Performance Analysis of Wired, Wireless and Optical Network using NS2

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Abstract- In computer terminology, the definition for networks is simply a group of computers physically or logically connected with each other for sharing information or services. In this paper, wired, wireless and optical networks have been analyzed and implemented using network simulator tool NS2. A systematic simulation based performance analysis of wired, wireless and optical networks using distance vector routing protocol has been carried out. Analysis of the performance of these networks on the basis of three metrics- Packet delivery ratio, end to end delay, throughput using NS2 based Simulation has been undertaken.

Keywords: *Networks, Wired, Wireless, Optical, NS2*

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1. INTRODUCTION

Computer networks are the base of modern communication. All modern aspects of public switched telephone network are computer-controlled. The scope of communication would not be possible without computer network. A data network is a communication network which is used to exchange information from one node to another node using a data link or a data network is a system in which multiple computers are connected with each other to share information. The connections between nodes are established by using cable media, wireless media or light pulse [1].

Computer network provide different type of interpersonal facilities to user like email, instant messaging, telephone, video telephone calls and audio conferencing. A network allows users to share data, files and information. The user has the ability to access information which is stored on the computer network that may be used by unauthorized user to generate viruses or computer worms, to prevent these devices from viruses access that network via denial of service attack [1].

2. NETWORK

A data network is a communication network which is used to exchange information from one node to another node using a data link or a data network is a system in which multiple computers are connected with each other to share information. The connections between nodes are established by using cable media, wireless media or light pulse. The example of network is internet, which connects millions of computers all over the world [1].

1. Wired Network

Wired networks exist between a number of devices connected with each other using connecting media, such as cables and routers. These networks can be used within limited area by cables and routers that allow the data sharing (sending or receiving data). The word "wired" is used to differentiate between wireless connections and those involve cables to transfer data between different devices and computer systems. Most wired networks use Ethernet cables to transfer data between connected computer systems that's why wired networks, also called networks. In small wired network, a single router is used to connect all the computers. Larger networks often use multiple routers or switches [5].

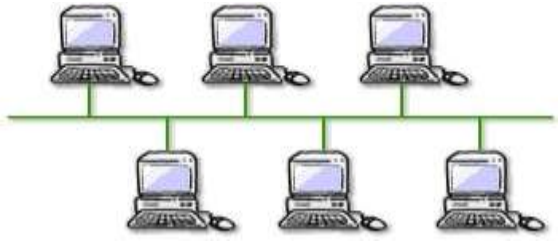

Figure 1: Wired Network [2]

2. Wireless Network

Wireless Networks used infrared or radio frequency signals to share information and resources between devices. Wireless networks have connection between nodes without use of wires. Theses network development are cost effectiveness and it can be applicable to environments where wiring is not possible or it is a preferable solution as compared to wired networks. A wireless network consists of an access point or a base station. The access point acts like a hub, providing connectivity for wireless computers. There are four types of wireless standards for wireless networking and these types are produced by Institute of Electrical and electronics Engineers (IEEE). These standards define all aspects of radio frequency wireless networking. They have established different type of transmission standards: 802.11, 802.11a, 802.11b, 802.11g. [4][5].

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All these type of transmission standards have different speed and radio frequency. 802.11 and 802.11b are the slowest at 1 or 2Mbps and 5.5 and 11Mbps respectively. They both operate off of the 2.4 GHz radio frequency and can transmit up to 54 Mbps. Actual transmission speeds may vary and depends on such factors as number and size of the physical barriers in the network and any interference in the radio transmissions. These networks are reliable, but when interference occurs it reduce the range and the quality of the signal. Interference can be caused by other devices operating on the same radio frequency and it is very hard to control the addition of new devices on the same frequency [4] [5].
Many types of wireless devices are available today for examples, mobile terminals, pocket size PCs hand held PCs, laptops etc. The emerging third generation cellular networks have enables a variety of higher speed mobile data services. [16] [17].

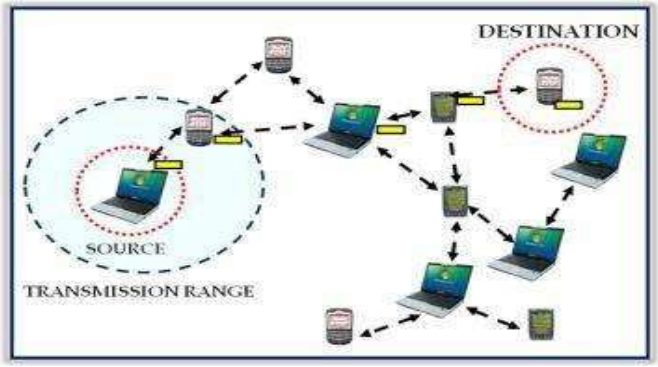

Figure 2: Wireless Networks [2]

3. Optical Network

Fiber optic communication is a communication technology that uses light pulses to transfer information from one point to another through an optical fiber. The information transmitted is essentially digital information generated by telephone systems, cable television companies, and computer systems as shown in the figure [7] [12].

An optical network is a type of communication network that built with optical fiber technology. It convert electrical signal into light pulses between sender and receiver nodes. It connects computers (or any other device which can generate or store data in electronic form using optical fibers. Optical fibers are essentially very thin glass cylinders or filaments which carry signals in the form of light. Optical network is implemented by using Wavelength Division Multiplexing (WDM). The WDM is a data transmission technology that transmits data in an optical fiber by establishing various channels, each channel have it's a specific light wavelength. It is a large complex network of server hubs at different locations on ground. The server hubs are also known as head-ends, nodes or simply, sites. These networks are the backbone of Internet Service Providers [6] [7].

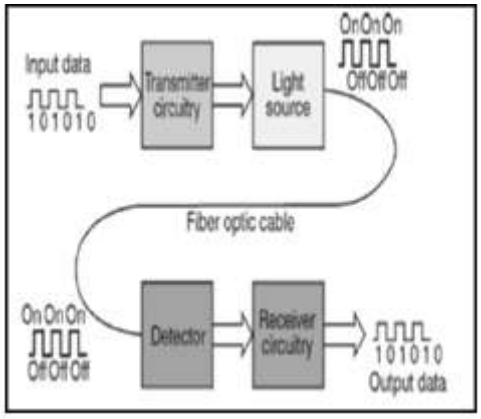

Figure 3: Basic Optical Fibre Communication [8]

3. TOOL USED

Network Simulator (Version 2) is known as NS2 which is an event-driven simulation tool. It source code is freely distributed and discrete event simulator which works on packet scenario of networking projects for both wired and wireless network. It is useful in studying the nature of communication networks. It is a portable tool that works on all Linux and windows operating systems. It support many routing protocols, network topologies like bus, ring, hybrid, star topologies to design both wired and wireless network with the help of simulation scripts. This tool is help to calculate throughput, error rate, end to end delay, packet delivery ratio, total number of packet send and received by destination using TCL scripts AWK, Perl. [13]

Ns-2 support both transport layer protocols TCP and UDP. Theses protocols are used to transmit data in the form of packets from source to destination and it also support various type of traffic generators to generate data in the form of packets and these packets send over transport layer protocols. CBR (Constant Bit Rate), exponential traffic (poison traffic), Pareto traffic (expoo traffic) and FTP are traffic generators which are used to generate data between nodes. [13]

To run the TCL script NS2 use the NAM (network animator) which is a visualization tool which show the nodes and flow of packet as written in the TCL script

1. Basic architecture of NS2

NS2 consists of two key languages: C++ and Object-oriented Tool Command Language (OTcl). The C++ and the OTcl are linked together using TclCL and mapped to a C++ object, variables in the Otcl domain. This language helps to create network scenario and also allows modification in Tcl

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script. [2] [3]

Simulation scenario contains network nodes, topology and connections between the nodes. NS2 provides users to executable command ns with the name of a Tcl simulation scripting file. In the scenario, Tcl language is used to design the network which set parameters, node configurations and topology, Connection between nodes, transfer packages and simulation time [2] [10].

NS2 outputs either text-based or animation-based simulation results. NAM (Network Animator) is a visualization tool which shows communication between nodes, flow of packets as written in the TCL script and also provides animation based result. XGraph are used to generate graph to analyze a particular behavior of the network presentation [2].

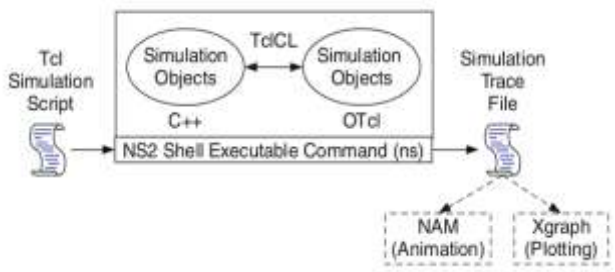

Figure 4: Basic architecture of NS2 [2]

2. Programming Language in NS2

NS2 provides a large number of built-in C++ objects. The C++ is used for the simulation with the help of Tcl simulation script but the users find that these objects are insufficient. They develop their own C++ objects and use an Otcl configuration and interface these objects. The two programming languages are used because this makes tool easy to use, yet fast and powerful simulator. C++ defines the internal mechanism of simulation objects and also used for the security packages in encryption and decryption while OTcl works for the frontend environment. OTcl and C++ interact with each other through Tcl/C++ interface called TclCL as show in figure 5 [3].

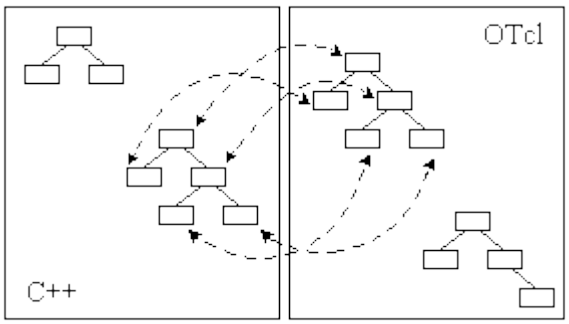

Figure 5: C++ and Tcl Communication [3]

Otcl is a language with simple syntaxes which can easily integrate with other languages. The characteristics of the languages are:

- It provides a graphic interface
- It is compatible with many protocols
- It is very flexible for integration
- The scripting language is used which is easy to understand

4. TRAFFIC SCENARIO FOR WIRED NETWORK

A wired network using distance vector routing protocol has been designed and implemented. The distance vector routing protocol selects a shortest path from source to destination. This wired network traffic scenario has been generated by using tcl script which specifies information about different nodes, links, delay and also agents used at source and destination nodes. After executing the program which is written in tcl script using ns command then this network has been visualized in the NAM animator as shown in the figure 6 [10].

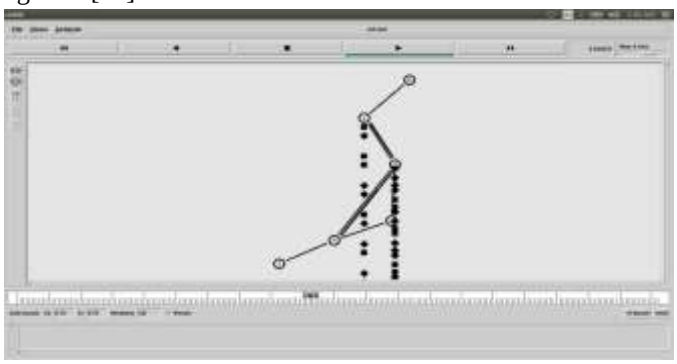

Figure 6: Wired Network Communication

1. Tracing

Simulation of network in NS2 generates traces of all the events in a trace file as shown in below figure7. The format for trace file of a network differs depending on whether the network is wired or wireless. This trace file is data is used to calculate the different performance metrics and for plotting the data on graphs for further analysis and comparison.

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```
+ 5.229533 0 1 exp 1000 ------- 0 0.2 5.2 0 0
- 5.229533 0 1 exp 1000 ------- 0 0.2 5.2 0 0
+ 5.229533 0 1 exp 1000 ------- 0 0.2 5.2 1 1
- 5.231533 0 1 exp 1000 ------- 0 0.2 5.2 1 1
r 5.232533 0 1 exp 1000 ------- 0 0.2 5.2 0 0
+ 5.232533 1 4 exp 1000 ------- 0 0.2 5.2 0 0
- 5.232533 1 4 exp 1000 ------- 0 0.2 5.2 0 0
r 5.234533 0 1 exp 1000 ------- 0 0.2 5.2 1 1
+ 5.234533 1 4 exp 1000 ------- 0 0.2 5.2 1 1
+ 5.234866 0 1 exp 1000 ------- 0 0.2 5.2 2 2
- 5.234866 0 1 exp 1000 ------- 0 0.2 5.2 2 2
+ 5.234866 0 1 exp 1000 ------- 0 0.2 5.2 3 3
- 5.236533 1 4 exp 1000 ------- 0 0.2 5.2 1 1
- 5.236866 0 1 exp 1000 ------- 0 0.2 5.2 3 3
r 5.237533 1 4 exp 1000 ------- 0 0.2 5.2 0 0
+ 5.237533 4 5 exp 1000 ------- 0 0.2 5.2 0 0
- 5.237533 4 5 exp 1000 ------- 0 0.2 5.2 0 0
r 5.237866 0 1 exp 1000 ------- 0 0.2 5.2 2 2
+ 5.237866 1 4 exp 1000 ------- 0 0.2 5.2 2 2
r 5.239866 0 1 exp 1000 ------- 0 0.2 5.2 3 3
```

Figure 7: Wired Network Trace file

5. TRAFIC SCENARIO FOR WIRELESS NETWORK

A wireless network using Destination-Sequenced Distance Vector routing protocol has also been designed and implemented. The Destination-Sequenced Distance Vector (DSDV) protocol is the commonly used proactive routing protocol in mobile ad hoc network. Proactive routing protocol maintains constant and updated routing information for each pair of networking nodes by propagating route updates proactively at fixed interval of time. The periodic and event-driven messages are responsible for route establishment and route maintenance. In DSDV, each node maintains a routing table with one route entry for each destination in which the shortest path is recorded. It uses a destination sequence number to avoid routing loops. The figure 4.3 shows a node configuration for a wireless mobile node that runs DSDV as its ad hoc routing protocol.

After that the program has been executed which is written in tcl script using ns command then could be visualized the network in the NAM animator as shown in the figure 8.

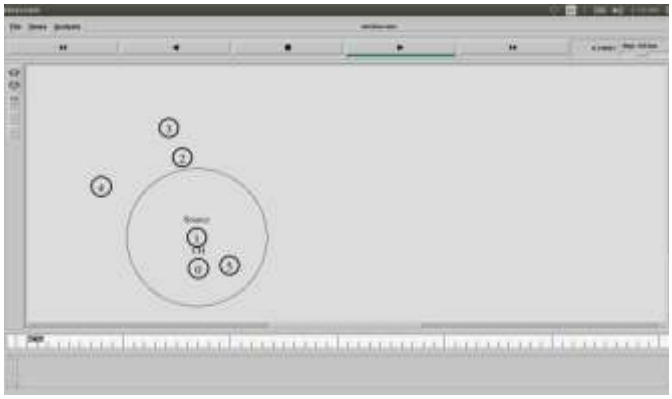

Figure 8: Wireless Network Communication

1. Tracing

Simulation of network in NS2 generates traces of all the events in a trace file as shown in below figure 9. The format in wireless network is different for different routing protocol. This trace file is data is used to calculate the different performance metrics and for plotting the data on graphs for further analysis and comparison.

```
s 0.003888772 _0_ RTR  --- 0 message 32 [0 0 0 0] ------- [0:255 -1:255 32 0]
r 0.004868879 _5_ RTR  --- 0 message 32 [0 ffffffff 0 800] ------- [0:255 -1:255 32 0]
r 0.004868882 _1_ RTR  --- 0 message 32 [0 ffffffff 0 800] ------- [0:255 -1:255 32 0]
r 0.004869170 _2_ RTR  --- 0 message 32 [0 ffffffff 0 800] ------- [0:255 -1:255 32 0]
r 0.004869217 _4_ RTR  --- 0 message 32 [0 ffffffff 0 800] ------- [0:255 -1:255 32 0]
r 0.004869279 _3_ RTR  --- 0 message 32 [0 ffffffff 0 800] ------- [0:255 -1:255 32 0]
s 0.031508112 _2_ RTR  --- 1 message 32 [0 0 0 0] ------- [2:255 -1:255 32 0]
r 0.032360225 _3_ RTR  --- 1 message 32 [0 ffffffff 2 800] ------- [2:255 -1:255 32 0]
r 0.032360400 _1_ RTR  --- 1 message 32 [0 ffffffff 2 800] ------- [2:255 -1:255 32 0]
r 0.032360410 _4_ RTR  --- 1 message 32 [0 ffffffff 2 800] ------- [2:255 -1:255 32 0]
r 0.032360509 _0_ RTR  --- 1 message 32 [0 ffffffff 2 800] ------- [2:255 -1:255 32 0]
r 0.032360529 _5_ RTR  --- 1 message 32 [0 ffffffff 2 800] ------- [2:255 -1:255 32 0]
s 0.182646019 _3_ RTR  --- 2 message 32 [0 0 0 0] ------- [3:255 -1:255 32 0]
r 0.183706133 _2_ RTR  --- 2 message 32 [0 ffffffff 3 800] ------- [3:255 -1:255 32 0]
r 0.183706331 _4_ RTR  --- 2 message 32 [0 ffffffff 3 800] ------- [3:255 -1:255 32 0]
r 0.183706418 _1_ RTR  --- 2 message 32 [0 ffffffff 3 800] ------- [3:255 -1:255 32 0]
```

Figure 9: Wireless Network Trace file

6. TRAFFIC SCENARIO FOR OPTICAL NETWORK

An optical network using distance vector routing protocol has been designed and implemented. The distance vector routing protocol selects a shortest path from source to destination. We create the optical network traffic scenario by using tcl script which consist with six nodes, duplex links, delay in ms and also used agents at source and destination nodes. After that execute the program which is written in tcl script using ns command then we could visualize the network in the NAM animator as shown in the figure 10.

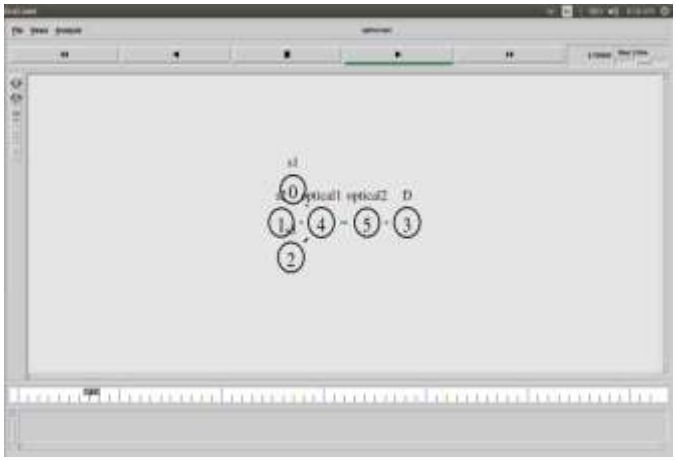

Figure 10: Optical Network Communication

1. Tracing

Simulation of network in NS2 generates traces of all the events in a trace file as shown in below figure 11. This trace file is data which is used to calculate the different performance metrics and for plotting the data on graphs for further analysis and comparison

```
+ 5.229533 2 4 exp 1000 ------- 0 2.0 5.2 0 0
- 5.229533 2 4 exp 1000 ------- 0 2.0 5.2 0 0
+ 5.229533 2 4 exp 1000 ------- 0 2.0 5.2 1 1
- 5.233533 2 4 exp 1000 ------- 0 2.0 5.2 1 1
+ 5.234866 2 4 exp 1000 ------- 0 2.0 5.2 2 2
+ 5.234866 2 4 exp 1000 ------- 0 2.0 5.2 3 3
r 5.235533 2 4 exp 1000 ------- 0 2.0 5.2 0 0
+ 5.235533 4 5 exp 1000 ------- 0 2.0 5.2 0 0
- 5.235533 4 5 exp 1000 ------- 0 2.0 5.2 0 0
- 5.237533 2 4 exp 1000 ------- 0 2.0 5.2 2 2
r 5.239533 2 4 exp 1000 ------- 0 2.0 5.2 1 1
+ 5.239533 4 5 exp 1000 ------- 0 2.0 5.2 1 1
- 5.239533 4 5 exp 1000 ------- 0 2.0 5.2 1 1
+ 5.2402 2 4 exp 1000 ------- 0 2.0 5.2 4 4
+ 5.2402 2 4 exp 1000 ------- 0 2.0 5.2 5 5
- 5.241533 2 4 exp 1000 ------- 0 2.0 5.2 3 3
r 5.242533 4 5 exp 1000 ------- 0 2.0 5.2 0 0
r 5.243533 2 4 exp 1000 ------- 0 2.0 5.2 2 2
+ 5.243533 4 5 exp 1000 ------- 0 2.0 5.2 2 2
- 5.243533 4 5 exp 1000 ------- 0 2.0 5.2 2 2
- 5.245533 2 4 exp 1000 ------- 0 2.0 5.2 4 4
```

Figure 11: Optical Network Trace file

7. PERFORMANCE ANALYSIS OF PARAMETERS

1. Average End-to-End Delay

The end to end delay is the time from the generation of the packet by the sender up to send at the destination application layer and expressed in second. It therefore include all the delay in the network such as buffer Queue, transmission and delay induced by routing protocol activities and MAC control data exchanges. [12]

End to End delay = [(Sum of Individual data packet delay) / (Total number of data Packets delivered)]

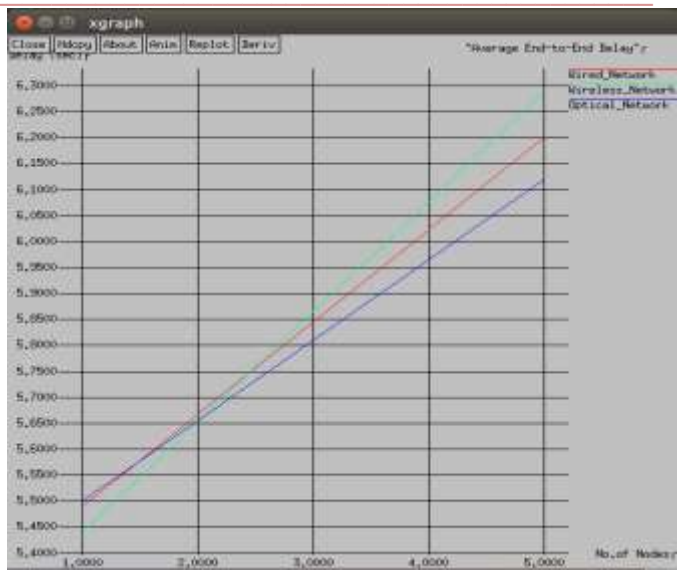

Figure 12: Comparison of average end-to-end delay

The figure 12 shows the graph between end to end delay and number of nodes. The graph shows that wireless network have more delay as compared to wired and optical network and optical network have less delay as compared to wired network.

2. Packet Delivery Ratio

Packet Delivery Ratio is defined as the ratio between the received packets at the destination and the generated packets at the source it is calculated by using awk script which processes the trace file and produces the result. [2]

Packet Delivery Ratio= [(Total packets received at the destination) / (Total packets generated at the source)]

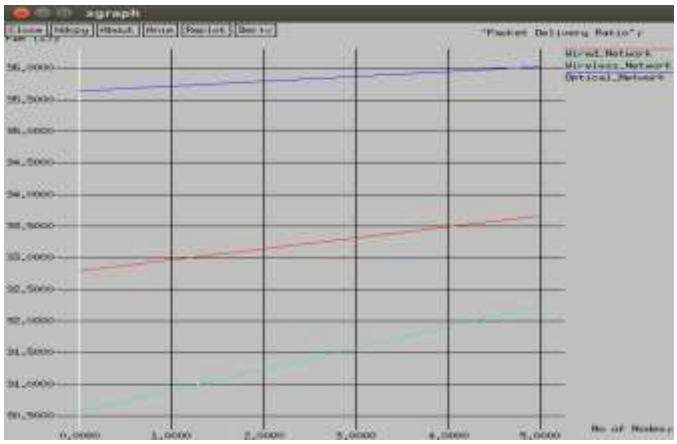

Figure 13: Comparison of Packet Delivery Ratio

The figure 13 shows the graph between packet delivery ratio and number of nodes. The graph shows that optical network have more packet delivery ratio as compared to wired and

optical network and wireless network have less packet delivery ratio as compared to wired network.

3. Average Throughput

The ratio of total amount of data that reaches from source to destination to the time for the destination to get the last packet is referred as Throughput. A network with high average throughput is desirable.

Throughput = (Number of data packets received*Packet size*8) / Simulation time

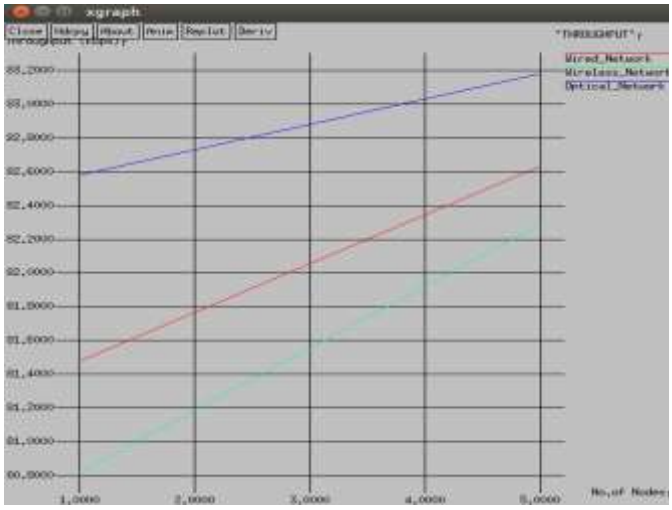

Figure 14: Comparison of Throughput

The figure 14 shows the graph between throughput and number of nodes. The graph shows that optical network have more throughput as compared to wired and optical network and wireless network have less packet delivery ratio as compared to wired network.

III. CONCLUSION AND FUTURE SCOPE

The optical network has many advantages over copper based communication in terms of bandwidth, signal security, electrical interference, size and weight but it is more costly as compared to wired and wireless network. A wireless network is that whose interconnection is implemented without use of wire. This network is mostly associated with telecommunication network. The electromagnetic waves are used for the communication and the reason for using wireless networks are cost effectiveness of network. This network is applicable in that environment where wiring is not possible or it is preferable solution. The optical network has higher bandwidth and high speed as compared to wired and wireless networks. The wireless network is easy to use but due to interference signal may lost.

In this research work, we designed and simulate a wired, wireless and optical network. The results of simulation are stored in a trace file that records data about all events that occurred during simulation process. The graphs show that the optical networks have more throughput and packet delivery ratio whereas end to end delay is less as compared to wired and wireless network. So from the results we can conclude that the optical network is better as compared to wired and wireless network.

In future, there is a lot of work that can be done and wide variety of parameters that can be compared for wired, wireless and optical networks for a large range of applications in different scenarios.

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