

Traffic Flows Modeling of a Digital Center at ABU Using OPNET Software

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Abstract— The large number of computers getting connected everyday to the Internet is becoming more and more seamlessly high with the decrease in the price of computers and network devices. The Digital Center attendants wish to better understand the behavior of applications traffic flows and expected merits of network topology before making final decision. To have the idea of the traffic behavior and expected performance of the new topology, simulation and modeling technique offers the best way of examining the optimal network design and applications traffic configurations. The objective of this work is to model a Digital Center at Ahmadu Bello University (ABU), Zaria-Nigeria, its network topology, applications environment and examine the usage of applications. Application and user profiles used in the Digital Center were developed. These applications include FTP clients, e-mail transfer agents, web browsers, VOIP and Video applications. The results obtained with live packet traces using Ethereal were examined and the simulation configuration adjusted accordingly. Finally, the simulation model was developed using the OPNET Modeler software package, and analysis of the traffic flows behavior were studied.

Index Terms— Simulation; Modeling; OPNET; Digital Center; and Traffics Flows

1 INTRODUCTION

The decrease in the price of computers and devices is increasing connectivity of large number of computers to the Internet. In the Internet business world, many are changing the topology of the network to support more Internet applications. The needs for better understanding of the anticipated benefits of new network topology cannot be under estimated. To help understand the benefits, simulation and modeling give quick and inexpensive way of studying multiple scenarios and identifying the best possible configuration [1]. Digital Center is a name used to refer to a place in ABU Zaria where students as well as staff browse the Internet for free. Those managing the Digital Centers may want to know if existing network topology and its resources are sufficient to support the new Internet applications services. The inexpensive way to understand the real situation is to create a model of the existing network and study it as surrogate of real system using network simulator. Simulation is an excellent tool for studying performance and identifying the cause of problems in the network [2]. This paper describes the first step in creating a simulation model of a Digital Center at ABU, Zaria-Nigeria which includes modeling its network topology, applications, and user profiles. Finally, describes the simulation model using OPNET Modeler.

2 METHODOLOGY

Network performance evaluation is a critical aspect of network services research that allows the evaluation of new ideas, identification of problems, bottlenecks and optimization of existing systems. There are three general approaches to network evaluation [1]:

1. Prototyping (Measurements): build the system and see how it works.
2. Analytical modeling: derive a mathematical model of the system and use it to analyze the system.
3. Simulation: build a software model of the system.

Prototyping is most of the time not viable or time consuming especially for large scale systems. It also provides limited control and observation. In addition, there are many obstacles in the process of performing some studies. The most well known technique among others is building real test-bed for performance analysis. This is often not feasible because of the cost involved. Similarly, analytical modeling cannot capture highly complex systems [3]. For these reasons, simulation technique emerged as an attractive alternative that is heavily used in performance evaluation of computer systems. Thus, it becomes necessary to build a simulation model and study it as a surrogate for an actual sys-

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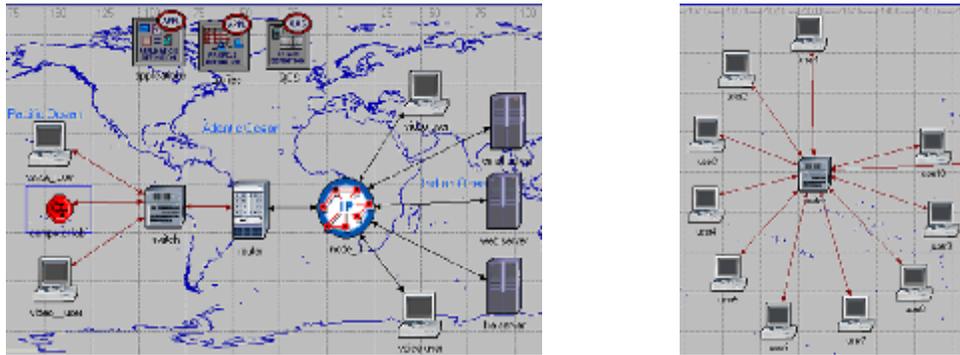


Figure 1: Network Map (left), Lab Setup (right)

To develop a simulation model of the targeted network environment, the physical topology of the network was examined and studied.

To substitute the targeted network environment, a network model to examine and validate the implementation of individual application models was developed using the OPNET modeler.

2.1 Network Topology

The physical topology of the Digital Center is depicted in Figures 1 and 2. The targeted Digital Center is a LAN network generating UDP and TCP traffic flows. The network environment consists of twelve client hosts installed with Windows operating system. Ten hosts are connected to a CISCO switch, and each of the hosts communicates with any of the three different servers via a wireless link. The switch and the other two workstations are connected via another CISCO switch. The last switch is connected to a router that serves as a gateway to the Internet. The LAN has bandwidth of 100 megabits, link data rate of 64,000 bps and router buffer of 2MB. The network is assumed to provide traffic flows significantly faster than what the wireless link can transmit. The Digital Center is actually connected to the University network and its Internet connection. Studying the entire University network is not part of the coverage for this paper. Figure 1 illustrates the topology of the targeted University Digital Center network and its Internet connections. In the simulated environment, two different hosts were set to generate voice and video streams and each of the ten hosts generates TCP traffic. Traffic shaping was not imposed in the network setup. The traffic flows are forwarded base on Best-effort scheme. The Internet is simulated using an IP32 cloud, a built-in OPNET model.

2.2 Modelling Traffics

The packet traces from the University Digital Center were collected and analyzed using Ethereal, public domain protocol analysis software [4]. The most commonly used applications in the targeted network environment were identified and deployed into the simulation model for the Digital Center. We divided these applications into five categories as shown in table 1.

TABLE 1
APPLICATION DEFINITIONS

Application	Meaning
e-Mail (light)	Indicate light activities of e-mail application
e-Mail (heavy)	Indicate heavy activities of e-mail
FTP (light)	Indicate light file transfer activities
FTP (heavy)	Indicate heavy file transfer activities
Web browsing (light)	Indicate light browsing activities
Web browsing (heavy)	Indicate heavy browsing activities
Video streaming	Indicate Watching live video transmission
VIOP stream	Indicate duplex voice activities

To configure and model the behavior of the targeted Digital Center in OPNET, the Application and Profile Configuration modules were added to the emulated target network environment as shown in figure 1. The Application Configuration module contains the application definitions, while the Profile Configuration module contains the profiles of user behavior.

2.3 Application and Profile Configuration of the Targeted Digital Center

Profiles describe the activity patterns of a user or group of users in terms of the applications used

over a period of time and for each application definition, you can specify usage parameters such as start time, duration and repeatability [6]. The targeted Digital Center has several different profiles running concurrently on its LAN. Using OPNET the different profiles were configured to run concurrently.

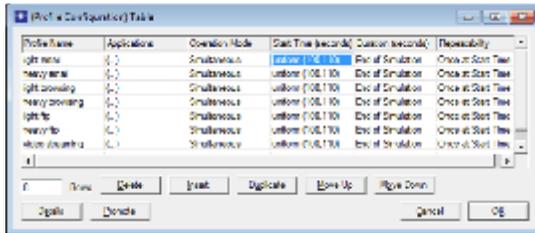


Figure 2: Profile Configurations

The profiles contain a list of applications shown in table 1. Figure 2 depicts the profile configurations.

A profile is constructed using different application definitions. The targeted environment has identical applications with different usage parameters. However, different names were used to identify these distinct application definitions. Figure 3 depicts the application configurations.

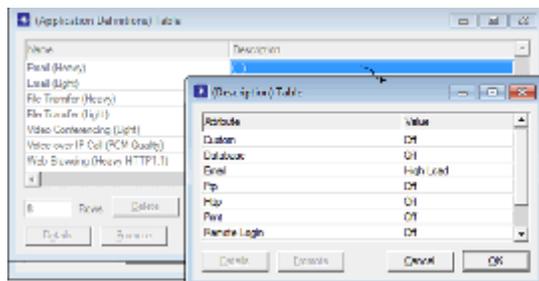


Figure 3: Profile Configurations

3 MODELLING APPLICATIONS IN OPNET

We modeled the user applications via OPNET Modeler simulation software. OPNET Modeler provides standard built-in models for software applications such as *web (HTTP)*, *e-mail*, *FTP*, and *remote login*, which can be easily configured to simulate applications used in the Digital Center [6].

3.1 Configuring Web (HTTP) Applications

To configure a web browsing application, the application named HTTP was selected from the

list of built-in models. OPNET provides pre-set configurations such as: *Light Browsing*, *Heavy Browsing*, *Searching*, or *Image Browsing*. For the targeted network environment, light and heavy browsing were selected. Table 2 shows the pre-set configurations parameters of the selected web applications, while Figure 3 illustrates steps for configuring a web application in OPNET. *HTTP Specification* which defines the version of HTTP protocol, *Page Interarrival Time* which specifies time in seconds between consecutive web-page downloads, and type of service specifies traffic shaping policy adapted.

TABLE 2
HEAVY (TOP) AND LIGHT (DOWN) WEB BROWSING CONFIGURATION

Attribute	Value
HTTP specification	HTTP 1.1
Page interarrival time (second)	Exponential (60)
Type of service	Best effort

Attribute	Value
HTTP specification	HTTP 1.1
Page interarrival time (second)	Exponential (720)
Type of service	Best effort

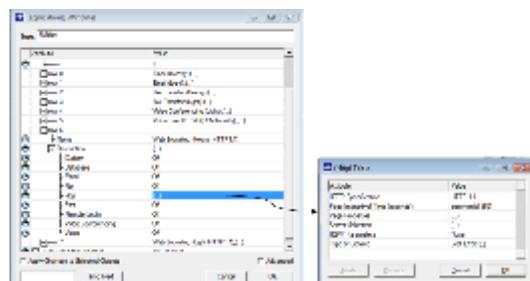


Figure 4: Configuring a Web Application in OPNET

3.2 Configuring e-Mail Applications

To configure an e-mail application, the application named e-Mail was selected from the list of built-in models. OPNET provides preset configurations for e-mail application as well.

The pre set e-mail configurations include *Low Load*, *Medium Load*, and *High Load*. The model also allows custom configuration via parameters such as *Send(Receive) Interarrival Time* which spe-

cify the amount of time in seconds between consecutive sent (receive) operations, *Send(Receive) Group Size* which determine the number of e-mails messages per single sent(receive) operation, and *E-Mail Size* which defines the size of e-mail message in bytes. The e-mail configurations for selected loads are shown in Table 3 and also figure 5 shows how to configure an e-mail application in OPNET.

TABLE 3
HIGH (TOP) AND LOW (DOWN) LOAD EMAIL CONFIGURATION

Attribute	Value
Send interarrival time (second)	Exponential (360)
Send group size	Constant (3)
Receive interarrival time (second)	Exponential (360)
e-mail size (bytes)	Constant (2000)
Type of service	Best effort

Attribute	Value
Send interarrival time (second)	Exponential (3600)
Send group size	Constant (3)
Receive interarrival time (second)	Exponential (3600)
e-mail size (bytes)	Constant (500)
Type of service	Best effort

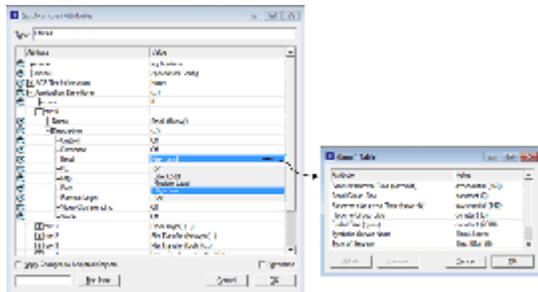


Figure 5: Configuring an e-mail Application in OPNET

3.3 Configuring FTP Applications

To configure ftp application, the application named ftp was selected from the list of built-in models. OPNET also provides preset configurations for FTP application. The preset FTP configurations include *Low Load*, *Medium Load*, and *High Load*. The *Inter-Request Time* parameter is the time in seconds between consecutive FTP requests. The *File Size* defines the size in bytes of

the FTP file to be transferred. The e-mail configurations are shown in Table 4, while figure 6 depicts how to configure an FTP application in OPNET.

TABLE 4
HEAVY (TOP) AND LIGHT (BOTTOM) FILE TRANSFER CONFIGURATION

Attribute	Value
InterRequest (seconds)	time Exponential (360)
File size (bytes)	Constant (50000)
Type of service	Best effort

Attribute	Value
InterRequest (seconds)	time Exponential (3600)
File size (bytes)	Constant (1000)
Type of service	Best effort

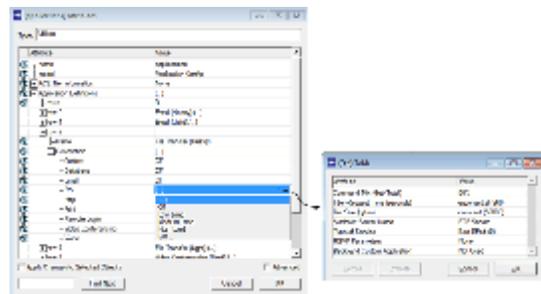


Figure 6: Configuring an ftp Application in OPNET

3.4 Configuring VOIP Stream

In order to model VOIP traffic in OPNET, an object called application definition attribute which consist of predefined applications was modified to support voice streaming. The Voice application was modeled by configuring the (*Voice*) *Table* parameters. The VoIP application uses G.711 encoder scheme and Interactive Voice (6) as the type of service for establishing the VoIP calls. The Video stream configuration is shown in Table 5 and figure 7 illustrates the configuration of VIOP stream application in OPNET.

TABLE 5
VOIP STREAM CONFIGURATION

Attribute	Value
Silence length (seconds)	Exponential (0.65)
Talk spurt length (seconds)	Exponential (0.352)
Encoder scheme	G.711 (silence)
Voice frame per packet	1
Type of service	Interactive (6)

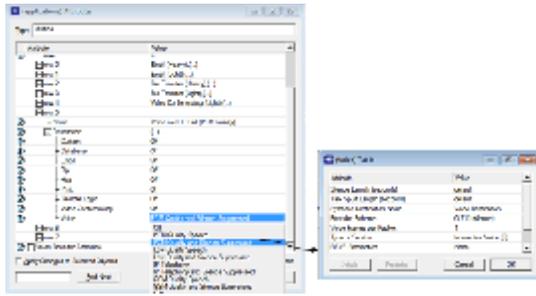


Figure 7: Configuring VOIP Application in OPNET

3.5 Configuring Video Stream

To model video stream application, application definition attribute object which consist of predefined applications was used with modification on the predefined parameters. The Video stream configuration is shown in Table 6, while figure 7 describes configuration of Video stream application in OPNET.

TABLE 6
VIDEO STREAM CONFIGURATION

Attribute	Value
Frame interval time	10 frames/sec
Frame size	128x120 pixels
Type of service	Best effort
Traffic mix (%)	All discrete

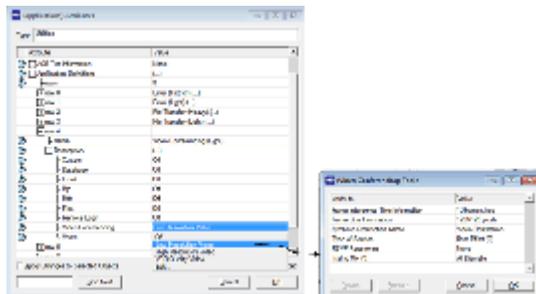


Figure 7: Configuring Video Stream Application.

4 CONCLUSION

It is quite common for multiple users of the Internet to get connected at the same time, and running multiple networking applications including video and VOIP applications. Consequently, there are many circumstances in which the last hop link becomes a bottleneck resulting in congestion among user's applications. This paper describes the methodology developed for modeling applications and user profiles in a Digital Center at Ahmadu Bello University, Zaria-Nigeria using OPNET Modeler.

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