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# SIMULATION OF WIDE AREA WIMAX NETWORKS IN URBAN AREAS

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**ABSTRACT**
In recent years Wireless network plays an important role due to its flexibility and easy portability. WiMAX(World Wide Interoperability for Microwave Access) is the developing 4G promising network to cover the customer requirement. WiMAX is a technology that gives a connection between mobile and fixed networks and it handles wireless data for several distances from point to point links to all cellular type access. The coverage area of WiMAX is high when compared to other technology and it gives good support and stability. In this paper, simulation is conducted for a WiMAX network in the city of Mecca, Saudi Arabia. By considering the geographical area of the city, 10 base station nodes and several mobile nodes are assumed. Network simulator 3 (NS3)[ ]is employed to obtain parameters such as packet delivery ratio (PDR), delay, dropping ratio, throughput, and good put for two frequencies 2.4 GHz and 914 MHz[[2]]

**Keywords:**
WiMAX; frequency; simulator; Interoperability

## INTRODUCTION

WiMAX is World Wide Interoperability for Microwave Access. The technology mainly is used to increase the coverage area and data rate for large metropolitan area networks (MAN).Thus these networks are designed to provide broadband access to the vast area. WiMAX can be operated on both licensed frequency band (10-66GHZ)[ ]and unlicensed frequency band (11GHZ)[ ]. WiMAX is the best technology designed for wireless network for good performance and effective cost. Whereas WiMAX faces the different type of problem in mobile communication. If the line of sight is the required communication then frequency higher than 10GHZ is required and if non-light of sight is required then frequency below 10GHZ is required[ ].

WiMAX allows broadband access service that helps customers to enjoy low-cost internet options. It provides data rates up to 75 Mb/s. And so, it becomes the backbone of many wireless communication services. In order to increase the applications of this technology, the service provider forum created e2e based specification based on protocol and network architecture[ ]. Figure (1) depicts an example of WiMAX technology that has the collection of subscriber stations and base stations.

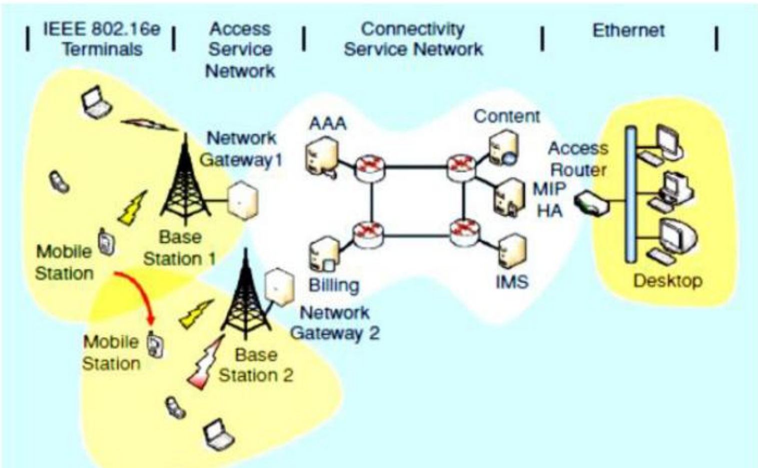

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***Figure 1: WiMAX Architecture***

WiMAX is the greatest solution for suburban and urban areas where there is the problem in wired technology. In this paper, a network is designed as a MAN in the city of Mecca, Saudi Arabia at two different frequencies. The first scenario is implemented with 10 base stations and 10 Mobile stations with the frequency of 2.4GHZ. In which mobile stations can communicate with other mobile stations with the help of Base Stations. The whole network is simulated using network simulator 3 (NS3)[ ] and metrics form the simulation are outlined. The second scenario is simulated with the frequency of 914 MHz Metrics from these scenarios are compared.

## NETWORK ADVANTAGES

Worldwide Interoperability for Microwave Access (WiMAX) [ ]is a developing fixed broadband wireless technology that delivers last-mile broadband connection in a larger geographic area than Wi-Fi. There are many advantages for these networks such as

- higher speed data
- throughput than its counterpart
- greater mobility
- high range
- wider operating range
- very useful in bad terrain areas

Whereas the network supports and acts as the interface between wireless and wired technology. In addition, it handles the wireless technology like VLAN, ATM, and Wi-fi. When the network is deployed in outdoor, the environment may provide delay due to intersymbol interference [ ].

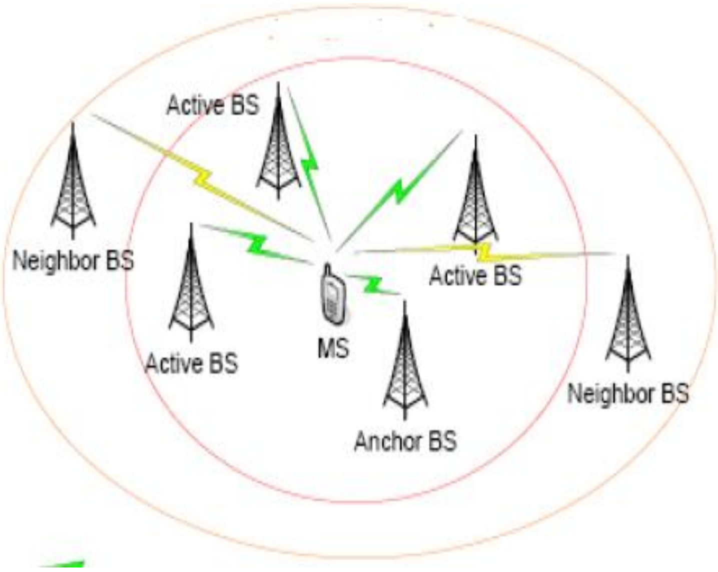


**Figure 2: Sample WIMAX Network**

## SIMULATION MODEL

ns-3 has been developed to provide an open, extensible network simulation platform, for networking research and education. In brief, ns-3 provides models of how packet data networks work and perform, and provides a simulation engine for users to conduct simulation experiments. Some of the reasons to use ns-3 include performing studies that are more difficult or not possible performing with real systems, to study system behavior in a highly controlled, reproducible environment, and to learn about how networks work[ ].

We used ns3 to simulate the WiMAX. Many parameters are used to tune WiMAX. Several parameters are listed in the below table. The simulation is done with two frequencies 914 MHZ and 2.4 GHz.

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| SNU | Parameter | Value |
|---|---|---|
| 1. | Frequency | 2400 MHz |
| 2. | BSAntennaHeight | 50 |
| 3. | BasicEnergyLowBatteryThreshold | 0.1 |
| 4. | BasicEnergyHighBatteryThreshold | 0.15 |
| 5. | Mobile Rx height | 1.5 meter |
| 6. | Effective radius | 4.34Km |
| 7. | Forest/Trees, Offset-loss | 10 dB |
| 8. | Open, Offset-loss | 17 dB |
| 9. | Buildings, Offset-loss | -4 dB |
| 10. | Suburban, Offset-loss | -3 dB |
| 11. | UL Carrier bandwidth | 1x3.3MHz |
| 12. | DL Carrier bandwidth | 9x3.3MHzusingFR 1/3 |
| 13. | DL Carrier bandwidth | 3 x 10 MHz using FFR 1/1 |
| 14. | Bearers for DL and UL | 1 |
| 15. | CINR requirement | 4.9 dB |
| 16. | Services for DL and UL | 1 |
| 17. | Receiver Sensitivity | -100.07 $dB_m$ |
| 18. | Max CPE Power | 23 $dB_m$ |
| 19. | CPE Antenna | 0 dB |
| 20. | Noise Figure | 7 dB |
| 21. | Horizontal Beamwidth of CPE | $360°$ |
| 22. | Tx Power | 35.3 $dB_m$ |
| 23. | Noise Figure | 4 $dB_m$ |
| 24. | Receiver Sensitivity | -109.7300 $dB_m$ |
| 25. | Control Activity | 20 % |
| 26. | BS antenna | Kathrein80010541 |
| 27. | BS antenna gain | 18 dB |
| 28. | The horizontal beam width of BS antenna | $60°$ |
| 29. | The vertical beam width of BS antenna | $6°$ |
| 30. | Feeder loss | 2 dB |
| 31. | Prediction radius | 5 Km |
| 32. | Prediction resolution | 10 m |
| 33. | Intra-Site fading correlation coefficient | 0.8 |

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| | | |
|---|---|---|
| 34. | Inter-Site fading correlation coefficient | 0.5 |

The simulation is done with the help of NS3 and the simulated environment is as shown in the below screenshots.

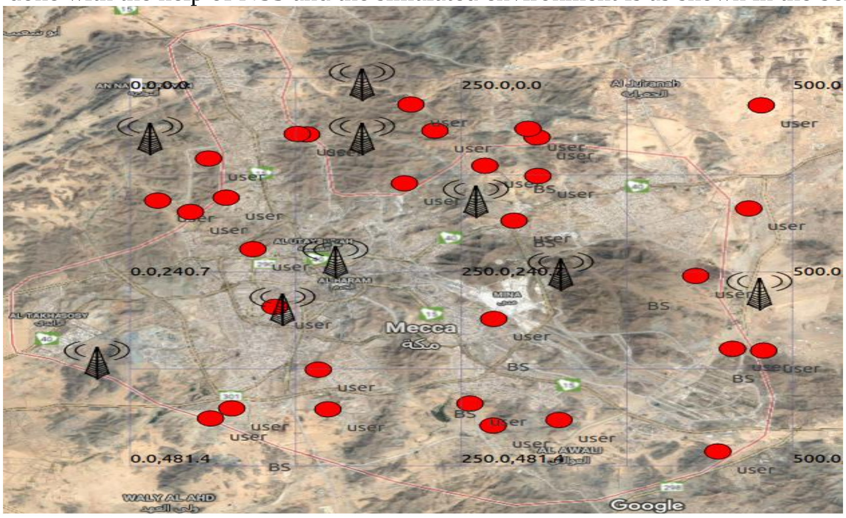


*Figure 3: ScreenShot1 of Simulated Scenario*

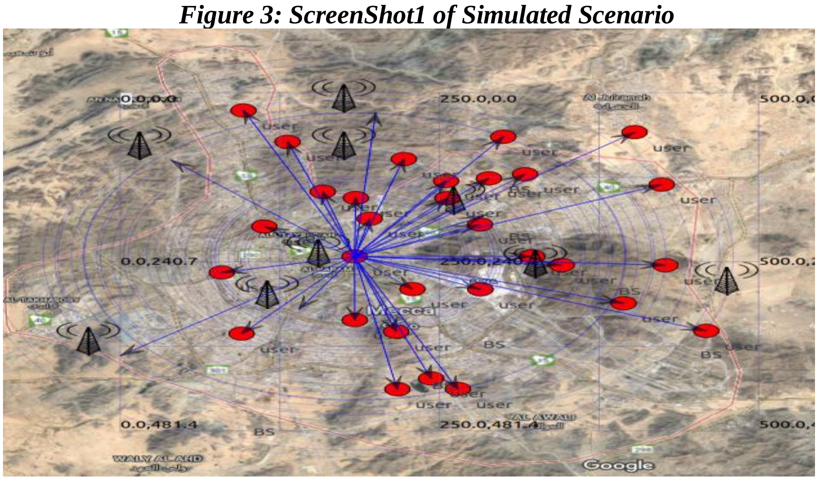


*Figure 4: ScreenShot2 of Simulated Scenario*

**RESULTS**

The simulation parameters are selected according to the environment of Mecca city. The parameters are defined and simulation is done with Network Simulator 3 and the results obtained are discussed in this section. The various metrics that we are calculating are

- Packet Delivery Ratio
- Delay
- No of Packets Dropped
- Dropping Ratio
- Throughput
- Good put

The graphs below illustrate PDR, delay, packets dropped, dropping ratio, throughput, and goodput of different frequencies.

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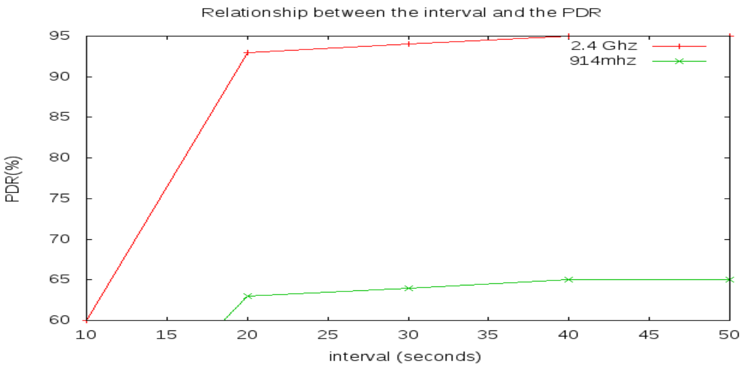


***Figure 5: Relationship between interval and Packet Drop Ratio***

Figure 5 depicts the relationship between interval and Packet Drop Ratio. As shown in thegraph, we can find that for frequency 2.4 GHz PDR gradually increases from the 60% and it became stable after 95%. And for frequency 914 MHz the PDR is stable still 60% and it became stable at nearly 62%.

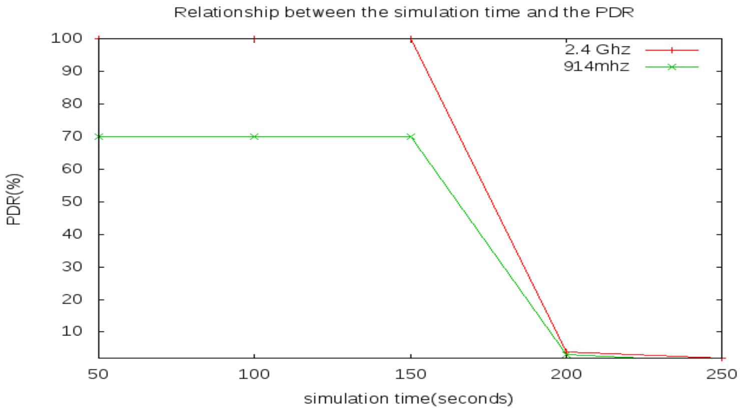


***Figure 6: Relationship between Simulation Time and PDR***

Figure 6. illustrates the relationship between Simulation Time and PDR. As shown in the graph, we could find that after 150 seconds of simulation the PDR percentage gradually decreases and at 200th second PDR drops almost zero for both frequencies 914MHZ and 2.4GHz.

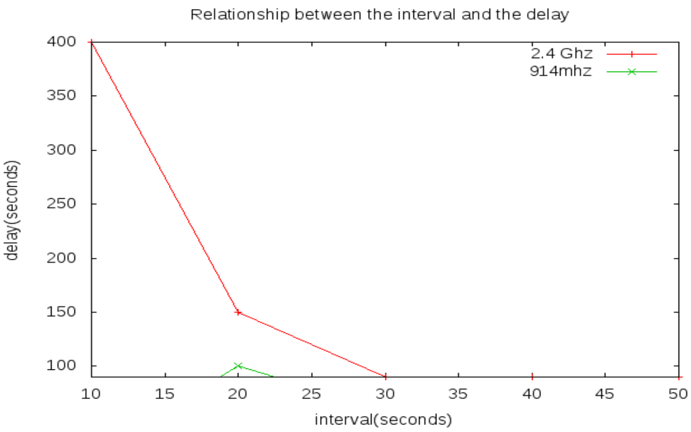


***Figure 7: Relationship between interval and delay***

Figure 7. represents the relationship between interval and delay. The delay range is high till 30 second and delay begins to drop for 2.4 GHz. And for frequency 914MHzdelay is very low when compared to the previous frequency

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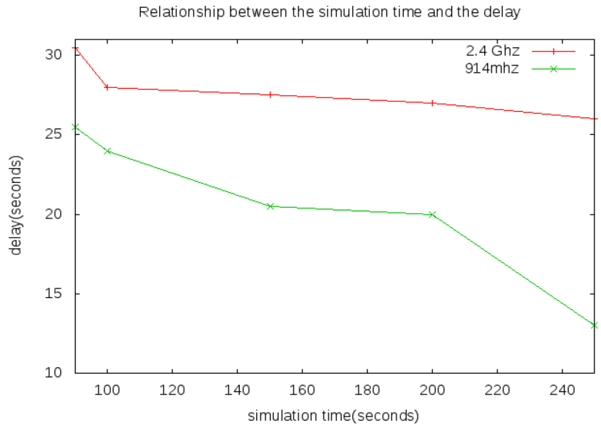


***Figure 8: Relationship between the simulation time and the delay***

Figure8. shows the Relationship between the simulation time and the delay. Till 100th second of the simulation the delay is 30 and generally, the delay is decreased. And for the frequency 914MHz, the delay level is low when compared to 2.4 GHz.

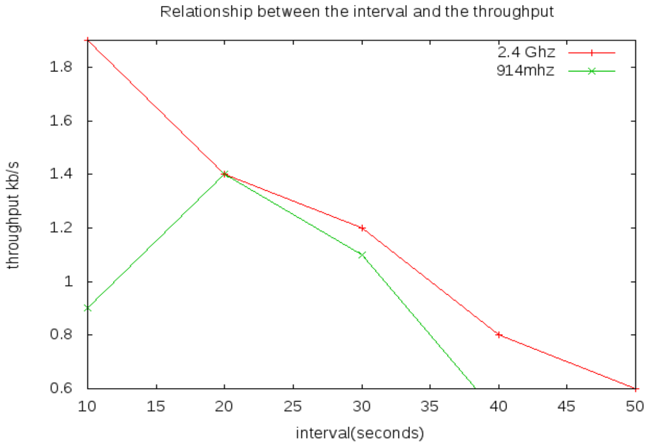


***Figure 9: Relationship between the interval and the throughput***

Figure 9.  gives us information of Relationship between the interval and the throughput. For 2 GHz at the starting stage throughput is very high and dropped gradually. And for 914MHz the throughput is near 1 at starting stage and increases when the simulation goes on. Approximately by 35 seconds throughput drops.

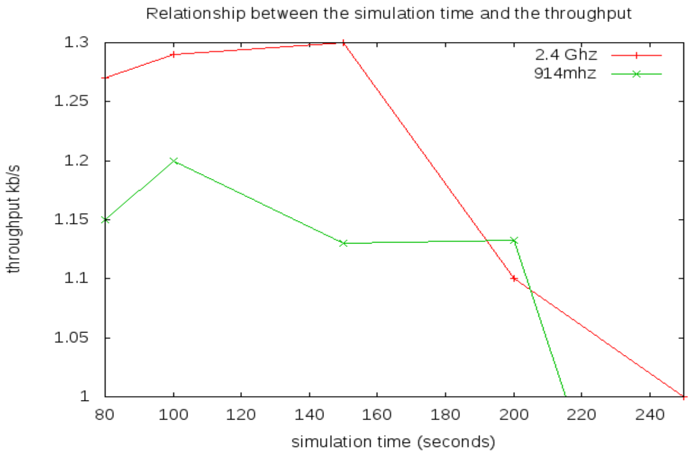


***Figure 10: Relationship between the simulation time and throughput***

Figure 10. shows a relationshipthe simulation time and throughput. The throughput is high both frequencies at the starting interval and throughput drop more or less same interval.

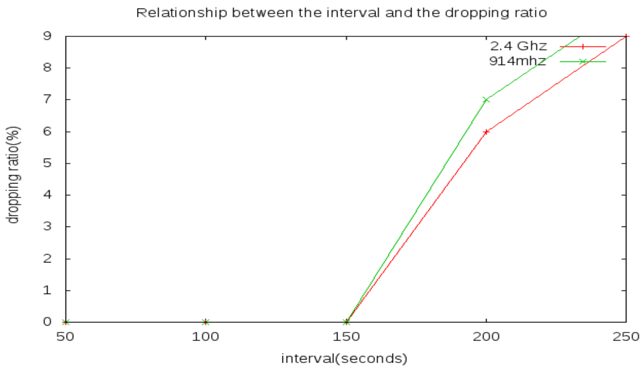


***Figure 11: Relationship between interval and dropping ratio***

Figure 11. shows the relationship between interval and dropping ratio. The results give us information like dropping ratio increases when the interval increases and vice versa. The state is similar toboth the frequencies.

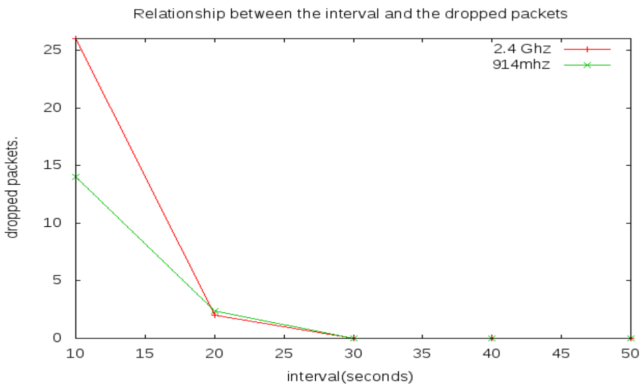


***Figure 12. Relationship between interval and dropping packets***

Figure 12. Illustrates a relationship between interval and dropping packets, the figure shows that when the interval increases the dropping ratio decreases for both the frequencies.

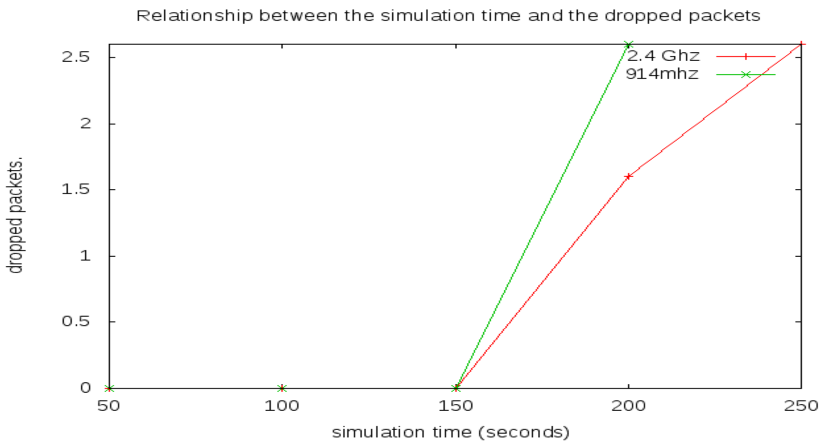


***Figure 13. Relationship between the Simulation time and the dropped packets***

Figure 13. depicts Relationship between the simulation time and the dropped packets, from the 150 th second the packet dropped get increases for both the frequencies. Hence when the simulation time increases the packets dropped also increases.

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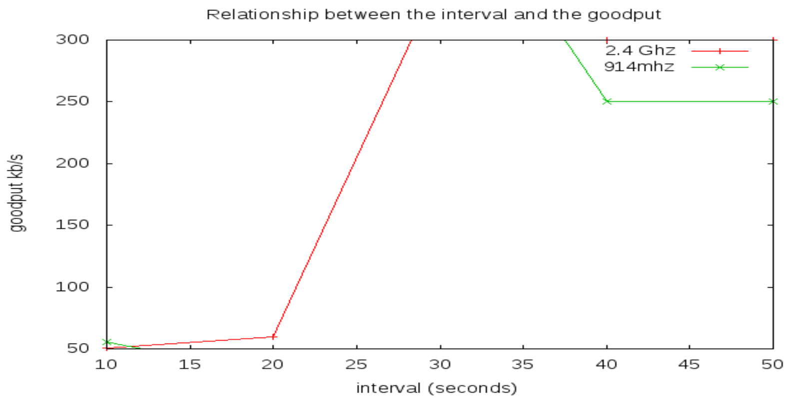


***Figure 14: Relationship between interval and good put.***

Figure 14. illustrates a relationship between interval and goodput. Our results show goodvalues put increases as the interval increases, after a certain interval the goodput reaches stability. For frequency 914MHZ the goodput is stable from the beginning and drops down approximately by 40 and reaches the stable level.

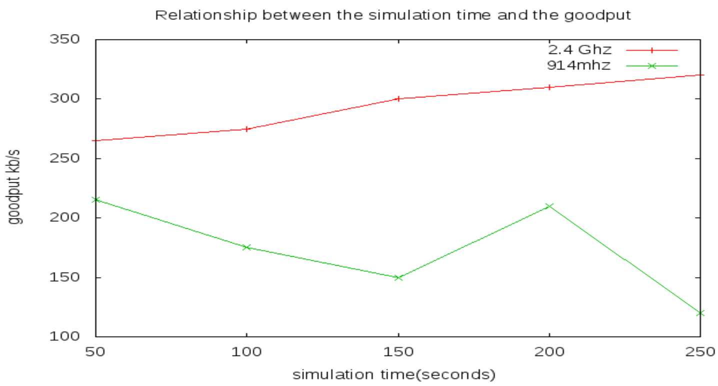


***Figure 15:Relationship between the simulation time and the goodput***

Figure 15. gives the relationship between the simulation time and the goodput the results show that the goodput increases gradually as the simulation time increases regardless the frequency differs.

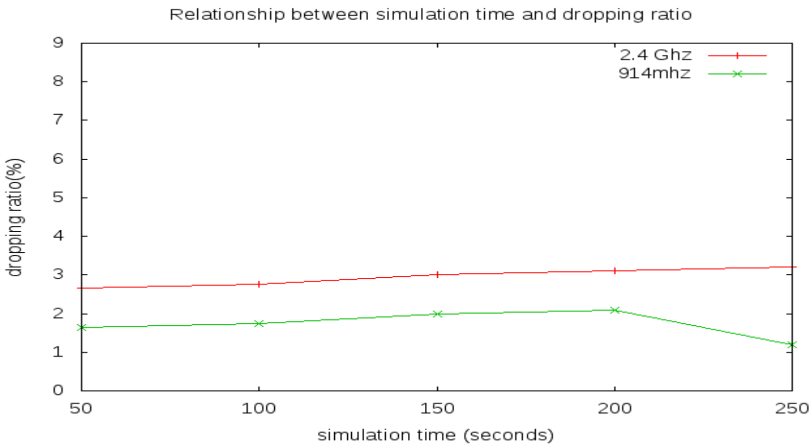


***Figure 16:Relationship between the simulation time and the dropping ratio***

Figure 16. gives the Relationship between the simulation time and the dropping ratio. The dropping ratio is increased gradually as the simulation time increases

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## CONCLUSION

In this paper, we have considered two scenarios in WiMAX technology. We did a simulation using theNS3 program. It has been concluded that for the frequency 1 (2.4 GHz) the throughput is high and goodput is also high. And for the frequency 2 (914 MHZ) the stability of the system varies and goodput is low when compared to the frequency

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