopted the OFDMA technology for multiple access is mobile WiMAX. There are many features which make Mobile WiMAX became popular in the radio access technology and network architecture. Some of them are mobility, transferring of high data rate, flexibility privacy etc. WiMAX works at 5bps/Hz and can peak up to 100Mbps in 20MHz channel [3]. The mobile version of fixed WiMAX (802.16 standards) is called the Mobile WiMAX (IEEE 802.16e amendment). IEEE 802.16e works in the 2.3GHz frequency bands [3].

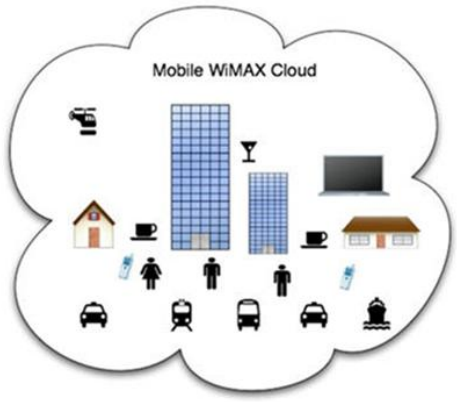

Figure 1. Mobile WiMAX

Actually there are a large number of advanced technologies involved in Mobile WiMAX system. Various different types of technologies that were developed independently are combined together to build up the Mobile WiMAX system. They include the conventional radio interface technologies such as duplexing and multiple access; newly emerging radio technologies such as MIMO and other multiple antenna technologies; communication system technologies such as AMC; mobility support technologies such as power saving and handover; bandwidth management and QoS technologies; and security technologies[1].

The main challenge of WiMAX is QoS. Efficient and proper scheduling design is for developers and designers. Therefore providing a QoS scheduling architecture for WiMAX base stations is a challenge for system developers. Smart antenna technology, hybrid ARQ, improved frequency reuse are some of the features that improve the system performance.

Smart antenna technology – Implementation of advance multi antenna techniques are used for improving the performance of the system. The overall capacity and spectral efficiency of the system can be increase by extending the Advance Antenna System. So that it will support the multi antenna solutions such as transmit diversity, spatial multiplexing and all.

Hybrid ARQ – Automatic Repeat Request (ARQ) combined with the Forward Error Correction (FEC) in the physical layer for the performance raising. As the name itself, it is clear that ARQ is involved in the system. The combination of both ARQ and the FEC contributes the H-ARQ version. During the time of transmission ARQ and FEC are combined together and merged with the CRC (Cyclic Redundancy Check) and then it is encoded with the help of an FEC coder. This takes place before the transmission starts. In this system retransmission process will takes place if the decoder fails to decode the combined block structure after the transmission. Thus the block structure will again transferred and this retransmitted blocks structure will compared with the previous one and then decodes with the help of a FEC coder. A correct decoded result is obtained by combined this two received blocks structure. Hence this H-ARQ is referred as type I chase combining. Further to improve the retransmission, WiMAX also supports type II H-ARQ, also called as incremental redundancy [2].

Improved frequency reuse - The major features of mobile WiMAX are reusing the frequency, increasing and decreasing the power and low rate coding. Providing a higher frequency spectrum for each user is really costly, so it is always good if the frequency spectrum can be reused in an effective way. Mobile WiMAX satisfies this by allocating sub channels to the user at the cell edge. For allocating this, the co-channel interference can be heavily controlled to minimum.

In a mesh environment if WiMAX and Wi-Fi work together, at least a temporary resolution to the issue of whether or not the technologies are actually competitive with each other. It seems that as the wireless newcomer, WiMAX always has been viewed as being potentially competitive with every other wireless broadband access technology, including 3G and Wi-Fi, but using WiMAX as the backhaul method in a Wi-Fi mesh topology will prove the two technologies to be complementary [6].

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3. WIRELESS MESH NETWORK

A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. It is also a form of wireless ad hoc network. Wireless mesh networks mainly includes mesh clients, gateways and mesh routers. The components of Wireless Mesh Network is shown in figure 2. WMN provide an inexpensive and non-complicated connectivity of networks wirelessly. This network combined of mesh routers and mesh clients. Mesh routers are the back bone of WMNs. Mesh clients can be fixed or be mobile. Mesh routers provide network access for both meshes as well as for conventional clients. One of the most outstanding advantage of the WMN is wirelesses. Auto configuring, inexpensive and maintainability make more effectiveness to WMN. The coverage area of the nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. When one node can no longer operate, the rest of the nodes can still communicate with each other directly or through one or more intermediate nodes.

There are many research works related to WMN's, mostly based on the IEEE 802.11 MAC (Media Access Control) protocol [4]. IEEE 802.11 WMN's having less capacity as compared to wired networks. This will leads to insufficiency in data transmission between the routers and also data between the mesh clients. To solve this problem WMN based WiMAX and Mobile WiMAX introduced into the field. The implemented designed system is that WiMAX are employed as multi hop communication by the mesh routers and on the other hand mobile WiMAX are employed for network access technology by the mesh clients.

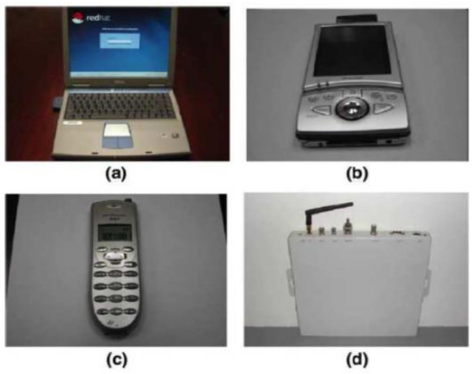

Figure 2. WMN Components

Handover failure will takes place when the mesh client transfers from one mesh router to the other. This is the main reason for the layer 2 handover failure. Because of the failure in layer 2 handover, layer 3 handover also gets fails. The main reason for modifying the procedure is that, we need an interrupted transmission while switching among BS with less handover latency, which leads to layer 3 handover for mobile WiMAX based WMN. From the mobile WiMAX Mobile IP (MIP) and Proxy Mobile IP (PMIP) are the two varieties of handover schemes. Generation of more handover message leads more chance of handover failure and large handover latency. To reduce the handover message and to increase the performance, layer 3 PMIP based came in to the field. Different environment in WiMAX is shown in figure 3.

A. Mobile WiMAX constituting in the layer 3 hand over technique

We chose layer 3 PMIP based handover mechanism due to the advantage of PMIP over MIP based handover. Figure 4 shows layer 3 hand over procedure started by MS's request. During the period of handover scanning, MS initiates the handover intension by sending MOB_MSHO_-REQ (Mobile Station Hand Over Request) message to the serving BS. "The serving BS that received MOB_MSHO-REQ message sends HO Request (Hand Over Request) message to the target BSs through the backbone network to identify one target BS that the handover is possible.

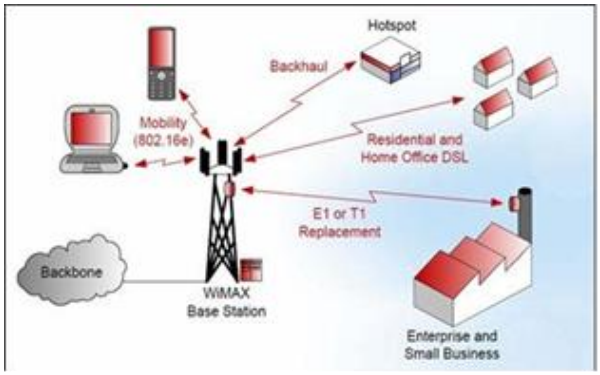

Figure 3. Different Environment of WiMAX

The target BSs performs Path Pre-Registration procedure for data integrity with the ASN-GW. At this moment, the ASN-GW buffers the packets destined to the MS which intends to initiate the handover. The target BSs which complete Path Preregistration procedure send HO Response

(Hand Over Response) message which informs the serving BS whether the handover is accepted or not. The serving BS sends MOB_BSHO-RSP message, which contains the list of the target BSs, to the MS and then sends HO Ack (Hand Over Acknowledgment) message that notify the target BSs of the receipt of HO Response message"[4].

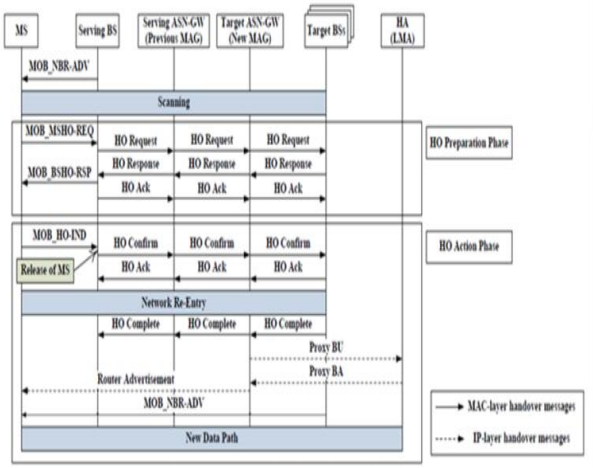

Figure 4. Layer 3 Hand over procedure [4]

Once the whole HO preparation phase gets over, MS select one target BS among the many. After selecting one target BS, MS sends MOB_HO-IND (Hand over Indication) message to the serving BS, at the same time MS initiates the procedure for network re-entry. Once the serving BS receives the MOB_HO-IND message, it starts sends HO Confirm message to the target BS. After receiving a HO confirm message, an HO Ack message is send to the serving BS from the target BS. After completion with the procedure for network re-entry, target BS initiates with the path registration procedure with the help of ASN-GW. After this, target BS sends an HO Complete message to the serving BS, notifying that the MS layer 2 HO has been completed. For registering the MS location, the target BS sends a PBU (Proxy Binding Update) message to the HA (Home Agent). Once the information is updated in the HA then it sends PBA (Proxy Binding Acknowledgement) message back to the target BS. Thus the received PBA's are holed by the target ASN-GW. This target ASN-GW sends a Router Advertisement to the MS.

During the time when MS is carried out by the HO procedures, it should be marked that no packets loss should be occurred and given rise to the HO latency. By taking care of a data integrity mechanism which reduces the data loss and duplication, we can promise a good quality of HO.

B. Layer 3 handover for mobile WiMAX based WMNs

Mobile WiMAX based WMNs is different from mobile WiMAX network because it has wireless backbone. Like that MIP based layer 3 HO mechanisms is not suitable for Mobile WiMAX based WMN and therefore we choose PMIP based layer 3 HO scheme. A lot of hand over messages make in wireless area by MIP. Therefore in mobile WiMAX based WMNs which haves wider wireless coverage area than mobile WiMAX networks, long handover latency is inescapable, and it can cause frequent handover failure [4]. Normally in the previous case the HO latency can be occurred due to the message exchange between PBU and PBA, after completion of layer 2 HO. Thus this issue can leads to packet loss. Therefore to reduce the HO latency a fast HO scheme like PMIP based layer 3 HO mechanisms should be carried out.

Operations: The layer 3 HO scheme for Mobile WiMAX based WMN can be carried out in three major operations.

1. Initiation of layer 2 handover.
2. Preparation for fast handover.
3. Connection with new ASN-GW and receiving packets.

Figure 5 shows the architectural mechanism of a layer 3 Handover for Mobile WiMAX based WMN.

Initiation of layer 2 handover - MS is served while periodically receiving the information about neighbouring BSs from the present serving BS using MOB_NBR-ADV message. The MS always looks for a strengthened receiving signal from the serving BS, only when the current serving BS signal falls below the predefined level. Hence once the MS captures the strengthened serving BS signal, then it's the time to initiate the HO mechanism. The HO mechanism is initiated by sending MOB_MSHO-REG message to the serving BS. Once the HO Request message is initiated, serving BS transmits a collection of list contains the BS's and MAC information of MS to the serving ASN-GW. Once it found from the list that it belongs to the same or other ASN-GW, then further proceedings is carried out. If it belongs to the other ASN-GW, then serving ASN-GW itself go ahead and initiate for the layer 3 HO mechanism.

C. Preparation for fast handover

If the BS's belongs to the new ASN-GW, then the serving ASNGW initiates the buffering that prevents the packet lossage. It also transmits an HO Request and hence obtains a HO Response for the HO Request. A traffic tunnel is accomplished between the serving ASN-GW and the target

ASN-GW with the help of serving BS. Transmission of buffered signal is carried out from the serving ASN-GW to the target ASN-GW. This will takes place only when the tunnel implementation is fulfilled. With the help of MOB_BSHO-RSP message, MS will come to know about the result of the HO Request. The serving BS is taking a major role in the transmission of MOB_BSHO-RSP message to the MS. During this time, to prevent the packet loss, the target ASN-GW initiates its buffering characteristics. Selection of BS, which takes part in the HO, is carried out only when the MS receives the MOB_BSHO-RSP message. After that the MOB_HO-IND message is transmitted, according to the MOB_BSHO-RSP message, from the MS to the serving BS. By the transmission of HO Confirm message from the serving BS to the target BS, gives information about the MS to the target BS. Once the HO Confirm message is reached at the target BS, then an HO Ack message is transmitted to the serving BS.

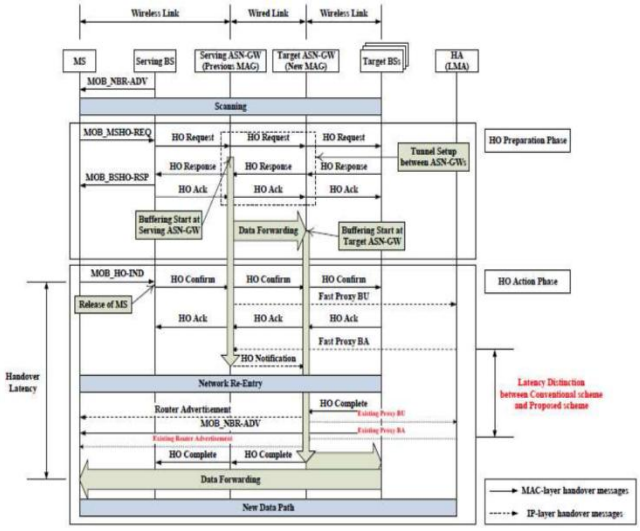

Figure 5. Layer3 handover for mobile WiMAX based WMN [4]

D. Connection with new ASN-GW and receiving packets

A different way of registration of location process to the MS is carried out here. When the HO Confirm message is reached serving ASN-GW, then instead of ASN-GW, FBPU message will carried out with this process. Similarly the HA registration of MS is carried out by serving ASN-GW, rather than with the target ASN-GW. Network re-entry procedure for connecting to target BS is identical to the procedure which was defined in conventional mobile WiMAX [4]. If the connection to target BS is established through the network re-entry procedure, target BS sends HO complete message, which means the completion of layer-2 handover, to target ASN-GW [4]. Since target ASN-GW can send RA message to MS as soon as the layer-2 handover is completed due to the pre-performed layer-3 handover procedure, MS is able to use existing IP address which was used in serving ASN-GW. Lastly, target ASN-GW finishes handover procedure by transmitting the buffered packet [4].

4. CONCLUSION

WiMAX Technology is facing number of barriers in market but it has some great advantages which make it a technology of today. In this paper, we made an overall view about Mobile WiMAX and its applications, and a general out view about Wireless Mesh Network and a layer 3 handover mechanisms in Mobile WiMAX based WMN. Thus in this proposed layer 3 HO mechanism of Mobile WiMAX based WMN, we seen the techniques to reduce the HO latency and their by provides a fast HO scheme without any interruption or lossage of packets.

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