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Benefits of Relay Station to Enhance Network Signal

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ABSTRACT:
This paper describes the benefits of relay station to enhance network signal in rural areas , and the cost/benefits of using the relay , in addition to review the standard activities of IEEE 802.16 in this field . The researchers find many results in this paper , the most important one is that adding the relay station (rs), to the IEEE 802.16 networks, improves many aspects in the WiMAX networks, first one is that it will enhance the capacity of the system, especially in the overlapped areas (such as in the shadow of a large building, indoor, or underground) and that places where the quality of the signal is weak (by supporting spatial reuse).

KEYWORD: Relay Station , IEEE 802.16 , WiMAX , WiFi

INTRODUCTION:

Activity in the WiMAX community continues apace: products are reaching the market, networks are being rolled out and service offerings are in their early stages. The community is an area which continues to innovate in many ways, one of which is the development of new standards to solve open problems [6].
The more interest in wireless broadband communications is a consequence of both rapid growth and the rising importance of wireless communications and multimedia services to end users. In rural areas, broadband wireless access (BWA) represents an economically viable solution to provide last mile access to the Internet, thanks to the easy deployment and low cost of its ”light” architecture. Standard activities for BWA are being developed within IEEE project 802, Working Group 16, often referred to as 802.16. The IEEE 802.16 standard is also known in the trade press as Worldwide Interoperability for Microwave Access (WiMAX) [3].In wireless communications, relay stations are used to relay radio signals between radio stations that cannot directly communicate with each other due to the signal attenuation [1].
Cooperation has recently emerged as a novel networking paradigm that can improve the performance of wireless communication networks at different levels. For instance, in order to mitigate the fading effects of the wireless channel, several nodes or relays can cooperate with a given source node in the transmission of its data to a far away destination [5].
Section 2 is about related work, where section 3 is for (IEEE 802.16 & WiMAX), we discussed the Relay stations in section 4, section 5 depicts the proposed system and section 6 is conclusions.

RELATED WORKS

D. Schultz et al. (2006):
Authors provided a qualitative performance assessment of relay based deployment concepts in comparison to single-hop deployment. The results in this paper prove the general assumption that the deployment of relay nodes (RNs) provides a strong opportunity to reduce the network deployment cost substantially. It is shown how low power RNs have to be applied in cellular scenarios with high power base stations (BSs) and what cost benefits can be expected. The qualitative results show that the low power relays do have the potential to decrease the deployment cost. It is further shown that a parallelization of the relay link between the RNs and the serving BS will help to improve the cost efficiency of the relay based deployment concept.

Kai Dietze et al. (2007):

This paper considered the factors affecting interference and channel capacity in a WiMAX system. As discussed in this manuscript, uplink and downlink interference analysis have to be approached and analyzed differently. System capacity is dependent on the distribution of the users in the service area as well as the type of service that is requested. In systems that employ adaptive modulation such as802.16, capacity is also a function of the C/I ratio since higher modulation orders can achieve higher spectral efficiencies. Channel and, if necessary, sub-channel planning also has an effect on the data rate that can be supported per unit bandwidth.

H. A. Ahmed et al. (2010):

The authors developed an analytical model to obtain the expected number of collisions of OFDMA technique in mobile multi-hop relaying system, In the analytical model, calculation of the expected number of collisions resulting from the simultaneous use of subcarriers in different non-transparent relay stations is done, then for different numbers of interfering RSs, authors obtained the symbol loss probability as a function of the required SNR as well as we calculated the average symbol loss probability in the system, and obtained the proportion of symbol with degraded SNR, moreover the average proportion of symbol with degraded SNR (Signal and Noise Ration) when two service classes (voice and data) are exist is calculated and we showed that the SNR degradation becomes more frequent as more calls arrive to the system. Finally, we showed that the collision rate increases as the number of calls increases.

IEEE 802.16 AND WIMAX

In the mid-1990s, in the United States of America, private operators started offering wireless broadband Internet to their customers based on proprietary technologies. These efforts consolidated into two main technologies, namely Local Multipoint Distribution System (LMDS) and Multi-channel Multipoint Distribution System (MMDS) [3].

Worldwide interoperability for microwave access (WiMAX) based on Institute of Electrical and Electronics Engineering (IEEE) 802.16 standards, enables wireless broadband access anywhere anytime and on virtually any device [4].

In an IEEE 802.16j network, the base station (BS) is the entity that controls the resource allocation in both uplink and downlink to the mobile stations (MSs) [Joint]. IEEE standard 802.16, often referred to as WiMAX, is considered a “last mile” broadband wireless access alternative to conventional DSL and Cable Internet [8].

IEEE 802.16j has the potential to deliver higher capacity networks at lower cost than more conventional single hop wireless access technologies. This is attractive to network operators. Previous literature has shown the capacity gains that can be delivered by the system, but planning approaches for such systems have received little attention [7].

The wireless MAN as defined in IEEE 802.16 provides wireless broadband access anywhere, anytime, and on virtually any device. It is an access technology that promises high data rates and wide coverage at low cost. It also provides mobile broadband access.

To promote compatibility and interoperability between IEEE 802.16-based BWA systems, WiMAX Forum R, an industry-led not-for-prompt consortium, defined WiMAX (Worldwide Interoperability for Microwave Access). WiMAX is a proper subset of IEEE 802.16 standards [3].

WiMAX is an ideal technology for backhaul applications because it eliminates expensive leased line or fiber alternative. It can provide broadband access to locations in worlds rural and developing areas where broadband is currently unavailable [4].

The group of companies supporting the development of the IEEE 802.16 family of standards, commercially known as the WiMAX, is members of the WiMAX Forum [7].

WiMAX has been dubbed "WiFi on Steroids" and "Great Wireless Hope." The terms IEEE 802.16 and WiMAX are used interchangeably in this paper, even though they are not exactly the same as noted above. There are many challenges that need to be overcome for successful deployment of WiMAX networks. WiMAX is considered a disruptive technology as it has the potential to alter the current telecommunication landscape. Also, WiMAX could face competition from 3G technologies such as 3GPP and 3GPP2, and from metropolitan-scale deployments of WiFi networks [3].

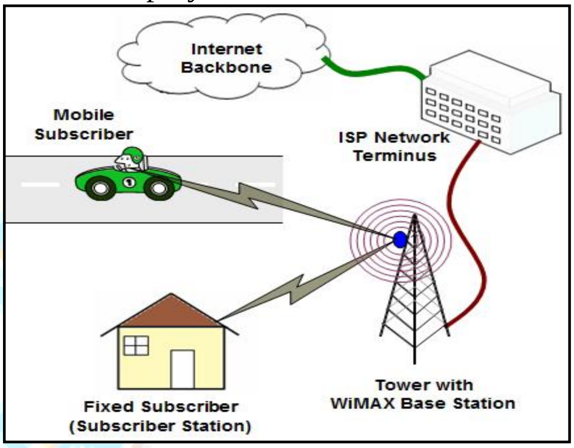

Fig. 1. **Working of WiMAX**

WiMAX is a term coined to describe standard, interoperable implementation of IEEE 802.16 wireless networks in a way similar to Wi-Fi being interoperable of the 802.11 WLAN standards. However, the working of WiMAX is very different from Wi-Fi. The network architecture consists of a base station in the center of the city, with the base station communicating with all the subscribers or access points. Each sector can provide broadband connectivity to dozens of businesses and hundreds of homes. The various parameters of IEEE 802.16 standard in WiMAX are related to the MAC and PHY layers [4].

Now every network has its own features therefore, we will discuss the features of WiMAX:

In table 1, we can see list of the more important features of WiMAX from operation point of view. The 70 Mbps data rate that WiMAX provides could be shared among multiple subscribers. Even though IEEE 802.16 standards allow all frequencies between 1 and 66 GHz, WiMAX standards, to promote compatibility and interoperability between devices manufactured by different vendors, restrict spectrum usage to the the frequency ranges mentioned in table 1. Fixed and mobile access types are same as the ones depicted. In nomadic/portable access, as against fixed and mobile access types, a subscriber can move from one place to another (like a nomad) but his/her WiMAX access will be from one location. That is, a subscriber is associated with a particular base station for each Internet access session, but each Internet access session could be from a different location.

The point-to-multipoint (PMP) operation mode is used for communication between a base station and multiple subscriber stations; point-to-point (PTP) operation mode is used for communication between two base stations (for backhaul purposes). In the mesh mode of operation, subscriber stations connect to each other to form a mesh topology. This is useful when a particular subscriber station is not in the vicinity of a base station (or a relay station) but can reach a base station through another subscriber station.

TABLE I. WIMAX FEATURES

Property	Value
Range	50 km (LOS), 6-8 km (NLOS)
Data Rate	70 Mbps (shared)
Spectrum	2.3 – 2.7 GHz, 3.4– 3.6 GHz, 5.8 GHz
Access Type	Fixed / Mobile
Modes of operations	PMP(point to multipoint), Mesh
Channel size	1.5 MHz to 20 MHz (flexible)
Spectral Efficiency	3.7 (bit/s) Hz (for 802.16 – 2004)

WiMAX is built to support many types of wireless broadband connections including but not limited to the following: high-bandwidth MANs, cellular backhaul, clustered Wi-Fi hotspot backhaul, last-mile broadband, cell phone replacements and other miscellaneous applications such as automatic teller machines (ATMs), vehicular data and voice, security applications and wireless VoIP. Today, wherever available, these applications use expensive, proprietary methods for broadband access figure 2 [3].

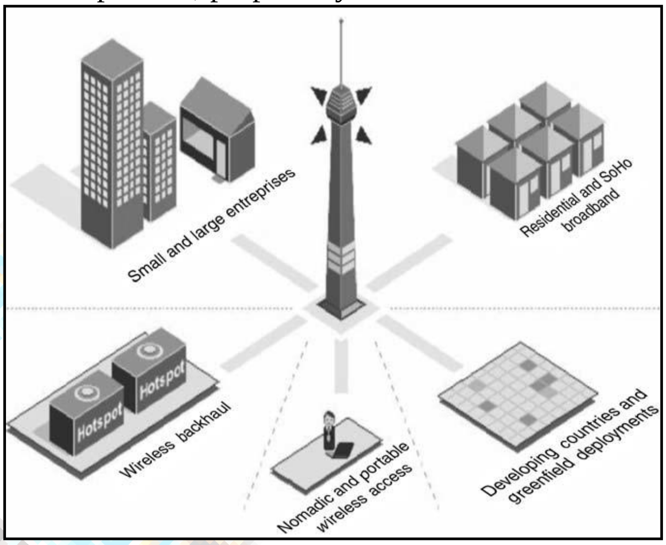

Fig. 2. **WiMAX Applications**

WiMAX was developed to provide low-cost, high-quality, flexible, BWA using certified, compatible and interoperable equipments from multiple vendors. As WiMAX is based on interoperability-tested systems that were built using the IEEE 802.16 standard-based silicon solutions, WiMAX will reduce costs. WiMAX is well placed to address challenges associated with traditional wired access deployment types

SUCH AS:

1. large area coverage access, covering a large area (also referred to as hot zones) around the base station and providing access to 802.16 REV E clients using point-to-multipoint topology;
2. last-mile access, connecting residential or business subscribers to the base station using point-to-multipoint topology;
3. backhaul, connecting aggregate subscriber sites to each other and to base stations across long distances using point-to-point topology.

RELAY STATIONS

Relay station (RS) is an intermediate station that passes data between Base Station (BS) and the Subscriber Station (SS).

The concept of relay originated as an information theoretical scenario in a paper entitled "Capacity theorems for the relay channel" by T Cover and AE Gamal in 1979, they considered a relay channel along with the main channel where a relay acts as a helper node in the transmission of information bits. An upper bound on the capacity of this channel was found. Also the capacity was found in the case of degraded relay channel [3].

One such initiative which is receiving much interest right now is the development of the multi-hop relay standard, 802.16j. This standard is being developed to provide low cost coverage in the initial stages of network deployment and increased capacity when there is higher utilization of the network. A fundamental assumption being made in this work is that the relays can be developed at significantly lower cost than Base Stations (BSs) [6].

The utility of such a helper node was not realized in practice until recently when some practical issues had solution based on this relay concept. Let us look at some of these issues typical to WiMAX.

1. Coverage limitation due to low Signal to Noise Ratio (SNR) at the cell edges, this is due to the significant signal attenuation caused when operating at high spectrum.
2. Poor signal reception due to coverage holes
3. Higher cost of increasing the number of base stations

RSs are classified into two categories, non-transparent mode and transparent mode. A non-transparent RS operates as a BS for connected SSs, i.e., the RS transmits management messages and forwards data traffic, while a transparent RS forwards only data traffic to and from SSs based on the frequency allocation information obtained from BS. Thus, transparent relays have to use a centralized scheduling mode. Additionally, the major difference between the two modes is that the frequency reuse is not allowed in the transparent mode. Therefore, transparent RSs are suitable for throughput improvement while non-transparent RSs are appropriate for coverage extension. We consider the placement of transparent RSs that maximize cell capacity [8].

The relay station placement problem can be found in different application scenarios, such as wireless sensor networks, wireless local area networks and IEEE 802.16j networks consider placing a given number of relay stations in a multi-rate WLAN cell with a given MS distribution. This problem is then formulated as an optimization problem and solved by an iterative algorithm based on Lagrangian relaxation, under the assumption that the MS distribution is uniform. The results show that the best strategy is to have multiple ring structures of RSs evenly distributed in the cell, under the assumption of the dual-relay mode in an IEEE 802.16j network with uniformly distributed traffic, the RS placement within a single cell is formulated as a cost minimization problem. A heuristic is proposed to solve this problem [2].

AS ANY TECHNOLOGY DEVELOPMENT THERE IS ALWAYS A BENEFIT FOR USING IT, THEREFORE WE MENTIONED THEM BELOW:

1. Throughput (Data Rate) Enhancement: This can be achieved by providing higher uniform Signal-to-Interference plus Noise Ratio (SINR) to the users within the cell coverage. In other words, RS can provide higher throughput to individual SS within the cell coverage by using higher data rates.
2. Capacity Enhancement: System capacity can be increased by allowing aggressive frequency-reuse capabilities of RSs within the BS cell and by enhancing the SINR where the SINR is limited. Thus RSs are deployed to increase the system capacity to high load regions within the BS cell. The RS might be deployed individually or in clusters around the perimeter of the BS cell according to the needed capacity.
3. Deployment Cost Reduction: ISPs can utilize RSs to deploy wireless broadband services over wide area coverage and dense populated areas. The RSs will allow for coverage extension and system capacity enhancement that in turn will increase the system capacity at a lower cost in comparison of using more than one costly BS.
4. No need to backhaul.
5. Simplicity.
6. Using Omni-antenna (360 degree).

THE PROPOSED SYSTEM:

WORKING:

The aim behind this dissertation is to increase the capacity of the network in the places that the signal is weak to the sub-scriber, also enhance the data rate for a long distance in the IEEE 802.16 network. This can be done by adding the relay station to the IEEE 802.16 network as shown in the figure 3.

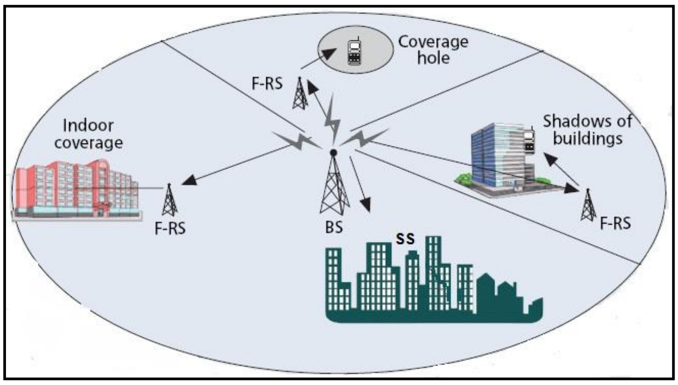

Fig. 3. **IEEE 802.16 network with RS**

- Generally relay station is an intermediate station that passes data between BS and SS.
- RS deployment enhances the capacity in areas where the capacity of the direct link between the BS and SS is low; Such as the areas in the shadows of large objects like tall buildings, within the buildings themselves, or underground.

RS here is called amplifying and forwarding (AF) which uses as a repeater for amplifying and forwarding the signal (data) only without the control signal and maps (processing delay is low). For that it will enhance the capacity.

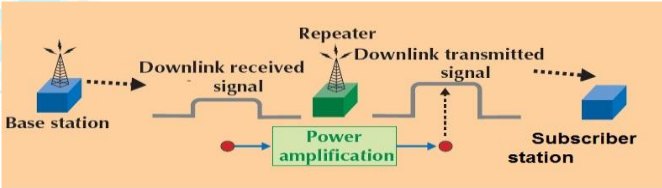

Fig. 4. **AF relay station**

- Relay station (RS) will divide each sub-frame into two zones:

1. **Access zones.**
2. **Relay zones.**

To communicate between BS and SS directly or through the RS, as shown in the figure 5.

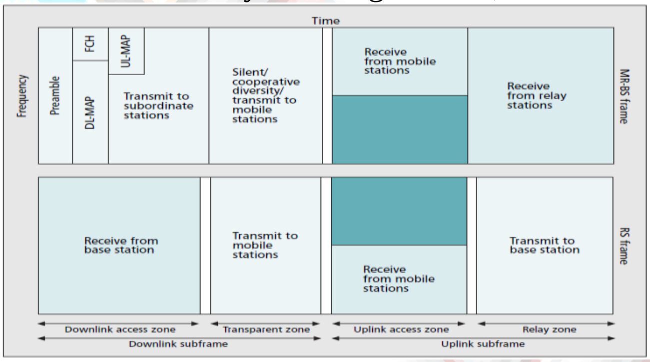

Fig. 5. **Modification of physical layer**

- BS determines which path it will select in the path (packets transmission) , either direct path from (BS → SS) or through the RS (BS → RS → SS) depending on packet route efficiency comparison of each path from source to destination.
- We use LOS/NLOS environment Between the BS and SS use line-of-sight, and between the RS and SS use non-line-of-sight.
- Relay station will increase the data rate of the system by providing better SINR (Signal to Interface and Noise Ratio)
  (SINR= PG/I+N)
  P: transmission power
  G: gain of signal.
  I: interferences between multiple SS
  N: thermal noise

A. SOFTWARE REQUIREMENT :

The term simulation is defined as the "reproduction of the essential features of something as an aid in order to training or study". In common words, we can also say that process of constructing the simulation model to solve the problem of system is called as the simulation. This kind of process is repeatedly used in order to reproduce the characteristics related to the complex work. For the simulation of the various kinds of networks such MANET, Mobile IP networks, there are various simulators are available for the commercial basis as well as free basis such as OPNET, NS2, Qualnet etc. Overviews of all this networks are presented in the following section with their advantages and disadvantages and then finalized the one which is feasible according to our work. Here we used the NS2 for the simulation results.

NS2 is nothing but the Network Simulator with the version 2 which is specially targeted for the simulation of various kinds of networks. NS2 is also called as the discrete event simulator for the networking researches. Simulations as well as research level supports are provided by the NS2 for the networks like wireless networks, wired networks, wireless sensor networks etc by using the various kinds of communication patterns such as UDP, TCP, IP, CBR etc. There two parts into which the whole NS2 is divided like NS and NAM. NS means the Network simulator which is used to simulate all kinds of network protocols using the TCL configuration script. Whereas the NAM which means the Network Animator tool is used in order to visualize the simulation results in the form of real time patterns of communication.

B. COMPARISON SIMULATION TOOLS:

There is no such conclusion made on the selection of the network simulator which is more accurate as in comparison with the others. Even though there are many kinds of researches were conducted by researchers to find out the accuracy of these network simulators, but from that researches no one concludes that which one is more accurate to use. Still we have to choose one of the above simulation tools for the simulation of our research and all. We will choose the simulator depending on the simulator availability, flexibility and kinds of services that simulator will gives us. As per the knowledge gained from the study of this three network simulators, following table shows their comparisons in terms of their availability, programming language support etc.

TABLE II. COMPARATIVE STUDY OF THE NETWORK SIMULATORS

	Free	**Open Source**	**Programming Lang.**
NS-2	Yes	Yes	C++, TCL
GloMoSim	Limited	Yes	Parse
Opnet	No	No	C

C. RESULTS:

PERFORMANCE PARAMETERS:

We simulated our dissertation in the Network Simulator version 2 (NS-2) for the IEEE 802.16 networks in two scenarios, one with the relay stations (RSs), and another without the relay station(RS). Then, we made the comparison between them in these network parameters:

1. Average Throughput: is defined as the amount of data selected for transmission by a user per unit time, the throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.
2. Jitter: is defined as the undesired deviation from true periodicity of an assumed periodic signal in electronics and telecommunications, often in relation to a reference clock source. It is undesired factor in the design of almost all communications links, or it is unwanted variation of one or more signal characteristics.

We simulated our dissertation in (NS-2) for the IEEE 802.16 network without relay station (RS) by using one base station (BS) and two subscriber-stations (SSs), while during the Through Relay Station (TRS), we used one base station (BS), two sub-scriber stations (SSs), and two relay stations (RSs).

We considered the IEEE 802.16 network for comparison with following network configurations which is common in our WiMAX networks:

Max Packet interface queue: 50
Number of Nodes: 3 (1BS- 2SS)
Routing Protocols: AODV
Network Size: X= 250 and Y=250
Algorithm: we can set either TRS or without RS.

WITHOUT RS:

THROUGHPUT

This figure 6 shows the throughput of the received bits in case of network without RS.

From the figure we can see that the throughput will increase until it will reach approximately 8.2 Mbps (maximum throughput) and then it will decrease, this is in the WiMAX network without using the relay stations.

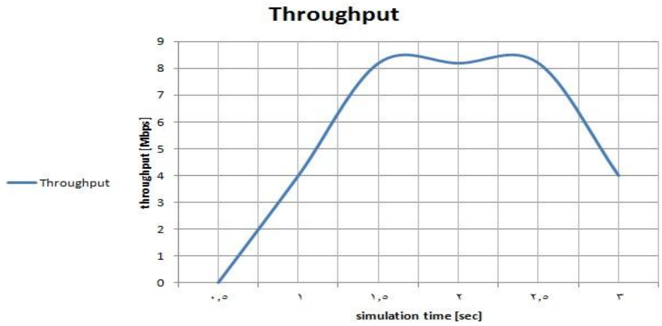

Fig. 6. **Throughput (without RS)**

JITTER

The figure 7 shows the jitter result in case of network without relay station (RS). And we can see from the figure that the jitter is gradually increasing until reach value of (0.03 sec), and then it will be like a stable. As we said before the jitter is undesired factor in the design of almost all communications links, or it is unwanted variation of one or more signal characteristics.

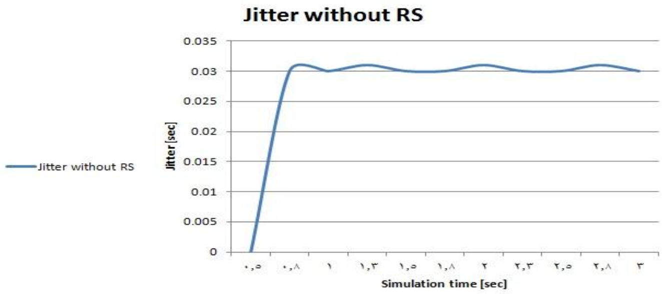

Fig. 7. **Jitter (without RS)**

a) TRS

These are the graphs when using TRS (Through Relay Station) concept in the WiMAX networks and after that we can compare its performance with the WiMAX network without using the Relay Station (RS):

THROUGHPUT

From the figure 8 we can see that the throughput will increase until it will reach approximately 10 Mbps (maximum throughput) and then it will decrease, this is in case of using the relay station in the WiMAX

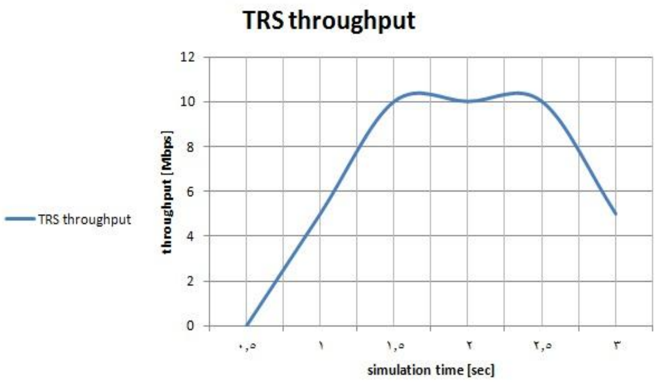

Fig. 8. **Throughput with TRS**

JITTER

The figure 9 shows the jitter when using the TRS concept in the WiMAX networks.

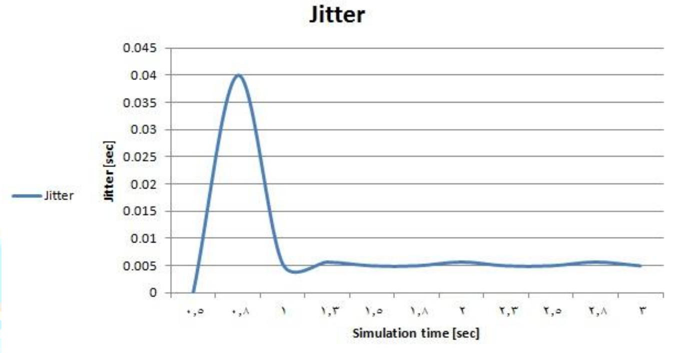

Fig. 9. **Jitter with TRS**

In figure 9 , we can see that the jitter increase until reach (0.04) sec then it will decrease to the value of (0.005) sec, the reason behind the high jitter in the beginning is that, at the beginning the WiMAX sender searches about the efficient route to the destination, either through the relay station (RS) or directly send from WiMAX sender to the WiMAX receiver without using the relay station, so this path selection will take some time in the stating and then it will decrease.

b) THROUGHPUT COMPARISONS

The following figure shows the throughput comparison between network without using relay station (RS), and TRS -Through Relay Station- network (with RS), and the values is took from the simulation results. So we can see that TRS algorithms has the higher throughput (it can reach 10 Mbps) Compare to another one (8.2 Mbps).

In the figure 10 below :

- X axis: simulation time (Sec)
- Y axis: throughput (Mbps)

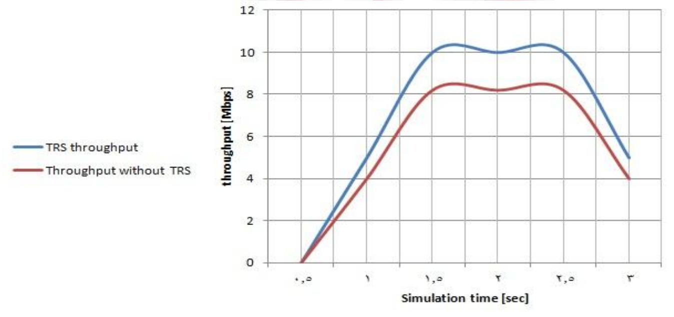

Fig. 10. **Throughput comparison**

c) JITTER COMPARISON

Figure 11 shows the jitter performance comparison for the two networks,WiMAX with RS and WiMAX without RS.

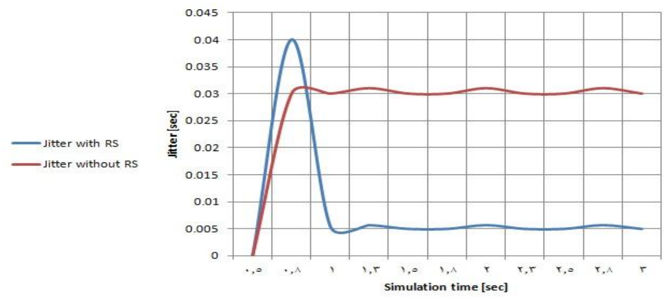

Fig. 11. **Jitter comparison**

From the above graph, the results shows that the network with RS shows it has lower jitter delay as compare with that without RS.

CONCLUSION:

From this dissertation and the simulation results that are obtained under the network simulator version-2 (NS-2), we can conclude that adding the relay station (RS), to the IEEE 802.16 networks, improves many aspects in the WiMAX networks, first one is that it will enhance the capacity of the system, especially in the overlapped areas (such as in the shadow of a large building, indoor, or underground) and that places where the quality of the signal is weak (by supporting spatial reuse).

Second one, using the relay station in the IEEE 802.16 will enhance the throughput of the WiMAX system, by increasing the signal to interferences and noise ratio (SINR), especially for the users who are located in the edge of the IEEE 802.16 cell.

As well as, relay station (RS) is simple in implementation, and it doesn't need for a backhaul like the base station (BS).

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