ENHANCEMENT OF TRADITIONAL WIDEBAND NETWORKS BY USING ENHANCED WIMAX TECHNOLOGY

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I certify that in my opinion, the thesis submitted by Ali Huzber Hussien titled "ENHANCEMENT OF TRADITIONAL WIDEBAND NETWORKS BY USING ENHANCED WIMAX TECHNOLOGY" is fully adequate in scope and quality as a thesis for the degree of Master of Computer Science.

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Ali Huzber HUSSIEN

ABSTRACT

M. Sc. Thesis

ENHANCEMENT OF TRADITIONAL WIDEBAND NETWORKS BY USING ENHANCED WIMAX TECHNOLOGY

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The expansion of networks involved a higher jump on the users utilizing the network's resources, requiring extra higher bandwidth. Due to the development of technology, the new demand for higher data rates has been witnessed among the users. To feed the demand of users with high data rates, broadband networks are required where a high data rate can be ensured for each user. Broadband networks can be established using an optical network that carries the data through wide broadband. Areas such as rural and forest sides which are witnessing plenty of natural obstacles such as mountains, trees, seas, etc. are forming a big challenge for propagating a cable (wire) or optical network. Due to the limitations of the wired network, WiMAX technology has been introduced as a substitutional for the broadband network. Such kind of alternative can be deployed through any geographical area without concern about the wire paths. This proposal offers a wireless broadband network as a replacement for the traditional optical network.

A fixed wireless broadband network might solve the data rate issue while also offering a network that is easy to use and free of natural impediments such as trees and mountains.

The architecture of the chord network describes the increase in the performance of wireless broadband networks, for example, humidity and rain significantly and directly affect the rate and speed of wireless data transmission. Therefore, this proposed type of loop wireless network allays these concerns and provides network connectivity reliability. The chordal wireless ring was designed to relieve network congestion and compensate for capacity limitations. With ten nodes and a diameter of 100 km, IEEE 802.16 (WiMAX) networks of the third and fifth degrees (D=3 and D=5) are built. According to the study, a chordal ring network may need a queuing delay during packet transmission. As the number of chords grows, the line will get longer. Increasing the chordal ring degree, on the other hand, enhances the packet delivery ratio. The DSDV protocol outperforms the AODV protocol by 2.937 seconds in terms of average queuing delay.

Key Words: WiMAX, Fiber, Backbone, WAN, Throughput, IEEE802.16, MAC Address, LAN, TDM, FDM, SDM, PCMCIA card, Chordal Ring

Science Code: 92407

ÖZET

Yüksek Lisans Tezi

GELİŞTİRİLMİŞ WIMAX TEKNOLOJİSİ KULLANARAK GELENEKSEL GENİŞ BANT AĞLARININ GELİŞTİRİLMESİ

Ali Huzber HUSSIEN

Karabük Üniversitesi
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Ağ genişletme, daha yüksek bant genişliği gerektirebilecek ağ kaynaklarını kullanan kullanıcılar üzerinde daha yüksek bir sıçrama sağlar. Teknolojinin gelişmesi nedeniyle, Kullanıcılar arasında daha yüksek veri hızlarına yönelik yeni talep gözlemlendi. Kullanıcıların taleplerini yüksek data hızları ile beslemek, Kullanıcı başına yüksek veri hızının garanti edilebildiği yerlerde geniş bant ağlar gereklidir. Geniş bant ağlar, verileri geniş bant üzerinden ileten bir optik ağ kullanılarak oluşturulabilir. Dağlar, ağaçlar, denizler vb gibi birçok doğal engelin bulunduğu kırsal ve orman alanları, kablo (tel) veya optik ağ dağıtımı için büyük bir zorluktur. Kablolu ağ sınırlamaları nedeniyle, WiMAX teknolojisi, geniş bantlı bir ağa alternatif olarak tanıtıldı. Bu tür bir alternatif, kablo yolları hakkında endişelenmeden herhangi bir coğrafi alana yerleştirilebilir. Bu öneride, geleneksel optik ağa alternatif olarak bir geniş bant kablosuz ağ sunulmaktadır. Sabit bir kablosuz geniş bant ağ, kullanımı kolay ve ağaçlar ve dağlar gibi doğal engellerden arınmış bir ağ sağlarken veri hızı sorununu çözebilir.

Akor ağ mimarisi, kablosuz veri iletiminin hızını ve hızını önemli ölçüde ve doğrudan etkileyen, örneğin nem ve yağmur gibi kablosuz geniş bant ağlarının performansındaki artışı tanımlar. Bu nedenle, önerilen bu kablosuz halka ağı türü, bu endişeleri ortadan kaldırır ve ağ bağlantısı güvenilirliği sağlar. Kordon kablosuz döngüsü, ağ tıkanıklığını azaltmak ve kapasite sınırlamalarını telafi etmek için tasarlanmıştır. IEEE 802.16 (WiMAX) ağları, on düğüm ve 100 kilometre yarıçaplı (WiMAX) ve Sınıf 3 ve Sınıf 5 ağlar (D = 3 ve D = 5) ile oluşturulmuştur. Çalışmaya göre, akor döngü ağı, paketleri gönderirken kuyruğa almada bir gecikmeye ihtiyaç duyabilir. Daha fazla dize, çizgi daha uzun olacaktır. Öte yandan, sicim döngüsünün perdesini artırmak, ışın iletim oranını iyileştirir. DSDV, ortalama kuyruk gecikmesi açısından AODV'den 2,937 saniye daha iyi performans gösterir.

Anahtar Kelimeler: WiMAX, Fiber, Backbone, WAN, Throughput, IEEE802.16, MAC Address, LAN, TDM, FDM, SDM, PCMCIA card, Chordal Ring

Bilim Kodu: 92407

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I would like to dedicate this achievement to the teacher who taught me my first word, who is my first word, my beloved mother. I would also dedicate it to the candle that burned to lighten my way, my darling father. And, to my dear brothers and sisters, who supported me in all circumstances. Also, to my beloved wife who helped me, and stood with me to achieve this achievement.

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ABBREVIATIONS

WIMAX : Worldwide Interoperability for Microwave Access
IEEE 802.16 : Institute Of Electrical And Electronics Engineers
WI-FI : Wireless-FI
CHR : Chordal Ring Topology
IP : Internet Protocol
D=5 : 5th Degree
AODV : Ad Hoc On-Demand Distance Vector
DSDV : Destination-Sequenced Distance-Vector Routing
TCP : Transmission Control Protocol
NS2 : Network simulator II
LAN : Local Area Network
WAN : Wide Area Network
RAM : Random Access Memory
BS : Base Station
SS : Shard Station
PCMCIA : Personal Computer Memory Card Interface Adapter
OFDM : Orthogonal Frequency Division Multiplexing
TDM : Time Division Multiplexing
FDM : Frequency Division Multiplexing
SDM : Space Division Multiplexing
QPSK : Quadrature phase shift key
MAC : Media Access Control
Tx : Transmitted Packets
Rx : Received Packets
DP : Dropped Packets
AQD : Average Queuing Delay
PHY : Physical Layer
RREQ : Read, Repeat, Remotely Executable Program

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Telecommunications or fiber-optic networks represent the infrastructure of broadband networks in the world. The optical cable provides wide bandwidth and transmits the signal to long distances very quickly in a short time. Optical fibers are widely used for several distinct aspects, including commercial, government institutions, cellular communications, and so on. It has a large transfer capacity measured in gigabytes. The demand for data has become large and increasing globally, so researchers are seeking, in various ways, to find new ways or techniques to provide similar data capacity to bypass the defects in optical fibers network and reduce costs [1].

There are two main types of network connections, wired networks that connect devices using cables (such as coaxial cable and optical fiber). The other type is wireless networks that connect devices using radio waves, and the channel in the wireless network is divided into uplink and downlink (such as a satellite).

The good performance of the network depends on the connection topology between the nodes in the network whether it is parallel or distributed and it can be represented graphically. Where edges represent links and nodes represent vertices. The researchers were interested in one of these models, which is represented by the chordal ring network in the form of an undirected circular graph [2].

Global Interoperability for Microwave Access (WiMAX) is a wireless network that ensures the quality of service over the network. Wireless broadband WiMAX also combines different quality control mechanisms to reach a secure information service and allocate multiple channels with different configuration schemes [3].

Signal transmission via radio waves rather than wires is referred to as "wireless." Wireless technologies are used for everything from turning off the television to sending information to the sales force while they are out in the field from an automated corporate program. Wireless keyboards and mice, PDAs, pagers, digital and cellular phones, and wireless keyboards and mice have all become prevalent in our daily lives. Individuals and businesses are expected to benefit from WiMAX systems, which are expected to provide cost-effective broadband connectivity. WiMAX is a wireless version of Ethernet that has been standardized to provide broadband connectivity to client premises as a replacement for wire technologies including Cable Modems, DSL, and T1/E1 lines.

"Worldwide Interoperability for Microwave Access "WiMAX is a trade group founded by prominent communications, components, and equipment companies to promote and certify the compatibility and interoperability of IEEE 802.16 and ETSI HIPERMAN-compliant broadband wireless access equipment. WiMAX would function similarly to WI-FI, but at higher rates and across longer distances to accommodate more users. WiMAX has the potential to give service even where wired infrastructure is difficult to access, as well as the ability to circumvent the physical limitations of standard wired infrastructure. WiMAX was founded in April 2001 in anticipation of the release of the first IEEE 802.16 specifications for the 10-66 GHz range. In the same way that the WI-FI Alliance corresponds to 802.11, WiMAX corresponds to 802.16. WiMAX is such an easy term that people tend to use it for the 802.16 standards and technology themselves, although strictly it applies only to systems that meet specific conformance criteria laid down by the WiMAX Forum.

1.2 PROBLEM STATEMENT

The expansion of network users influenced by internet network expansion and handset technology development triggered a demand for reliable and fast Internet connections. In that data can be exchanged through the internet including high-resolution multimedia data and real-time communications. In general, those demands are fulfilled by integrating broadband networks using optical fiber channels where high-speed connections can be achieved. Problem is raised while considering the area of rural and unmanaged roads where optical/wired network infrastructure cannot be established. Depending on a traditional wireless connection is left as the only feasible solution for energizing those areas with data connectivity. Unfortunately, two challenges are faced: firstly, for the wireless internet, bandwidth cannot be compared with broadband, so the network's speed has remained challenging. Secondly, current mobile connectivity such as 4G, and 5G connections are providing a good speed of data exchange for user-level but the cost of using such service is high.

1.3 OBJECTIVES

To process the problems encountered by the networks while using the wireless infrastructure, the following objectives are targeted in this dissertation work.

Development of a wireless network that can meet the specifications of a broadband network to provide a similar bandwidth for the users located in none accessible and none managed locations.

Developing a wireless network according to the IEEE 802.16 (WiMAX) specifications that support a big data rate reaching one gigabyte per second.

Ensuring that the developed network is not suffering from wireless drawbacks and performance degradations such as handoff and mobility issues. It is noteworthy to state that IEEE 802.16 is supporting a very large coverage area that is reaching 8000 Square meters which means no handoff issue will be encountered. On the other hand, no mobility is required in the proposed work, so to say the proposed network standard is the best to serve the designated purpose.

To support the consistency of radio channel and quality of service (QoS), the chordal ring network topology is to use.

Chordal ring topology over a wireless network is proposed for implementation of the the-so-called Fixed wireless broadband network that performs like the one of regular wire broadband.

The proposed network must obey the cost limitation and economic constraints that are expected from any service provider.

1.4 THESIS ORGANIZATION

This dissertation report is consisting of five technical chapters that demonstrate the proposed wireless chordal ring network. The distribution of the chapters can be illustrated in Table 1.1.

Table 1.1 Thesis structure and parts overview.

Chapter No.	Chapter Name	Details
1	Introduction	States the background of the study and summarized the problem statement as well as the research objectives.
2	Literature Survey	Demonstrates the previous research activities that is having similar research interests.
3	Methodology	Detailing the underlying techniques and the theoretical part that was used to construct this study.
4	Empirical Model	Detailing the proposed chordal wireless ring topology and discussing the results taken from the proposed models.
5	Conclusion	Which made to conclude the facts and the findings achieved after analyzing the results.

The final section of this dissertation report is made to enlist the references used to construct this work along with the publications made after the completion of this work

CHAPTER 2

LITERATURE REVIEW

At [4], the development of communication has triggered new technologies supporting high data transmission through the communication channels. the high data rate is feasible to transmit through the optical network using the so-called wavelength division multiplexing. The communications over the optical network are taken place by the accurate formation of routing request e.g., R {x, y} where routing request R is made to transmit the data from the position x to position y (destination) in the network. Coordination of x and y are standing for the location of nodes pair in the network where data is generated from and transmitted to.

The author of this study revealed that communication networks through optical channels are dealing with variable wavelengths depending on the data and the application that the network has established. Communication networks through the optical channel are suffering from the variable wavelength since the fiber channel can be designed to serve a particular wavelength. To tackle this issue, a chordal ring network is established as shown in Figure 2.1.

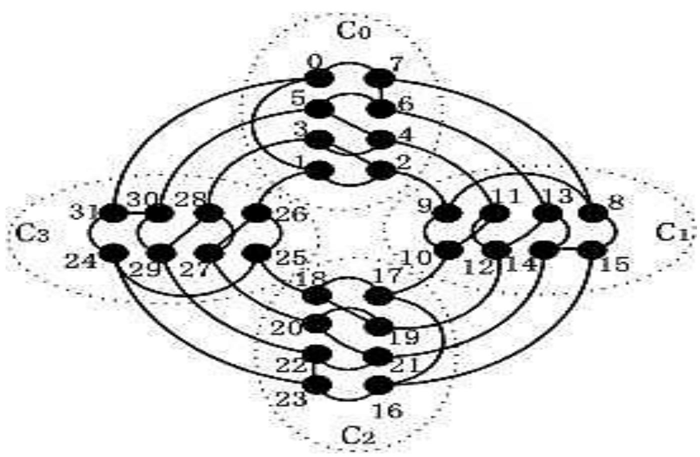

Figure 2.1.Chordal ring topology hat proposed to support WDN

At [5], researchers have shown that optical networks can be optimized by reducing the number of wavelengths that participates in the transmission game. In most of the big communication networks, several applications are participating in the transmission such as voice transmission, video transmission, and other multimedia data. The network might need to purchase new bands or channels to fulfill all the application requirements. In an optical network, new fiber cables might be required for allowing multiple wavelengths to be transmitted.

This demand may require upgrading the network design. One of the feasible solutions that have been proposed is using intermediate connections to link nodes through the network of ring topology. The nodes which are preserving a different wavelength than the main operational wavelength used in the network can be connected using an additional link called a chordal link.

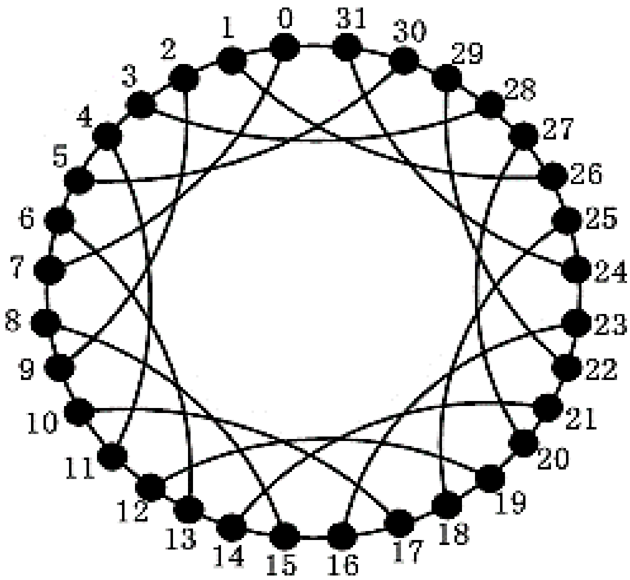

Figure 2.2.Chordal ring network based on the optical fiber network

In [6], the author defined the chordal ring network as a network of Q chords number and P nodes where the number of chords should not be exceeding fifty percent of the total number of nodes. As the chordal network is a ring network, each p node is to interfere with p-1 and p+1 nodes. The author mentioned that the chordal ring can be further characterized by the number of edges in each node.

The same is termed degree; in this study, the author tested the performance of the chordal ring by changing the topology of the network. Changing the network degree implies changing the diameter of the chordal ring as well as changing the length of the chords which directly impacts the network performance. In Figure 2.3, a chordal ring with a fifth-degree involving twenty nodes is demonstrated.

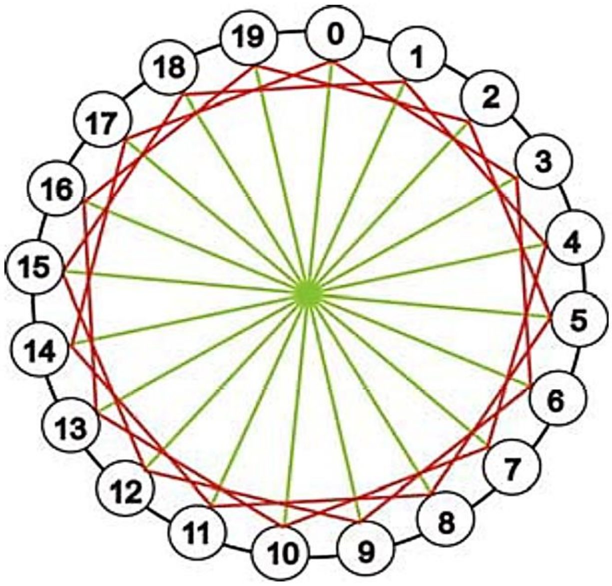

Figure 2.3.Basic Degree 5 Chordal Ring CHR5

At [7], another approach was illustrated in this study which stated the optimization of a large chordal ring network to preserve a particular cost. Ring topology preserves many nodes that are interfaced using the optical channel. The communication between those nodes is taking place using network devices like optical multiplexers, switches, and optical amplifiers. As the number of network edges extends, the cost required to establish the network is also enlarged.

However, this study involves a comparative analysis of a seven-degree chordal ring and a three-degree chordal ring network. The authors of this study stated that a six-degree chordal ring network can yield close transmission parameters to the four-degree chordal ring network. However, the seven-degree chordal ring network is then replaced by the three-degree chordal ring.

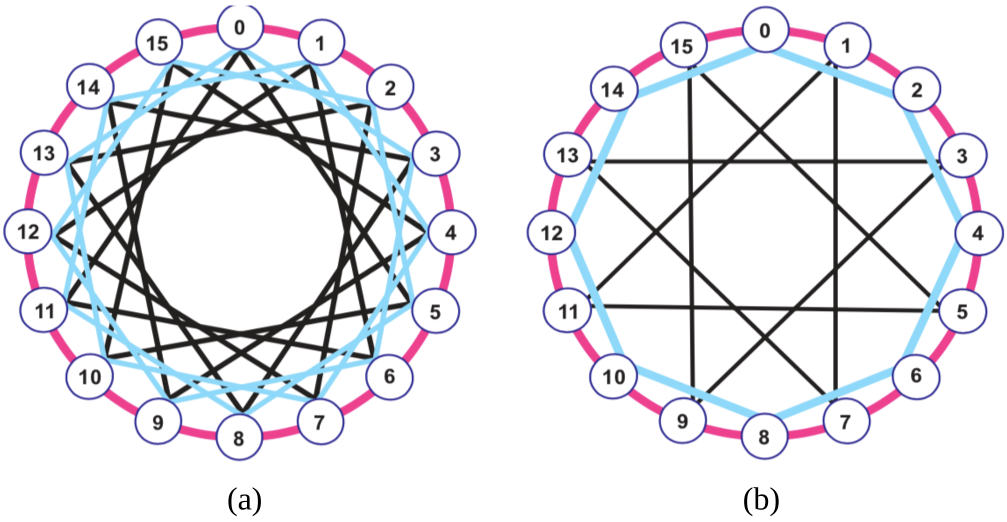

Figure 2.4.Difference between Regular Degree, (a) D6 Chords,(b) D4 Chords

In [8], the author defined the network topology as the visible interfaces between the nodes which impact the node degree, bandwidth, network diameter, etc. So, to say, all the mentioned parameters of the network are responsible for changing the network topology. That implies different topologies can be achieved by varying the networking (interfaces) parameters.

The need for extra bandwidth in the networks is one of the major challenges of network designing. To create extra bandwidths, channels with capacities are to be established, one of the feasible solutions to establish new channels for an existed network is by assigning different degrees for the nodes. This is achievable by allowing interconnections between the network nodes so that, the specific data that is required to be transmitted from any node, is to be transmitted in a special channel propagated from this node to the destination node.

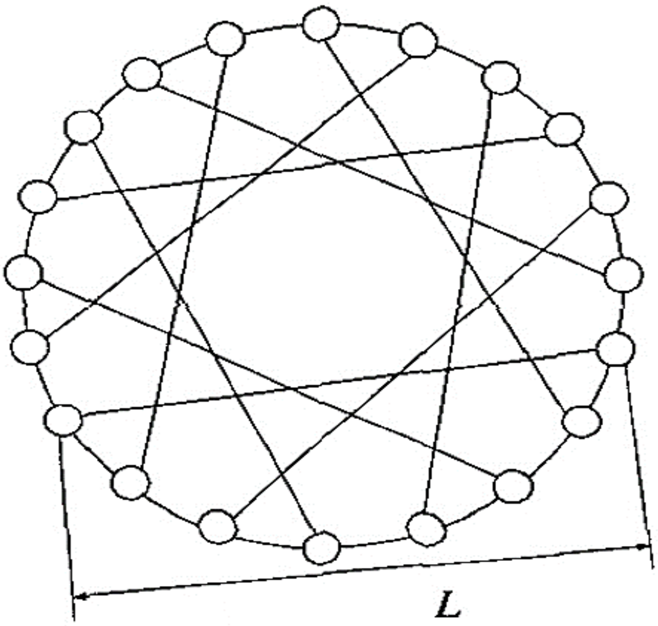

Figure 2.5.Chordal ring network topology

At [9], studies have shown that two main sorts of the chordal network are available namely: node symmetrical chordal ring and periodic regular chordal ring network. In a node symmetrical chordal ring network, nodes relate to some degree of chords and hence, same diameter and same specifications. The node symmetrical chordal ring is demonstrated in Figure 2.6 showing that identical distances between each chordal link and the same number of chords have been connected to each node. However, Figure 2.6 depicts the case of a periodic regular chordal ring, the nodes relate to no identical chords.

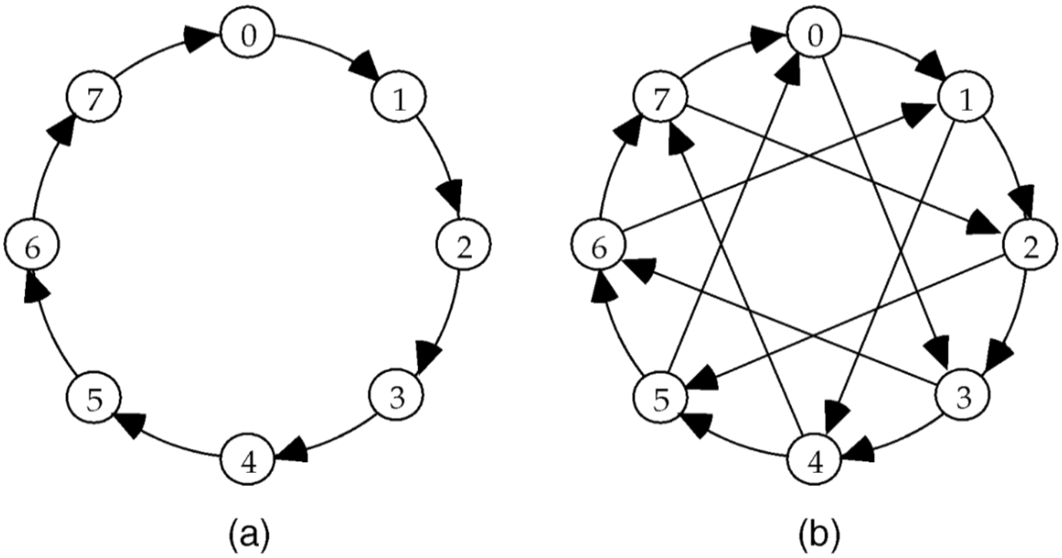

Figure 2.6.Periodic regular chordal ring.nodes are connected without chords

At [10] communication networks are usually designed in the form of graphs on paper before they are implemented so the design topologies must be purposeful to provide for future reliability. In this study, a modified 6th-degree chord topology was proposed to represent the network. The author of this study discussed multiplexing and focused on odd and even nodes. The CHRm6 mathematical model was used to derive the results. This model provides multiple sending of nodes to send a message to many destinations at the same time.

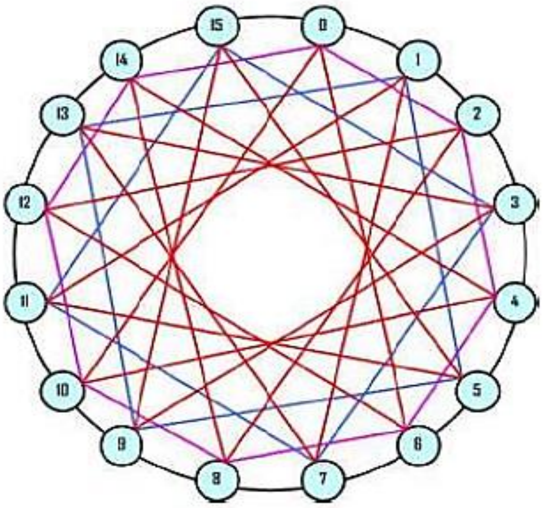

Figure 2.7.CHRm6 Structure

At [11] The good performance of a network depends on the interconnection of nodes in a parallel or distributed manner. It can be modeled graphically. Researchers have been interested in the chord network since its inception. This study discussed a modified chord ring of six degrees $CHR6o3$ and showed that $CHR6o3$ is asymmetric and may disintegrate into similar subgraphs, each of which represents a type of nodes in its class if the loop links are bypassed. These links help in the development of the routing scheme. The existence of the Eulerian circle is proven in $6o3$. The presence of Eulerian circuit plays a role in routing in optical networks.

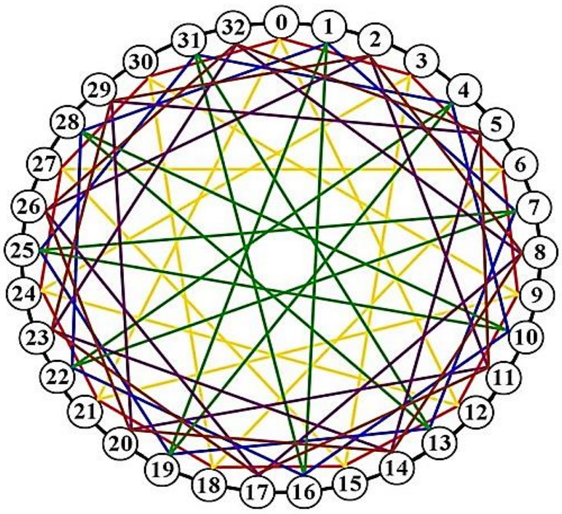

Figure 2.8.$CHR6o3$

At [12] In this study, the author improves the performance of the wireless network by using the chord ring network. A set of routing protocols was used, and the network performance was examined after the project was implemented for various degrees of chord ring (D = 4, D = 5) and a set of measures were applied. The results obtained by the author of this paper showed that the fifth-degree wireless chord network gives better results in performance using the routing protocol (DSDV).

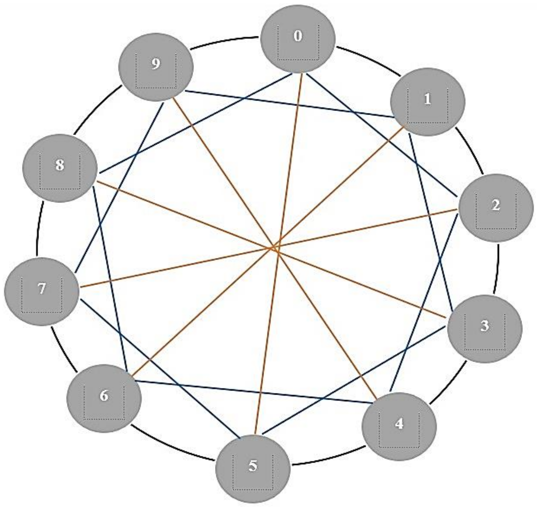

Figure 2.9.Ring topology with 5th-degree chords.

At [13], the essential methodology that has been used for long years for the transmission of multiple channels through a single communication medium (wired or wireless) is the multiplexing technique. Multiple data streams can be multiplexed into a single channel and can be sent at the same time. Multiplexing technology permits transmission of data either with time constraints or frequency constraints or even by using both constraints. Data from several channels can be sent at the same time by using the so-call frequency multiplexing, where the channels will be allowed to transmit the data by distributing their frequencies depending on multiplexing technique specifications, the same is called frequency division multiplexing. The other breed of multiplexing technology is the time-division multiplexing where multiple channels can synchronously begin the transmission as demonstrated in Figure 2.10.

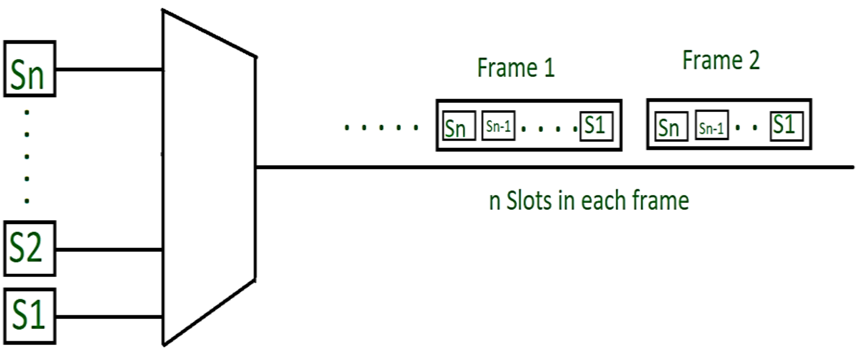

Figure 2.10.Multiplexing Technology in Communication Network

At [14], routing the data in the communication systems is an essential process performed by the communication network. Routing the data or network payload from the source node into the destination node may take place through a particular path in the network. The selection of that path is happening by fulfilling the delay and throughput tradeoff formula. The network may employ the so-called routing protocols to route the data (payload) through the nodes. The main function of routing protocols is finding the shortest path with minimal losses to route the data packets. One of the essential technologies to ease the routing process is using the packet switching network where data payload is converted into smaller blocks called packets and those packets are then segregated across the network by different paths reaching the destination. Figure 2.11 demonstrates the process of data routing in a cellular network.

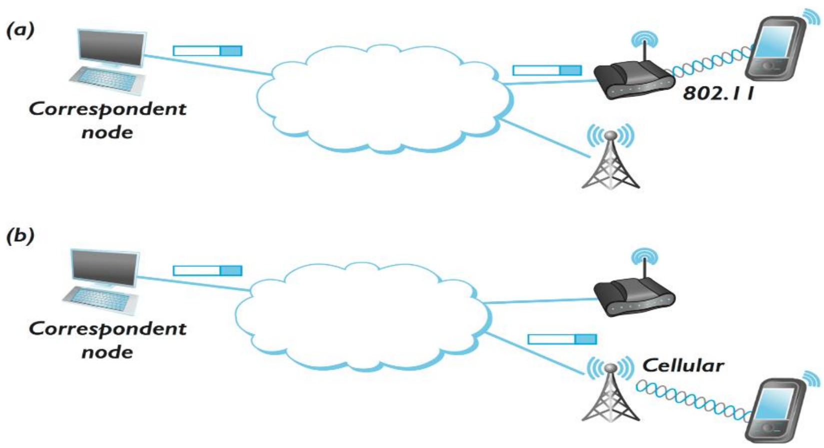

Figure 2.11.The process data routing in cellular network

At [15] WiMAX networks are one of the future technologies that need a lot of research. Homogeneous horizontal delivery and heterogeneous vertical delivery in the delivery architecture of WiMAX networks are key to transportation. This study discussed potential delivery problems and focused largely on the homogeneous performance of delivery, the article showed an improvement in the delivery process by reducing vibration and increasing traffic rates, adding that the vertical delivery process takes more time to deliver because it adds additional administrative signals, and the study shows that both mechanisms decrease the time in the delivery process.

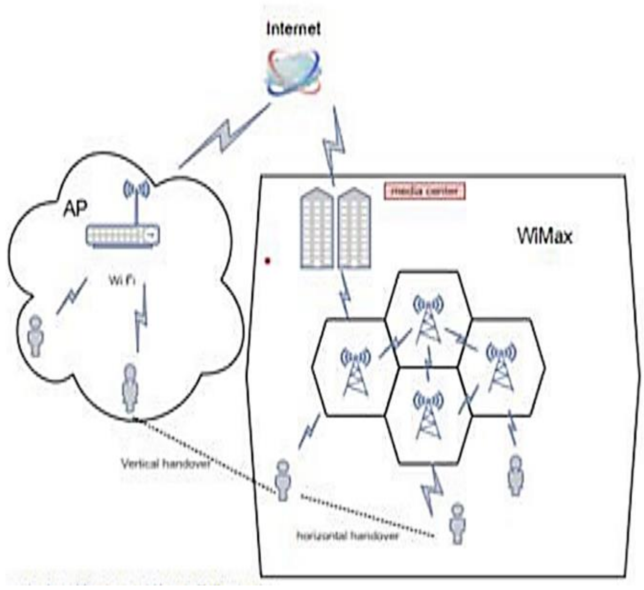

Figure 2.12.horizontal and vertical handover

At [16] In this study, the researcher focused on the problems of network congestion, adding that one of the indicators of network congestion is the dropped packets during the transition from the source to the destination. He referred to various TCP variants as models (Sack, Fack, Reno, Veno, and Vegas) to control network congestion and improve network performance by improving throughput, reducing delay time, and routing packets. This article added that TCP improved quality and reduced time lag by controlling congestion across the network.

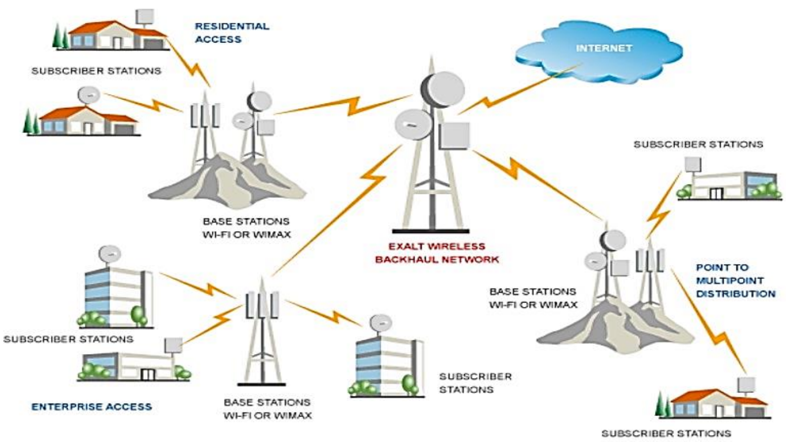

Figure 2.13.IEEE 802.16 WiMAX Network

At [17] The actual demand by users for time services is increasing with the advent of wireless technologies such as voice and video, as well as data called VoIP. The reason is the need to provide high-quality services. This article discusses WiMAX support with VoIP to provide quality services through parameters (such as time lag, jitter, and throughput). The study author emphasized improving VoIP traffic in its various aspects. The study proved that VoIP needs to consider more considerations to get high-quality VoIP.

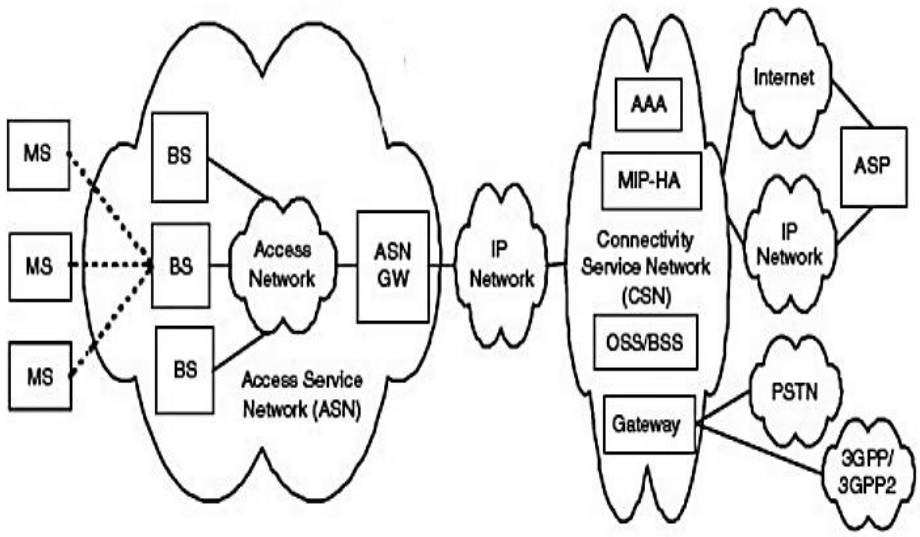

Figure 2.14.WiMAX Architecture

At [18] In this study, the author presented an analysis of the strategies of three types of routing protocols used in wireless networks (interactive and proactive protocols), such as (AODV, DSR, and FSR). He added that the performance of these protocols was measured with different measures depending on the transmission rate, time delay, and the rate of packet delivery from the source node to the destination node for each case, also in this study the QUALNET program was used. After implementing the performance measures, this study proved that the (AODV and DSR) protocol showed better results than the (FSR) protocol, thus the AODV protocol outperformed the packet delivery speed over the network from the source to the destination node.

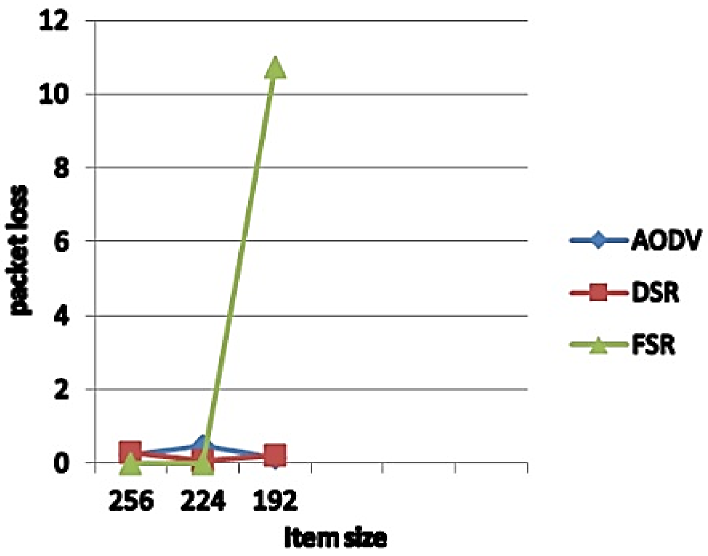

Figure 2.15.End to End delay of Protocols

At [19] This study presented an analysis of the performance of three types of routing protocols intended for wireless networks. The model was tested using simulation software (NS2), different routing protocols (AODV, DSR, DSDV), and different performance measures (to measure throughput, lost packets, and time delay of packets from source to the destination node within the network). The study proved that the AODV protocol outperformed the DSR and DSDV protocols.

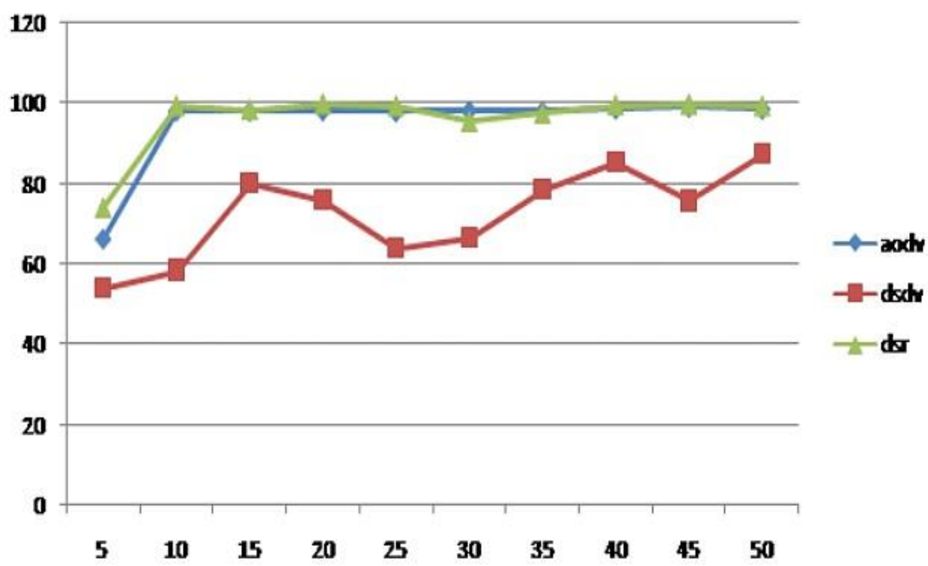

Figure 2.16.A Comparison between the Routing Protocols

At [20] This study compared the performance of four frequently used routing protocols with WiMAX technology (such as AODV, LAR1, OLSR, and ZRP), and measures were applied, which depended on analyzing network performance in different conditions (vibration, packet delivery rate, delay interval, and throughput rate between the two ends of the network), for a variable number of nodes. The study proved that the LAR1 protocol is better in performance in terms of throughput and less time delay.

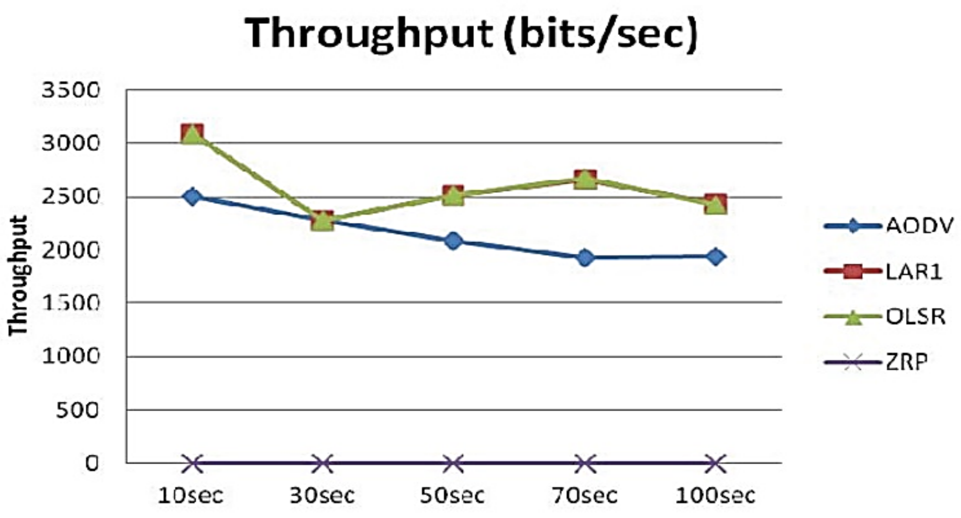

Figure 2.17.This shows that LAR1 and OLSR give maximum throughput.

At [21] This study presented an evaluation of four types of routing protocols commonly used in wireless networks such as (destination sequential distance vector routing (DSDV), dynamic source routing (DSR), distance vector on demand (AODV), and multipath distance vector on demand (AOMDV)). The author used (NS-2) simulation program and (TCL) commands to execute it. The metrics used were (packet delivery, packet loss, throughput, and delay). The results showed that each protocol has advantages and importance different from the others, for example, the DSDV protocol is better in terms of throughput, and low drop packet. Thus, the researcher concluded that the best option to use the protocol depends on the network infrastructure.

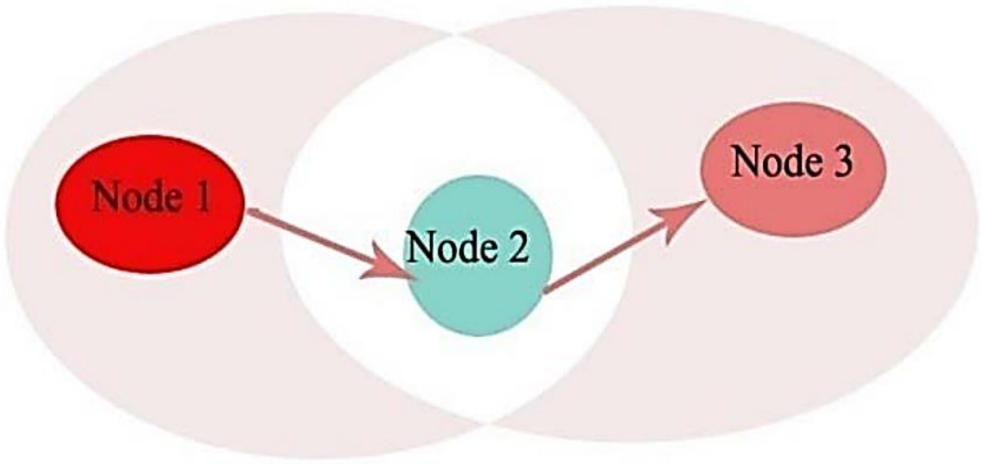

Figure 2.18.Example of a simple Ad hoc network with three participating nodes

CHAPTER 3

METHODOLOGY AND MATERIALS

Table 3.1 Information of Device

MATERIALS	INFORMATION
COMPUTER DEVICE	LAPTOP DELL
DEVICE GENERATION	8^{TH} GEN
RANDOM-ACCESS MEMORY (RAM)	8 GB
PROCESSOR TYPE	INTEL® CORE ™ i7-8750H
PROCESSOR SPEED	2.20 GHz / 2.21 GHz
SYSTEM TYPE	64-bit O.S X64 BASED PROCESSOR (WINDOWS 10)

3.1 CASE STUDY

Chordal ring topology involves the interconnection of the nodes within the ring so that each node can communicate with the main ring connection as well as with the chordal connection. A chordal ring network is generally used in wire connection to link far nodes located in far geographical regions. This type of network has been widely used over optical networks for addressing problems like fiber cuts. However, the optical network is outperformed to provide a high data rate and reliability in transmission [22].

Propagating optical networks in large projects such as networks in urban cities may solve a lot of problems related to bandwidth. To establish an optical network, several factors are required to cooperate. Infrastructure related to the civil work and construction that is needed for housing the fiber cables. The cost of implementing an optical network might go double as compared to a wireless network if the network infrastructure does not exist [23].

Wireless broadband and optical networks have been the subject of intense study for a long time. Natural impediments make it difficult to deploy the optical network in certain regions, such as agriculture. Furthermore, optical or any wired network is prone to cutting, necessitating far more maintenance than a standard network. In this proposal, a wireless broadband network is presented as an alternative to the traditional optical network [24].

The creation of a fixed wireless broadband network might help to solve the data rate issue and create a network that is simple to use and not hampered by natural obstacles like trees or mountains. A chordal ring network architecture is recommended for smooth wireless broadband network operation. For example, rain and humidity have a direct influence on wireless data rate and speed. As a result, the proposed chordal ring broadband wireless network is projected to address these difficulties while maintaining network stability. The chordal wireless ring was designed to reduce network congestion and compensate for bandwidth limitations [25].

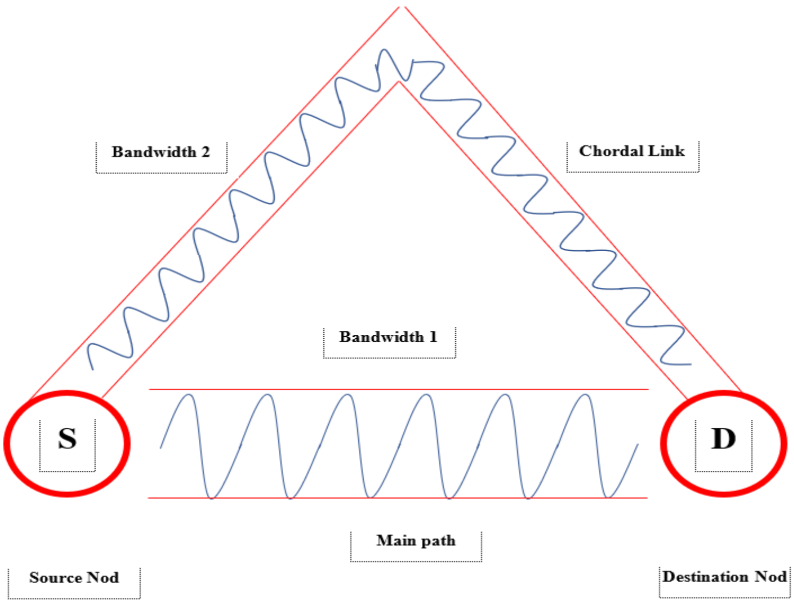

Figure 3.1.Chordal ring model transmission style.

3.2 NETWORK TOPOLOGY

Networks are developed further to involve many hosts and to provide big computational services. The local area network is a small, scaled network that attends a good performance in connecting hosts computers. The local area network can be extended to cover a complete building. The performance of local area networks as in (Figure 3.2, and Figure 3.3) depends on the routing mechanism as well as the medium of transmission. Generally, it permits good data rates as well as low transmission delay [26].

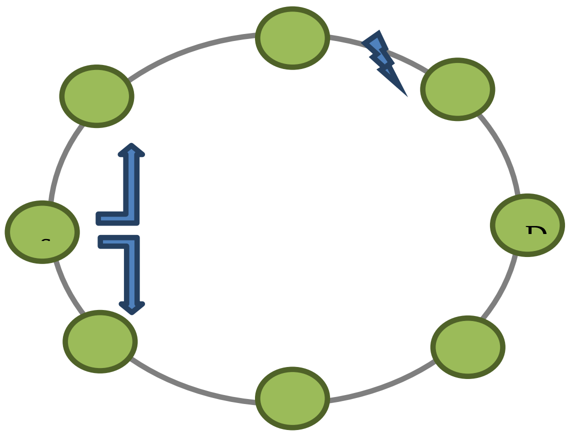

Figure 3.2.Ring topology bi-directional transmission.

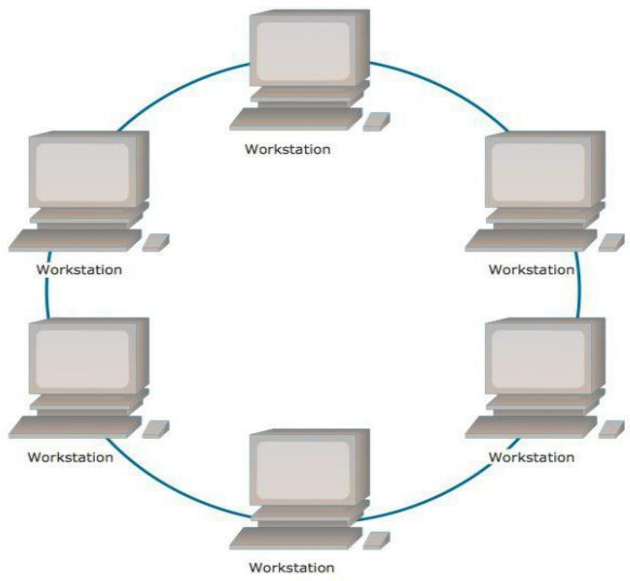

Figure 3.3.Local area network topology.

On the other hand, the network can be extended to cover big compounds and even cover cities, in that new network topology is established which is called a wide area network. This type of network is usually used as a backbone network that connects different locations within the city. Where inside each location a local area network might be operative. Figure 3.4 demonstrates the wide-area network structure. Other breeds of the networks are also popular such as wireless local area networks and regional local area networks. Such types of networks are being used for serving demands such as wireless-based applications. Examples of those networks can be the WIFI and ground television broadcasting which are considered applications of wireless local area networks and regional area networks respectively [27].

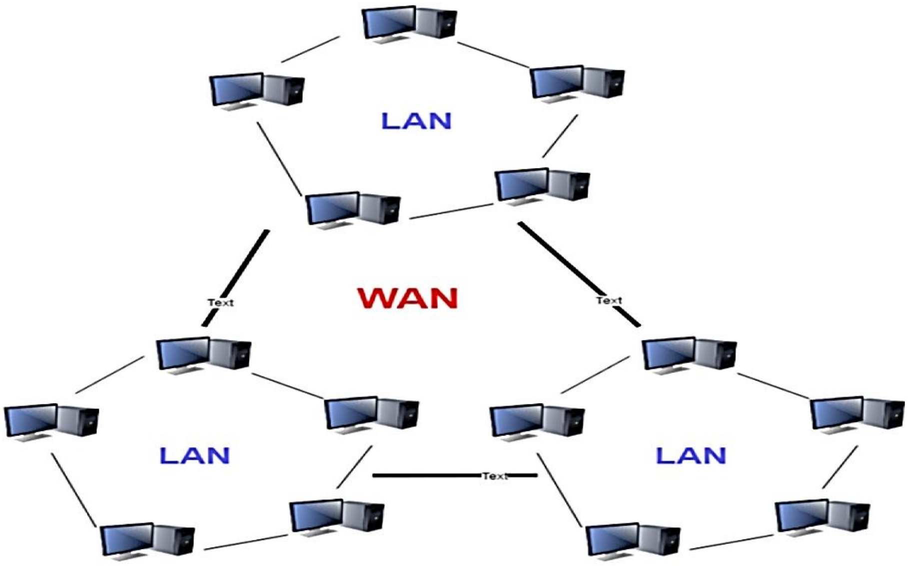

Figure 3.4.Wide area network structure.

During the internet development, the necessity of a wired network is not preserved as it was in the past. A new type of network (e.g., cloud network) has been established to pride services throughout the internet without the need for physical connectivity. Cloud-based computing has grabbed the interest of individual developers as well as organizations and industries. Since the cost and the efficiency are the main key players in the network context. Some computing services such as office and design programs are not easily available for individuals due to the license price of the software. Some software is demanding large storage space with high RAM power which is not available on all computers. However, cloud computing has paved the road for easing all these challenges by providing all those services one could and can be accessed using the internet. Cloud services can be illustrated in Figure 3.5 [28].

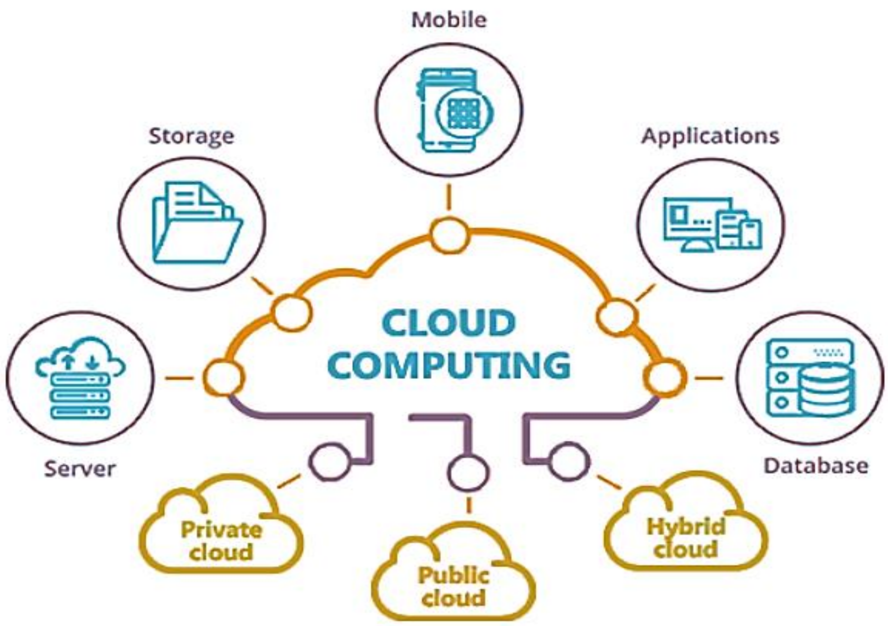

Figure 3.5.Cloud computing-based network services.

3.3 WiMAX TECHNOLOGY

WiMAX is worldwide interoperability for microwave access. This technology provides wireless broadband services to both mobile and fixed users. It was implemented in 2006 by Korea Telecom, which began deploying a 2.3 GHz version of a mobile service in WiMAX called WiBro, to provide high-performance services to Seoul. WiMAX is a not-for-profit organization that includes more than 540 companies in 2008 (service providers, vendors of equipment and chips, and content makers). The main task of WiMAX technology is to ensure interoperability between applications based on the IEEE 802.16 standard, on which the WiMAX air interface is based. The process of allocating flexible frequency bands allows for providing high-speed quality access to the Internet. In this regard, the 2.3 GHz version including (four base stations and four mobile stations) was approved in April 2008 by the WiMAX Forum. Also, in June of the same year, four base stations and six mobile stations were certified by WiMAX for the 2.5 GHz version, which included more advanced features [29].

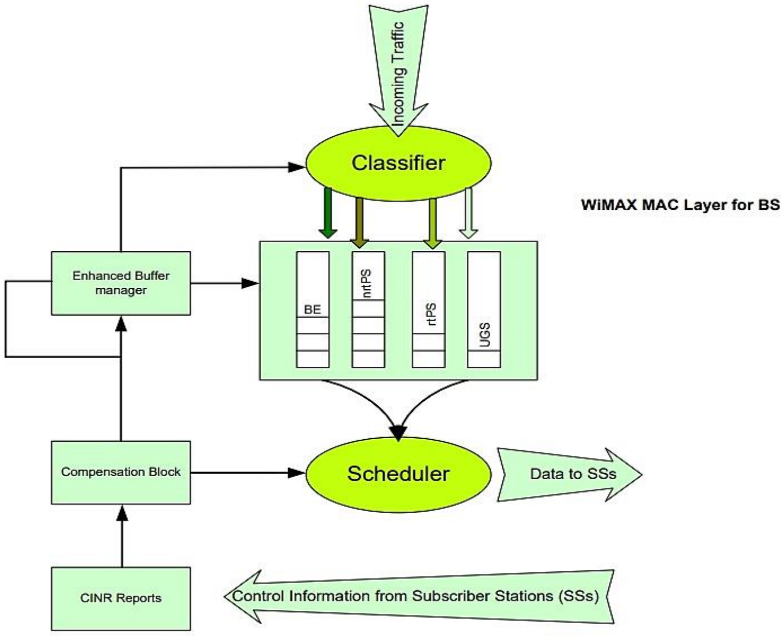

Figure 3.6.WiMAX BS Architecture

3.3.1 IEEE 802.16

WiMAX "Worldwide Interoperability for Microwave Access" is the popular network infrastructure of the broadband access wireless network standard referred to as an electrical and electronics engineering institute IEEE802.16. This standard has been developed to produce a wireless network model with mac and multiple physical layers. It can deliver a data rate between 40 mega bites per second to one Giga bite per second. WiMAX network is compatible with both time and frequency multiplexing, making it the best for applications demanding high throughput and short time delay [30].

This technology is used in the broadband access network and is termed last-mile technology; it provides a high-speed service with immediate availability in the designated coverage area. The network-based solution can be implemented rapidly (quicker) than the wired network, it also provides the required speed at a reasonable cost. A network using a WiMAX connection can accommodate hundreds of users and ensures a speed like that in a broadband network [31].

Taking into accordant broadband speed is not expected from a wireless channel, WiMAX has tackled this drawback. Broadband speed could now offer by the wireless network within 30 miles of the coverage area using the WiMAX technology. This network model is consisting of a base station covering a large geographical area. It can provide services for any receiver (individual user or company) within 8000 square kilometers, which tackled the problems of handoff where network designers may not think a lot of handoff issues as the users may enjoy uninterrupted services across a large geographical area [32].

Services can be received from the network base station using an individual receiving tower. The advanced network standard had come with more ease in terms of service receiving, the developed small chip can be integrated into the host computers directly. A microchip is implemented over the PCMCIA card (Figure 3.7). Personal Computer Memory Card International Association" PCMCIA has developed this card with efforts of producing small and portable electronics receivers of the different networks that to be implemented easily with any terminal computer as well as mobile handsets [33].

Figure 3.7.Network chip that supports WiMAX network.

3.3.2 WiMAX Network Architecture

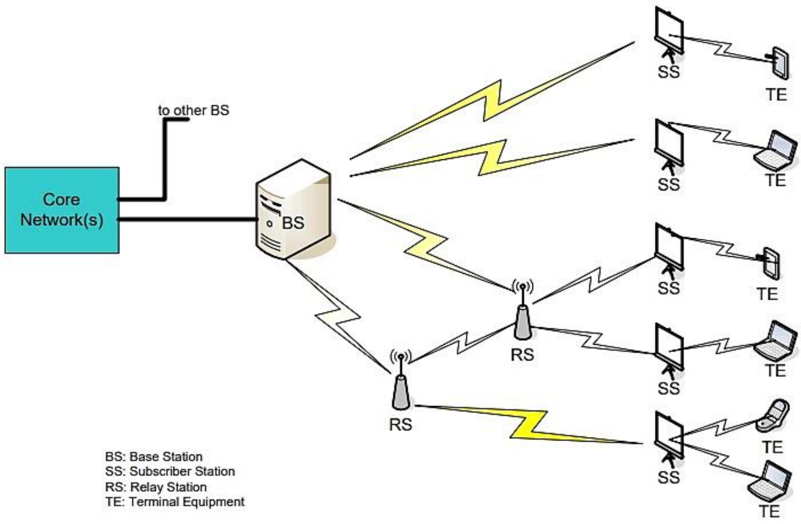

Figure 3.8.IEEE 802.16 network architecture (WiMAX)

First: The structure of WiMAX technology consists of two types of base stations:

1- The subscriber station (SS) is used in local buildings, whether in residential or commercial buildings.
2- The base station (BS) provides the connection to the public network and provides the connection to the (SS) in the networks.

There are two ways of communication between (SS and BS):

- Uplink (SS to BS).
- Downlink (BS to SS).

Second: WiMAX layer structure:

1- Physical layer: This layer performs the functions (transmitting and receiving data, encoding, and decoding signals, and generating and removing preamble).

The physical layer supports the following multiplexing technologies:

- OFDM: Orthogonal Frequency Division Multiplexing
- TDM: Time Division Multiplexing
- FDM: Frequency Division Multiplexing

- SDM: Space Division Multiplexing
- QPSK: Quadrature phase shift key

2- The data control layer performs access control functions:

- During data transmission, it detects errors and addresses and collects data within frames.
- While receiving the data, it detects errors, recognizes the address, and decodes the tires.
- Organizing the access process via wireless channels.

3- Data link layer: It performs several functions:

- The upper layer frame (PDU) is encapsulated within the original 802.16 MAC/PHY frames.
- Set upper layer addresses to 802.16 addresses.
- Coordination of QoS at higher layers with MAC 802.16.
- Time management according to the traffic in the upper layer is equivalent to the MAC service.

The WiMAX MAC physical layer supports per-channel broadband, provides point-to-multipoint (P2MP), supports sequential traffic, and provides support for (ATM, Ethernet, 802.1Q, IPv4, and IPv6). This layer provides packet fragmentation and sublayer merging, as well as features for authentication, key exchange, security, and encryption in the sublayer.

The network standard is demonstrated in (Figure 3.9), WiMAX model is consisting of three main layers namely, the link control layer, the data link layer, and the physical layer. It is responsible to receive the data and tackling the challenges of the physical channel such as noise and other interferences. The topmost layer is responsible to maintain the live connection and aborting it whenever that is required e.g., on the existence of high congestion, lack of radio recourse, large waiting delay for the acknowledgment, etc. [34].

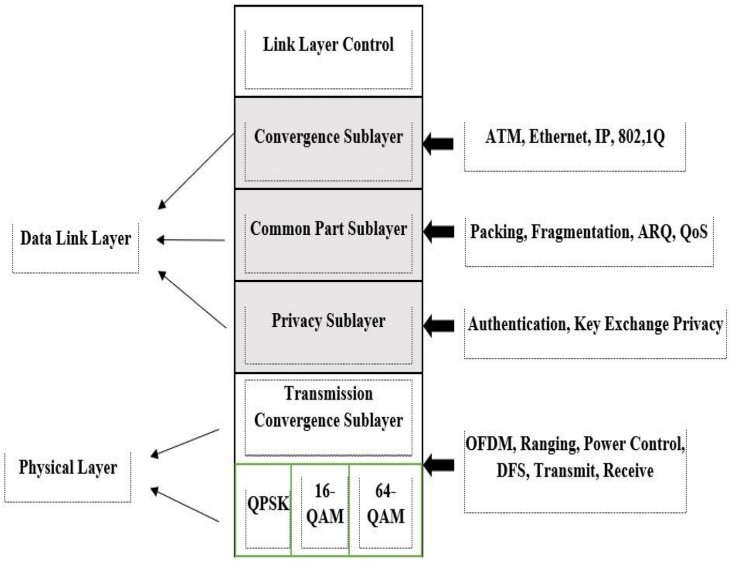

Figure 3.9.IEEE 802.16 stack structure.

3.4 ROUTING PROTOCOLS

When establishing any wireless network, a set of considerations must be considered, such as the routing protocols that are used, as these protocols must have the best performance in terms of time delay, speed, security, and throughput.

The transmission of data packets between nodes within a network is governed by the so-called routing protocols. It is a set of software that controls the flow of packets from the sender node until it is successfully delivered to the receiving node. Packages created in the source nodes are always named with unique identification numbers as well as unique pointers called tags. The routing mechanism considers several parameters that are vital for successful packet delivery to destinations. Path congestion and the shortest path are the most important metrics analyzed by routing protocols. When the shortest path (least loss path) is detected, the routing protocol may start a routing table consisting of several fields, all related to the organization of sending packets and recording packets into three groups namely: the suspended packet, the transmitted packet, and the packet with acknowledgment.

This study presented the design of a wireless network based on the ring topology. The topology of the three-degree and five-degree chord ring. The routing protocols (AODV and Destination Serial Distance Vector (DSDV)) were used, using the NS2 network simulator [35].

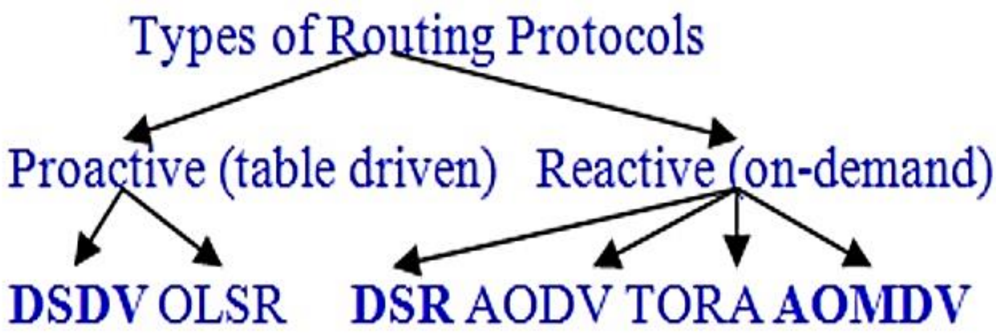

Figure 3.10.Types of Routing Protocols

3.4.1 AODV Protocol

The on-demand distance vector routing protocol supports the WiMAX network, one of the most popular networks of its kind. Thus, this routing protocol can outperform those networks that do not care about security matters. AODV protocol improves the performance of the DSDV protocol. Each node in the network has a table that contains special information for the routing of the sent packets, and at the same time, it does not keep all the routes of the routing nodes in the network [36]. (Figure 3.11) shows operations in AODV Protocol, and the mechanism of this protocol can be summarized in the following points:

- If node R is willing to communicate with node S, node R will firstly broadcast a Hello message which can be reached to all the nodes in the network. The targeted node is supposed to receive this request and reply with an availability back message to the sending node intimating it that receiving data is possible at this time and requesting it to share the first packet block (Figure 3.11).

- The Hello message is said to be received by all the nodes in the network and hence, any of the nodes might reply to the sender. Hello, the message includes abstracting information such that node R is willing to begin a transmission session with node S. So, to say, the Hello message has information about the node name and does not have any idea about the MAC address of the node so any node in the network may rely back upon it.

- Upon receiving the Hello message, the nodes in the network are supposed to have a complete idea about their location, which means nodes that intermediate the transmission are expected to replay back with their location so that the source node will be able to recognize the nearest/shortest path and begin the transmission. Ultimately, upon receiving the request of transmission by node S from node R, node S will replay back with a return request called “Read, Repeat, remotely Executable Program” RREQ.

- If the node S is not willing to receive data or not start the session with node R, it might replay back with a return request to tell the node R that node S is not available at this time for starting a session.

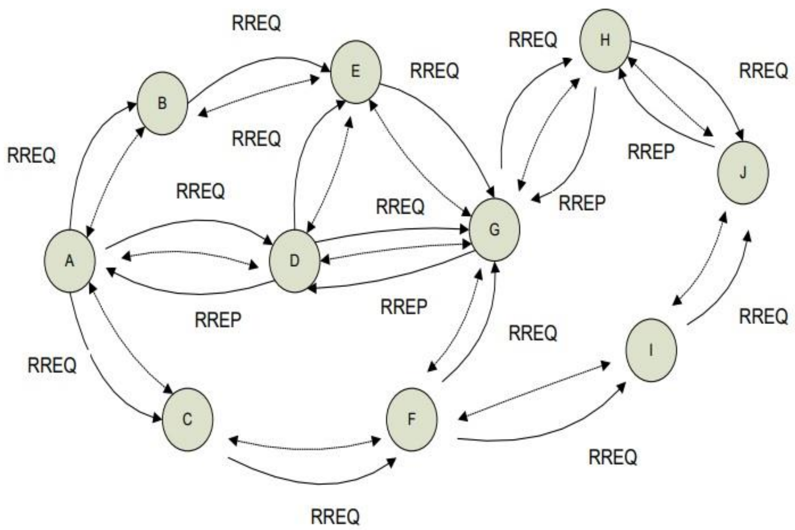

Figure 3.11.Hello message broadcasting in AODV transmission.

3.4.2 DSDV Protocol

It was declared that the transmission of packets within the network nodes (stations) is being controlled with routing tables that are integrated with each node and worked user the surveillance of routing protocols. The routing table keeps track of the source nodes and destination node sequence number and location, it also has the number of hops required to deliver packets from each source node to each destination node. A routing protocol is maintaining the reliability of the routing table by updating it periodically. Node paths keep changing from time to time due to variable network conditions such as congestion, demand, and supply of information, so to say, routing table consistency is being periodically maintained with help of routing protocols [37].

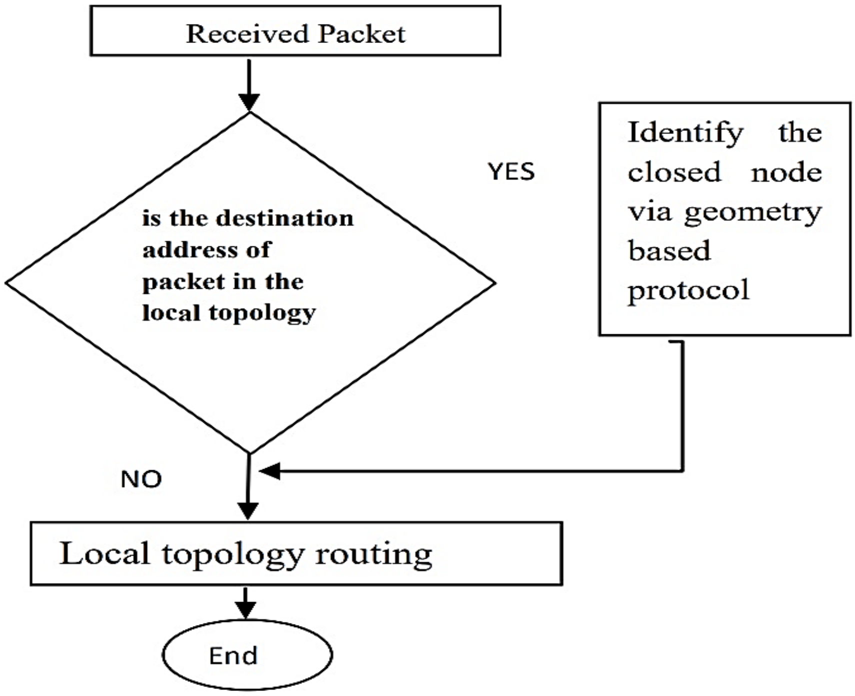

Figure 3.12.Flowchart of DSDV

The distance sequence distance vector routing protocol (DSDV) is used to perform the routing of packets effectively through the proposed network topology. The working mechanism of this routing protocol can be illustrated in the below points.

- nodes participating in the network must declare to reach other the routing status information like the location as well as its neighboring nodes and its complete routing table. The same is to be achieved by broadcasting the information by each node so that the whole network node will get it received.

- nodes should repeat the process of (A) periodically to upgrade the information of the current traffic conditions to the other nodes.

- Taking the same example as in Figure 3.13, if node R is willing to start packet transmission to node S, DSDV will mark the shortest path and will assign an even number to this path in the routing table. If this path is seemed not available, DSDV will assign an odd number for the same path in the routing table and will begin to search for another path.

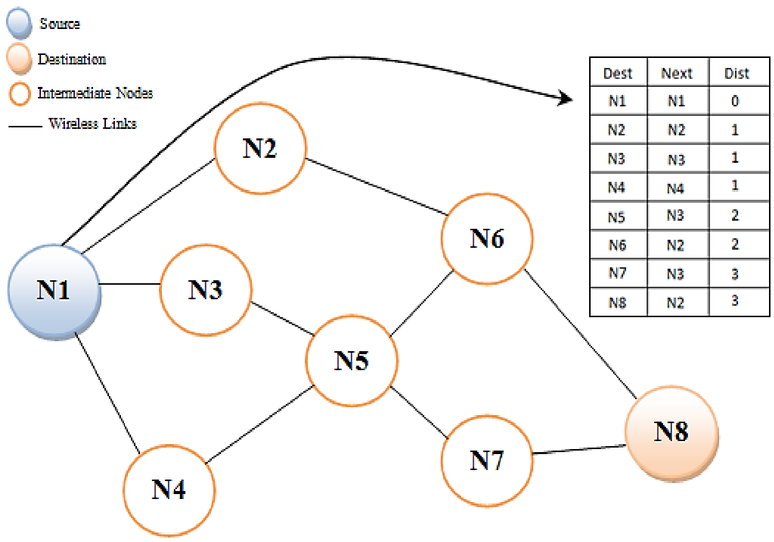

Figure 3.13.DSDV Routing Protocol

3.5 PACKETS NETWORKS

Data transmission in computer networks is controlled under the so-called two-way-hand-shaking. If the transmission between two parties; source nodes and sink nodes, each one of the source nodes is willing to send its payload into the sink node. In packet networks, the payload from each node is broken up into a set of smaller blocks called packets as depicted in (Figure 3.14). To propagate packets throughout the nodes, it is required to be assigned to some information such as source address, destination address, packet sequence number, acknowledgment number, and mac number. The mentioned information is integrated into each packet header and used as the legend for the packet's voyage from the source node into the sink node [38].

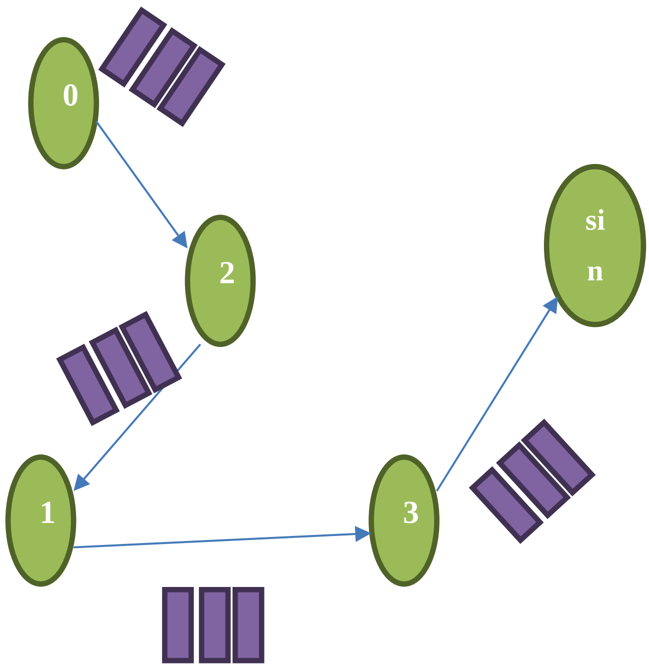

Figure 3.14.Structure of packets network (transmission overview).

Packets train from the node (0) is heading towards node (sink) through the path (0-2-1-3-sink). (Figure 3.15) demonstrates the headers in each packet overhead. However, the information mentioned in the above section e.g., source address, destination address, packet sequence number, acknowledgment address, and mac number are used for directing data packets between the nodes. The allotment of the header's information is performed by the routing protocol, and the amount of data at the packet's overhead is one of the performance-limiting factors. Adding more information in the header will lead to an increase in the payload of the packet and hence will cause a noticeable delay.

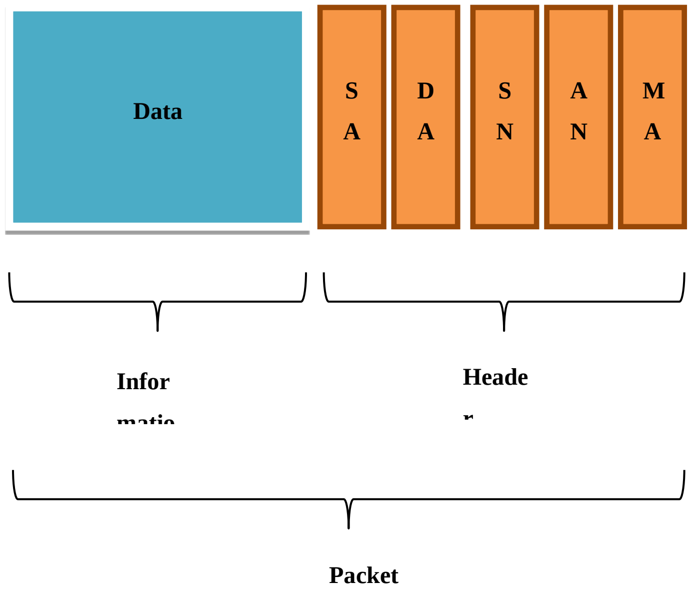

Figure 3.15.Packets frame structure including the headers and payload.

The header may involve information that helps to prevent malicious attacks in the network. MAC address is an important field in the header which involves the mac protocol unique address of each node which cannot be faked by the malicious nodes. The other fields such as sequence number (SA) and acknowledgment number are used by the routing table which is formed in each node by the routing protocol. It is also linked with the two-way-hand-shaking process that ensures the packets are delivered without a drop [39].

3.6 CHANNEL MODELING

3.6.1 Channel Overview

Transmission of information through the communication network required a medium of transmission to hold the data from one point to another point within the network. The physical medium in network terminology is referred to as a channel. Data voyage through the channel may account for several performance degradations such as additive white Gaussian noise, fading effect, and doppler effects. Depending on the channel specifications (e.g., bandwidth) and type (wired or wireless), communication systems are being established.

Channels are being modeled as a random process where the anticipation of noise level as well as other performance degradations is governed by the probability rules. In mobile communication; as the user moves from the base station, the signal may start facing a doppler impact (Figure 3.16). On the other hand, fading is another phenomenon taking place. The presence of physical and natural objects (obstacles) in the vicinity of the communication channel trigger multipath propagation. Signal (transmitted) is getting reflected by the nearby objects and hence, multiple copies of the original signal reach the receiver end as in (Figure 3.17). [40].

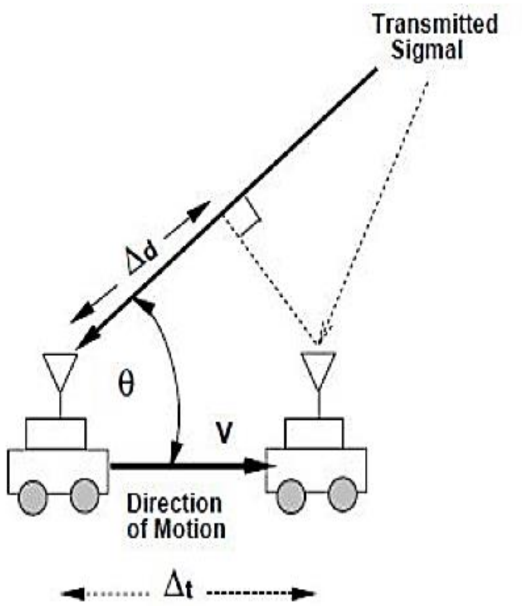

Figure 3.16.Doppler impact in wireless communication.

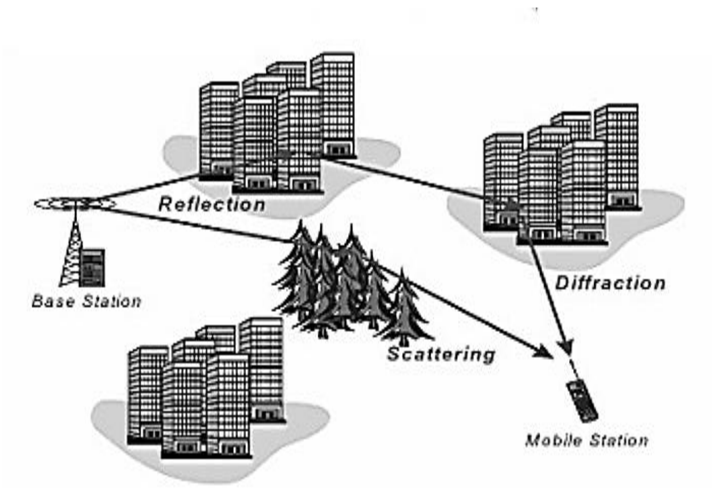

Figure 3.17.Diversity in communication channels.

In the wire network context, the channel is formed by propagating a physical wire. Depending on the network bandwidth specifications, the wireline can be changed between (coaxial cable, broadband cable (twisted pairs cable), and optical cable (Figure 3.18). Those three types of cables are differed by their wavelength as well as the bandwidth. The twisted pair is providing bigger bandwidth than the coaxial cable while the optical cable has the topmost data rate and bandwidth over all available channels. In wireless communication e.g., mobile communication, satellite transmission, walkie-talkie, etc. channel is subdivided into two bands, uplink, and downlink (Figure 3.19). [41].

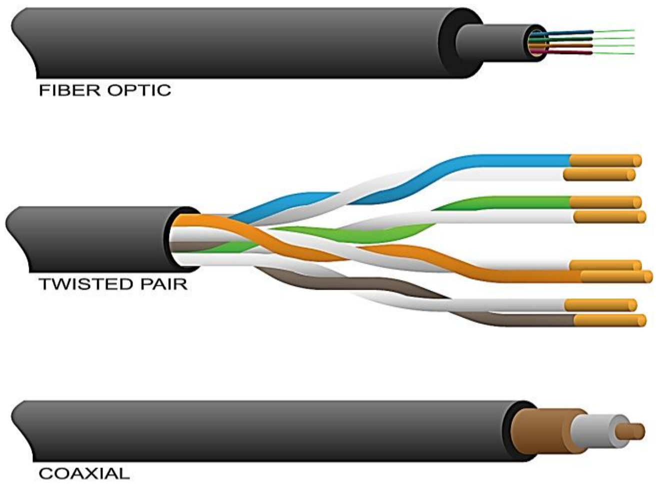

Figure 3.18.Comparison between the wire network cables.

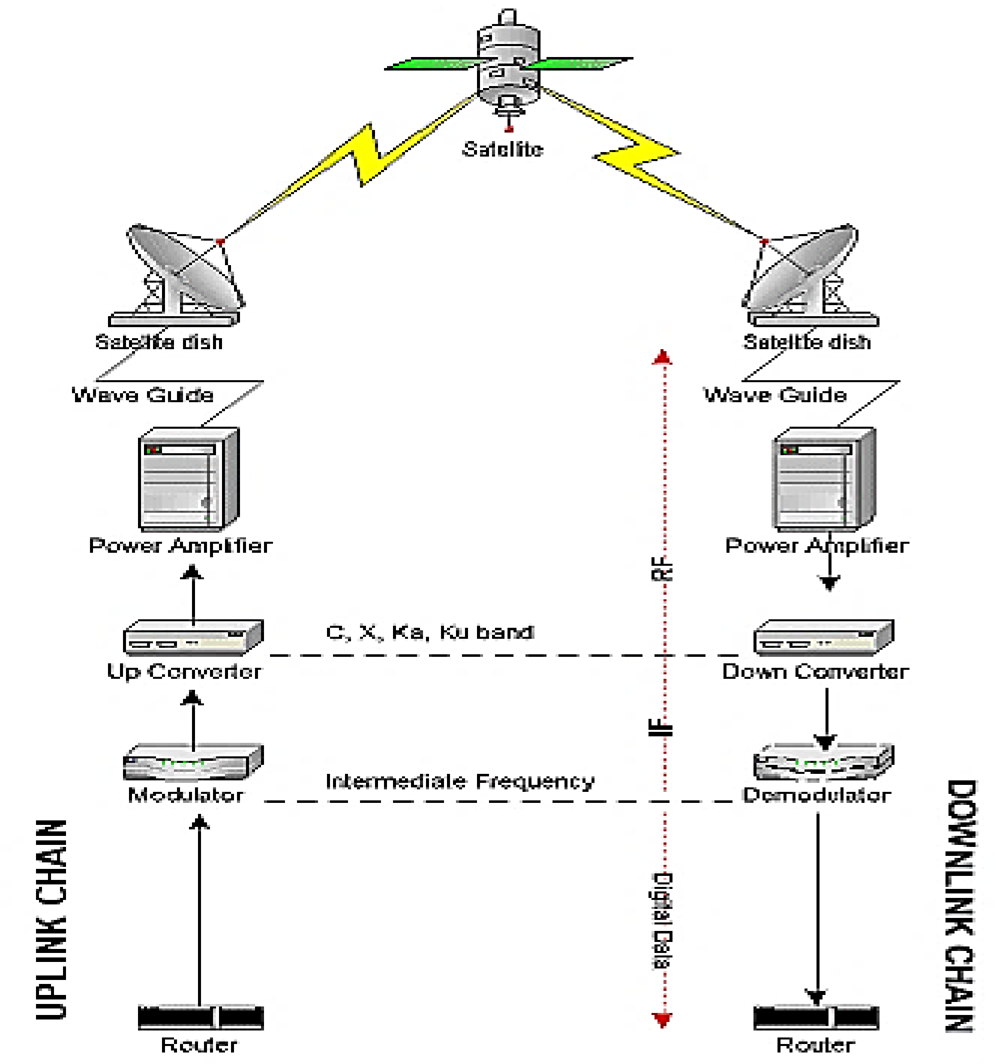

Figure 3.19.Uplink and downlink in wireless networks.

3.6.2 Channel Allocation

The expansion of technological applications due to internet development has triggered the so-call band's congestion. New applications that required new band allotment have been left without bands. All popular communication networks such as mobile communication, satellite communications, etc. are working for frequency bands as stated in (Table 3.2). if new technology arrived, it may be facing a band-reject. Naturally, the licensed bands are allocated for applications (licensed users) and cannot permit unlicensed user transmission. Technology is addressing unlicensed users' problems by promoting the so-call band utilization approach [42].

Table 3.2 Standards of the definition of radio spectrum

Name	Frequency Range	Applications
Low Frequency (LF)	30 to 300 kHz	Navigation, time standards
Medium Frequency (MF)	300 kHz to MHz	Aircraft, AM broadcast
High Frequency (HF)	3 to 30 MHz	Mobile radio, short wave broadcasting
Very High Frequency (VHF)	30 to 300 MHz	Land mobile, FM\TV broadcast
Ultra-High Frequency (UHF)	300 MHz to 3 GHz	Wireless LAN, PAN, radio mobile, cellular phone
Super High Frequency (SHF)	3 GHz to 30 GHz	Satellite radar, WLAN, backhaul, 5G cellular, TV
Extremely High Frequency (EHF)	30 to 300 GHz	Satellite radar, WLAN, backhaul, 5G cellular, experimental

This approach is attempting to sense the licensed band periodically and check for any empty (free) slot in the band. Upon finding a free slot in the band, unlicensed users can be placed on those free slots. One of the existed approaches for doing this task is called a cognitive radio network. This technology is helping to utilize the free bands in the existing licensed band without violating the licensed user activity routine.

3.7 MULTIPLEXING TECHNOLOGIES

One of the fundamental approaches to allowing multiple users to access the same bandwidth without collision is multiplexing technologies. It is varying into three trends: time, frequency, and space multiplexing. Channels can be divided in time between the users where every user can begin the transmission during the time slots defined by the time-division multiplexing system (Figure 3.20). One of the important features of a time division multiplexing system is allowing the full bandwidth (frequency) to be used by every user [43].

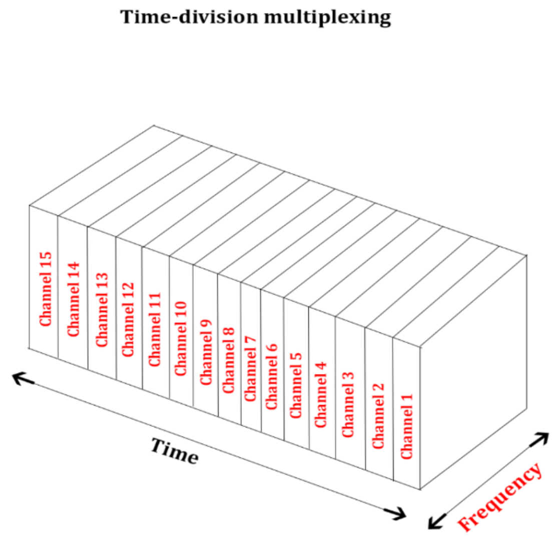

Figure 3.20.Time-division multiplexings.

On the other hand, frequency division multiplexing is another approach proposed for ensuring that each candidate of the spectrum operates full-time. The frequency, in this case, is to be a compromise between the candidates. The frequency of the channel is to be divided amongst the users so that each user will use a smaller slow bandwidth all the time for data transmission (Figure 3.21) [44].

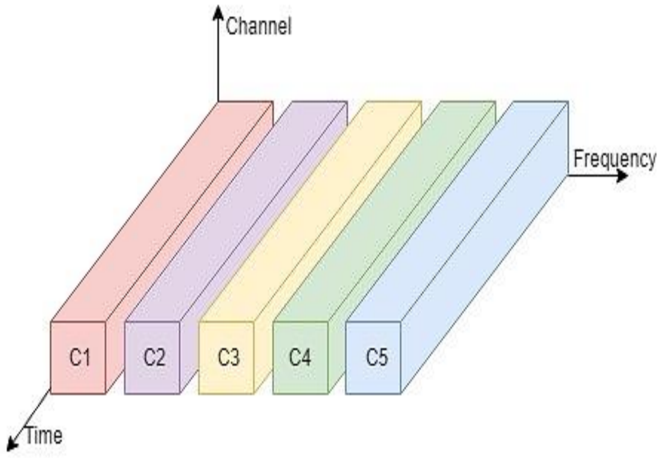

Figure 3.21.Frequency division multiplexing.

One other approach that was proposed for allowing multiple users band occupancy is called space multiplexing and can be interpreted as a hybrid multiplexing approach that adds both time and frequency constraints are applied. Space division multiplexing permits different bandwidths to operate at different times, granting the advantages of time-division multiplexing and frequency division multiplexing to each candidate in the spectrum (Figure 3.22) [45].

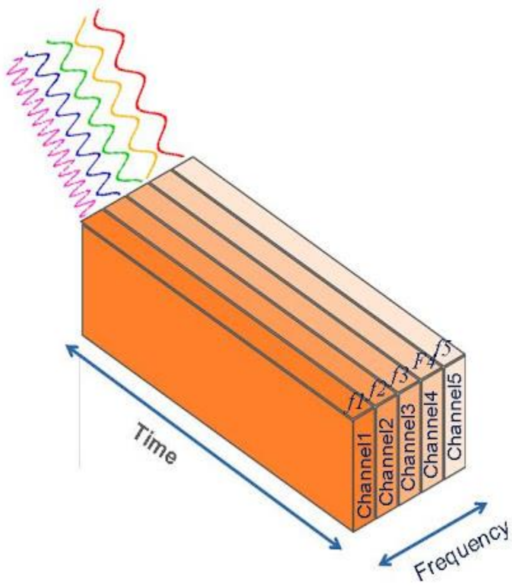

Figure 3.22.Space division multiplexing.

CHAPTER 4

EMPIRICAL MODEL

4.1 MODEL FABRICATION

The Chordal Ring Architecture is suggested as the WiMAX underlying network architecture, although the model was constructed using different routing technologies like AODV and DSDV. Ten nodes and Network Simulator II (NS2) were used to develop the model, each of which is a participant in a 120-kilometer-radius ring topology. The third and fifth chordal ring degrees are most likely being used. By changing the topology degree and routing protocol, the model is put to the test. In each circumstance, the following performance metrics are utilized to determine the outcomes:

- The number of transmitted packets reflects the total number of packets transported over the network from the source node to the destination nodes (Tx packets) across each link.
- Received packets (Rx packets): The total number of packets received by network destination nodes from the source node is shown in this statistic across each link.
- PDR percent (Packet Delivery Rate Percentage): the total number of packets delivered by all network nodes.
- Total packet loss (DP): The total loss of packets lost between the source and destination nodes for each link.
- Average queuing delay (AQD): the amount of time it takes for a packet to transit from the source to the destination node, measured in seconds after the destination node confirms, for all links.

4.2 RESULTS AND DISCUSSION

Table 4.1 Simulation Environment (parameters)

Parameter	Value
Simulator	NS-2 (Version 2.35)
Nam version	Nam console v1.15
Environment (NS2)	Oracle VM VirtualBox (CENT O.S-7)
Channel type	Channel/Wireless channel
Radio-propagation model	Propagation/Two Ray Ground
Network interface type	Phy/Wireless Phy
MAC Type	Mac /802.11
Interface queue Type	Queue/Drop Tail/PriQueue
Link-Layer Type	LL
Antenna	Antenna/Omni Antenna
Maximum packet in ifq	50
Area	The radius of the Ring is 120 Km
Number of nodes	10 Nodes
Simulation Time	20 sec
Routing Protocols used	AODV, DSDV
Packets sent across every link	10000

4.2.1 Standard Ring

(Figure 4.1) depicts a typical ring topology-based IEEE 802.16 (WiMAX) network with ten nodes and a diameter of 120 km. The transmission will start at node ZERO, transit across all nodes, and end at node ZERO. Each ring node will wirelessly send its payload to the next node in the ring and succeeding nodes will do the same.

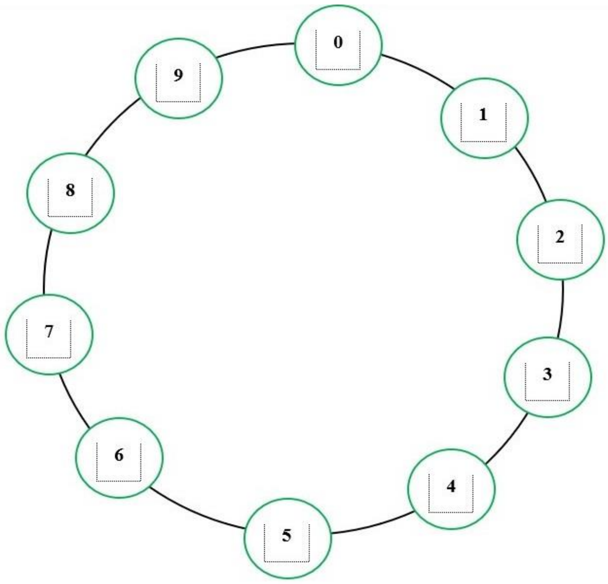

Figure 4.1.Ring topology (plain) without chords (first model).

Two different protocols (AODV and DSDV) were used, and the performance parameters that were mentioned at the beginning of the chapter were applied to measure network performance. The results of the first case appeared in the (Table 4.2 and Table 4.3):

Table 4.2 Results of ADOV Protocol With Ring Topology

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
Ring	10000	5408	0.760619%	4592	2.53423

Table 4.3 Results of DSDV Protocol With Ring Topology

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
Ring	10000	5337	0.750633%	4663	2.77564

In this case, 10,000 packets were sent through the normal ring topology, using both protocols, according to the results that showed that the packets received, and time delay are less in the AODV protocol, which means that the AODV protocol is better than the DSDV protocol in this case.

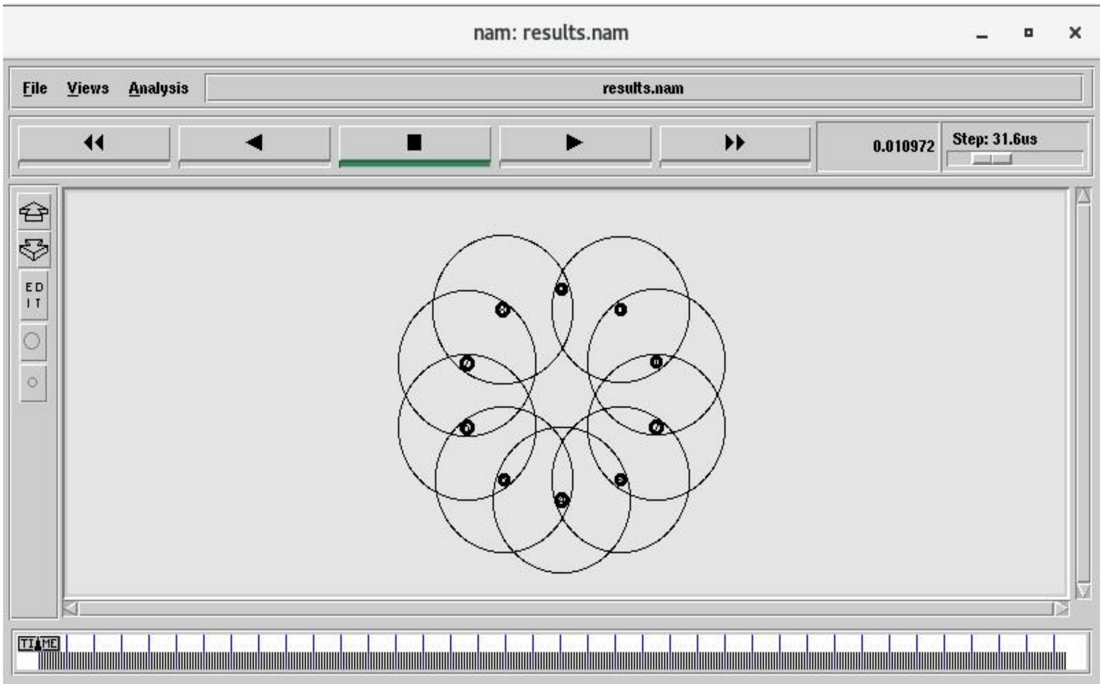

Figure 4.2.Simulation Overview of Ring Topology Chords

4.2.2 First Chordal Ring

The ring topology of the third degree (D=3) is depicted in Figure 4.3. each node (P) is being connected to node P+1 by using a chordal line as shown in Figure 4.3, where each chordal line is a wireless channel with the same bandwidth as the main ring channel. These chordal channels are kept for supporting the main link for tackling the environmental impact on the radio signal (e.g., heavy rain).

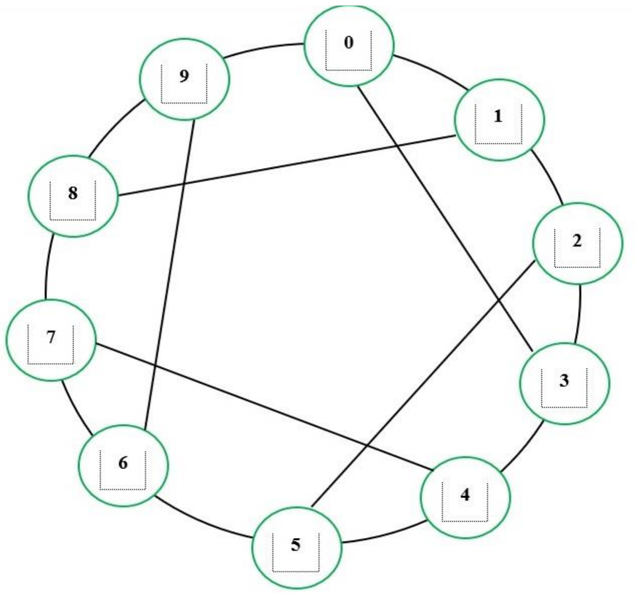

Figure 4.3.Ring Topology With 3rd-Degree Chords.

In this case, 30,000 packets are sent through the chord topology of three degrees spread over three links, and 10,000 packets are sent through each link. After executing performance measures on the model using the protocols (AODV and DSDV), we have gotten the results in the (Table 4.5 and Table 4.6):

Table 4.4 Results of AODV Protocol With Third-Degree

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
D=3	30000	5133	0.240647%	4867	8.09059

Table 4.5 Results of DSDV Protocol With Third-Degree

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
D=3	30000	5332	0.249977%	4668	7.71836

The results show that the DSDV protocol is better than AODV. Low time delay and less packet loss, and higher total packets received.

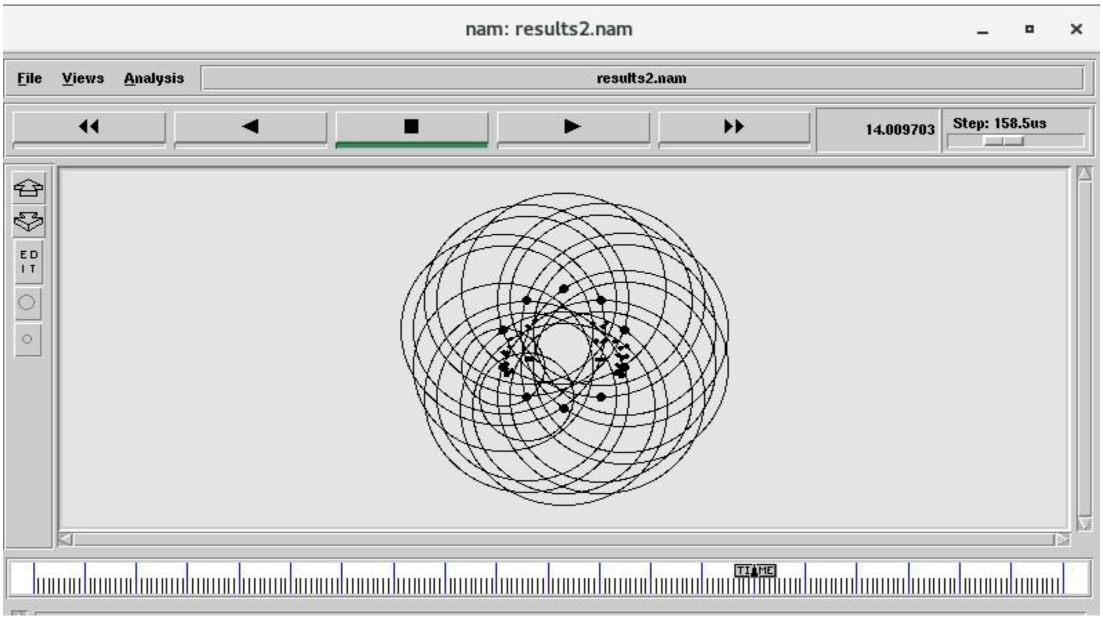

Figure 4.4.Simulation Overview of Ring With D=3 Chordal Topology.

4.2.3 Second Chordal Ring

(Figure 4.5) shows an IEEE 802.16 (WiMAX) network based on the fifth-chords ring of (D = 5) ring topology. Each node (P) is connected to the P+3 node using the chord line as shown in (Figure 4.5), where each chord line is a wireless channel within the network. The transmission process between nodes takes place in the form of links, each link represents a channel that sends packets independently of the other channels.

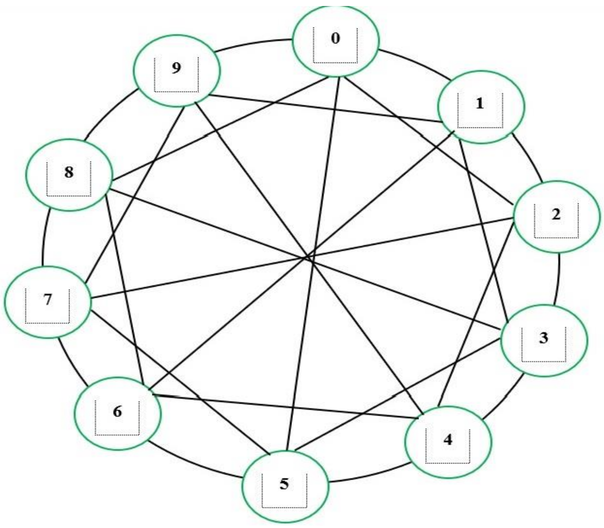

Figure 4.5.Ring Topology With Fifth-Degree Chords.

In this case, 50,000 packets were sent across the network, with each link transmitting a total of 10,000 packets. The network performance was measured, and we got the results in the (Table 4.6 and Table 4.7):

Table 4.6 Results of AODV Protocol With Fifth-Degree

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
D=5	50000	3466	0.0974965%	6534	12.077

Table 4.7 Results of DSDV Protocol With Fifth-Degree

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
D=5	50000	5147	0.144782%	4853	8.50381

The results showed that the DSDV protocol outperformed the AODV protocol. The difference between them is large in terms of time delay, packet loss, and higher in total received packets.

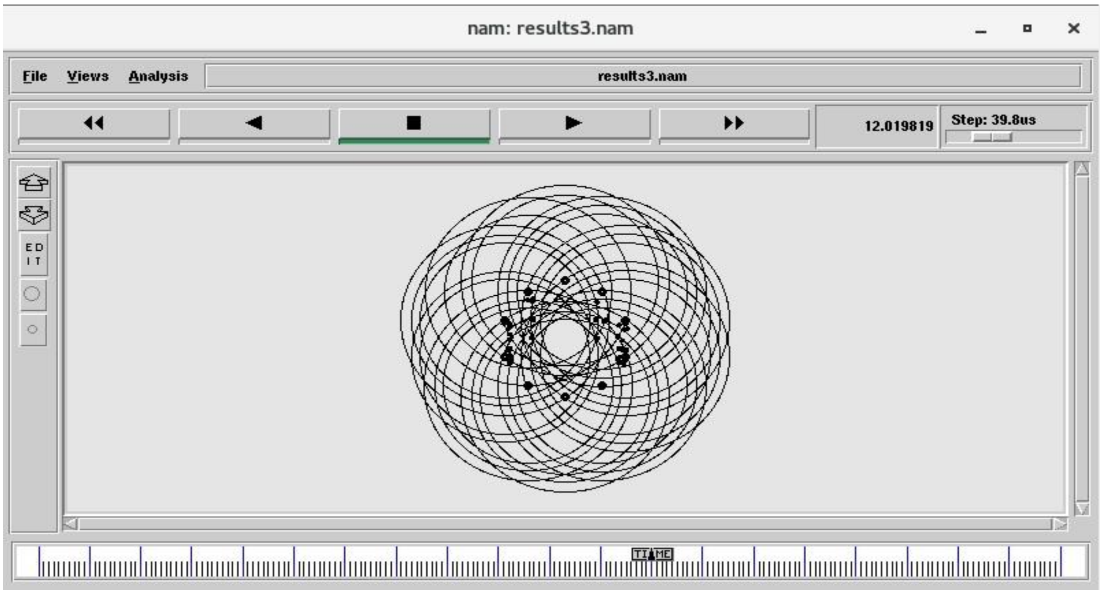

Figure 4.6.Simulation Overview of Ring With D=5 Topology.

Using the parameters from the previous step, three models were generated in network simulator II. Two alternative routing protocols were used to evaluate the simulation models' performance (AODV and DSDV). In terms of network performance, the DSDV protocol surpasses the AODV protocol, according to the findings. The higher the chordal degree, the larger the time delay and missing packet losses, according to statistics. The performance of the recommended models for the AODV and DSDV routing protocols is shown in (Tables 4.8 and Table 4.9), respectively.

Table 4.8 Routing performance of AODV protocol.

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
Ring	10000	5408	0.760619%	4592	2.53423
D=3	30000	5133	0.240647%	4867	8.09059
D=5	50000	3466	0.0974965%	6534	12.077

Table 4.9 Routing performance of DSDV protocol.

Topology	Transmitted packets (Tx)	Received packets (Rx)	Packet Delivery rate (PDR %)	Dropped packets (DP)	AQD
Ring	10000	5337	0.750633%	4663	2.77564
D=3	30000	5332	0.249977%	4668	7.71836
D=5	50000	5147	0.144782%	4853	8.50381

The performance can be graphically demonstrated in Figures 4.7 through 4.11. In Figure 4.7, many transmitted packets in the case of AODV and DSDV routing protocols for each model are given. The figure shows that the maximum number of packets transmitted across the network is realized in the bigger degree (D=5) while the smaller number of the same is being realized with plain ring topology.

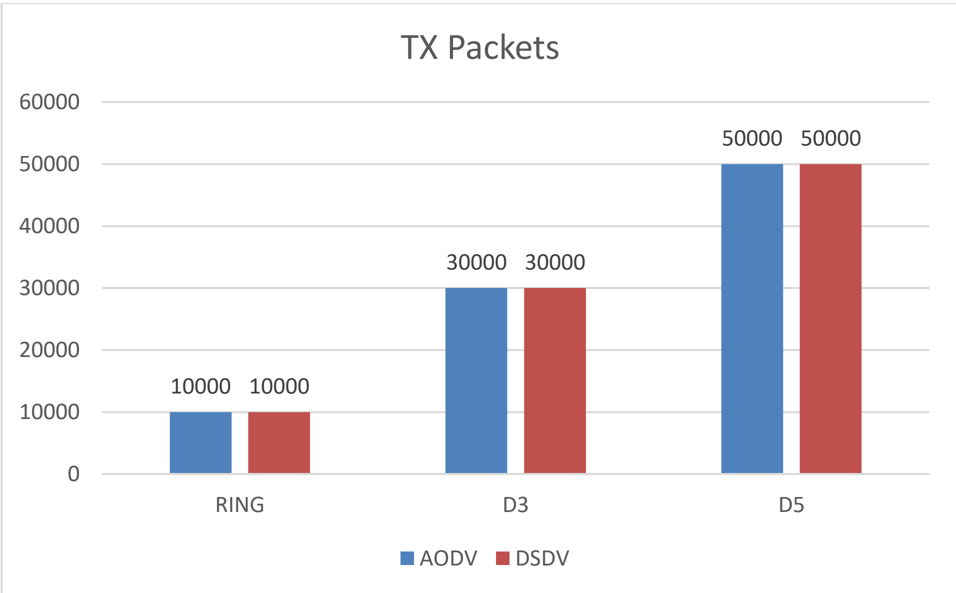

Figure 4.7.Total transmitted packets in both routing protocols.

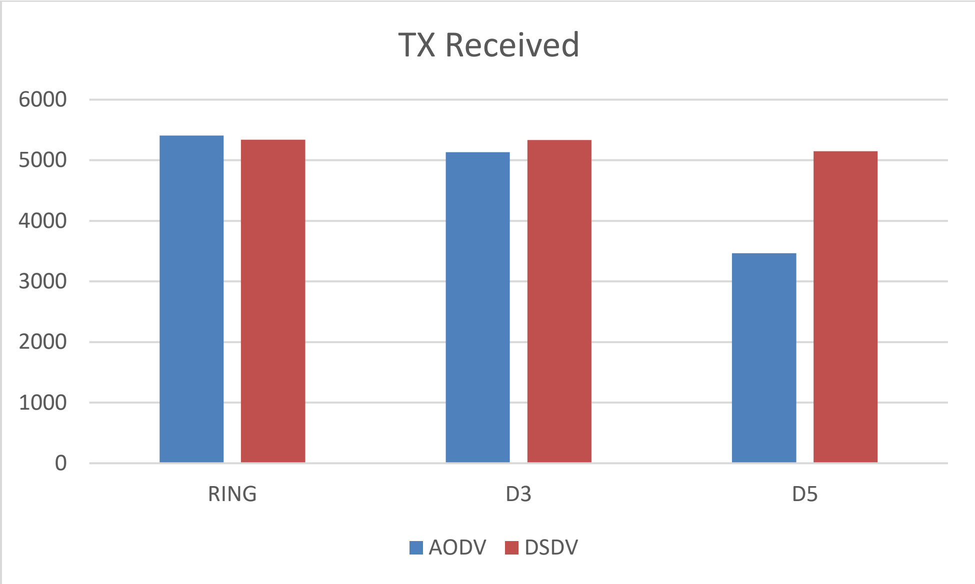

Figure 4.8.Total received packets in both proposed routing protocols.

The number of received packets is shown in Figure 4.8, the number of received packets is decreasing with a more and more chordal degree in the case of AODV protocol while it is increasing by the increment of chordal degree in the case of DSDV protocol.

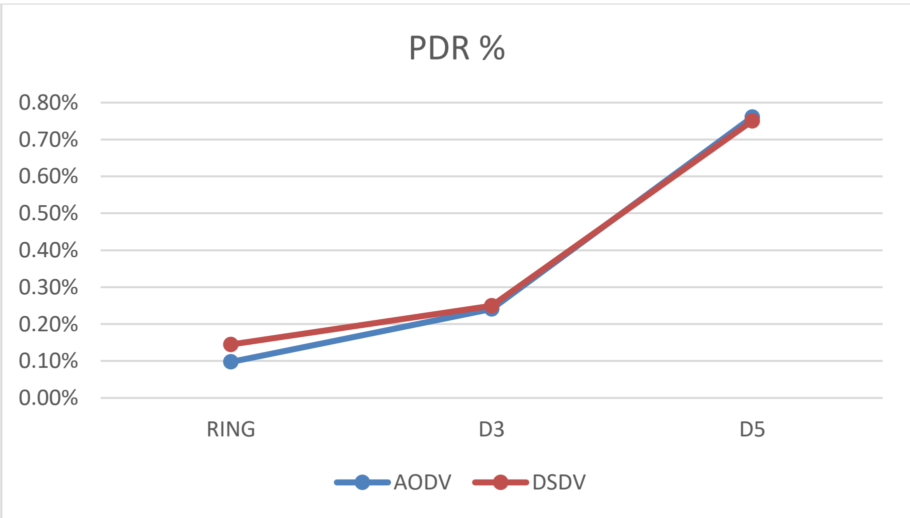

Figure 4.9.Packet delivery rate in both proposed routing protocols.

On the other hand, the packet delivery rate is increasingly increasing the chordal degree in both AODV and DSDV protocols, the DSDV protocol performance is appeared to be enhanced over the AODV protocol as a lesser packet delivery rate is being realized in DSDV as shown in Figure 4.9.

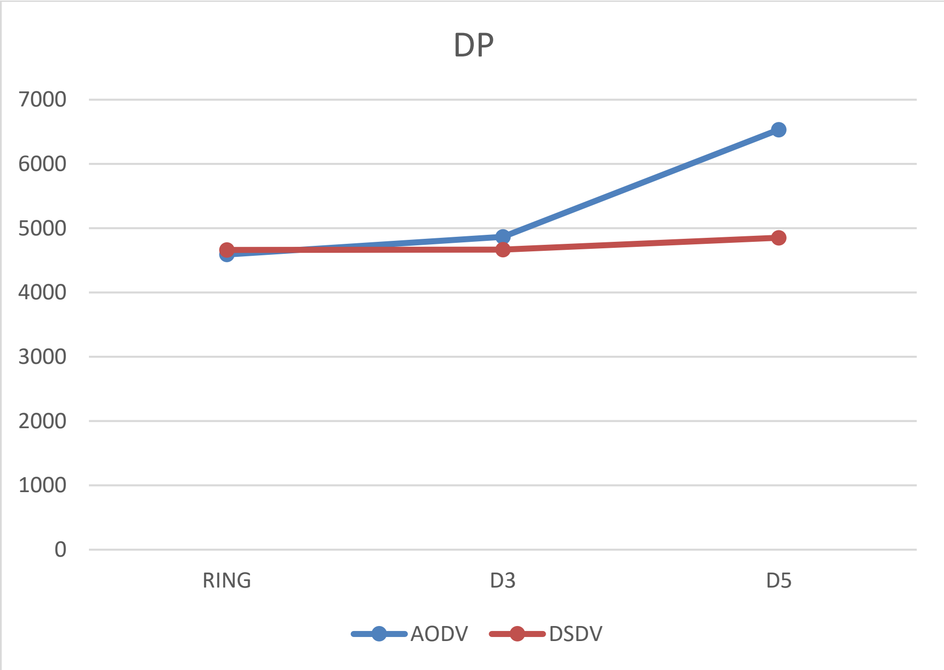

Figure 4.10.Total dropped packets in both proposed routing protocols.

The number of total packets dropped in the network is increasing by increasing the chordal degree in both protocols, DSDV is outperformed over AODV in this regard as shown in Figure 4.10.

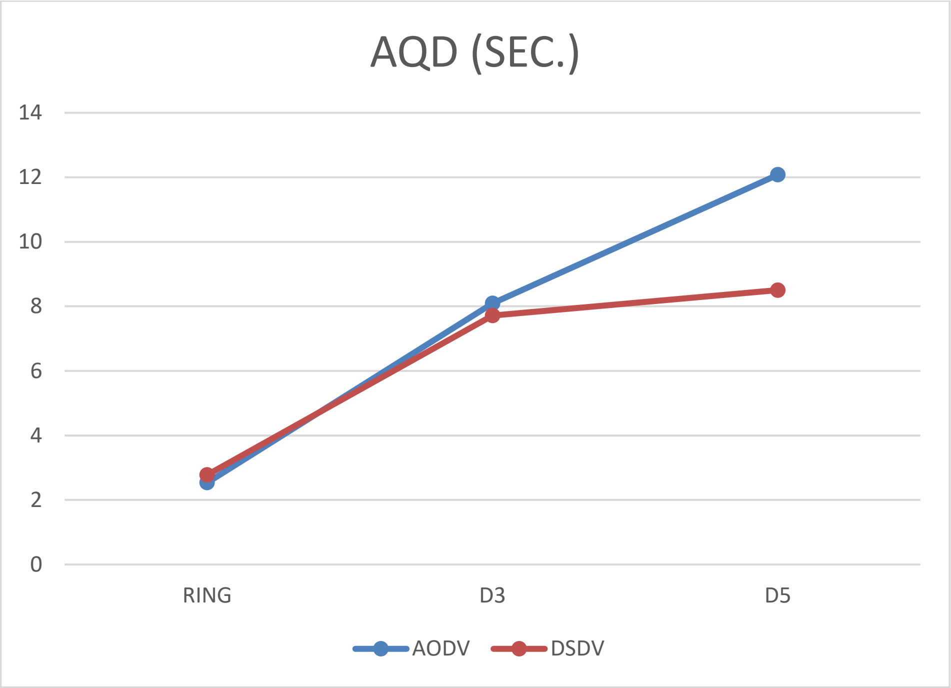

Figure 4.11.Average queuing delays measured for both routing protocols.

The last performance metric is the average time delay that a packet needs to wait in the queue before it reaches the destination. Since the number of transmissions will be increased while more chordal ring exists, the time delay (average queuing delay) is shown longer with increasing the chordal degree. Comparing both proposed routing protocols, DSDV is experiencing the least average queuing delay (Figure 4.11).

CHAPTER 5

CONCLUSION

Wireless broadband and optical networks have been the subject of intense research for a long time. Natural barriers make optical network penetration difficult in some industries, such as agriculture. Furthermore, optical or any wired network is vulnerable to cutting, necessitating significantly more maintenance than a traditional network. In this study, a wireless broadband network is offered as a replacement for the traditional optical network. A fixed wireless broadband network might solve the data rate issue while also offering a network that is easy to use and free of natural impediments such as trees and mountains.

A chordal ring network architecture is described to increase the performance of wireless broadband networks. For example, rain and humidity have a direct influence on wireless data rate and speed. As a result, the proposed chordal ring broadband wireless network is intended to solve these concerns while still maintaining network stability. The chordal wireless ring was designed to relieve network congestion and compensate for capacity limitations. With ten nodes and a diameter of 120 km, IEEE 802.16 (WiMAX) networks of the third and fifth degrees (D=3 and D=5) are built. According to the study, a chordal ring network may need a queuing delay during packet transmission. As the number of chords grows, the line will get longer. Increasing the chordal ring degree, on the other hand, enhances the packet delivery ratio. The DSDV protocol outperforms the AODV protocol by (in the second case = 0.37223 seconds, in the third case = 3.57319 seconds) in terms of average queuing delay.

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RESUME

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