Explore the Feasibility of Implementing Local Multi-point Distribution System Technology in Oman (Framework Analysis)

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Abstract-**With a substantial growth of using the internet across the world especially via wireless connection, the types of wireless connection became more development than before. Local Multipoint distribution System (LMDS) is one of wireless connection which growth around the world. LMDS is a fixed broadband wireless point to multipoint communication system that can provide internet services. In addition, it can provide excellent internet services in remote areas, because it can operate from 26 to 40 GHz. This research explores the feasibility of implementing LMDS in Oman, evaluation of LMDS with other wireless systems and proposes a framework of implementing LMDS in some remote areas in Oman.**

Keywords-LMDS: Local Multipoint Distribution System, RF: Radio Frequency, LOS: Line Of Sight, BS: Base Station

I.INTRODUCTION

The growth of broadband internet access has paved the way for the development of many newer existing technologies [1]. As well as the need of new wireless systems even keep pace with development of technologies in Oman. At the moment Oman has used different wireless systems that enable people to access the internet connection. In addition, this research will focus to enable the people in remote areas in Oman to use internet connection by using new wireless system. Also, the research will present a framework of the explore feasibility of implementing of the Local Multipoint Distribution System (LMDS) in Oman step by step.

II.RESEARCH AIMS AND OBJECTIVES

The main aim of this research is to study the LMDS system and propose a mechanism framework for implement the LMDS system in remote areas in Oman.

- The research is done to achieve the following objectives:
- To study the feasibility of deployment of the LMDS wireless network system in remote areas in Oman and thereby covers the whole country.
- To evaluate different problems that may appear while using this technology (noise from other available telecommunication, rain interference in the area, etc.)

III.PROBLEM STATEMENT

Today, internet services are important for anyone and they are used daily in their life. At present, there is no internet connection in some of remote areas in Sultanate of Oman, the lack of internet bandwidth in the area due to the need of more international links to the world and some companies spend a lot of money to install internet in their building. They need either OmanTel or Ooredoo station to allow these areas to access the internet services. However, this will take a lot of time and cost especially the wired network that takes long time to install and it is more expensive than the wireless network. In addition, there are no backgrounds about the internet among people in remote areas. Thus before making the internet reaches their remote places, they should know about the importance of it in their life.

The real problem for the remote areas is the Companies cannot offer internet services either the wired or the wireless network if the area has low population (lower than 50 people as a minimum number). That is because the companies face a lot of difficulties when the areas are mountainous and far away from cities. The companies need to break the mountains and dig the ground for may be (or sometimes) more than 20 km. So accessing the internet service in mountainous places is more costly than other places in Oman.

IV.LMDS

Local Multipoint Distribution System (LMDS) is a solution for the communication problems in Oman. It is a fixed broadband wireless point to multipoint communication system operating above 20 GHz that can provide internet services [2]. Also, it offers service

providers a method of providing high capacity local access that is less capital intensive than a wireline solution and able to offer a combination of applications.

The LMDS is the most secure technology since it uses licensed bands and not anyone can interrupt it. However, the other technologies use unlicensed bands and therefore any person with some knowledge in the radio frequency (RF) technologies and its equipment can interfere, demodulate and read it. The capacity of each base station is very large in the LMDS systems since it can hold up to 155 Mbps. When this capacity of a base station the LMDS is compared to the capacities of all the other technologies, a very good advantage can be seen since it gives more bandwidth for users per base station.

In addition, the LMDS is a good choice for providing point to multipoint since LMDS stations are very cheap and can be deployed easily. Table 1 shows why the LMDS is chosen to provide internet access in remote areas in Oman, main advantages and disadvantages of the different contemporary wireless broadband technologies and comparison of most important technical properties for a telecommunication system.

	UNII	MMDS	I-WLL	LMDS
Frequency bands	5.15 to 5.35 GHz	2.5 GHz	3.5 GHz	26 to 29.25 GHz
Bandwidth Allocated	300 MHz	200 MHz	824 to 844 MHz	1300 MHz
Cell Radius	Up to 100m	50 Km	8/ 10 Km	3 to 5 Km
Nominal Data Rates	25 Mb/s	2 Mb/s	25 Mb/s	10 to 34 Mb/s
Duplex Method	FDD	TDD	FDD	FDD/ TDD
MAC method	-	TDMA/CMDA	DS-DMA	TDMA
Modulation method	N/A	QPSK	QPSK (Spreading)	Any but not 64 -QAM
User Channels	N/A	N/A	120* 32 Kbits/s	64
Subscribers per system	N/A	N/A	up to 1536	No limit
Deployment	Easy Deployment	Easy Deployment	Easy Deployment	Easy Deployment
Security	security issues	Security issues	Confidentiality of communications	Secure /Licensed bands
Capacity	Up to 155Mbps Downlink	Up to 10 Mbps/Base Station	2.8 to 11.3Mbps per downlink and per Uplink per CPE	Up to 155Mbps/Base Station
Equipments	Very cheap equipments for CPE Expensive for Base station	Cheap equipments, easy in installation	Capacity and Lightness of equipment installations	Cheap equipments, easy in installation
Digital/analogue	Digital	Digital	Digital	Digital
Mobility	Limited mobility	No mobility	Limited mobility	No Mobility
Capacity of cells	Very low capacity	Large cell capacity	Limited capacity of cells	Very Large cell capacity

Table I. Comparison of different wireless technologies

V.LMDS SYSTEM FRAMEWORK

Some steps should be taken into consideration to produce a framework for designing and implementing the LMDS system in Oman. According to the literature review that discusses the implementation of LMDS system the first step, selecting the remote areas that need the internet connection and where the base station will be located. Second, gathering the requirement and equipment's that will be used for this purpose, such as the software (radio elements) and calculating the free space between those areas and the base station, the area of each one of remote areas. After that, showing how these requirement and equipment's will be used to design and implement the LMDS system and by which software. After that, how the system will be evaluated.

VI.LMDS Equipment's

The LMDS is a wireless technology that can transmit large amount of data and information at very high rate of speed using microwave radios. One of the microwave radio should be installed onto a building at the client side and another microwave radio is installed at the LMDS base station [3]. The below figure 1 illustrates the remote areas that need internet services and the base station for them. It is necessary to have a base station when using the LMDS system and the base station will be either a wireless or wireline link [4]. For this system the base station will be wireless.

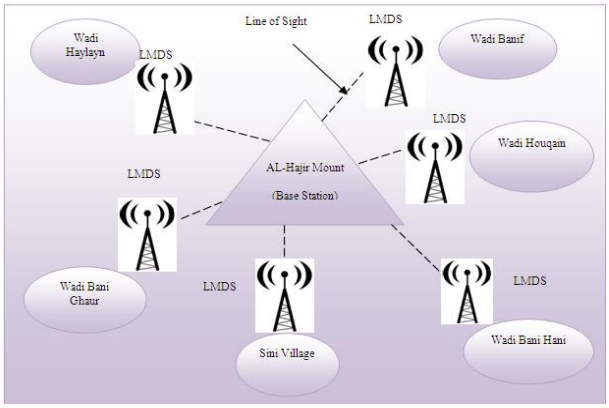

Figure 1 the remote Areas and Base Station

A. Radio Element Design for LMDS in Oman

The radio elements and radio frequency design for a fixed wireless broadband use many aspects from microwave point to pint designs and Cellular/PCs system Designs [5]. The radio elements that are used in fixed wireless broadband system are similar to the ones which are used in a wireless mobile system.

This part explains each radio element that is used in a wireless system and the radio frequency design which both create the fixed wireless broadband system (LMDS).

The research will use the equipment's which are created by a wireless telecommunication company called Hughes Network Systems©. This company is one of the leading companies in implementing LMDS broadband systems and can provide the appropriate equipment's for this system.

The research will use equipment's from Hughes Network Systems© [6], which contains two main equipment's and all the above equipment's which are mentioned in table 1 are based in these two:

Base Station (BS): BS is a fixed communication location and is part of a network wireless telephone system. It relays information to and from a transmitting/receiving unit, such as mobile phone [7]. In addition, it is normally positioned in a location for above the grounded area providing coverage.

Customer Premises Equipment (CPE): is a telephone or other service provider equipment that is located on the

customer's premises rather than on the provider's premises [7].

1) Radio Element

Because this research use Hughes Network Systems© equipments and these equipments, Base Station (BS) and Customer Premises Equipment (CPE), are both contain the antenna system, the transmitter and the receiver

a) Antenna

The most important component of the Radio Elements in a wireless system is antenna. It is a reciprocal device that can serve as a transmitting and receiving device at the same time [8]. The transmitting antenna sends the RF signal through free space and another antenna receives the signal.

b) Transmitter

The two types of transmitter (Master Transmitter and Repeater Transmitter) their characteristics will be according to Hughes Network Systems© equipments.

From Hughes Network Systems© equipments and when using the 28 GHz frequency, the downlink transmit band in both the BS and the CPE are as the following:

Transmit Band (downlink): Hub to Remote 27.5485–28.4445 GHz [6]

The Transmitter output power for Hughes Network Systems© BS and CPE are as the following:

For BS, Transmit Output Power is +18.5/+16 dBm [6].

For CPE, Transmit Output Power is +18.5/+16 dBm [6].

c) Receiver

A receiver is a main component of a fixed radio system. Its characteristics based on Hughes Network Systems© equipments and when using the 28 GHz frequency, the downlink transmit band in both the BS and the CPE are as the following:

Receive Band (downlink): Remote to Hub 28.5565–29.4525 [6].

B. Modulation and Access Method

For the LMDS system and for the modulation technique used, different factors affect the choice of the modulation technique used. These choices are related to the system capacity, to the duplex method and technologies use in Oman, to the equipments that it is using, and to the system that will be designed. The system will depend on different factors which are:

1. Medium access control techniques TDMA will be used for LMDS systems.
2. LMDS system will use QPSK modulation technique and 16-QAM modulation technique according to equipments from Hughes Network Systems©.
3. The FDD duplex method is used in all telecommunication systems in Oman and this is because the government only provides the FDD duplex method for wireless technologies.

C. Bandwidth

Information and channel bandwidth are very critical parameters in determining the modulation schemes to utilize for the telecommunication system. The bandwidth for LMDS system that will implement for the specific remote areas in Oman will be 1.5 Gbps for downstream to the users and 200 Mbps for upstream from the users according to the all bandwidth for LMDS system for 28 GHz.

D. Propagation and Fixed Wireless Path

This section will present the calculation of propagation and the fixed wireless path for the LMDS system in Oman for the specific areas that are mentioned in figure 1. In addition the LMDS needs Line of Sight (LOS) to enable the user to receive the signal with minimum interface and loss of signal power.

Free Space Loss Calculation

Based on the literature reviews which discuss the design and implementation of the LMDS [4], the free space for this system will be calculated for different places. This is because the system uses GSM900 system (this system operates in any 900 MHz and it will use to send information from the mobile station to the base station) to connect different areas that the LMDS will cover. Also, it needs to calculate the Free Space Loss between the nearest base station where the user is located and the user location.

The LMDS system in this research will cover only six main cities in Oman which do not have internet connection. The main base station will be located on the top of "AL-Hajir Mountain", thus the free space loss can be calculated between these six areas that mentioned before and the top of "AL-Hajir Mountain". The six areas to be covered will be Wadi Banif, Wadi Houqain, Wadi Bani Hani, Sini Village, Wadi Bani Ghaur and Wadi Haylayn. By using Google Earth© and the information from OmanTel and Ooredoo Companies through the interview, the Line of Sight between the points needed are shown in table 2.

TABLE I. LINE OF SIGHT BETWEEN AREAS AND MOUNTAIN

Top of AL-Hajir Mountain to	Line of Sight (KM)
Wadi Banif	**50 KM**
Wadi Houqain	**30 KM**
Wadi Bani Hani	**50 KM**
Sini Village	**60 Km**
Wadi Bani Ghaur	**55 Km**
Wadi Haylayn	**30 KM**

In order to calculate the free space of these areas and the top of the mountain, the below formula should be used:

$$L = 32.4 + 20\log_{10} f + 20\log_{10} d \quad (1)$$

Where:

f is the downlink transmission frequency for GSM900 system, f=935 it is fixed number

d is the LOS between the top of AL-Hajir Mountain and each city that the LMDS should cover. Figure 2 show the analysis the above formula.

The free space loss calculation is shown in table 3 below.

TABLE II. FREE SPACE BETWEEN AL-HAJIR MOUNTAIN AND THE CITIES

Top of AL-Hajir Mountain to	Free Space Loss (dB)
Wadi Banif	125.795 dB
Wadi Houqain	121.358 dB
Wadi Bani Hani	125.795 dB
Sini Village	127.379 dB
Wadi Bani Ghaur	126.623 dB
Wadi Haylayn	121.358 dB

Figure 2 which illustrate two areas and the base station.

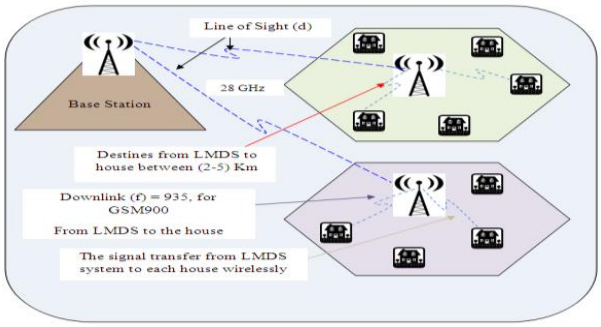

Figure 2 Cell Site and Coverage Required

The LMDS system uses the typical cellular shape for its cellular design. The LMDS system range of coverage is 5 Km Line Of Sight LOS, according to the LMDS a frequency of 28 GHz [9] which will implement in Oman.

Since this research uses the Hughes Network Systems© equipments with the frequency of 28 GHz then the equipments that will use it to operate on 27.5485–28.4445 GHz for downlink and 28.5565–29.4525 GHz for Uplink [6] which means that the allocated bandwidth for Hughes Network Systems© equipments are as following:

Downlink: 28.4445 – 27.5485= 0.896 GHz = 896 MHz allocated Bandwidth for Downlink [6]

Uplink: 29.4525 – 28.5565=0.896 GHz = 896 MHz allocated Bandwidth for Uplink [6]

Using the below formula to calculate the cell area for LMDS system which will be implement and the range of the LMDS system is 5 Km radius [9]. Thus the radius R is 5 Km (R = 5 Km).

$$\text{cell Area} = \left(\frac{3\sqrt{3}}{2}\right) R^2 \quad (2)$$

By using the cell area formula as the following calculation

$$R = 5 \Rightarrow \text{CellArea} = \frac{3\sqrt{3}}{2} \times (5)^2$$

$$\Rightarrow \text{CellArea} = 47.5 \times 1.7321$$

$$\Rightarrow \text{CellArea} = 64.9519 \approx 65 \text{ Km}^2$$

The cell area of the LMDS system in Oman is (cell area = 65 Km2) according to the above formula.

The coverage of the LMDS system in Oman is only limited to six cities which have been mentioned earlier, the area of each one of cities are calculated from digital map1 as shown in the below table 4.

TABLE III. AREA OF CITIES

Cites	Area in Km2
Wadi Banif	50.2400
Wadi Houqain	625.00
Wadi Bani Hani	706.50
Sini Village	113.04
Wadi Bani Ghaur	628.00
Wadi Haylayn	530.66

The Number of Base Station (NBS) that will be required for each city is different. Thus each city demands a specific calculation in order to know the needed number of base stations or cells to cover the whole city and it will depend the area of the city itself.

For Example, here is the calculation of the NBS that are required for Wadi Houqain region.

The NBS is calculated by using the below formula.

$$\text{NBS} = \frac{\text{Total Area To Be Covered}}{\text{Cell Area}} \quad (3)$$

$$\Rightarrow \text{NBS for Wadi Houqain} = \frac{\text{Total Area of Wadi Houqain}}{\text{Cell Area}}$$

$$\Rightarrow \text{NBS for Wadi Houqain} = \frac{625.00}{65} = 9.6153$$

NBS for Wadi Houqain = 9.6153 ≈ 10 Base Station for Wadi Houqain

Note: the NBS should be integer number, if it is not integer the RF engineer should make it an integer number, like the previous example.

In addition, to all the above calculation the system analysis for the LMDS system in Oman is very important and it will be calculated by using the below equation.

[1] The area of each city that needs LMDS system was calculated from a digital map by using Arcmap Arccatalog Software.

$$\text{HubSites} = \frac{C \times 10^3}{S \times Z \times M \times E} \quad (4)$$

From the Hughes Network System© equipments and from previous section, it can determine each of the following parameters:

M is the bandwidth per channel in Mbps/channel. M= 29.184

Since I am using 16QAM for modulation [6]

S is the nominal number of sectors per hub site; S=4 sectors per Hub [9].

Z is the maximum radios per sector; Z=2 radios per sector [9].

E is the efficiency factor (how much needs to load the channels); E=0.8 [9].

C is the capacity that is required to be carried in Gbps in busy hours, C =55Gbps during busy hours for all the country [9].

Now, the hubSites will be:

$$\text{HubSites} = \frac{C \times 10^3}{S \times Z \times M \times E}$$

$$\text{HubSites} = \frac{55 \times 10^3}{4 \times 2 \times 29.184 \times 0.8}$$

$$\text{HubSites} = 294.467 \approx 295 \text{ Hub Site for the whole system}$$

Note: all the formulas which has been discussed above should be used when implementing the LMDS system by any software

VII.FRAMEWORK ANALYSIS

An important step after determining the suitable equipments for the LMDS in remote areas in Oman is the implementation process. The LMDS for Oman (LFO) software will be designed and implemented by any software that will produce professional results for the users such as using MatLab software. This is because it will allow a designer to finish it in short time, to be easily for an engineer to use it and in the future may implement it by using other software that will keep pace with new technology. At first, when need to use the system, only an RF (Radio Frequency) engineer will be able to use this system and later may the system will be improved to allow internet users to use it. It is only directed to RF engineers in networking companies such as OmanTel or Oredoo. Therefore, the things the system address and solve are not for use for internet users at home. It is only for use for RF engineers who are working on connection users to the internet through the LMDS in Oman. The requirements of the software are divided into two parts since the software itself is divided into two parts. The first part allows the RF engineer to determine the connection between the Base Station between the different cities that the LMDS internet will cover. The second part allows the RF engineer to determine the capability of a specific user to receive the internet in one of the specific regions where LMDS will be implemented.

The LFO software that will be designed is a wireless networking application that illustrates the implementation of the LMDS technology in Oman. The user (engineer) will be able to generate data and information for the LMDS system in Oman in each specific city where the coverage is needed using the GSM 900 MHz frequency for connecting the base stations in each cities to each other. The engineer will also be able, to given the coordinates for a specific user, to check if an LMDS connection to a specific user can be given and will be able to generate a report that shows data and information about the type of connection the user will be able to receive and the attenuation, free space loss, weather, valleys and mountains factors on the connections basing on the coordination given. The engineer will also be able to see information about the system in overall which will provide him with data about each city that the LMDS covers including the area of the city, how many cells in contains, how many base stations, how it is connected to the GSM base station and how many users it can take. In addition, the requirements define the users who are going to use the software. In this LFO software is not an application to be sold for individual. It should only be used by internet service provider (ISP), by providers and by engineers and technician who will try to implement the LMDS system.

CONCLUSION

LMDS is well suited to fixed broadband wireless transmission. This research intended to study the wireless telecommunication systems available and compare them to find the most suitable one for implementation to Oman Telecommunication. The chosen technology will have to solve the interference problems that a wireless signal can face such as weather factors, mountain heights and depth of valleys are all factors that should be taken into consideration when designing the system. Also Oman Telecommunication infrastructure has to be covered to show that there is a need for a wireless broadband internet in Oman. All of these problems and statements stated above were mentioned in this research.

ACKNOWLEDGMENTS

I would like to express my gratitude to all people who helped me to reach this stage and to complete my thesis. The first person that I would like to thank is Dr. Arun N.S., he has made me smile during my most difficult times. I thank him for his support, guidance and encouragement during my graduate study. I thank Dr.

Vrigash lecture at Computing Department. I also thank my family who supported me.

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