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Analysis of Quality of Service Parameters Using a Simulation Tool[1]

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ABSTRACT

Simulation tools are a key element for data network design and implementation, since they allow for network behavior to be analyzed under defined parameters. This article analyzes the behavior of the IPTD and IPDV parameters on an MPLS core network, using several queuing algorithms, in order to discover which algorithm has the best performance under a defined set of constraints, according to ITU Y.1541 recommendations. The article presents the methodology employed for setting up the simulation experiments, as well as a survey of simulation tools.

Key Words: Simulation tools, IPTD, IPDV, queuing algorithms, QoS, Y.1540, Y.1541.

RESUMEN

Las herramientas de simulación son un elemento clave para el

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diseño e implementación de redes de datos, ya que permiten que el comportamiento de la red sea analizado bajo parámetros definidos. En este artículo se analiza el comportamiento de los parámetros IPTD e IPDV en una red central MPLS, utilizando algunos algoritmos de colas, con el fin de descubrir el algoritmo que tiene el mejor rendimiento en un conjunto definido de restricciones, de acuerdo con las recomendaciones UITY 1541. El artículo presenta la metodología empleada para la creación de los experimentos de simulación, así como un estudio de herramientas de simulación.

Palabras Claves: Herramientas de simulación, IPTD, IPDV, cola, algoritmos, QoS.

1.INTRODUCTION

Simulation tools play a fundamental role in data network design and implementation because they allow for the re-creation of environments and for the analysis of network behaviors taking numerous variables into consideration. These tools allow for a network's behavior at various levels, particularly those of access and transport, to be simulated. In addition, they allow for the simulation of the network's applications or the services to be offered through it.

The process of simulating a network consists of a series of steps resulting in a set of data that can then be analyzed and used to predict the behavior of the network under defined conditions.

The objective of this article is to illustrate the process of simulating a network with MPLS technology and to present the results obtained in order to analyze the quality of service parameters using different queuing algorithms.

The article is organized as following: section 2 describes some of the different simulation tools available, section 3 outlines the methodology used in simulating a specific environment, section 4 presents the results in order to analyze the quality of service parameters for a defined simulation environment, and the final section presents the conclusions.

2. TYPES OF SIMULATION TOOLS

Simulations tools can be classified as either licensed tools or free use tools, and a variety of both are available. Depending on the type of tool, the learning curve (the average time it takes a user to learn to manage the tool and obtain results) may be another factor to assess in deciding on its suitability for a given simulation scenario.

Among the licensed tools are the following:

2.1 Packet Tracer

This tool is owned by Cisco. It is very didactic, introducing students to the configuration of network devices, allowing for the visualization of the path of packets within the network and for learning to manage operating systems of devices. The learning curve for the tool is low owing to its didactic nature.

2.2 Boson Simulator

This tool allows for the simulation of a virtual laboratory with Cisco interconnectivity equipment. It is very useful for preparing for certification on Cisco devices and is generally employed by experienced users. The learning curve for this tool is moderate. The simulation must be done in a two-step process; the simulation scenario should first be implemented independently, and that scenario will then be used for the configuration process.

2.3 OPNET Modeler

This is a very powerful simulation tool used by operators and service providers that allows for the simulation of nearly any type of wireless or cabled network device access or transport technology. It is employed by users with extensive research experience and has a high learning curve.

A variety of free use tools for both Linux and Windows operating systems are available, among which are the following:

2.4 NCTUns

This simulator runs in Linux. It can simulate a variety of cabled and wireless networks, and is very didactic in that it allows the user to view the path the packets take and easily obtain graphics of network parameters. It has a medium learning curve, even for students who are relatively inexperienced in the study of data networks.

2.5 IT Guru Academic Edition

This is the academic version of OPNET used in introductory courses to networks at universities. It runs in Windows and requires instructor assistance in order to be used in an instructional setting. The tool has a medium learning curve.

2.6 GNS3

This tool allows the user to work with Cisco operating systems, to simulate complex networks, and to realize the configuration processes in the network devices. It has a low learning curve after installation and configuration, but occupies a lot of the memory resources of the machine executing it.

2.7 NS2/NS3

This is a very powerful simulator that can simulate nearly any kind of network. It is frequently utilized in academic research groups by expert users with knowledge of C programming language and has a high learning curve.

2.8 OMNET

This tool can simulate cabled and wireless communication networks, protocol modeling, and the modeling of queuing algorithms, among others.

OMNET has several user interfaces (graphical, animating, and command-line) and runs on most common operating systems. The learning curve is high, but it is a very powerful tool.

3. METHODOLOGY FOR RUNNING THE SIMULATIONS

When simulating a network with the aim of analyzing its behavior under certain defined variables, a series of steps must be undertaken, the exact number and sequence of which depend on both the type of simulation and the variables chosen to simulate. The basic steps are described below.

Step 1: Choosing a simulation tool.
When choosing a simulation tool, there are a number of factors that must be analyzed: the tool's specifications, its cost, and the learning curve.

In order to choose a simulation tool, one must begin by analyzing its technical specifications, which types of protocols the tool supports, the network devices that it allows to be configured, and the applications and services it can simulate, among others. In addition to this, the cost of the tool and the project budget must be considered, as, for example, OPNET is an excellent tool, however in order to use it, a user must have a budget sufficient to purchase both the tool and the license for it, which must be renewed annually. One must also be very careful to consider the learning curve, as investing a significant amount of time in learning to manage a tool may lead to a delay in the timetable of a given project.

Step 2: Defining the simulation scenario
It is important for the design of the simulation scenario to be well-defined in order to avoid having to make changes during the process. A well-defined design additionally assures that the data obtained will be coherent and can later be compared with data from other sources. It is recommended that this process begin with simple scenarios and that the complexity of the simulation scenarios only be increased once reliable results have been obtained.

In this step, the types of network devices to be used, the technology to be used in the transport network, the routing protocols, the number of users to simulate, the bandwidth of the links, and the size of the scenario to be implemented must all be defined, along with simulation time, which is a crucial element. Simple scenarios can employ simulation times of 10, 15 or even 60 minutes, whereas in complex scenarios the time must be increased in order to achieve stability of the protocols and the performance of the network. The longer the simulation, the more resources the machine running it will need to devote to processing, thus compounding the time required to obtain results.

Step 3: Defining the services to be simulated

In this step, the services that will be offered by the network are defined, taking into account that each service generates traffic in a specific way. This component of the simulation tool is known as the traffic generator, of which there are four types: application-level traffic generators, flow-level traffic generators, packet-level traffic generators, and closed loop and multi-level traffic generators. Each of these four types is documented in (Botta, 2010).

In order to configure packet-level traffic generators, one must be familiar with Inter Packet Departure Time (IPD) and Packet Size (PS). IPD and PS values must be adjusted to a statistical distribution, and the packet-level traffic generator must be configured with this statistical distribution. In some cases, traffic analyzers (sniffers) are employed to identify IPD and PS values in order to analyze the traffic flow of each service. The data obtained is adjusted to a particular statistical distribution, and the traffic generator is configured based on this statistical distribution.

During this process, it is very important to understand the operation of each service and to be clear about which statistical distribution most realistically represent the behavior of a particular service and therefore obtain the most realistic results.

Step 4: Variables or parameters to be measured

At this point, the parameter or variable to be measured should be chosen. This should be clearly defined from the beginning of the simulation given that these parameters will supply the data for future analysis and about which conclusions about the behavior of the network being simulated will be drawn. Potential parameters to measure include: bandwidth, loadlink, delay, jitter, packet losses, MOS, convergence time of routing protocols, and file size, among others.

Step 5: Analysis of data and results

This step is crucial because this is where conclusions will be reached, which will then be used to understand and explain the operation of the network with the services that have been configured in the simulation.

4. ANALYSIS OF QoS PARAMETERS

This section will present a description of the simulation scenario, the services simulated, and the parameters selected, based on the methodology presented above. The objective of the simulations is to analyze which queuing mechanism maintains the IP Transfer Delay (IPTD) and IP Delay Variation (IPDV) values within acceptable levels for the VoIP service in a network with an MPLS core and a previously defined configuration within the network.

The tool chosen for the simulation was **OPNET Modeler, version 14.5** based on the fact that the tool supports MPLS. Other tools analyzed did not support MPLS, and thus were rejected.

The simulation scenario, consisting of three routers and two LAN networks with 10 users each, is shown in figure 1. The transport technology used was MPLS, and the WAN links were configured with a speed of 1544 Kbps.

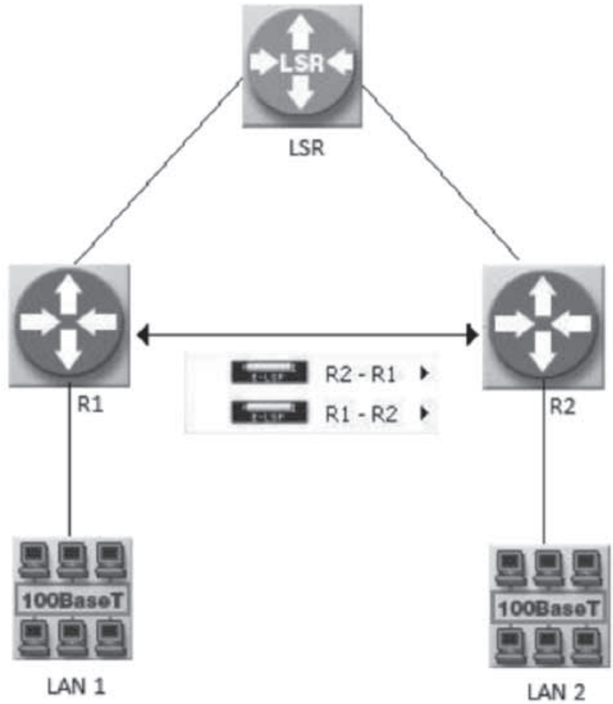

Figure 1. Schematic of the simulated network for comparing the various queuing algorithms. Source (Cuéllar & Navarro, 2010b).

The following queuing mechanisms were configured in the routers: Weighted Fair Queuing (WFQ), Class-Based Distributed Weighted Fair Queuing (CB-WFQ), Class-Based Distributed Weighted Fair Queuing (DWFQ), Custom Queuing (CQ), and Priority Queuing (PQ). The operation of each queuing mechanism is explained in (Cuéllar, 2009).

Within the MPLS network, Label Switched Paths (LSPs) were configured in the following manner: (Cuéllar & Navarro, 2010b).

- **Configuration 1:** 2 LSPs, one incoming and one outgoing, were configured between routers R1 and R2 with a bandwidth of 1544 Kbps. Each application was assigned a trunk with a bandwidth equal to that of the LSP.

- **Configuration 2:** One LSP per application (4 incoming and 4 outgoing LSPs) was configured between routers R1 and R2. A trunk was assigned for each LSP for the application being simulated. The bandwidths of the LSPs and the trunks configured were 1544 Kpbs.

- **Configuration 3:** 2 incoming and 2 outgoing LSPs were configured between routers R1 and R2. In this scenario, the traffic was divided; voice and video conferencing traffic was assigned to one LSP, and ftp and http traffic to the other. Each application utilized a trunk with a bandwidth of 1544 Kpbs.

The services simulated were ftp, http, VoIP, and video conferencing, each service being configured with a constant statistical distribution. A constant distribution is configured because it is necessary to load the link to its maximum capacity in order to simulate congested links where the delay of the applications increases or its performance degrades.

The parameters being analyzed were taken from the Y.1540 (ITU-T, 2002) and Y.1541(ITU-T, 2006) recommendations. The Y.1540 recommendation defines the parameters used to specify and evaluate the quality of functionality in terms of speed, exactitude, security of operation, and availability of the transfer of packets in an IP network. The Y.1541 recommendation specifies the values of quality of functionality for each of the parameters defined in the Y.1540 recommendation. Based on this, the following parameters were selected to be measured and analyzed:

- **IP Packet Transfer Delay (IPTD):** IPTD refers to the time that a packet takes to pass through one component of the network, whether it be a host, a router, or a section of the network. This is one of the critical parameters for all the applications that a network utilizes and is commonly known as delay.

- **IP Packet Delay Variation (IPDV):** IPDV refers to the expected time for each packet to arrive to its destination and is commonly known as jitter.

After running multiple simulations, it can be seen that the parameters performed better with the queuing mechanisms simulated, as is shown in figure 2.

In Table 1 shows the results of all the simulations run.

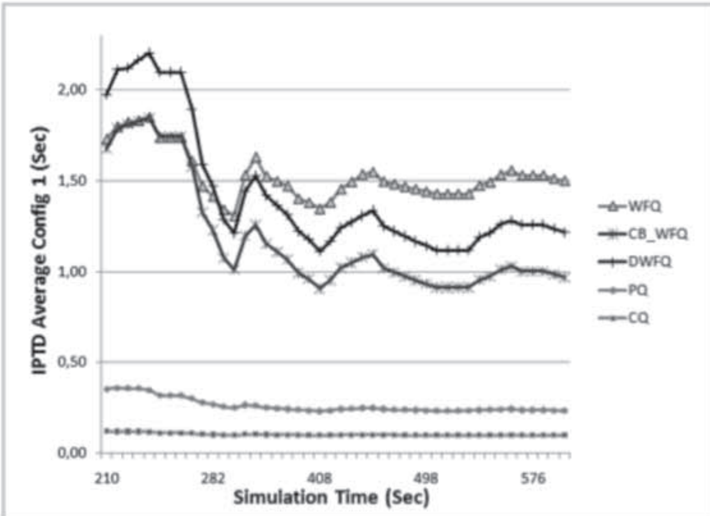

Figure 2. IPTD parameter for the simulated queuing mechanisms. (Cuéllar & Navarro, 2010c).

Table 1. Results for the IPTD and IPDV parameters for the three configurations in the simulation scenario. Source (Cuéllar, 2010a).

Queueing type	Configuration 1		Configuration 2		Configuration 3	
Parameter (mseg)	IPTD	IPDV	IPTD	IPDV	IPTD	IPDV
WFQ	1530,63	333,70	1422,71	318,65	1.464,41	176,02
CB-WFQ	1175,90	421,50	1422,71	318,65	2.563,88	805,76
DWFQ	1430,06	716,84	1931,44	442,94	2.100,15	616,93
PQ	262,36	5,91	246,17	5,45	249,10	5,63
CQ	102,66	1,11	104,73	1,18	103,49	1,12

Analysis of the data in table 1 shows that the queuing mechanism CQ used in conjunction with configuration 1 maintains the IPDV parameter closest to the value indicated in the Y.1541 recommendation. The IPTD parameter remained within proper levels. An IPTD beyond proper levels indicates that the bandwidth of the link needs to be increased as simply employing quality of service mechanisms is not sufficient for ensuring the proper operation of the applications. (Cuéllar, 2010a).

In configurations 2 and 3, the value for IPTD is higher due to the fact that more LSPs were configured in the routers, and therefore the labeling and selecting of the LSPs took a longer time to process.

5. CONCLUSIONS

The proper selection of the simulation tool is a crucial aspect when running network simulations. Within this process, time must be devoted to analyzing which tool is the best fit the scenario being simulated, as well as reviewing both the budget and the complexity in learning the simulation tools.

Once the tool has been chosen and the simulation scenario has been defined, the proper configuration of the traffic generator is very important in order to realistically recreate the operation of the network. After analyzing the data obtained in the simulation, the necessity of upgrading the setup configuration for the actual network devices can be determined.

Analyzing the results obtained in the simulation of the IPTD and IPDV parameters, it is recommended that a service provider at the very least separate the traffic of the services on the LSPs, more specifically, voice and video traffic should be transported on one LSP and other, non-critical traffic on another. However, it is not recommended that an LSP be assigned for each application, which, due to the increased processing on the routers, is not necessarily the most efficient way to guarantee QoS.

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