Analysis of WiMAX

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Abstract- When a WiMAX network has no downlink or uplink data, it will enter either Sleep Mode or Idle Mode, both of which aim to trim down the power utilization of the mobile station. Upon the availability of data, the serving base station will awaken the mobile station. The mobile station then establishes a connection with the base station via initial ranging. Ranging parameters are then adjusted for the connection. Finally, the service flow is reactivated for data transfer, and the mobile station returns to the normal operation stage. Depending on whether the serving base station has the necessary information, the mobile station may need to carry out more signaling operations, such as basic capability negotiation, authentication and key management, re-registration, as well as IP connectivity reestablishment. Given the above signaling procedures, attackers may also launch similar signaling attacks to WiMAX base station by triggering unnecessary state transitions that overload the base station with signal processing that leads to Denial of Service (DoS) attack.[1]

Index Terms— Access Service Network (ASN), Base Station, CSN (Connectivity Service Network), Interoperability, Microwave Access, Mobile Station, OFDM, Spectrum.

1. INTRODUCTION

WiMAX (Worldwide Interoperability for Microwave Access) is a telecommunications protocol that provides fixed and mobile Internet access. WiMAX is the next-generation of wireless technology designed to enable pervasive, high-speed mobile Internet access to the widest array of devices including notebook PCs, handsets, smart phones, and consumer electronics such as gaming devices, cameras, camcorders, music players, and more. As the fourth generation (4G) of wireless technology, WiMAX delivers low-cost, open networks and is the first of all IP mobile Internet solution enabling efficient and scalable networks for data, video, and voice. As a major driver in the support and development of WiMAX, Intel has designed embedded WiMAX solutions for a variety of mobile devices supporting the future of high-speed broadband on-the-go.

2. ARCHITECTURE

The architecture framework is defined such that the multiple players can be part of the WiMAX service value chain. More specifically, the architecture allows for three separate business entities:

[1] N/W Architecture
[2] Principles of architectures
[4] Two forms of wireless service

A. N/W Architecture
- Network access provider (NAP), which owns and operates the ASN.
- Network services provider (NSP), which provides IP connectivity and WiMAX services to subscribers using the ASN infrastructure provided by one or more NAPs.
- Application service provider (ASP), which can provide value-added services such as multimedia applications using IMS (IP multimedia subsystem) and corporate VPN (virtual private networks) that run on top of IP.

This separation between NAP, NSP, and ASP is designed to enable a richer ecosystem for WiMAX service business, leading to more competition and hence better services. The network reference model developed by the WiMAX Forum NWG defines a number of functional entities and interfaces between those entities. (The interfaces are referred to as reference points.)

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 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

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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, and 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. Further, CSN can also provide gateways and interworking with other networks, such as PSTN (public switched telephone network), 3GPP, and 3GPP2. The WiMAX architecture framework allows for the flexible decomposition and/or combination of functional entities when building the physical entities. For example, the ASN may be decomposed into base station transceivers (BST), base station controllers (BSC), and an ASNGW analogous to the GSM model of BTS, BSC, and Serving GPRS Support Node (SGSN). It is also possible to collapse the BS and ASN-GW into a single unit, which could be thought of as a WiMAX router. Such a design is often referred to as a distributed, or flat, architecture. By not mandating a single physical ASN or CSN topology, the reference architecture allows for vendor/operator differentiation [8].

B. General Design Principles of Architecture

Development of the WiMAX architecture followed several design tenets, most of which are all into the general design principles of IP networks. The NWG was looking for greater architectural alignment with the wire line broadband access networks, such as DSL and cable, while at the same time supporting high-speed mobility. Some of the important design principles that guided the development of the WiMAX network systems architecture include the following:

1. Functional decomposition

The architecture shall be based on functional decomposition principles, where required features are decomposed into functional entities without specific implementation assumptions about physical network entities. The architecture shall specify open and well-defined reference points between various groups of network functional entities to ensure multivendor interoperability.

2. Deployment modularity and flexibility

The network architecture shall be modular and flexible enough not to preclude a broad range of implementation and deployment options.

3. Support for variety of usage models

The architecture shall support the coexistence of fixed, nomadic, portable, and mobile usage models.

4. Decoupling of access and connectivity services

The architecture shall allow the decoupling of the access network and supported technologies from the IP connectivity network and services.

5. Support for a variety of business models

The network architecture shall support network sharing and a variety of business models. The architecture shall allow for a logical separation between (1) the network access provider (NAP)—the entity that owns and/or operates the access network, (2) the network service provider (NSP)—the entity that owns the subscriber and provides the broadband access service, and (3) the application service providers (ASP).

6. Extensive use of IETF protocols

The network-layer procedures and protocols used across the reference points shall be based on appropriate IETF RFCs. End-to-end security, QoS, mobility, management, provisioning, and other functions shall rely as much as possible on existing IETF protocols. Extensions may be made to existing RFCs, if necessary.

7. Support for access to incumbent operator services

The architecture should provide access to incumbent operator services through interworking functions as needed. It shall support loosely coupled interworking with all existing wireless networks (3GPP, 3GPP2) or wire line networks, using IETF protocols [8].

C. Protocol Layering Across a WiMAX Network

It is instructive to view the end-to-end WiMAX architecture using the logical representation shown in Figure 5. The architecture is quite similar to most...
other wide area IP access networks, where a link-layer infrastructure is used for concentrating traffic of individual users, with a separate entity providing an IP address to the end-user device for access to IP-based applications and services. Here, ASN is the link-layer infrastructure providing link concentration, and CSN is the infrastructure providing IP address and access to IP applications. The concentrated links are forwarded from the ASN-GW to the CSN via a managed IP network.

Figure 2: Logical representation of the end-to-end WiMAX architecture

D. **Two forms of wireless service**

1. **Non-line-of-sight**
   - A small antenna on your computer connects to the tower
   - 2 GHz to 11 GHz frequency range
   - Limited to a 4-to-6 mile radius

2. **Line-of-sight service**
   - A fixed dish antenna points straight at the WiMAX tower from a rooftop or pole.
   - 66 GHz frequency range
   - Higher frequencies, there is less interference and lots more bandwidth
   - 30-mile radius

3. **Specifications**
   - Range: 30-mile radius from base station
   - Speed: 70 megabits per second
   - Line-of-sight not needed between user and base station

“In practical terms, WiMAX would operate similar to Wi-Fi but at higher speeds, over greater distances and for a greater number of users.”

3. **PROTOCOL ARCHITECTURE**

An 802.16 wireless service provides a communications path between a subscriber site and a core network such as the public telephone network and the Internet. The Wireless MAN technology is also branded as WiMAX. We can see different parameters for technologies such as WiMAX, WLAN, and Bluetooth.

A. **Physical layer functions**
   - Encoding/decoding of signals
   - Preamble generation/removal
   - Bit transmission/reception

B. **Medium access control layer functions**
   - On transmission, assemble data into a frame with address and error detection fields
   - On reception, disassemble frame, and perform address recognition and error detection
   - Govern access to the wireless transmission medium

C. **Convergence layer functions**
   - Encapsulate PDU framing of upper layers into native 802.16 MAC/PHY frames
   - Map upper layer’s addresses into 802.16 addresses
   - Translate upper layer QoS parameters into native 802.16 MAC format
   - Adapt time dependencies of upper layer traffic into equivalent MAC service

4. **WORKING OF WiMAX**

The main problems with broadband access are that it is pretty expensive and it doesn't reach all areas. The main problem with Wi-Fi access is that hotspots are very small, so coverage is sparse. What if there were a new technology that solved all of these problems?

This new technology would provide:

- The high speed of broadband service
- Wireless rather than wired access, so it would be a lot less expensive than cable or DSL and much easier to extend to suburban and rural areas.
- Broad coverage like the cell phone network instead of small Wi-Fi hotspots.
- This system is actually coming into being right now, and it is called WiMAX. WiMAX is short for Worldwide Interoperability for Microwave Access, and it also goes by the IEEE name 802.16.
WiMAX has the potential to do to broadband Internet access what cell phones have done to phone access. In the same way that many people have given up their "land lines" in favor of cell phones, WiMAX could replace cable and DSL services, providing universal Internet access just about anywhere you go.

5. FEATURES

WiMAX technology based on IEEE 802.16 standard and it is a telecommunication protocol offering full access to mobile internet across cities and countries with a wide range of devices. WiMAX technology has salient features as described below:

A. WiMAX support multipath
WiMAX technology is offering OFDM - based physical layer which is based on orthogonal frequency distribution. The WiMAX technology is providing confrontation to multipath. Due to its good architecture it allows the user to operate in NLOS condition. Now WiMAX is familiar as a technique of multi path for wireless network.

B. WiMAX broadband access
WiMAX technology is offering very high speed broadband access to mobile internet. When you are using 20MHz the data rate can be high up to 74Mbps. Generally 10MHz with the TDD scheme provides 3:1 up and down link ratio.

C. WiMAX offer high speed data rate
Another feature of WiMAX Technology is high speed data rate. The scalable architecture of physical layer is offering high speed data rate. WiMAX technology is providing easily scaling of data with possible bandwidth of channel. If the bandwidth of channels may from 1.25MHz to 10MHz then a system can use 128, 512, 048 bit FFTs which provide dynamically roaming across numerous network having dissimilar bandwidth.

D. WiMAX offer modulation and error correction
The use WiMAX technology is increasing rapidly because it supports lots of modulation and error correction facility to user. It also allowing a user that they could change the scheme according to channel condition. (AMC) Adaptive Modulation and Coding is a valuable method to exploit throughput in a varying channel.

E. WiMAX support reliability of data
Automatic retransmission of data supported by WiMAX at data link layer for link is a great feature. It is not only improving reliability but also enabled ARQ which necessitate each broadcast packet to be recognized by the receiver, and if any unacknowledged data packets are unspecified to be misplaced and are retransmitted.

F. WiMAX support TDD and FDD
Another significant feature of WiMAX technology is that it supports Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD). They both are offering low cost system accomplishment.

G. WiMAX TDM scheme
The WiMAX technology holds all system therefore any data may be in form of uplink or downlink checked by scheduler from the base station. The total capacity shared between several users according to their demand. And it is done by WiMAX TDM (Time Division Multiplexing) scheme.

H. WiMAX MAC layer
The architecture of WiMAX technology based on MAC layer which is a connection oriented layer. Through MAC layer a use can perform a variety of functions such as various type of application including multimedia and voice can be used. It also supports best efforts for data traffic as bit, real time, traffic flaws etc. The aim to design WiMAX technology is to facilitate large number of user with a variety of connection per terminal.

I. WiMAX strong encryption
WiMAX technology also facilitates the user with strong encryption. By using AES (Advanced Encryption standard) a user can get strong privacy and administration. The EAP protocol offer flexible substantiation architecture which make enable a user to get access to username, password, certificates, and smart card.

J. WiMAX mobility
The basic and most important feature of WiMAX technology is to support mobility applications as VoIP. The power saving mechanism of WiMAX technology is used to extend the battery life of handheld devices. To get access to wide range of connectivity of WiMAX, it provides access to base...
station from home. Installation of hardware is also very easy with WiMAX technology. With the growth of WiMAX technology its more feature may also come up [9].

6. COMPARISON

The drawback of Wi-Fi is that it has less strength with limited area access. This requirement is fulfilled by WiMAX with the following features:

1. WiMAX handles up to 70Mbps
2. WiMAX range is about 30 miles (50 km) with wireless access
3. WiMAX (10-66 GHz frequency)

A. WiMAX is not Wi-Fi

There are many initiatives to bring Wi-Fi to communities across America. As the figure below illustrates, Wi-Fi is inferior to WiMAX in terms of range and throughput (speed) as well as quality of service (QoS) and security.

B. WiMAX vs. Wi-Fi

Comparisons and confusion between WiMAX and Wi-Fi are frequent because both are related to wireless connectivity and Internet access.

- WiMAX is a long range system, covering many kilometers that uses licensed or unlicensed spectrum to deliver connection to a network, in most cases the Internet.
- Wi-Fi uses unlicensed spectrum to provide access to a local network.
- Wi-Fi is more popular in end user devices.
- Wi-Fi runs on the Media Access Control’s (MAC) CSMA/CA protocol, which is connectionless and contention based, whereas WiMAX runs a connection-oriented MAC.
- WiMAX and Wi-Fi have quite different quality of service (QoS) mechanisms.
- WiMAX uses a QoS mechanism based on connections between the base station and the user device. Each connection is based on specific scheduling algorithms.

- Wi-Fi uses contention access - all subscriber stations that wish to pass data through a wireless access point (AP) are competing for the AP’s attention on a random interrupt basis. This can cause subscriber stations distant from the AP to be repeatedly interrupted by closer stations, greatly reducing their throughput.

- Both 802.11 (which includes Wi-Fi) and 802.16 (which includes WiMAX) define Peer-to-Peer (P2P) and ad hoc networks, where an end user communicates to users or servers on another Local Area Network (LAN) using its access point or base station. However, 802.11 supports also direct ad hoc or peer to peer networking between end user devices without an access point while 802.16 end user devices must be in range of the base station [10].

C. Comparisons with Broadband Wireless Technologies

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fixed WiMAX</th>
<th>Mobile WiMAX</th>
<th>HSPA</th>
<th>TD-EDVDO Rev A</th>
<th>Wi-Fi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standards</td>
<td>IEEE 802.14-2004</td>
<td>IEEE 802.16-2005</td>
<td>3GPP Release 6</td>
<td>3GPP2</td>
<td>IEEE 802.11a</td>
</tr>
<tr>
<td>Peak downlink data rate</td>
<td>11 Mbps / 5.5 Mbps</td>
<td>11 Mbps / 5.5 Mbps</td>
<td>14 Mbps using 802.11a</td>
<td>2.5 Mbps</td>
<td>54 Mbps shared using 802.11g</td>
</tr>
<tr>
<td>Peak uplink data rate</td>
<td>11 Mbps using 802.11a</td>
<td>10 Mbps using 802.11a</td>
<td>14 Mbps using 802.11a</td>
<td>2.5 Mbps</td>
<td>54 Mbps shared using 802.11g</td>
</tr>
<tr>
<td>Modulation</td>
<td>OFDM, 16-QAM, 64-QAM</td>
<td>OFDM, 16-QAM, 64-QAM</td>
<td>OFDM, 16-QAM</td>
<td>OFDM, 16-QAM</td>
<td>OFDM, 16-QAM</td>
</tr>
<tr>
<td>Duplexing</td>
<td>TDD, FDD</td>
<td>TDD, FDD</td>
<td>TDD, FDD</td>
<td>FDD</td>
<td>TDD</td>
</tr>
<tr>
<td>Frequency</td>
<td>2.5 GHz and 5 GHz initially</td>
<td>2.5 GHz and 5 GHz initially</td>
<td>800 MHz 800 MHz</td>
<td>800 MHz 800 MHz</td>
<td>2.5 GHz and 5 GHz initially</td>
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</tbody>
</table>

Table 1: Comparison WiMAX with Other Broadband Wireless Technologies

7. ADVANTAGES AND DISADVANTAGES
WiMAX carries wireless network which gives long range of access to the user with many merits and demerits such as follows:

A. **Advantages**
- Full support for WMAN service
- Improved user connectivity
- Longer Ranges
- High Throughput
- Higher Quality of Service (QoS)
- Ensures Interoperability
- Line of sight not required
- 802.16e version allows for Mobility
- Easy Installation
- lower cost CPE

B. **Disadvantages**
- Line-of-sight (LOS) is required for long distance (5-30mile) connections.
- Certain conditions—terrain, weather and large buildings—can act to reduce the maximum range
- Other wireless electronics can interfere with the WiMAX connection & cause a reduction in data throughput.
- Licensed airwave frequencies are limited availability.
- Unlicensed airwaves are free but all can use them difficult to control service quality as other users of the same band could cause interference.

8. **APPLICATIONS**

A. Connectivity for SMBs
B. WiMAX Backhaul
C. Nomadic Broadband
D. Broadband for Developing Countries
E. Private Networks
F. Technology to the Kid

9. **CONCLUSION**

802.16e offers cost reductions to mobile operators who wish to offer broadband IP services in addition to 2G or 3G voice service, and allows operators to enter new markets with competitive services, despite owning disadvantaged spectrum.

When WiMAX chipsets are integrated into laptops and other portable devices, it will provide high-speed data services on the move, extending today’s limited coverage of public WLAN to metropolitan areas. Integrated into new generation networks with seamless roaming between various accesses. The combination of these capabilities makes WiMAX attractive for a wide diversity of people: fixed operators, mobile operators and wireless ISPs (Internet Service Provider), but also for many vertical markets and local authorities.

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