

## WIMAX ARCHITECTURE FOR IRAQ ENVIRONMENT: MOSUL CASE STUDY

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**Abstract:** WiMAX is a broadband technology that provides an access to the internet using a wireless microwave approach which known also as Worldwide Interoperability for Microwave Access. WiMAX is a trade name that represents IEEE 802.16 standard technology which is implemented in the metropolitan area networks (MAN) level. This paper is conducted because no WiMAX architecture technology has been implemented in Iraq. In this case, we need to propose a suitable WiMAX architecture that provides the most benefit out from this technology to be suitable by determining the best approach solution that will be the best choice from the all kinds that are related to this particular topic to be used in Iraq. Our methodology classified into four phases, the Investigation phase, collecting data and analysis phase, proposing phase, evaluations and discussion phase. The Investigation phase will investigate current research in the WIMAX. Background study, problems, importance, issues in the current research in order to address gaps in WIMAX domain. In collecting data and analysis phase, we are permitted to collect and analyze the data from different sources for the sake of getting better and efficient results in our paper. In proposing phase a suitable WiMAX architecture will be proposed. In order to finalize our work, the evaluations and discussion phase will take place.

**Keywords:** WiMAX: Worldwide Interoperability for Microwave Access, Wi-Fi: Wireless Fidelity, WLAN: Wireless Local Area Network, ISP: Internet service provider.

### 1. Introduction

The need for more bandwidth and speed (Data rate) is desirable nowadays which it creates the need for newer technologies to be implemented and used in real life. The need for high rate of data comes from the use of high bit rate applications, video streaming, TV broadcasting, and so on [5].

WiMAX is a broadband technology that provides an access to the internet using a wireless microwave approach which known also as Worldwide Interoperability for Microwave Access [18]. WiMAX is a trade name that

represents IEEE 802.16 standard technology which is implemented in the metropolitan area networks (MAN) level. It can provide different kinds of access method such as internet access points and point-to-point access. The difference between Wi-Fi technologies that represent IEEE 802.11 and WiMAX is that WiMAX can support up to 75Mbps transmission speed and a wider distance wirelessly up to 50Km unlike Wi-Fi that designed for indoor and support up to 100m which is not enough for a wide distance according to [4,11]. IEEE 802.16 is designed for outdoor wireless as a standard for the Data link

layer 2 and Physical layer 1 of the OSI reference model according to [16].

WiMAX has been used in many countries [6]. However, WiMAX technology has not been implemented or used in Iraq, because Iraq country influenced to three wars in a row, the first was started at 1980 and least to 1988. The second started by the imposition of economic sanctions on the country by America from 1991 until 2003 when their soldiers occupy the country and the last one is just starting now (2014). In addition, there is no any infrastructure that will help this country grow up as the developed countries. So that is the reason why I propose WiMAX to be implemented in this country.

Although WiMAX is a technology that widely used by Europe, Latin America, Africa, and so on, but the deployment or implementation of this technology in the Middle East is less than %5 which is very low [6]. Unfortunately this technology (WiMAX) is not yet been explored and used in Iraq environment.

### **Research Problem**

This paper is conducted because no WiMAX architecture technology has been implemented in Iraq. In this case, we need to propose a suitable WiMAX architecture that provides the most benefit out from this technology so it can suit to Iraq geographical and environmental area. In order to deploy and implement WiMAX technology, we need to determine the recent trend that influenced by this standard to gain the ability to conduct this study in a better way. In addition, deploying this standard in the Iraqi cities will need to investigate the aspects of challenges that could be faced in that particular environment. By surveying the requirements of implementing this technology will provide all the information that is required for the study to be done. We also need to determine the best approach solution that

will be the best choice from the all kinds that are related to this particular topic to be used in Iraq.

### **Research Questions**

This research has a number of questions that needed to be answered both while doing the study and that can be provided at the end of it. The research questions list is stated as in the following:

- i. What are the current WiMAX technologies and the factors that depend on?
- ii. Which factors majority effecting the implementation in Iraq?
- iii. Which architectures can be used and applied in Iraq environment and geographical characteristics based on the findings?

### **Objectives**

We trying to do and achieve these objectives as in the following:

- i. To investigate and study current WiMAX technologies suit with Iraq environment.
- ii. Determine key factors for successfully implementing WiMAX technology in Iraq.
- iii. Propose a WiMAX architecture to be implemented based on the key factors.

## **2. Related study**

### **Wireless Broadband Networks**

Broadband word has become commonly been used as a marketing term that called when talking about reliability and high-speed accessing to internet networks provided by large bandwidth capacity, but in fact Broadband is a technical term. We also can define Broadband networks as a name referring to a number of different technologies that have been used and implemented by the Internet Service Provider (ISP) which provides high speed data transmission with more than 150 Mbps. Additionally, there are two main technologies demand that characterize broadband networks,

Fiber optical technologies, and wireless technologies [17]. In the next few sub paragraphs we will discuss only the wireless broadband technologies.

### WiMAX network

WiMAX works similarly as Wi-Fi work which is based on wireless radio microwaves that carry and transmit data using this form to a receiver which can be a laptop, mobile device, another WiMAX access point, or any device has the ability to receive data using wireless communications [12]. Usually the microwaves are encrypted via username and password to prevent any security threat to the privacy of the transmitted user data. Figure 1 shows how WiMAX works and distributes the service across a network.

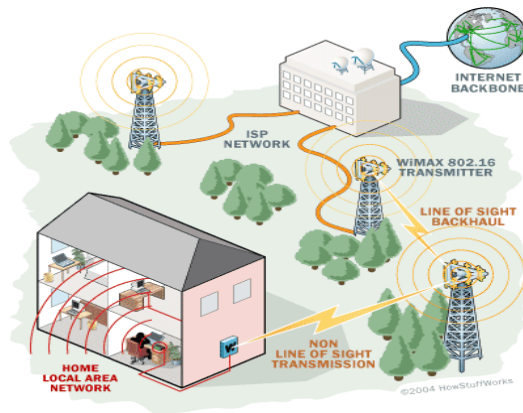


Figure 1: How WiMAX works in a network environment [12].

### 3. Comparison of Wireless Broadband Networks

#### WiMAX and 3G

As [10] study shows that 3G is developed and being used for providing Integrated Services Digital Network (ISDN) for mobile devices, including voice and internet access services. The difference between WiMAX and 3G in terms of the coverage area of the base station; where 3G tower covers a lower distance than WiMAX base stations. There is another difference, which is the speed of data communication that considerably in WiMAX is 30 times faster than 3G.

#### WiMAX and 4G (LTE)

According to [17], a comparison between WiMAX and 4G was made significantly. As we mentioned earlier the two technologies adapt advanced schemes such as MIMO and OFDMA, also they operate and provide high speed data rate with IP-based functionality. Both of them support video streaming and fast internet access. When making a comparison between them, we can realize that every one of them has a different development history background which created differences in some aspects and characteristics.

#### WiMAX and Wi-Fi

Even though WiMAX and Wi-Fi was proposed and developed by the same organization (IEEE), but each one of them has its own characteristics and belong to a different category. As mentioned earlier, WiMAX has a different standard where Wi-Fi is 802.11x and WiMAX 802.16x and each type has its own purpose. In this case, WiMAX was developed for MAN network level purpose because it has the ability to cover large areas. And Wi-Fi was developed to provide the connectivity within LAN network level purpose, according to [10] Also the range of WiMAX around 84.3 Kilometers while Wi-Fi 91.4 Meters; and the coverage Wi-Fi optimized for indoor; while WiMAX Outdoor Non-Line of Sight NLOS and so on.

#### WiMAX background and history

WiMAX is a technology that provides the user the ability of connecting any computer or mobile device that has a wireless capability to the internet without the physical cables constraints. The wireless capability technology for networking has been enhanced precipitately since the last 20 years. Worldwide subscribers for the services for mobile devices have been increased from eleven million in 1990 to approximately two billion in 2005 [14]. In addition the users for the internet services have been increased also in the same mentioned period. In this case, it was leading to highly need for a reliable high-speed internet which resulting

in a broadband development and then increase the subscribers to more than 200 million users [2].

The major implementation of WiMAX technology is the fourth generation (4G) of mobile networks. The 4G is one of many WiMAX applications which have the following advantages [5]:

- i. Comparing with the previous generations, 4G is the best by having better Quality of service (QoS), enhanced security and performance.
- ii. Providing a high-speed network accessing to mobile devices with high-speed transmission of data.
- iii. It's providing multimedia (Voice, video stream, and data) to be available to the user anywhere and anytime with a high rate of data by providing IP address for each user.

#### **WiMAX Network Reference Model**

The logical design of architecture is known as a Network Reference Model (NRM) which illustrates a structure of the standard. WiMAX architecture is limited to only physical (PHY) and MAC (Media Access Control) layers in which they will be explained in further sections in this chapter. The NRM specifies the provided support of connecting end-to-end network, also it has several aspects to declare such the supported protocols and the used procedures in order to provide services to the end-users in which ensures the security and authentications as well as the mobility [6].

#### **The components of WiMAX**

##### **Base station**

Mostly, the base station (BS) is a tower that has an electrical device or multiple devices (antennas) at the top, which is able to provide the connection wirelessly (Joseph et al. 2008). In addition, each base station provides a coverage area with maximum 50 km and each tower in this case called a cell [13]. Usually, the installation and deployment of base stations are made from 5 to 10 km to make sure the

connection signal is high and to distribute the users with a way to prevent the load on a single base station.

##### **Receiver**

It is the equipment that placed or deployed on the user side to provide the ability to connect and access the internet through the base station wirelessly [13]. These devices vary, some of them are dependent with antennas and some are USB devices that need to be attached to the computer to operate. The connection is similar to the Wi-Fi connection, but the key difference is the large coverage area provided by WiMAX base stations.

##### **Backhaul**

Backhauled are referred when one of two connection types happened, one is the connection from the base station back to the service provider and the other is the connection from the service provider side to the world wide core network. In addition, backhaul is referred to provide the communication between two or more base stations that is deployed within the coverage range [1, 13].

##### **WiMAX categories**

There are two main categories of WiMAX, which is based on the way of the user connection to the base station, Mobile connection that established directly between the user and the base station, or Fixed connection using an equipment to connect known as Customer Premises Equipment (CPE). We can determine that Fixed and Mobile WiMAX are independent subsets within the WiMAX technology.

##### **Mobile WiMAX**

Known as IEEE 802.16e-2005 [15], it is a standard that can provide the ability to connect mobile devices and fixed devices to the broadband which is provide up to 15 Mbps data rate and has the ability to cover an area with up to 3 miles.

##### **Fixed connection using CPE**

Usually, this type of connection is fixed at a certain location and it is also known as IEEE

802.16d-2004. The CPE is installed at a certain place in a home or a building that can communicate with the base station and it need to be within its coverage area. In addition, the user connects to this equipment (CPE) using Ethernet in order to reach the network services [8].

#### 4. Methodology of the research

In order to do this paper in a consistent way we need to address and classify the research methodology into a number of phases to make it very clear of what we will involve in the next sections. We separate our methodology into four phases, they are the investigation phase, implementation phase, proposing phase, and discussion phase respectively. Each one of them involves separate processes, but each further phase depends on the previous phase output. Meaning that, the next phase will take its input from the previous phase output in order to do its task completely. The four mentioned phases. As we mentioned, the second phase (implementation phase) takes its input from the investigation phase output and the proposing phase take its input from the implementation phase output, and so on. See figure 2 that illustrates the methodology four phases in a flow chart figure type.



#### Figure 2: Research methodology four phases. ANALYSIS AND PROPOSING WIMAX ARCHITECTURE

##### 5. Analysis summary

In conclusion, we are now clear about what we need to offer, what we need to consider, and lastly what we need to avoid. Collecting data and then making analysis on it; help us much more to determine all the facts and requirements to provide in our new proposed network. Also, it helps us to determine the issue reason of the current internet service, which is considered to avoid in the WiMAX technology. Furthermore, a lot of additional information was offered and gained, which may benefit from in the future work of the project. We can list the factors that we need to consider in the following points:

1. We are required to reduce the fees for the service and make it acceptable by the user.
2. We are required to provide high speed access, which is up to 4Mbps.
3. We are required to provide a number of subscription packages after deploying WiMAX to help the user to choose the best service for his need.
4. We are required to ensure the scalability of the network for the future growth.
5. We are required to provide both connection wire and wireless to the end-user, which can be achieved by include an equipment at the high end to ensure that.
6. We need initially to start on the left side of Mosul to be successfully deployed.

##### 6. Proposing WiMAX architecture

By determining all the factors that we have now from the survey analyzing process, we are now able to propose the WiMAX architecture. Our knowledge now telling us that WiMAX is suitable for Mosul city environment to be deployed successfully; because it is cost effective. While talking about cost WiMAX has no wiring installation, because it relies on



Wireless infrastructure, unlike other architectures that relies on wired infrastructure. As we found in our results, the deployment starting point should be on the left side of Mosul city. And we need to provide both connections, because the users have different kinds of devices to connect to the internet. In this case, a router device at the user resident is required to have wired and wireless connection, also there should be another device to receive the WiMAX signal from the WiMAX tower in order to have communication between each other. This device can be mounted on the roof of the user's house (Outdoor) in order to receive the strongest possible signal.

However, in terms of cost saving we will choose IEEE 802.16e WiMAX standard, which is the recent standard. The reason why this standard is cost saving because each WiMAX tower can cover up to 16 square kilometers. The deployment of the architecture will be in part A of Mosul city as shown in figure 3 below.



Figure 3: Separating Mosul into two parts. We can see our architecture in figure 4 below.

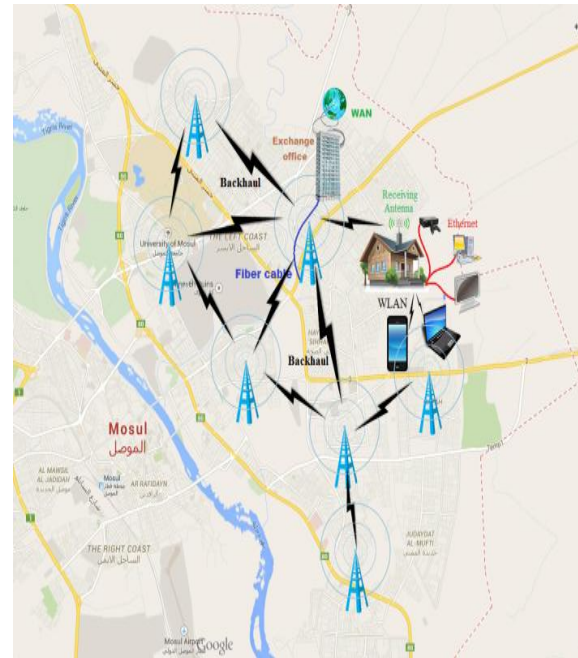


Figure 4: proposed WiMAX architecture for Mosul.

Now we need to provide some details and explanation about the mathematical model, which we need to calculate how many towers we need to cover the area. The equation below shows the number of towers needed.

Equation 1: calculating the number of towers needed for the deployment.

$$W = \frac{A}{C} \quad (1)$$

Which  $W$  is the number of needed towers to be deployed in part A of Mosul,  $A$  is the area of part A of Mosul, and  $C$  is the capability of coverage by the WiMAX tower, which is 16  $\text{Km}^2$ .

Part A of Mosul area can be calculated using a website that offer this service as shown in the figure below.

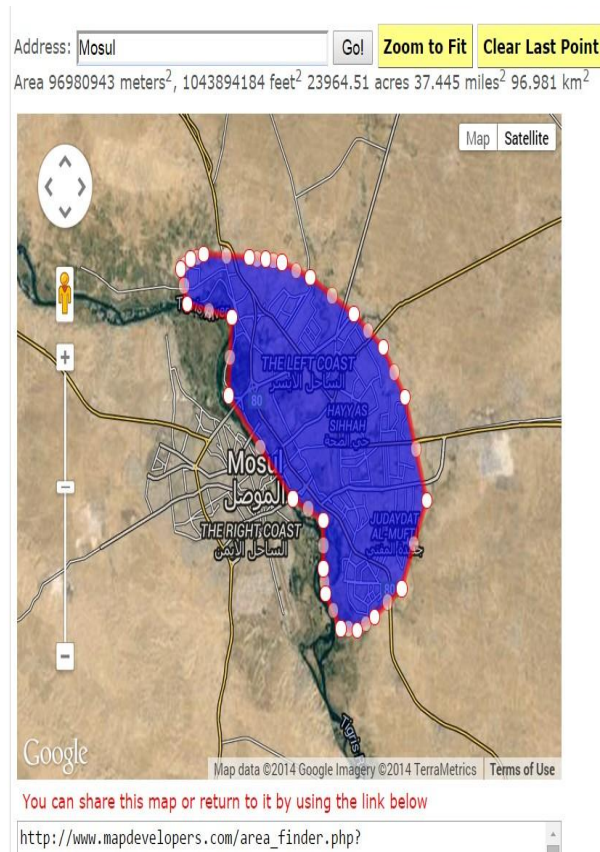


Figure 5: Calculating the area of part A of Mosul.

Each WiMAX tower covers 16 Km<sup>2</sup> and the area of part A of Mosul 97 Km<sup>2</sup>. In this case we can calculate how many towers we need to cover part A of Mosul. While A is 97 Km<sup>2</sup>, and C is 16 Km<sup>2</sup>, so the number of needed towers can be calculated as below:

$$W = \frac{97}{16} = 6.0625$$

So we can conclude that we need 7 towers to cover part A of Mosul. We took 7 not 6 because we need more to enable the scalability aspect.

In terms of the number of people in the area and whether the WiMAX towers can cover all the others, which depending on the number of antennas that installed on the towers. However, when the number of people is increased we need to put more antennas on the tower, which supports scalability. In this case, in my opinion the number of people connecting to each tower does not affect the number of towers needed,

because as we mentioned earlier, installing more antennas on that particular tower will solve this problem as well.

Another feature for this architecture is the ability to connect smart phones or laptops that has wireless connectivity to have the service directly, which is preferred for the portable devices. Eventually we can list the advantages of this architecture as below:

1. Wireless devices can be connected directly.
2. The WiMAX tower can cover up to 16 square kilometers, which is a big coverage area to support.
3. The internet speed can be supported from 1 to 75 Mbps.
4. The WiMAX signal type is NLOS (None Line Of Sight), which is not limited to installing the receiver facing the tower to receive the signal.
5. The operating signal is 2 GHz to 6 GHz, which supports mobile.
6. Support point-to-multipoint mesh, which supports scalability aspect.
7. Support TDM, TDMA, and FDMA multiplexing, which is the recent algorithm to support multiple accesses.

## 7. Conclusion

In this paper, we have identified the people of Mosul part A want WiMAX services to be available in their place based on our developed questionnaire that has been distributed to them.

We have proposed a WiMAX framework to be deployed in Mosul, based on the size of Mosul part A and the population. However, from our calculation that we already made in equation 1, we found that 7 WiMAX towers are enough to cover part A. Our scope of this study is the number of the correspondent and size of the area need to be increased in order to facilitate all types of Mosul people.

I hope that this research can give benefits to Mosul government in order to provide better internet facilities for their people.

### Future work

At this particular stage we are able to provide some suggestions to be considered, which in our case, couldn't perform these suggestions due to what we already mentioned in the previous sections. However, we have some knowledge and ideas of what can be done to improve this work or what is needed to be performed to conduct a new study based of our work results in specific. We can conclude some ideas from what we already discussed in the previous sections, which turning the limitations into a study cases to be working with them to improve this study. However, we have two suggestions stated as the following:

1. Do more questionnaires to ask more people and have more data to collect from users in Mosul.
2. The signs of samples that we divided into two in orders to get good feedbacks from various type of people background.

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