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Simulation and Performance Analysis of CIT College Campus Network for Realistic Traffic Scenarios using NETSIM

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Abstract

A network is a group of hardware devices and software components that are designed to connect devices. To be effective and efficient, a network must meet a number of criteria. The most important of these are performance, throughput, delay and security. CIT college network is a well designed and an efficient network but suffers from various problems like hardware failure, bandwidth congestion, application server processing time, quality of data, authentication service and the like. Hence diagnosing network performance issues is part of our daily work. This paper aims to simulate and analyze the performance of LAN network implemented in our college using NETSIM, and to study its performance metrics. A proper study on the network metrics is made and solutions for improvement measures are provided. A considerable increase in throughput and decrease in delay is been noted by modifying the parameters in the application type, switching mode and transport layer of wired and wireless node in the current network structure.

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Keywords: Network performance; LAN Network; NETSIM

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1. Introduction

A network is the grouping of hardware devices and software components that are designed to connect devices. Categories of IP internetworks in workplaces are well designed, and that have been pieced together in sections over time. Networks that arise from network design plans are typically better and a well-planned network must allow for resilience and scalability. Today's high performance and successful LANs must use hardware and software that is compatible with the current network technology. So understanding and analysis of network devices and their metrics is essential to help network users to diagnose and resolve connectivity problems, efficiency, load balance, delay, throughput, clustering, and many others thus saving valuable time and money that can be used toward other productive endeavours within an organization [5]. A well-designed network is a successful network and a decent level of security could be got out of it. Our college network is a well-designed network and it is necessary to review its performance metrics. It is essential to design, model and simulate IEEE802.11 WLAN network of our college and analyse its performance metrics and do the required modifications to improvise it.
The rest of the paper is organised as follows:
Section 2 comprises of context and references related to simulating an enterprise network. Section 3 gives an overview of the Netsim framework. Section 4 describes the simulated campus network. Section 5 discusses the obtained results and Section 5 – The conclusion and future work.

2. Related works

“NetSim - The framework for complex network generator” [1] says Networks are everywhere and their types, including social networks, the Internet, food webs, etc. However, in real-world networks, it's hard to find examples that can be easily comparable, i.e. that have the same density or even number of nodes and edges. This paper proposed a flexible and extensible NetSim framework that could be used to understand how properties in different types of networks change with varying number of edges and vertices. Simulation with three classical network models (random, small-world, and scale-free) with easily adjustable model parameters and network size is carried out. The performance metrics of the different network models are compared keeping the number of edges and vertices fixed across the models. To understand how they change depending on the number of nodes and edges 30,000 simulations are run and different network characteristics are analysed that cannot be derived analytically. Two of the main findings from the analysis are that the average shortest path does not change with the density of the scale-free network but changes for small-world and random networks; the apparent difference in mean betweenness centrality of the scale-free network compared with random and small-world networks.
"Modeling, implementation and evaluation of IEEE 802.11 ac inNS-3 for enterprise networks” [2], implemented IEEE 802.11ac features in NS-3 network simulator, evaluated its performance under various channel conditions and deployment scenarios and bit-error calculations for higher modulation coding schemes. Simulated and implemented four wireless LAN deployment scenarios from the 802.11ax working group scenario document and their performance under different operating conditions are evaluated. The simulation results show that increasing the number of nodes in an enterprise network will yield lower average throughput to each AP and several APs on the same channel will create unreliable networks with some stations getting high throughput and some not able to send at all. Significant improvement in throughput was also observed with the use of frame aggregation.
“Simulation of 802.11n and 802.11 ac based networks in NetSim” [3]. This technical blog says 802.11n is an amendment to the IEEE 802.11 wireless networking standards to improve network throughput over the two previous standards—802.11a and 802.11g with a significant increase in the maximum net data rate from 54 Mbps to 600 Mbps. IEEE 802.11ac is the fifth generation in Wi-Fi networking standards and will bring fast, high quality video streaming with dramatic improvements in transmission speeds. This blog helped in ‘Getting started’ with Netsim and also to design, model and simulate wireless networks using AP, Wireless and wired Node, Router, Switch.
“Simulation & Performance Analysis of Wired and Wireless Computer Networks”[4]. In this, performance analysis of the Wireless and Wired computer networks through simulation has been attempted using OPNET as a simulating tool. For wired networks, the performance parameters like delay and throughput have been investigated with varying transmission links and load balancers. The load-balancing has been analyzed through traffic sent and traffic received. While in wireless networks the metrics like delay, retransmission attempts and throughput have been

estimated by varying physical characteristics and buffer size. From the obtained results, it is gathered that the performance of the wired networks is good if high speed Ethernet links like 1000 Base X and server-load balancing policy are used whereas the performance of Wireless LAN can be improved by fine tuning and properly choosing the WLAN parameters. For the tested simulation scenarios the performance is observed to be better with wireless networks using infra-red type physical characteristics and higher buffer size (1024Kbps).

"Performance evaluation of the IEEE 802.11 wireless LAN standards"[5]. IEEE 802.11 supports multiple transmission rates. Choosing an IEEE protocol for a network is highly dependent on the traffic load as well as running application. In this paper, methods for improving the performance of WLANs were investigated. Results shows that better tuning of WLAN PCF parameters for low speed WLAN can be used to enhance network performance achieving performance compared to high speed WLAN.

"Wireless network performance optimization using Opnet Modeler"[6]. In this, WLAN performance optimization has been shown via a series of simulation tests with RTS/CTS threshold, fragmentation threshold and data rate using OPNET. Simulation results show a satisfactory performance when the environment parameters are tuned accurately.

"Evaluating the performance of IEEE 802.11 Network using RTS/CTS Mechanism"[8]. In order to effectively analyze the performance of wireless local area networks (WLANs), it is important to identify the types of network settings that can cause bad performance. The RTS/CTS mechanism is simulated in Netsim to evaluate the performance of IEEE 802.11 MAC protocol. It is concluded that RTS/CTS mechanism is helpful to reduce the number of retransmissions if hidden node problem persists in network scenarios by comparing the total WLAN retransmissions, data traffic sent/received and WLAN Delay.

3. NETSIM Framework

NetSim Pro version is suited for commercial (enterprise / defense) customers while NetSim standard and NetSim Academic is targeted at education customers. The following are the salient features available in NETSIM.

Designing a network:

- Creating network scenarios using NetSim's GUI or using XML configure files.

Run the simulation:

Viewing packet animation:

Result analysis:

- Examine output performance metrics at multiple levels - network, sub network, link, queue, application etc.

Interfacing with external software:

- The external interface allows NetSim to pass the instantaneous network data to another tool like MATLAB.

4. CIT Campus Network

Our campus network is a proprietary local area network (LAN). Reliance is the service provider and provides overall block rate of 154Mbps.

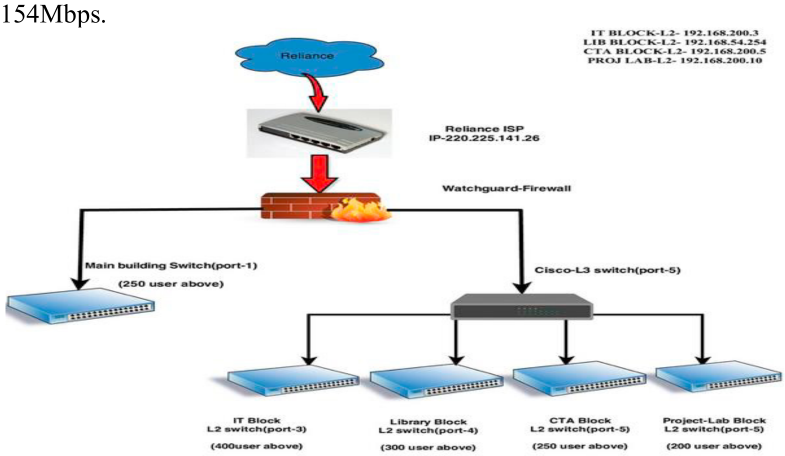

Fig. 1 Overall network infrastructure of CIT campus

This is split between the building blocks by switches, APs and ports. Among these building blocks the network is simulated for Library building block in Netsim. Fig. 1 shows the overall network structure of our college campus. Fig. 2 shows the Library building block (second floor) network plan. First a rough report on number of wired nodes, wireless nodes, access points, switches, hubs is taken.

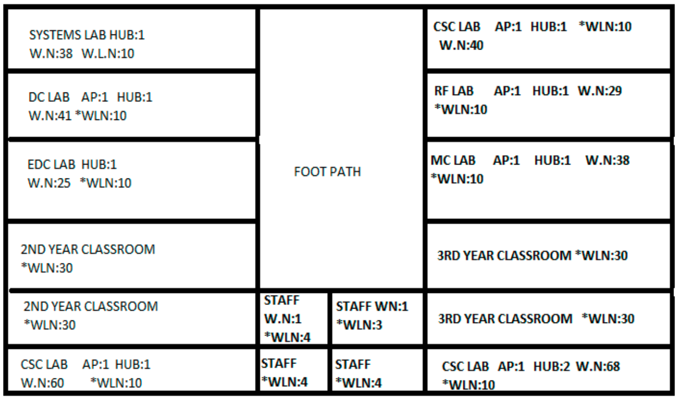

Fig. 2 Library block network plan (second floor)

Their configuration settings, connection settings and position settings were analyzed. Then the same network is constructed in Netsim and simulated with the configured settings and the throughputs are analyzed.

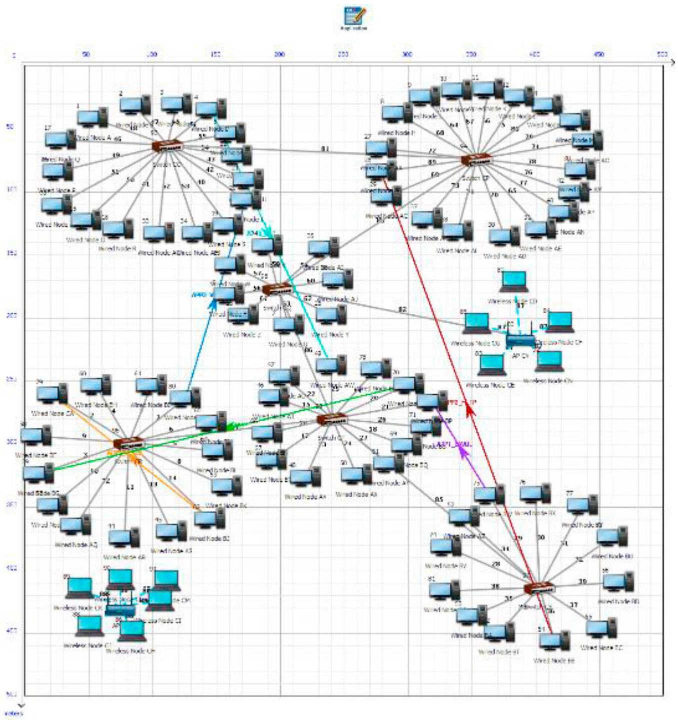

Fig. 3 Second floor of Library building block: Simulation model in Netsim[1]

[1]Not all application types are specified

The second floor in Library building block has eight laboratories, four classrooms and four faculty rooms. The main hub for the library building block is placed in two places: one in 2nd floor computer science laboratory and other in ground floor computer science laboratory. The number of wired nodes, wireless nodes, access points, hubs is constructed with the same count as specified in Fig 2. The number of wireless node is taken an approximate count as it varies based on the number of students, faculties and others utilizing the lab/classroom. The library block second floor network plan simulated in Netsim is shown in Fig. 3. The network is constructed with wired nodes, wireless nodes, switches, wired links, wireless links and access points. These hardware devices can be configured in almost all the layers.

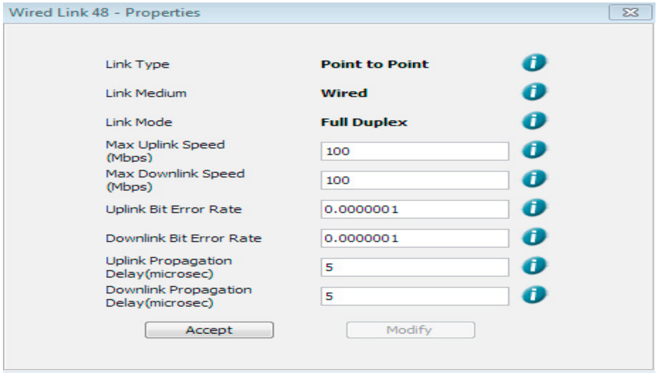

Fig. 4 Wired link properties

Fig. 4 shows the Second floor of Library building block configuration setting of wired link updated in Netsim.

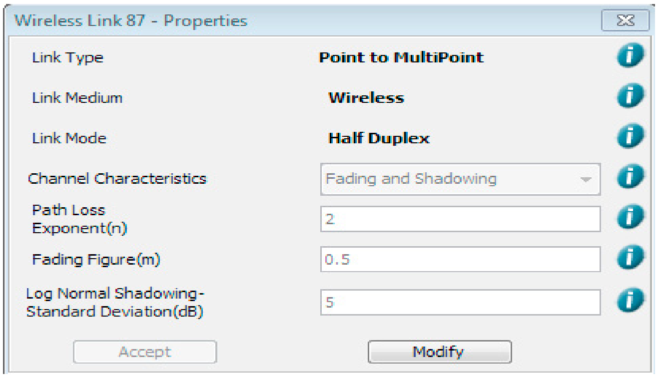

Fig. 5 Wireless link properties

Fig. 5 shows the Second floor of Library building block configuration setting of wireless link updated in Netsim. Table 1 shows the Second floor of Library building block configuration setting of wired and wireless nodes updated in Netsim. In wired node the global properties are changeable, and it can be reconfigured at application, transport and network layers. Three layers of OSI perform a major role in this simulation. The transport layer specifies the protocol type, maximum segment size, congestion control mechanism, window size and segment size. Four types of congestion control algorithms can be employed; Old Tahoe, Tahoe, Reno and new Reno. Old Tahoe is the combination of slow start and congestion avoidance algorithm. Tahoe comes with fast retransmission. Reno implements fast recovery in case of three duplicate acknowledgements and new Reno improves retransmission during fast recovery of TCP Reno. The network layer specifies the range of ICMP continuous polling time. The Ethernet interface can also be specified at network, data link and physical layers.

Table 1. Library building block configuration setting of wired and wireless nodes

DESCRPTION	WIRED NODE	WIRELESS NODE
APPLICATION LAYER	X/LAT=23 X/LON=32	X/LAT=297 X/LON=164
TRANSPORT LAYER	PROTOCOL:TCP/UDP MSS(bytes):1460 Congestion Control method: Old Tahoe Window Size:8 ACK type: Undelayed UDP Segment Size: 1472	
NETWORK LAYER	PROTOCOL:IPv4 ICMP Count polling: 3	
Interface (Ethernet)	**NETWORK LAYER**	
	IP Address: 192.68.1.12	10.0.1.86
	Subnet mask: 255.255.0.0	255.255.0.0
	Protocol: ARP	ARP
	ARP retry interval(s): 10	10
	ARP retry limit(s): 3	3
	DATALINK LAYER	
	Protocol: Ethernet	IEEE 802.11
	MAC Address: FC99763B5D	CB3ED1469227
		BSS Type: Infrastructure
		RTS threshold: 3000bytes
		Rate adaptation: False
		Retry limit: 4
	PHYSICAL LAYER	
	Connection: Switch CO	AP CO
	Ethernet Standard: IEEE 802.3	IEEE 802.11b

Table 2 shows the switch configuration settings in Netsim. The switching latency and mode can be altered for effective results in delay but the throughput factor has to be compromised.

Table 2. Switch configuration

		LAYERS	PROPERTIES	
Switch 1	Interface-17	Data link layer	Protocol	Ethernet
			Mac address	731877688144
			Switching latency	21.7
			Switching mode	Store forward
			Ethernet standard	IEEE802.3u
			Speed	100 Mbps
			STP cost	19
		Physical layer	Protocol	Ethernet
			Link mode	full duplex
			Ethernet standard	IEEE802.3u
			Connection medium	wired

Three switching modes are possible; Store Forward, Cut through and fragment free. In store forward, forwarding occurs only after the receipt of the entire frame. It checks for error and if no errors are found it forwards the frame. Throughput can be significantly increased on the wave of delay. 100BaseT Ethernet standard is opted with speed of 100Mbps and Spanning tree cost of 19. Each switch can be configured for up to 24 different interfaces. Table 3 shows the AP settings for wireless nodes. AP can be configured at datalink and physical layers. Both wireless and Ethernet interfaces are possible with access points. The APs are not centralized. The wireless devices can communicate with each other or can communicate with a wired network through APs. At datalink layer the configuration is done in such a way that RTS packets are transmitted only for those frames whose size is greater than the specified RTS_Threshold value. Also the retry limit is configured as 4 for an optimal throughput.

Table 3. AP settings for wireless nodes

DATALINK LAYER	PHYSICAL LAYER
Protocol: IEEE 802.11	Standard: IEEE 802.11b
IEEE 802.11e: Enabled	Transmission type: DSSS
Rate Adaptation: False	Transmit Power(mW): 100
Mac address: 9266E4969A32	SIFS(us): 10
BSS Type: Infrastructure	Frequency band: 2.4Ghz
RTS threshold: 3000bytes	Bandwidth(MHz):20
Buffer Size: 1	CCA Mode: Energy detection
Retry limit: 4	ED threshold: -80dBm
	Slot time(us): 20
	Standard Channel: 1_2412
	CWmin: 31
	CWmax: 1023

At Physical layer DSSS radio transmission technique is opted with maximum transmission power of 100mW. SIFS is the min inter frame space time defined as, $SIFS_{Time}=RF_{Delay}+PL_{CPDelay}+MAC_{ProcessingDelay}+TurnAroundTime$. The simulated WLAN operates at 2.4GHz with Bandwidth of 20MHz. At the receiver, ED threshold is intended for use by PhyLayer as a part of channel selection algorithm. The slot time for each frame is set as 20 microsec. It is the combination of CCATime+TurnAroundTime+Air PropagationTime+MACProcessingDelay. In wi-fi 11 channels with 3 non-overlapping channel 1,6,11 operates at frequencies 2412, 2437 and 2462MHz respectively. The network is simulated to work for channel 1_2412MHz band. The min and max contention window size is set with an intention of getting an appreciable network performance.

Table 4. settings for Email application

	APPLICATION TYPE	EMAIL
APPLICATION 1	CLIENT ID	75
	SERVER ID	68
	START TIME	0
	END TIME	100000
	ENCRYPTION	None
	EMAIL RECEIVE	
	DURATION DISTRIBUTION	CONSTANT
	EMAIL SIZE DISTRIBTION	CONSTANT
	EMAIL SIZE(BYTES)	20000
	EMAIL SEND	
	DURATION DISTRIBUTION	CONSTANT
	EMAIL SIZE DISTRIBUTION	CONSTANT
	EMAIL SIZE(BYTES	20000

Table 4 shows the settings for an Email application. The Network is also simulated with 2 other types of such application protocols.

- VIDEO
- FTP (File Transfer Protocol)

5. Results and Discussion

Simulation is carried out by transmitting different traffic types between the wired and wireless nodes across the network. Throughput and delay parameters are the major consideration of study in the simulation.

5.1 Throughput and delay results for current network plan

The above said network configuration settings are set and the obtained throughput and delay is tabulated in Table 5. Three different data traffic: Email, Video and Files are been transferred between several wired nodes (WN) and wireless nodes (WSN). The payload has been fixed based on the application type.

Table 5. Results for current network plan

Application Name	Source Id	Destination Id	Payload Transmitted	Payload Received	Throughput (Mbps)	Delay (msec)
EMAIL_WN to WN	68	75	360000.0	360000.0	0.288	0.0013726
EMAIL_WSN to WN	24	82	360000.0	360000.0	0.288	0.1194586
EMAIL_WSN to WSN	90	82	360000.0	360000.0	0.288	0.1500822
VIDEO_WN to WN	2	13	56667.0	56667.0	0.045334	0.0002116
VIDEO_WSN to WN	87	23	67624.0	67624.0	0.054099	0.0031892
VIDEO_WSN to WSN	89	92	65611.00	65611.0	0.052489	0.0186106
FTP_WN to WN	79	47	100000.00	100000.0	0.08	0.0055771
FTP_WSN to WN	85	1	100000.00	100000.0	0.08	0.323148
FTP_WSN to WSN	83	84	100000.0	100000.0	0.08	0.3998453

It is been observed that throughput remains constant for the same application irrespective of nodes and the delay varies both for the application type and nodes due to the type TCP protocol. The delay is nominal when data is been transferred between wired nodes and it is high when transferred between wired and wireless nodes and it is much higher for transmission across wireless nodes. The Email size is fixed to be 20000 bytes with constant data distribution. No encryption is performed. The File size is fixed to be 100000 bytes with constant data distribution. The video model is assumed to be Continuous normal BER and 10 frames per second are processed. Mu and Sigma values are fixed as 0.52 and 0.23 respectively. G.711 Codec scheme is opted.

5.2 Throughput results for modified network plan

For an increased throughput and decreased delay from the existing network plan the following modifications are done. Table 6 shows the modifications done under each layer, nodes and links.

Table 6. Modifications done to current network plan

DESCRIPTION	MODIFCATIONS
APPLICATION	ENCRYPTION:XOR DISTRIBUTION:EXPONENTIAL
SWITCH	FRAGMENT FREE LATENCY: 30usec
WIRED NODE	CONGESTION CONTRO ALGORITHM: New Reno
WIRELESS NODE	ICMP POLLING:4 WINDOW SIZE:32
ACCESS POINT	RETRY LIMIT:4 ED THRESHOLD: -90dBM

1. XOR type encryption has been performed to achieve enhanced data security.
2. The distribution of data is made exponential. i.e the output is taken as continuous probability distribution.
3. Data are switched between the nodes in Fragment free fashion. In this method the switch forwards the incoming frames to its appropriate outgoing port upon receipt of the first 64 bytes of the frame. This leads to increased processing rate of the packets.
4. The increased processing rate of the switches should not lead to collision or dropping of packets. So to aid this switching latency is increased to 30usec for safe processing of packets.
5. New Reno congestion control algorithm is employed as it takes care of fast recovery of retransmitted packets.
6. The range of ICMP continuous polling time is increased to detect fault in a reasonable time.

7. The number of segments that can be transmitted by the sender at a time is increased for processing more data packets.
8. Retry limit count is increased by one to limit the loss of packets.
9. Detection of threshold level is decreased to avoid false detection of packets.

Switch and wired node configuration settings are altered with a view of increasing the throughput and decreased delay for wireless nodes. The throughput and delay for this modified network is tabulated in table 7.

Table 7. Results for modified network plan

Application Name	Source Id	Destination Id	Payload Transmitted	Payload Received	Throughput (Mbps)	Delay (msec)
EMAIL_WN to WN	3	2	360000.0	360000.0	0.288	0.001293217
EMAIL_WSN to WN	24	82	360000.0	360000.0	0.288	0.112210271
EMAIL_WSN to WSN	90	82	360000.0	360000.0	0.288	0.148688731
VIDEO_WN to WN	2	13	170006.0	170006.0	0.136005	0.000439401
VIDEO_WSN to WN	87	23	199514.0	199514.0	0.159611	0.006736755
VIDEO_WSN to WSN	89	92	194217.0	194217.0	0.155374	0.022610676
FTP_WN to WN	79	47	10000.0	10000.0	0.1207	0.015861657
FTP_WSN to WN	85	1	10000.0	10000.0	0.1207	0.110623591
FTP_WSN to WSN	2	3	10000.00	10000.0	0.1207	0.278587429

5.3 Results comparison

Fig. 6 shows the throughput and delay comparison of CIT campus network before and after modifications. The modifications are done for the same data size specified before in section A.

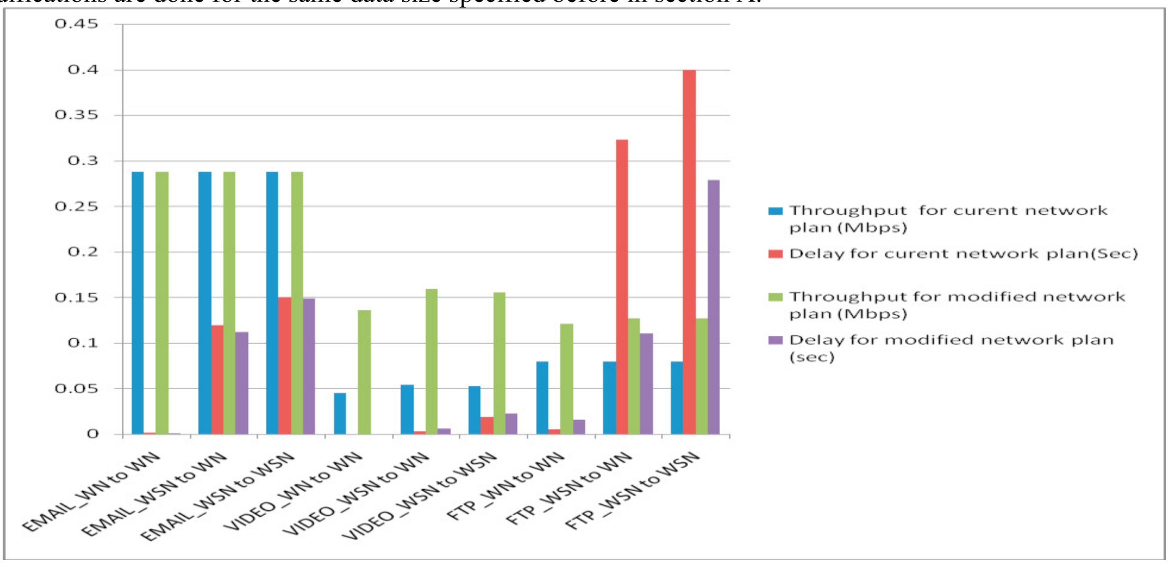

Fig. 6 Throughput and delay comparison chart

Email: The modifications did not work well and the throughput seemed to be unchanged but there is slight decrease in the delay by 0.079msec for wired node to wired node and 1.39msec for wireless node to wireless node. This is because of the type of traffic as Email does not worry much about either throughput or delay parameters.

Video: There is a reasonable change in throughput in the order of 100Kbytes for this data traffic. But unfortunately

there is a very slight increase in the delay which has to be compromised.
FTP: There is a considerable increase in throughput in the order of 40Kbytes and remain constant irrespective of the nodes. There is also a very little decrease in the delay by 0.107msec.

Inference: Security and performance of the network is good when the encryption type is changed to XOR. As it is more secure the connections are limited to restricted users hence network speed is been increased. Packet error and collision rate is reduced due to the New Reno congestion control algorithm and increased switching latency. There is fast transmission of ready packets, fast retransmission and recovery of lost and collided packets as there is an increase in the window size and by the adoption of Fragment free switching mechanism.

6. Conclusion and Future work

A portion of our college network is simulated in Netsim and its performance is analyzed. An increase in throughput of 70Kbytes and decrease in delay of 0.1msec is observed based on the traffic condition and the type of communicating nodes by modifying the parameters in the application type, switching mode and transport layer of wired and wireless node appropriately. In future the modified network configuration settings will be taken for consideration through our college network admin for considerable increase in throughput and decreased delay.

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