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To What Extent is the Use of LTE more Effective than the Use of WiMAX in a 4G Network?

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Abstract—*India has a growing population of 1.32 billion people. 63% of this population is under the age of 35. India has over 800 million active mobile devices and 200 million active Internet users. On a global scale, there are multiple billion mobile connections, approximately 25 billion interconnected devices by 2020, and hundreds of billions app downloads by 2017 itself. The numbers above give us a brief idea as to how important and prevalent telecommunications and mobile technologies are in today's world. All of this has been made possible only through the development of radio-based technology. All communications take place though the propagation of radio waves. The initial technology that made use of radio waves was 1G. It was released in the 1980s. Soon the telecommunications transgressed to 2G in the 1990s and 3G in the 2000s. The current standard for mobile communications is 4G (4rth Generation). 4G can be implemented through two main 4G network standards: LTE and WiMAX. Telecommunications companies in India have decided to implement their 4G networks through LTE instead of WiMAX. This report analyses the reason why LTE is largely implemented. However, before doing so, background information about 2G, 3G, and 4G networks will be provided. This will help in understanding the key differences between WiMAX and LTE.*

Introduction & Background Information

2G Technology:

2G or otherwise known as second-generation is a wireless telecommunications technology. 2G technology was launched in 1991 in Finland. When launched, 2G was a revolutionary technology as it had three key benefits over previous generation technologies. 2G technology was also known as mobile for the masses. It had improved scalability and could be used by many more people than 1G technology. The primary benefits of 2G technology over 1G technology are: 2G technology allowed for far superior mobile phone penetration levels as it was much more efficient on the spectrum. This made it possible to reach out to, and provide services to deeper locations in India for many telecommunications company's. 2G technology allows for the digital encryption of phone conversations, thereby increasing privacy and security. 2G was the first technology that introduced data services, such as accessing the internet and sending a text message or other multi-media messages containing audio and video.

Global System for Mobile Communications also known as GSM was the standard for 2G communications. The radio signalling and speech channels used in this technology are both digital. Initial 2G technologies such as D-AMPS and GSM were based on a new technology called Time Division Multiple Access (TDMA). TDMA technology significantly increased the number of users per channel. Each radio frequency channel can support up to 8 or 16 users who share the frequency. Time is divided into time slots and are allocated to the users. Only one user is able to transmit during each time slot. A TDMA frame diagram is shown below:

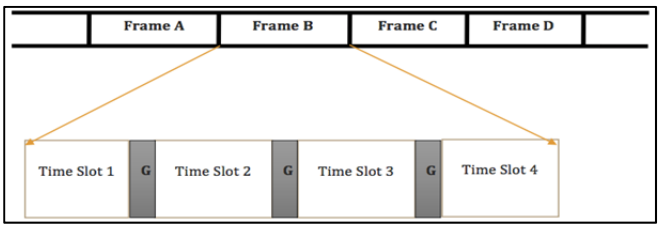

Fig. 1: The Fig. above depicts a TDMA frame. The grey bars in between the time slots represent represent guard time slots. Since it does not take the same time to transmit data signals from different user equipment, guard time slots are needed to prevent interference.

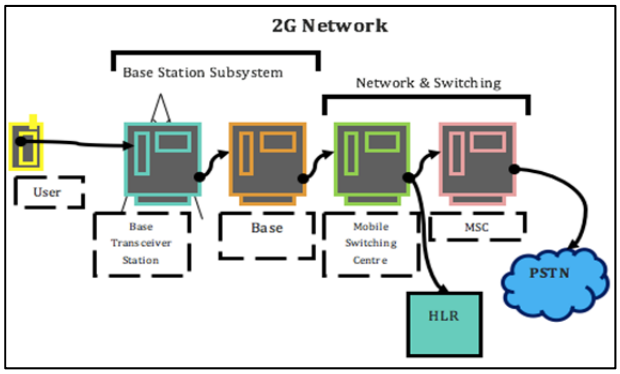

Fig. 2: Basic representation of a 2G network diagram.

The components of the above diagram are: **Mobile Station:** the mobile station contains the User Equipment (UE) which includes radio equipment and IMEI number, and the Subscriber Identity Module (SIM). The SIM is a small card that is encrypted and allows the network to uniquely identify users. **Base Transceiver Station:** controls multiple transmitters in the network. Each transmitter contains 8 signalling slots. **Base Station Controller:** controls and allocates the time slots to each piece of user equipment. It also manages the time slots and decides which frequency a particular user can operate on. **Mobile Switching Centre:** allows for the transfer of phone calls. It contains the Visitor Location Register (VLR) which is a database containing information on other active mobile sites. This facilitates signal transmission to the mobile site nearest to the called party. **Gateway:** the gateway is used to transfer the call to the public switched telephone network (PSTN). The PSTN is a collection of telephone networks that are voice oriented. **Home Location Register:** this is a database that contains information about subscribers. It helps connect the calling party to the called party.

3G Technology:

2G technology was well adept at handling large amounts of network traffic. However, one significant problem faced by users was the lack of data, or in other words, poor internet speed. Hence 3G technology was invented. 3G technology was made for the consumption of multimedia on newer devices such as tablets and smart phones. 3G technology is largely based on 2G technology, but it does have significant network upgrades. The part that is based on 2G is code division multiple access or CDMA. It was not mentioned under 2G technology because this technology is more pertinent to 3G.

Code Division Multiple Access differs largely from TDMA and FDMA. In CDMA, a user can access the network's entire bandwidth for the complete duration of the phone call. This has been made possible as CDMA technology uses specific codes to identify the various users on the network, thereby allowing for the matching of the calling party and the called party. CDMA allows for communication to be seamless as multiple phone calls can occur at the same time. Calls made on CDMA do not experience interrupts like those made on TDMA.

In CDMA, the data-bits are modulated by an orthogonal sequence of bits that are of a high frequency for example pseudorandom codes or Walsh codes. This helps in spreading the data signals over large frequency bands. The way in which the calling party and the called party are matched is when the calling party has the same spreading sequence of the bits as the calling party.

Initial 2G and 3G technologies that made use of CDMA had a network bandwidth of 1.25Mhz. A later CDMA technology called Wide CDMA allowed the signal to be spread across a higher bandwidth of 5MHz. Hence 3G technologies that use CDMA and WCDMA present these significant advantages over their predecessors: faster communication, allow for sending and receiving large multimedia files streaming audio and video, video conferencing, and high speed internet access. As 3G technologies evolved, EV-DO was introduced. EV-DO stands for Evolution-Data Optimized. This was a data only channel in the network, wherein one could access the internet, navigation, multimedia, and apps, without interfering with the standard CDMA network for phone calls and text messages. 3G technologies also make use of the Universal Mobile Telecommunications System (UMTS). This is a standard for 3G data communications. UMTS uses the 1900-2025Mhz bands 2100-2200Mhz bands for 3G transmissions. Soon after the launch of EV-DO, HSPA was introduced to the market. This allowed for even faster data transmission rates of up to 21Mbps. Soon after HSPA+ was introduced, which offered data transmission rates of 42Mbps. HSPA+ is also sometimes referred to as 3.5G

A scaled down version of a typical 3G network diagram is shown below:

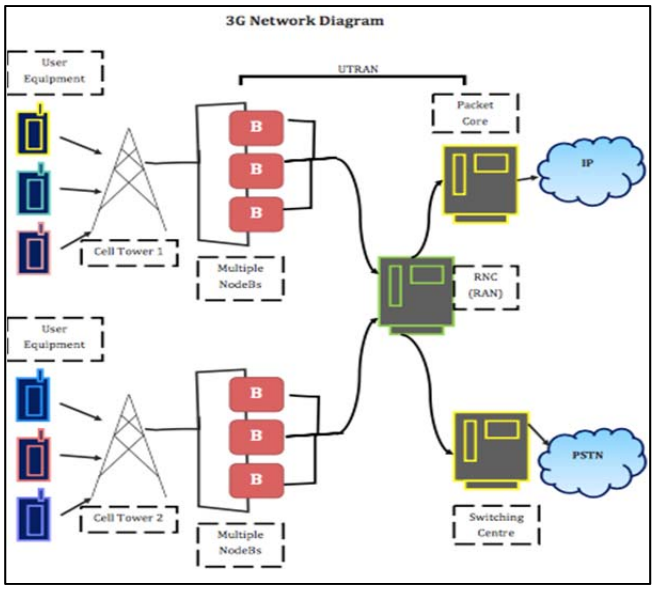

Fig. 3: Basic representation of a 3G network diagram.

The 3G network diagram represents a UMTS network architecture. This contains three main domains. These are the Core Network (CN), Universal Terrestrial Radio Access Network (UTRAN), and the User Equipment (UE).

The User Equipment are the terminals at which network activity requests are generated. The user may make a phone call or stream a video over the internet, thereby generating a request.

The UTRAN contains cell towers which contain multiple NodeBs. The control station that controls all of the NodeBs is know as Radio Network controller, or the RNC. The NodeBs

are responsible for modulation and demodulation. The radio network controller is used for channel allocation and handover control. The RNC also controls all of the NodeBs that are connected to it. It is also the point in the network where all of the encryption takes place. The radio network controller then connects to the switching centre and the packet core. Note that all RNCs are connected to the switching centre and the packet core. The packet pore is used to transfer the data to and from the internet. It makes use of multiple Internet Protocols. The switching centre is used for non-data requests such as voice calls and text messages. Hence the requests are transferred to the Public Switched Telephone Network (PSTN), like in 2G technology.

4G Technology:

4G is the 4^{th} generation of telecommunication technology. The primary advantage that it has over its predecessors is its high speed internet access. The data access speed offered by 4G technology was leaps and bounds ahead of those offered through 3G technology.

4G technology cannot function with pre-existing 2G and 3G infrastructure, thus implementation of this technology took a fair amount of time.

OFDMA & IPv6:

OFDMA stands for Orthogonal Frequency-Division Multiple Access. It allows multiple users on the popular OFDM modulation. On OFDMA, multiple units of digital data can be encoded and transmitted on various frequencies. OFDMA is successful because it facilitates multiple users at the same time. This was not possible with the earliest 1G technologies such as FDMA. OFDMA is a very advantageous 4G technology.

IPv6 stands for Internet Protocol version 6. It is the latest Internet Protocol, and it identifies and locates a computer within a network. IPv6 is supposed to replace its predecessor IPv4, which is facing the problem of exhaustion. This was an essential change in the telecommunications world as older technologies like 3G use circuit switching and packet switching, but newer technology such as 4G uses only packet switching. Circuit Switching is a method used to establish a network channel between a calling party and a called party. Packet switching on the other hand does not establish a direct network channel between two users. The analogue data is broken down into smaller packets and these packets are then sent across multiple channels in the network in such a way that network efficiency is increased and network traffic is decreased.

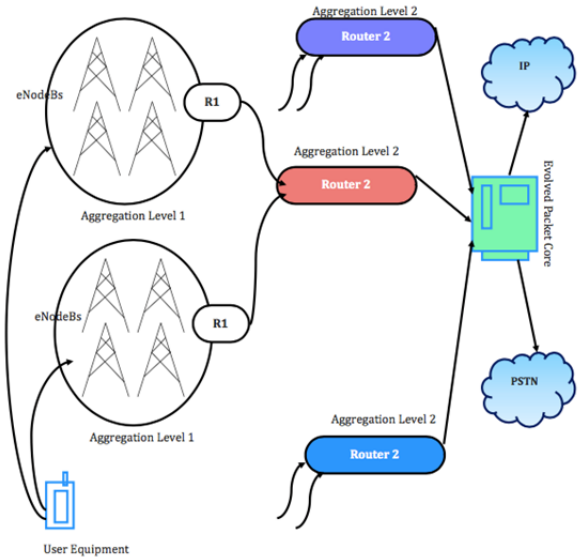

Fig. 4: Basic representation of a 4G network diagram.

The user first sends a request to the eNodeB. eNodeB stands for evolved NodeB. It has the exact same functions as the regular NodeBs used in 3G technology. The main difference in eNodeBs is that they do not need a radio network controller. This is because these eNodeBs are able to communicate within themselves. Hence this allows for easier and more seamless handovers. The eNodeBs pass the request onto the Evolved Packet Core. The Evolved Packet core checks whether request is an IP request or regular request and passes it on accordingly.

Research & Analysis

Since the implementation of 4G there have been two major networks that have developed. They are LTE and WiMAX. The rest of this report looks at why LTE is a more superior technology than WiMAX.

About LTE & WiMAX:

LTE stands for Long Term Evolution. LTE is the most popular 4G network that currently exists. LTE originates from technologies such as WCDMA, 3GPP, and HSPA+. In fact, LTE defines the long term evolution of theses technologies. It is also referred to as a more evolved version of the UMTS. LTE is a standard for wireless communications at high speeds.

These wireless communications are possible between smartphones, tablets, and other mobile data terminals. LTE has even evolved over time to LTE Advanced. LTE Advanced is able to deliver download rates greater than 300Mbps and upload rates greater than 75Mbps. LTE inherits all of UMTS bands.

WiMAX stands for Worldwide Interoperability for Microwave Access. It is a wireless 4G network that was created to replace the physical connections of DSL Cables and T1 lines. WiMAX can support a large number of at a fairly decent speed of 30-

40Mbps. WiMAX is intended to be a line of sight connection service. This means that the signals direct directly from the source to the receiver. This makes communication extremely cheap and fast. The greatest advantage of the WiMAX standard is that it is able to provide connections and coverage even in remote locations. This is made possible as there is no need to run cables to deliver connections through WiMAX.

Before pointing out the differences between LTE and WiMAX, some similarities between the two technologies have been put forth. Both WiMAX and LTE make use of OFDMA technology for downlinks. Both WiMAX and LTE make use of MIMO antenna technology. They both offer high speed data access. Both LTE and WiMAX make use of the same error correcting codes: Viterbi and Turbo. These are used to check for errors during the transmission of data. Both LTE and WiMAX have scalable bandwidths. This makes the network extremely flexible.

The following paragraphs highlight the difference between LTE and WiMAX.

Frequency Bands: As mentioned earlier, LTE inherits all the bands from UMTS. WiMAX on the other hand is a line of sight technology. It operates at much higher frequency bands from 10 – 66 GHz. The more recent version of WiMAX that support non-line of sight technology do not need very high frequencies. Hence they use frequencies from 2 to 11 GHz.

LTEs frequency bands are more preferable. It is much easier to license the frequency bands for LTE as they are more readily available and there are multiple telecommunication companies that have already been allowed to operate through them.

Data Speeds: Data speed for LTE are as follows: Downlink – 100Mbps – 324Mbps. Uplink – 50Mbps – 86Mbps. Data speed for WiMAX are as follows: Downlink – 75Mbps. Uplink – 25 Mbps

Yet another reason for one to chose LTE over WiMAX. In today's world, to most consumers, speed is all that matters.

Multiple Access Technology: WiMAX makes use of OFDMA technologies for both uplink and downlink transmissions. LTE makes use of OFDMA technology only for downlink transmission. It uses a newer technology called SC-FDMA for uplink transmissions.

It is obvious that any telecommunications company implementing a 4G network would prefer to use the newest and the best possible technologies that are available today. Since LTE makes use of SC-FDMA, it is another advantage that it has over WiMAX.

Antenna Technology: This is an extremely crucial factor in any radio network today. If antenna techniques and technologies are implemented appropriately it can increase the robustness of the network and can deliver high speed internet rates to customers at reduced costs. Antenna techniques used in LTE: LTE downlink makes use of SU–MIMO– Single User Multiple Input Multiple Output. LTE uplink on the other hand makes use of MU–MIMO – Multiple User Multiple Input Multiple Output.

Antenna techniques used in WiMAX: WiMAX downlink makes use of SU–MIMO, whereas WiMAX uplink makes use of SU–MIMO.

Both LTE and WiMAX are fairly similar when it comes to antenna techniques used. They both use the antenna techniques that facilitate their transmissions best. However, LTE still proves to be more advanced as it uses a technique known as cyclic delay diversity. This prevents signal cancellation.

Channel Bandwidth: In both WiMAX and LTE, the channel bandwidth is scalable from 1.25MHz to 20MHz. Hence this is not a deciding factor when considering a choice between the two technologies.

Legacy Support: On hand LTE supports legacy systems such as 2G and 3G devices, whereas, WiMAX on the other hand does not. This is essential if the company that is implementing the technology is looking at delivering 4G speeds on 2G and 3G phones through a wireless dongle. Hence LTE is an obvious choice when it comes to the support for legacy systems.

Cell Capacity: This is yet another category where LTE trumps WiMAX. In a WiMAX network, each cell can support up to 100-200 users. Whereas, LTE can support more than 200 users at a 5MHz frequency and more than 400 users at higher bandwidths. In order to be able to support a large customer base, one would choose LTE over WiMAX.

Latency: The general latency experienced in a WiMAX network is 50 milliseconds. On the other hand, the general latency experienced in an LTE network is about 10

milliseconds. Since LTE has a lower latency, it will be far more efficient.

Channel Utilization: WiMAX processes information and transmission through one large channels, whereas LTE adjusts the spectrum to smaller pieces, thereby making it more efficient.

Power Consumption: It has already been established that LTE is more efficient than WiMAX. Hence it would be fair to say that LTE uses less power than WiMAX does.

Cost: WiMAX is generally less costly than LTE. This one argument that could be made for choosing WiMAX over LTE. However, if we look at it as a long term investment, one would choose LTE over WiMAX. The long term benefits provided by LTE far outweigh the shot term costs.

Conclusion

To summarize here are the factors in which LTE trump WiMAX: Frequency Bands, Data Speeds, Multiple Access Technology, Channel Bandwidth, Legacy Support, Cell Capacity, Latency, Efficiency, Channel Utilization, and Power Consumption. If we look at it from the perspective of a telecommunications company, we can truly understand why they would spend the extra money and invest in LTE over WiMAX.

Furthermore, LTE Advanced technology is making great advancements today. The LTE Advanced spectrum is being extended to the unlicensed spectrum. This allows 4G speeds to be available on the Wi-Fi frequency. Such is not possible on a WiMAX network. In addition to this, LTE Advanced is going beyond mobile devices and is moving toward terrestrial television. Hence it is fair and justifiable to say that the use of LTE is far more effective than the use of WiMAX. The functionality and flexibility of an LTE network is far superior to that of a WiMAX network.

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WiMAX logo: https://i2.wp.com/www.cablefree.net/wp-content/uploads/2014/04/wimax-logo.jpg?fit=358%2C141

Rest of the figures were created by me with the help of Microsoft Word.