ENSC 427
COMMUNICATION NETWORKS

PERFORMANCE ANALYSIS OF VIDEO STREAM OVER WI-FI AND ETHERNET

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1. Abstract

Past couple of years have seen a steady upsurge in the demand of internet video streaming services; most notably Netflix, HuluPlus and HBO Now. This has motivated us to analyze the performance profile of internet video streaming over Ethernet, Wi-Fi and Wi-Fi connected Mobile user.

In order to achieve this we will be using the Riverbed Modeler to test a video trace file and measure the End-to-End delay as well as Throughput. We will be setting up a master server in California, connected to a subnet which will house an Ethernet server. To this server we will attach a switch that in turn will connect our end user in the form of a Ethernet Workstation, Wireless Mobile node such as a laptop or a cell phone and a Wireless capable fixed device such as a gaming console or a wireless Desktop

2. Introduction

With an increase in the popularity of smartphones as well as other portable wireless devices, there is an increased traffic growth when it comes to wireless networks. A decade ago, modem and routers were unheard of in many households, but now one can't live without a working wireless connection.

This increase in wireless networking has led to many companies offering a variety of services to consumers. Most notably, online video streaming, itself, has seen a upsurge in demand. The following Figure I [1] shows us that on average, North American users devote a large amount to online entertainment.

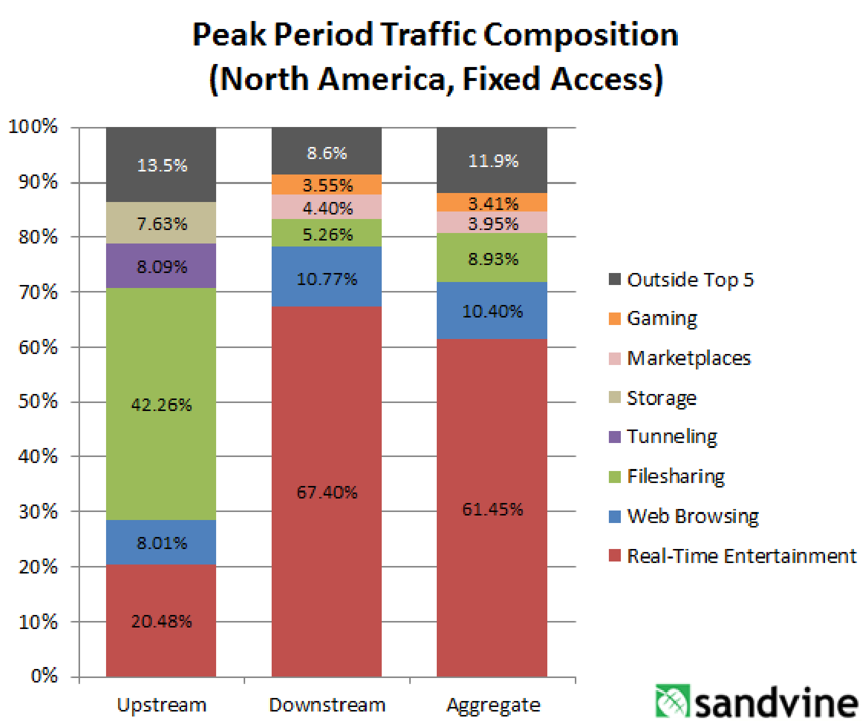


Figure I: Internet Traffic Composition of North American Users [1]

Among these video streaming services, Netflix has grown exponentially, as it can be seen from Figure II [1]. Netflix has implemented the best streaming services.

	Upstream		Downstream		Aggregate	
Rank	Application	Share	Application	Share	Application	Share
1	BitTorrent	36.35%	Netflix	31.62%	Netflix	28.18%
2	HTTP	6.03%	YouTube	18.69%	YouTube	16.78%
3	SSL	5.87%	HTTP	9.74%	HTTP	9.26%
4	Netflix	4.44%	BitTorrent	4.05%	BitTorrent	7.39%
5	YouTube	3.63%	iTunes	3.27%	iTunes	2.91%
6	Skype	2.76%	MPEG - Other	2.60%	SSL	2.54%
7	QVoD	2.55%	SSL	2.05%	MPEG - Other	2.32%
8	Facebook	1.54%	Amazon Video	1.61%	Amazon Video	1.48%
9	FaceTime	1.44%	Facebook	1.31%	Facebook	1.34%
10	Dropbox	1.39%	Hulu	1.29%	Hulu	1.15%
		66.00%		76.23%		73.35%

sandvine

Figure II: Peak Time Period Applications [1]

In this project we will analyze the performance of Video Streaming over Wi-Fi and Ethernet over a single user, two – user and three – user system topologies. For Wi-Fi topologies, both 802.11g and 802.11n will be used for comparison. Each of these topology's results will be compared atond decide which topology is more efficient for online video streaming.

2.1 Fundamental Concepts

Wireless Fidelity (Wi-Fi) & IEEE 802.11 Standard

Using radio waves, Wi-Fi transfers data wirelessly. The most common bands being used these days are 2.4GHz and 5GHz [2]. Due to the portability it offers, Wi-Fi has become popular mode of networking within both commercial and private sector. Wi-Fi offers various applications and is implemented across various devices such as cell phones, gaming consoles, laptops etc. Wi-Fi is based on IEEE 802.11 Standards

The 802.11 protocol has multiple sub classes. The most common classes are b, g, n, ac. In our project we included g and n sub classes. The 802.11g works over the 2.4GHz frequency band and is limited to up to 54Mbps data transfer rate [3]. However to simulate a more realistic data rate, our simulation used 24Mbps data transfer rate for 802.11g protocol. 802.11N, however has a data transfer range from 26Mbps to 260 Mbps.

802.11 operates on two modes: Distributed Coordinated Function (DCF) and Point Coordination Function (PCF). DCF is based on Carrier Sense Multiple Access/Collision Avoidance. However, PCF facilitates the coordination of timing by contention – free periods (CFP) and contention periods. [4]

Quality of Service (QoS)

Quality of Service is the measure of network systems overall performance. This measure can be calculated by various parameters such as latency, packet delay and loss, throughput etc. For our project, we only take into account the traffic received and the video throughput.

3. Riverbed Modeller Implementation

3.1 Ethernet – 1 User Topology

We implemented our Ethernet model using an advanced Ethernet station connected to an Ethernet switch which connected the advanced Ethernet server with a 100BaseT to complete the network. Application and Profile configurations were also placed in the network. The topology is shown below:

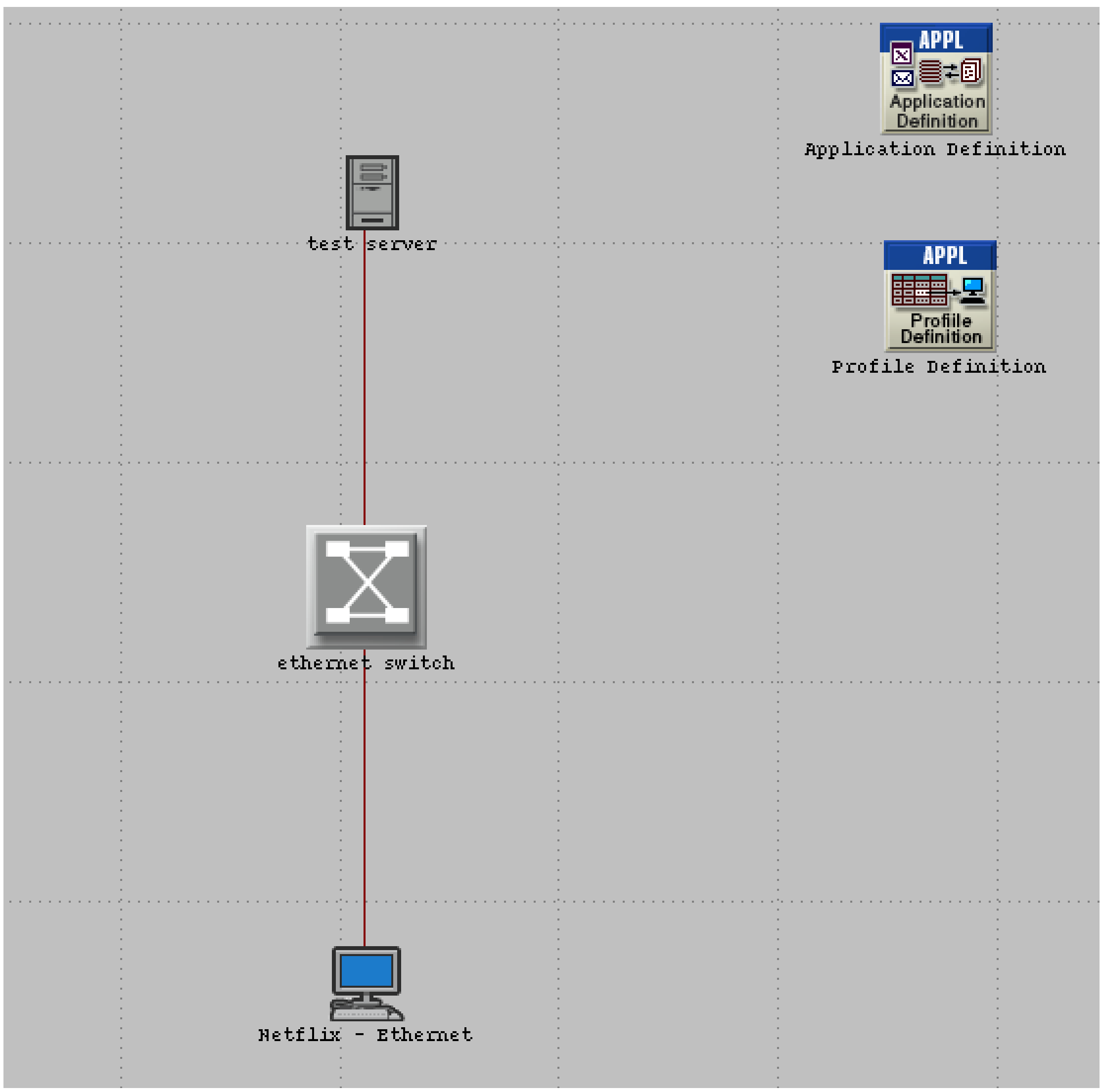


Figure III: Ethernet 1 –User Topology

3.2 WLAN – 1 User Topology

The WLAN topology for one user is implemented by using an advanced Ethernet server connected to an Ethernet Access Point through 100BaseT connection. The advanced WLAN workstation connects wirelessly to this access point. This topology is shown below:

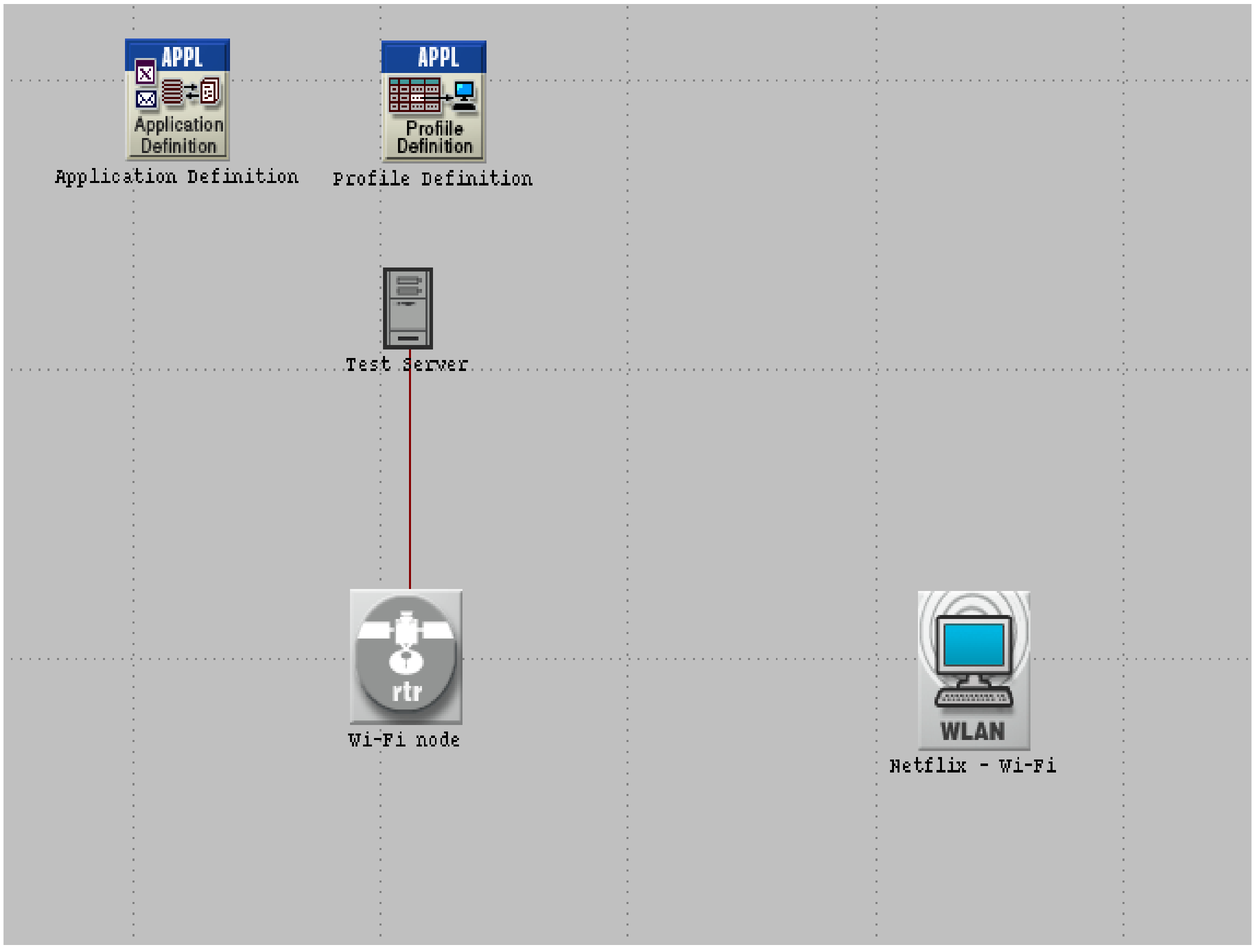


Figure IV: WLAN 1 – User Topology

<u>WLAN Settings</u>

In order to connect the Access Point (AP) to the WLAN workstation, we had to force assign BSSID to both AP and the workstation. Secondly, the AP functionality has to be disabled except for the AP router. The settings are depicted below:

Wireless LAN MAC Address	Auto Assigned
⊟ Wireless LAN Parameters	(...)
BSS Identifier	1
Access Point Functionality	Disabled
Physical Characteristics	Extended Rate PHY (802.11g)
Data Rate (bps)	24 Mbps
⊞ Channel Settings	Auto Assigned
Transmit Power (W)	0.005
Packet Reception-Power Thre...	-95
Rts Threshold (bytes)	None
Fragmentation Threshold (byt...	None
CTS-to-self Option	Enabled
Short Retry Limit	7
Long Retry Limit	4
AP Beacon Interval (secs)	0.02
Max Receive Lifetime (secs)	0.5
Buffer Size (bits)	256000
Roaming Capability	Disabled
Large Packet Processing	Drop
⊞ PCF Parameters	Disabled
⊞ HCF Parameters	Default
⊞ High Throughput Parameters	Default 802.11n Settings
⊞ WAVE Parameters	Not Supported

Figure V: WLAN Settings

3.3 WLAN – Ethernet – 2 – User Topology

The topology of this system is directly derived from the 1 – user topology. However, both Ethernet and WLAN are connected to a same common server. It is shown in the figure below:

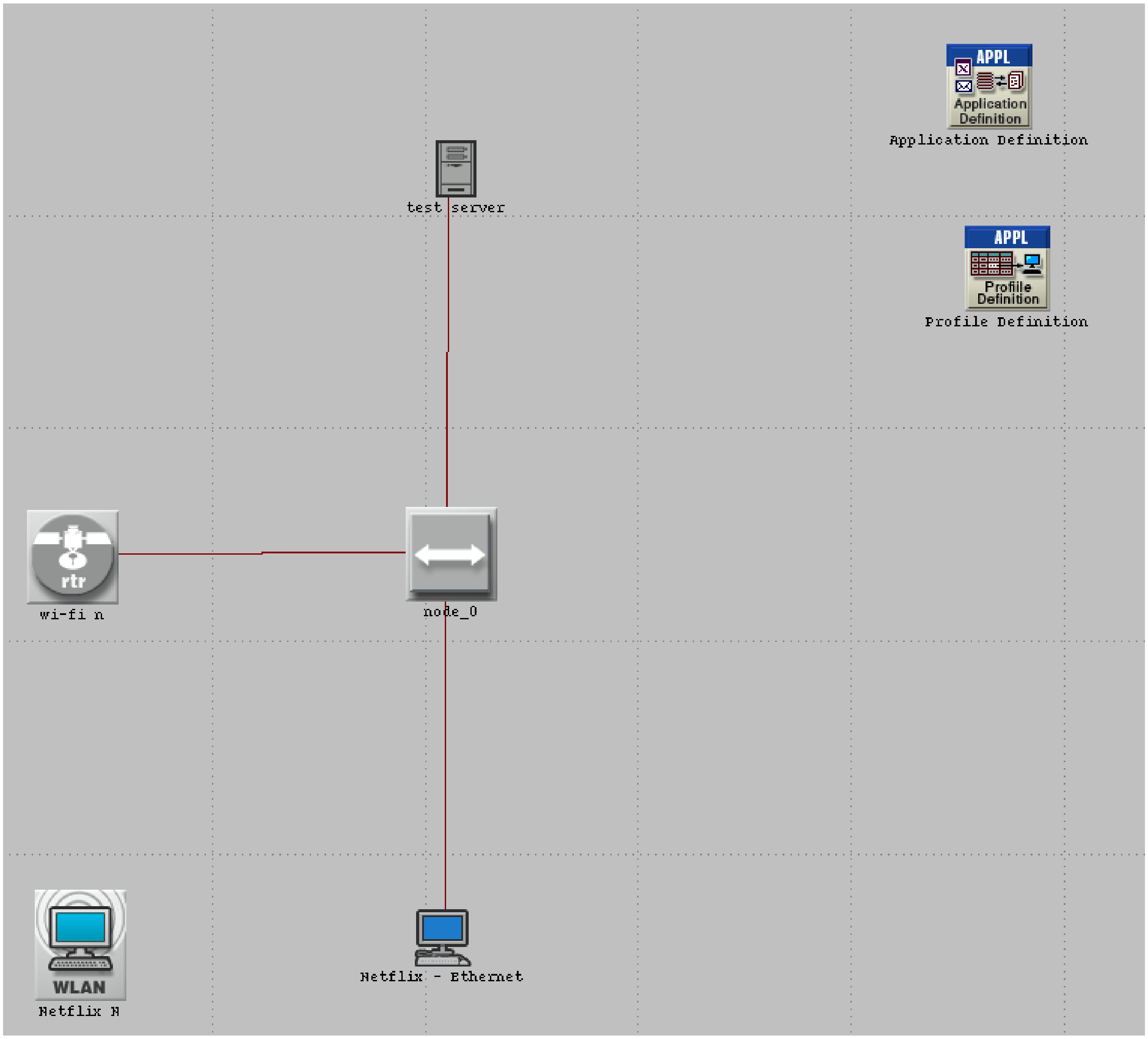


Figure VI: 2 - User Topology

3.4 Two WLAN – Ethernet – 3 – User Topology

In this topology, we implemented a WLAN N router connected to 802.11 N workstation and 802.11 G workstation along with a common Ethernet connection. It is depicted below:

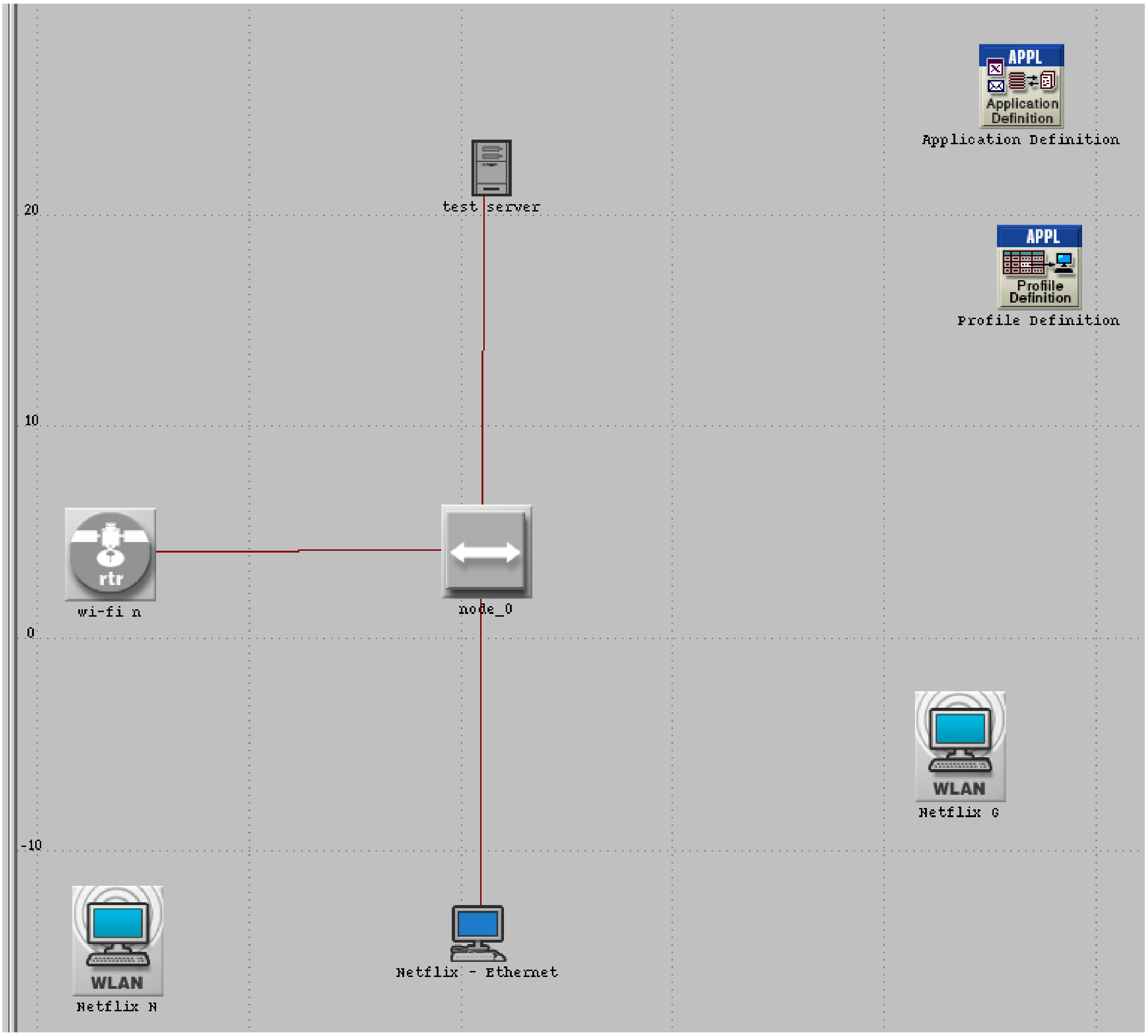
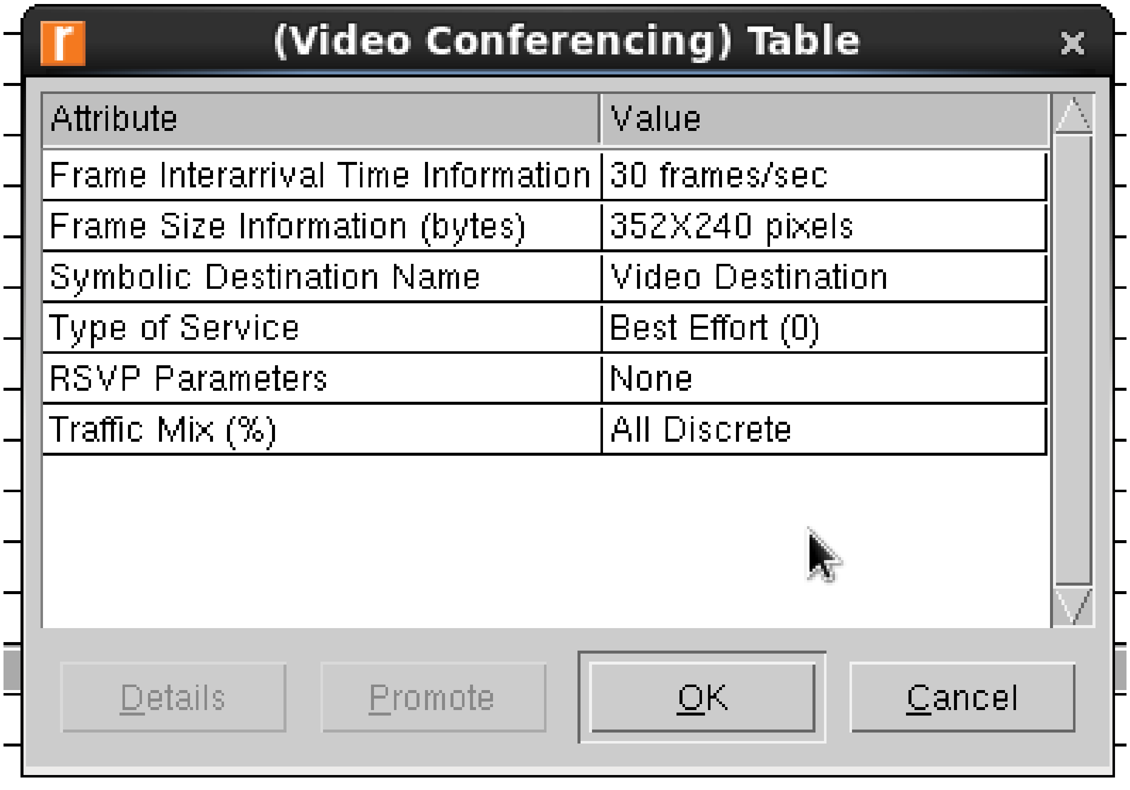


Figure VII: 3 - User Topology

3.5 Application Configuration

To configure the application configuration we decided to use the video conferencing module of Riverbed Modeller. Since video conferencing is a 2-way application we had to tweak it in such a way that it only send video packets but not receive any packets. These incoming frames were set a frequency of 30 frames/sec an average frame size of 320x240. These settings are depicted below:



(Video Conferencing) Table

Attribute	Value
Frame Interarrival Time Information	30 frames/sec
Frame Size Information (bytes)	352X240 pixels
Symbolic Destination Name	Video Destination
Type of Service	Best Effort (0)
RSVP Parameters	None
Traffic Mix (%)	All Discrete

Figure VIII: Applciation Configuration

4. Results and Discussion

4.1 Single User System Results

Figures IX – XI show the throughputs of our single user models. Since we were only able to implement a constant bit stream, we were able to differentiate the packet headers, characterized as the staggered spikes in traffic, and payloads in the Ethernet system, as seen in Figure IX. As the data is transferred (blue) at 1m53s mark, the network receives it with a delay, shown by the red spike. This delay is due to the network acknowledging the data packets received and vice versa.

Figure X show an overlaid view of the traffic seen through our single user systems. It should be noted that the traffic captured through the Wi-Fi nodes were captured in bits/sec and in being so the traffic sent appears inflated.

Figure XI compares the throughput seen between the workstation operating in 802.11g and 802.11n. Since 802.11g is limited to 24Mbps, to represent an accurate data transfer rate, the result conforms to this logic as the same packets have a higher throughput on 802.11n as compared to 802.11g counterpart. Thus, the 802.11n has higher throughput than 802.11g.

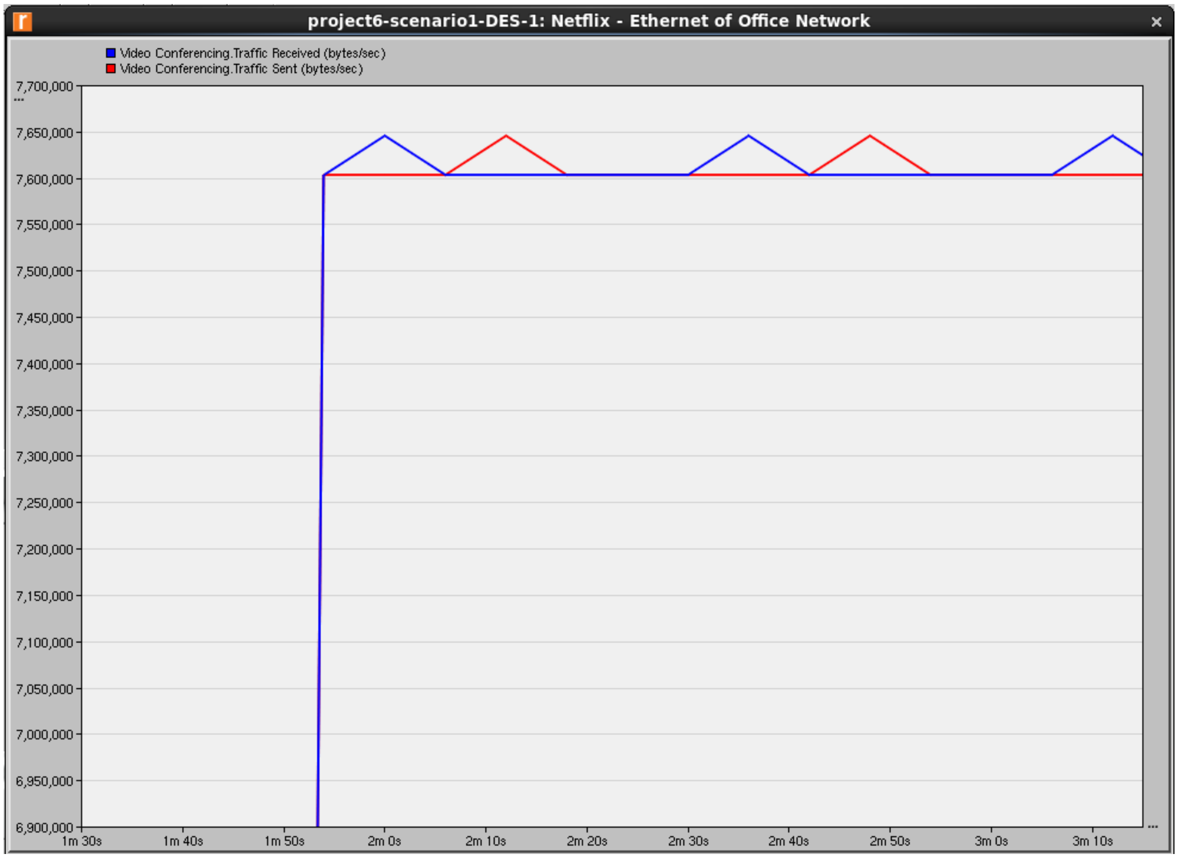


Figure IX: Ethernet Throughput

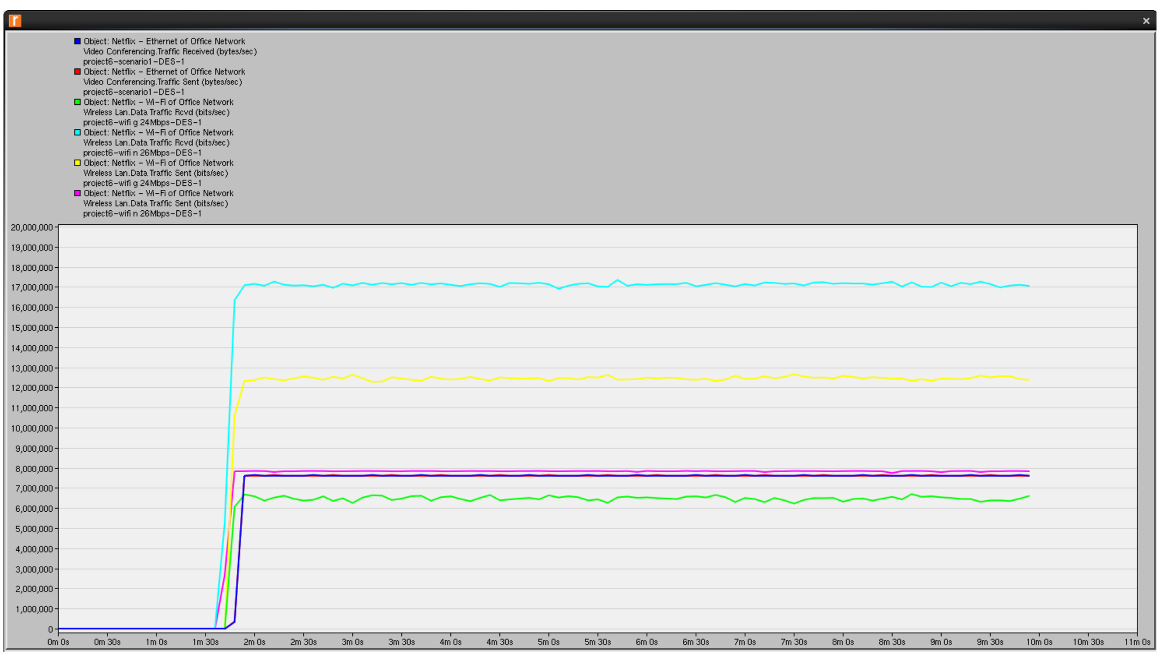


Figure X: Traffic Seen Through Single User Topologies

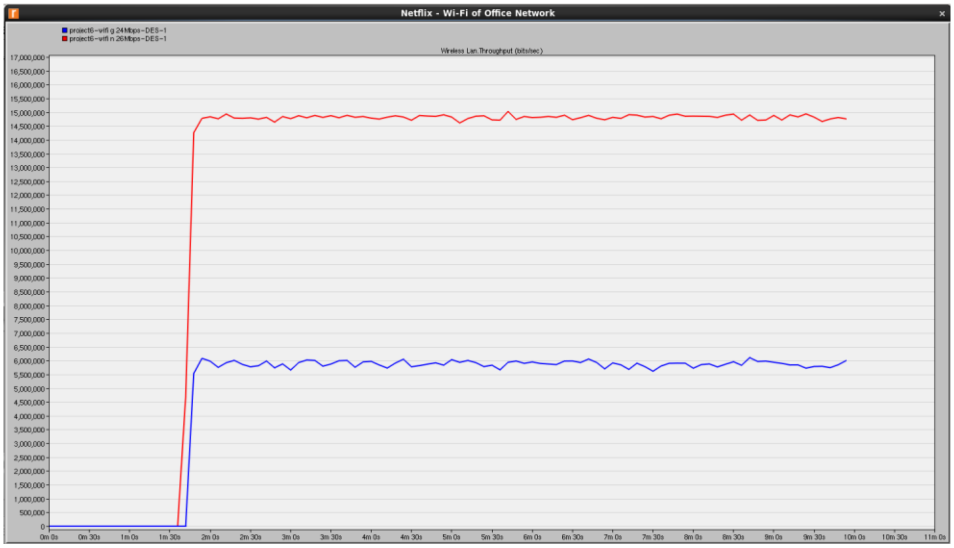


Figure XI: Single User Wi-Fi Node Throughputs

4.2 Comparison of Multi-User Systems

In Figure XII, we compare the throughput performance between the single user Wi-Fi workstations and 2 user topology. As seen in Figure VI, the Ethernet workstation had priority in the system, causing the severe drop in quality of service in the wireless N node. The wireless n node work station in the multi-user system still maintains a higher throughput compared to the single user wireless workstation using 802.11 g. This is obviously due to the higher speeds which 802.11n (upwards of 450Mbps) supports over 802.11g (54Mbps).

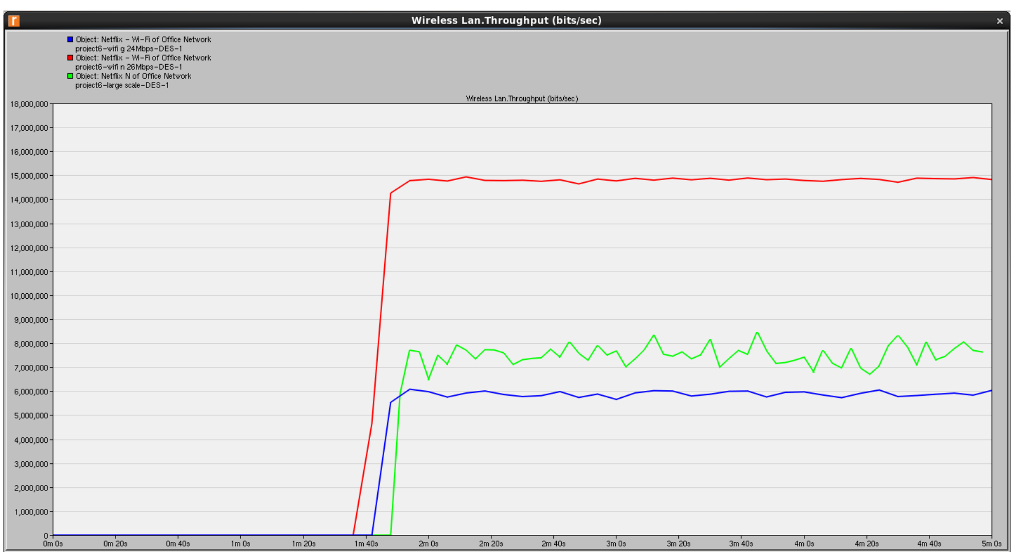


Figure XII: Throughput of 2 User Topology vs. Single User Topologies

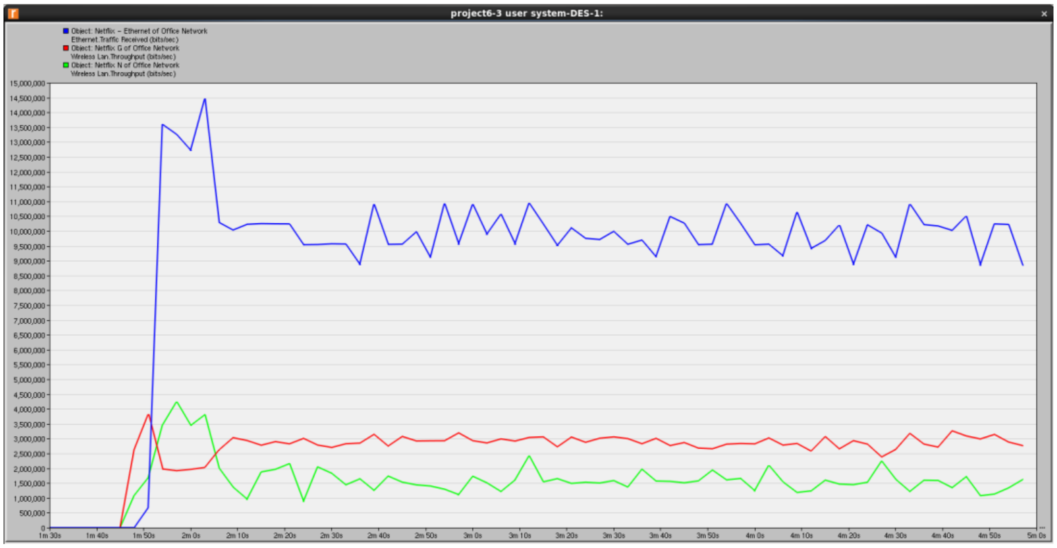


Figure XIII: 3 User Topology Throughput

Figure XIII shows the throughput of each workstation in the 3 user topology of Figure VII. The blue waveform, is the throughput of the Ethernet workstation. This is expectedly high due to its direct connection to the switch hub. The Ethernet connection gets a direct connection, while the remaining nodes must split the remaining traffic bandwidth between themselves. Due to our setup, the wireless n workstation, represented by the green waveform, has a lower priority to that of the wireless g workstation, being the red waveform. Thus by having a lower priority, the wireless n node gets a smaller chunk of the available bandwidth. It can be better observed in Figure XIV, the blue waveform is the throughput of the 2 user topology, is the average of both the green and red waveforms. You will also notice a correlation in throughput peaks; where one workstation requires a larger throughput, the other workstation experiences a drop in quality of service.

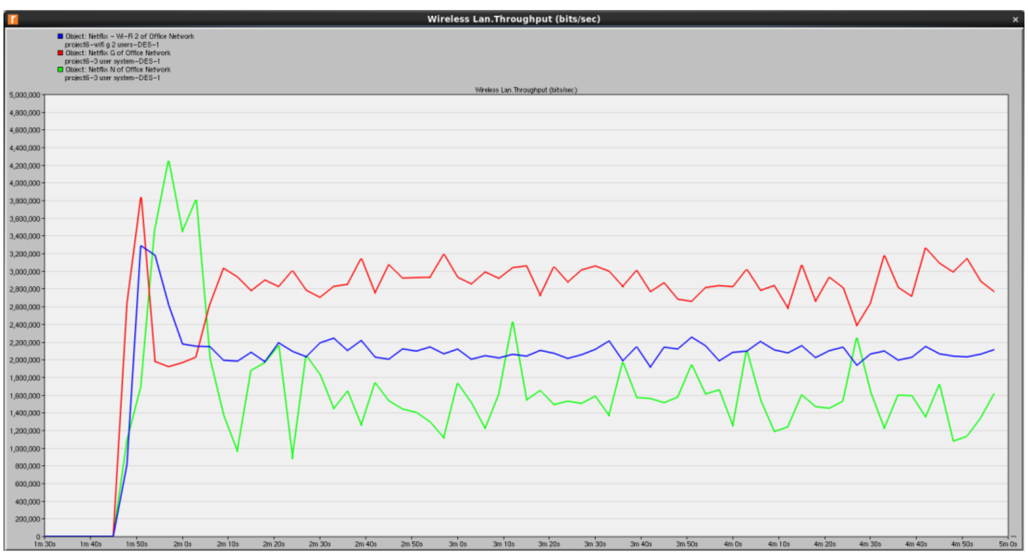


Figure XIV: Throughput of 2 User vs. 3 User Topologies

5. Conclusion and Future Work

5.1 Conclusion

Through our analysis of our various network topologies, it has been shown that Ethernet provides the highest quality of service in any home network. This means that all other users on the same network are subject to the whims and requirements of workstations connected via Ethernet. Service priorities also greatly affect the quality of service for workstations. Also by adding more users into a system, means a splitting of available resources between the wireless nodes with little impact on the direct connected network. Quality of service can be further be improved by upgrading to 802.11n as opposed to 802.11g. The 802.11n protocol supports higher speeds and boasts larger supported channels.

5.2 Future Work

In the future we would like to simulate the same topologies with more realistic data. As of the moment, the video stream simulated is only equivalent to 240p video quality. We would like to examine a high quality video stream, 1280x720 or 1920x1080, like what Netflix and YouTube are capable of supporting. We would also like to simulate on a larger scale, where data is accessed on a server much further away from the home server. This will facilitate the observation of the delay of data on a much larger system. Finally we would like for there to be future support of the fiber optics protocol on future versions of Riverbed Modeler. With the recent development of Google Fibre, we want the ability to compare between the drastic performance differences between 802.11 protocol and service over optical fiber.

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