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WiMAX (802.16) - A Study of Mobility and MAC layer

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Abstract :- Future generation networks will be characterized by variable and high data rates, quality of services, seamless mobility both within a network and between networks of different technologies and service providers. An important aspect of components in a global next generation network is standardization to allow vendor independence and interoperability. A technology developed to fulfill these characteristics, standardized by IEEE, is 802.16, also referred to as WiMAX. This architecture aims to apply high data rates, quality of services, long range and low deployment costs to a wireless access technology on a metropolitan scale. The technology and architecture of WiMAX is the focus of this paper, and more specifically its mobility capabilities. The paper investigates the handover and internet-working capabilities of WiMAX and then implements selected MAC-layer functionality in the GloMoSim network simulator. Through simulation attempts are made to identify MAC-parameters affecting performance during handovers. Results indicate that the study needs to be extended to cover upper layer protocols and procedures. At the MAC-layer the most deciding factors are predicted to be procedures executed in preparation for handover, rather than the specific handover process. The original IEEE 802.16 standard (now called "Fixed WiMAX") was published in 2001. WiMAX adopted some of its technology from WiBro, a service marketed in Korea. Security has become a primary concern in order to provide protected communication in Wireless environment. This report is a survey of security vulnerabilities found in WiMAX network. Vulnerabilities and threats associated with both layers in WiMAX (Physical and MAC layers).

Keywords: - Authentication, MAC, Physical Layer, WiMAX, Security Threats Layer, QoS, 3G, BS

I. INTRODUCTION

With the rollout of the third generation cellular networks, 3G, the aim is already set towards the next generation. Future generation networks will be characterized by variable and high data rates, quality of services and seamless mobility both within a network and between networks of different technologies and service providers.

An important aspect of components in a global next generation network is standardization to allow vendor independence and interoperability.

A technology developed to fulfill these characteristics, standardized by IEEE is 802.16. Even though this IEEE standard is limited to the air interface, it is commonly referred to as Worldwide Interoperability for Microwave Access (WiMAX). WiMAX is the end-to-end network architecture built on the IEEE Std. 802.16 and amendments such as the IEEE Std. 802.16e.

This architecture aims to apply high data rates, Quality of Service (QoS), range and low deployment costs to a wireless access technology on a metropolitan scale.

The network architecture is developed by the WiMAX Forum, an interest group backed by technology companies, such as Intel, Fujitsu, Samsung, AT&T and Alvarion. See WiMAX Forum for a complete member roster.

The technology and architecture of WiMAX is the focus of this Paper, and more specifically its mobility capabilities. These capabilities are evaluated in comparison with other technologies and are concluded with a practical study of a Medium Access Control (MAC) layer implementation

I.1 Problem Description

There are many new wireless access technologies and standards under development to-day, looking to extend mobility, data rates and user services and thus filling a position in the future generation networks. The building blocks of these networks are however uncertain due to this technology diversity.

Mobile communications, originating from fixed circuit switched voice traffic in public phone networks, has evolved to support stringent QoS and packet based traffic together with global mobility. The telecom industry expects data rates to reach 100 Mb/s with the new Super 3G networks as a part of 3GPP's 1 Long Term Evolution of 3G networks. Before that Turbo 3G will enable data rates of 14 Mb/s as an extension to deployed 3G networks with High Speed Downlink Packet Access, HSDPA.

The Internet Protocol (IP) technology, with front figures such as IEEE and IETF 2 [29], has gone from indoor, fixed high speed networks with 802.11, to outdoor wireless access with support for mobility with standards such as 802.16 for broadband wireless access, 802.21 for mobility between networks and 802.20, the all-mobility standard.

As both of these paradigms of mobile and computer communications strive to meet the market requirements of both high speed and quality of service, they seemingly also move to meet each other's characteristics.

WiMAX, based on IEEE Std. 802.16 attempts to bring quality of services, high data rates and coverage to wireless computer networks and to work as a "last mile" solution for end user access. Although not designed for mobility from the start, the standard could lend itself for use in mobility scenarios and for this purpose the IEEE Std. 802.16e has been developed with requirements to support vehicular mobility and seamless handover while maintaining differentiated QoS.

This technology shows promise in filling the gap between 3G and Wireless LAN (WLAN). A gap where the superior QoS of cellular networks are combined with the flexibility and scalability of IP technology.

As WiMAX is currently under development with parts of the 802.16 standard being complete, this is an interesting case for an observational and comparative study. Will WiMAX meet the goals of its creators and the market, and what issues can be expected to arise during development and deployment?

This paper serves as an orientation on the subject of mobility in WiMAX and the IEEE Std. 802.16. This orientation is done in comparison with other technologies as a frame of reference.

I.2 Problem Statement

Different degrees of mobility for communication devices is a capability becoming in-creasingly desired by end users together with emerging services for mobile devices such as streaming audio/video through packet data. The methods for supporting various degrees of device mobility, e.g. portability, roaming, full mobility, often vary between technologies and define the mobility characteristics of each.

What are the mobility capabilities of WiMAX and what are the issues when this mobility is set in motion within a WiMAX network and between other types of tech-nologies?

How does WiMAX suggest intra-network mobility and can it be compared to similar contemporary technologies?

These questions hope to highlight the tools available for devices moving both within WiMAX networks or crossing borders between WiMAX and other technologies.

As WiMAX is a fairly new and hyped context in the debate on wireless networks and broadband an interesting study is also the WiMAX MAC-layer, IEEE Std. 802.16.

What tools would be suitable for building and simulating a complete WiMAX net-work? GloMoSim[40] is a library for parallel simulation of wireless networks open for own implementations and familiar to the authors through previous experience. Is Glo-MoSim a suitable platform for a WiMAX simulator? To summarize, this Paper will attempt to answer the following questions:

What are the mobility capabilities of the WiMAX network architecture with re-gards to both heterogeneous and homogeneous networks?
How efficient is this mobility support with regards to handover delays and over-head? Is GloMoSim suitable for developing a WiMAX simulator environment?

II. PURPOSE

As the standard is new and still under development at the writing of this thesis, there is a need to gather and filter information on this technology and to present it in a collected fashion.
This thesis contributes with a theoretical part presents the following

Theoretical background of the subject of WiMAX
Study on heterogeneous and homogeneous mobility
Summary of the 802.16 MAC-layer functionality and its key components.

The practical study presents a suggested framework for implementing the 802.16 MAC-layer and the WiMAX architecture in a simulator environment.

III. SCOPE

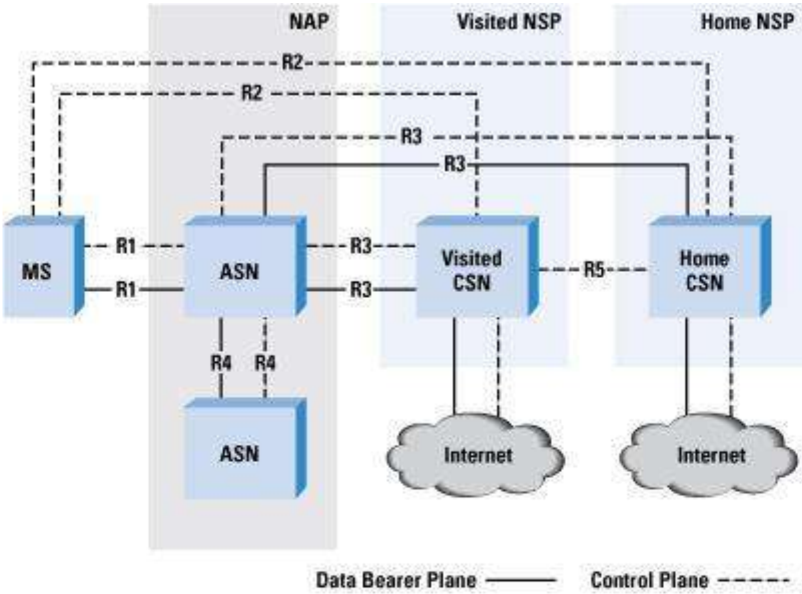
This thesis has limited the scope to mobility and will not focus on the fixed wireless aspects of WiMAX. Since the WiMAX network architecture and parts of the 802.16 standard is still undergoing changes, this paper will not be able to in-depth study certain aspects of WiMAX within the mobility scope, but should rather open up to discussion where applicable.

The thesis reflects the status of WiMAX and its underlying standards during the period of which this study is being performed, and the end results can come to differ with later revisions of the WiMAX architecture.

The implementation is limited to scenarios developed during the analysis and design of the framework. It primarily focuses on movement of subscribers in a WiMAX network, and leaves other fundamentals like scheduling and QoS for future work.

IV. WIMAX FORUM

The WiMAX Forum website provides a list of certified devices. However, this is not a complete list of devices available as certified modules are embedded into laptops, MIDs (Mobile Internet devices), and other private labeled devices.



WiMAX Forum NWG Network Reference Model

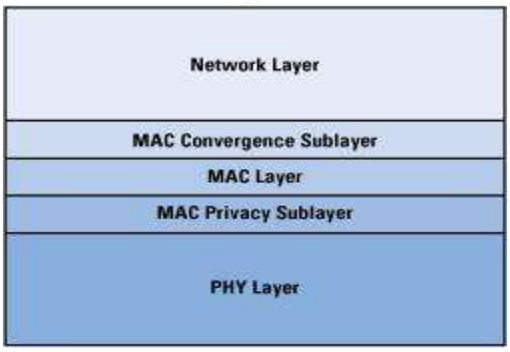


Figure 1: WiMAX Protocol Stack

Similarly with the PHY layer, shown in Figure 3, the MAC layer allows flexible allocation of transmission capacity to different users. Variably sized MPDUs from different flows can be included into one data burst before being handed over to the PHY layer for transmission. Multiple small MSDUs can be aggregated into one MPDU and, conversely, one big MSDU can be fragmented into multiple small ones in order to further enhance system performance. For example, by bundling up several MPDUs or MSDUs, the PHY and MAC layer header overheads, respectively, can be reduced.

4.1. IP-BASED WIMAX NETWORK ARCHITECTURE

The network reference model developed by the WiMAX Forum NWG defines a number of functional entities and interfaces between those entities. Fig below shows some of the more important functional entities.

Base station (BS): The BS is responsible for providing the air interface to the MS. Additional functions that may be part of the BS are micro mobility management functions, such as handoff triggering and tunnel establishment, radio resource management, QoS policy enforcement, traffic classification, DHCP (Dynamic Host Control Protocol) proxy, key management, session management, and multicast group management.

Access service network gateway (ASN-GW): The ASN gateway typically acts as a layer 2 traffic aggregation point within an ASN. Additional functions that may be part of the ASN gateway include intra-ASN location management and paging, radio resource management, and admission control, caching of subscriber profiles, and encryption keys, AAA client functionality, establishment, and management of mobility tunnel with base stations, QoS and policy enforcement, foreign agent functionality for mobile IP, and routing to the selected CSN.

Connectivity service network (CSN): The CSN provides connectivity to the Internet, ASP, other public networks, and corporate networks. The CSN is owned by the NSP and includes AAA servers that support authentication for the devices, users, and specific services. The CSN also provides per user policy management of QoS and security. The CSN is also responsible for IP address management, support for roaming between different NSPs, location management between ASNs, and mobility and roaming between ASNs.

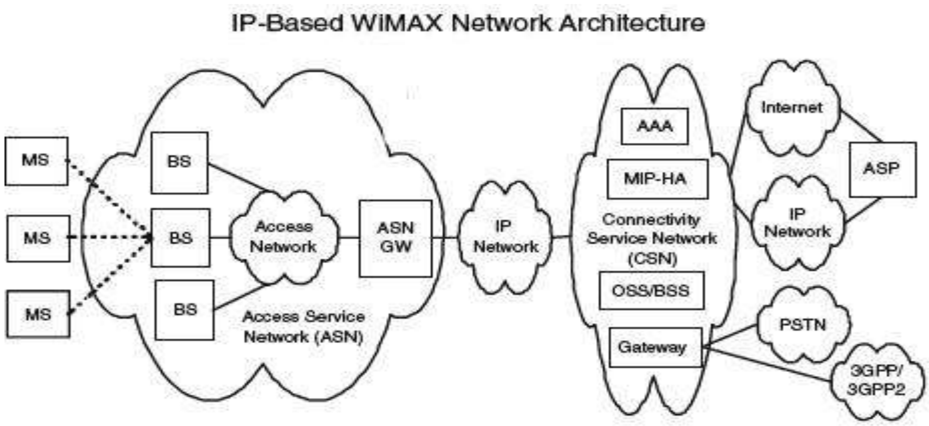


Fig-2.Wimax Network Architecture

V. IEEE 802.16 SCHEDULING ARCHITECTURE

The basic IEEE 802.16 architecture (Jain and Verma, 2008) includes Base station and multiple Subscriber Stations (SS). Both base station and subscriber station are immobile when client wants to connect SS to a mobile station. Base station acts as a central entity which transfers all the data from the subscriber stations in point-to-multi point architecture. Two or more subscribers are not allowed to communicate directly. The BS and SS architecture are connected through wireless links. Communication occurs in two directions: From BS to SS is called downlink and from SS to BS is called uplink. During downlink, BS broadcasts data to all subscribers and subscriber selects packets destined for it. Uplink channel is shared between all multiple SSs while downlink channel is used only by BS. In order to ensure slotted channel sharing and the slots are allocated by BS to various SS in one uplink frame, Time Division multiplexing (TDD) or Frequency Division multiplexing (FDD) is used. This slot allocation information is broadcast by BS through the uplink map message (UL-MAP) at the beginning of each frame. ULMAP contains information element which includes the transmission opportunities and the time slots in which the
SS can transmit during the uplink sub frame.

5.1. Scheduling Algorithms

IEEE 802.16 MAC layer adopts a connection oriented architecture in which a connection must be established before data communications. Each connection is assigned a unique identifier (connection IDI) and it is associated with a service flow which defines the desired QoS level of the connection. In a standard scheduling framework, data packets arriving at the BS are classified into connections which are then classified into service flows. Packets of same service flow are placed in a queue and then further classified based on their service priorities of the connection. For packets in multiple queues with different service requirements, a packet scheduler is employed to decide the service order of the packets from the queues. If properly designed a scheduling algorithm may provide the desired service guarantees.

The scheduler should consider the following important parameters:

- The traffic service type
- The set of QoS requirements of the connections
- The capacity of bandwidth for data transmission
- The bandwidth requirements from the connections
- Waiting time of bandwidth request in the system

The ideal scheduler should be able to make optimum use of the available bandwidth to reduce traffic delays and satisfy the QoS requirements to the best extent so as to reduce packets drop rate and sustain the QoS support. Imax schedulers can be classified into two main categories, channel unaware schedulers where the channels are assumed to be error free and channel aware schedulers where channel state information is taken into consideration while scheduling the packet. Channel unaware schedulers are further classified into homogeneous and hybrid schedulers. Hybrid schedulers combine more than one scheduler to satisfy the QoS requirements of the multiple service class traffic in Wimax networks.

VI. IMPLEMENTATION

The original plan was to take parts of the already available 802.11 protocol for GloMoSim and customize it to suit 802.16e. However few pieces of the 802.11 protocol proved useful for code reuse, but it was very useful for studying use of internal GloMoSim methods and data structures. As the available documentation of source code and design was limited, trial and error formed the corner stone for actual implementation. In the work of prototyping a complex technical standard, the challenge has been to identify both crucial functionality and scenarios interesting to perform measurements on.

VII. FUTURE RESEARCH

The section on future work covers much of the limitations of the current implementation. This implementation only covers specific parts of the 802.16e standard and much remains to be designed and built. Besides the MAC-layer, ASN Gateways and other core network components also needs to be defined for a complete WiMAX architecture, probably spanning many different layers of the protocol stack. The IEEE 802.16 standard comes with many optional PHY layer features, which can be implemented to further improve the performance. The optional Block Turbo Coding (BTC) can be implemented to enhance the performance of FEC. Space Time Block Code (STBC) can be employed in DL to provide transmit diversity. In this paper we have described many security issues and solution till our researchers was given but the area of security in WiMAX has many issues which need to be resolved in the future. As our WiMAX network will reach all over world by 2012 than in that case our responsibility also increase how we can provide maximum data rate with maximum security. In this report, we have focused on the security issues related to Physical Layer, Mac Layer and lastly on-going project on Tower stream's RF Security. In my view in this area all security issues in Initial condition a lot of work we can do in the future. We are thinking research in following security issues with respect to above research. An analysis of the threats to the security of WiMAX/802.16 broadband wireless access networks was conducted. Critical threats consist of eavesdropping of management messages and BS masquerading. Major threats include jamming, MS masquerading, management message and data traffic modification, and DoS attacks. Countermeasures need to be devised for networks using the security options with critical or major risks.

An intrusion detection system approach can be eve loped to address some of the threats, but more research is needed in this direction.

VIII. CONCLUSION

In paper report, security solution, various vulnerabilities and possible attacks to WiMAX network have been discussed and illustrated. The threats apply to both layers of WiMAX. At PHY layers, jamming can be considered a major threat. At MAC layer, critical threats include eavesdropping of management messages, masquerading, management message modification or DoS attacks. Some of these issues have been fixed with the adoption of recent amendments and security solutions in IEEE 802.16 but some still exist and need to be considered carefully. However, through this review, we can see that WiMAX does offer much more strong security solutions in comparison with other wireless technologies such as Bluetooth or Wireless Fidelity (WiFi). WiMAX is still under development and need more research on its securities vulnerabilities. In the near future, when WiMAX achieves a maturity level, it would have a great opportunity to be a successful wireless communication technology.

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