Preserving network QoS during remote images-management

Hélder Mendes[†], Jorge Mamede[¥]
[†] GILT-Instituto Superior de Engenharia do Porto, Rua Dr. Bernardino de Almeida, 4200-072 Porto, Portugal
Phone: +351-228340500 – 1151, Fax: +351-228321159, e-mail: hvms@isep.ipp.pt
[¥] Instituto Superior de Engenharia do Porto, Rua Dr. Bernardino de Almeida, 4200-072 Porto, Portugal
Phone: +351-228340500 - 1134, Fax: +351-228321159, e-mail: jbm@isep.ipp.pt
[¥] Instituto de Engenharia de Sistemas e Computadores do Porto – INESC Porto, Campus de FEUP, 4200-465 Porto, Portugal
Phone +351-222094000, Fax +351-222094050, email: jmamede@inescporto.pt

***Abstract* — Network Management System with Imaging Support (NMSIS) was developed to facilitate LAN management. Among other features, NMSIS integrates tools for the software installation in remote computers, through the network, called image-management. One of the main issues associated with the remote installation of software is the traffic congestion at network intersection points, such as switches and routers. Traffic congestion constrains the quality of services (QoS) in network. This article presents the Bandwidth / Traffic Control (BWTC) tool of NMSIS. The BWTC modulates the traffic flow from the images server to the various clients, depending on the load of the network. Tests were conducted in order to evaluate the performance of BWTC that enable to conclude that it improves the overall QoS in network during the image-management tasks.**

I. Introduction

Nowadays small and medium-sized enterprises have complex and sensitive networks with management requirements comparable to the networks of bigger companies of ten years ago. However, despite the mass deployment of the networks, the cost of commercial management tools did not become accessible to the majority of small and medium enterprises. The acquisition of such software is still understood as an unprofitable investment for such companies. Even large companies have adopted the Open Source tools to avoid those costs [1]. In this context, the Network Management System with Imaging Support (NMSIS) [2] for managing and monitoring local area networks was developed.

Remote software installation and image restoring are management tasks realized frequently in academic networks for restoring classroom and laboratory PCs. These tasks are usually performed to install additional software modules or packages or restore entire file systems without spending time in the installation of all its applications. However, such operation requires the transmission of large amounts of data which increases the network load and, under the normal operation of other services, causes problems of traffic congestion at the network intersection points, such as switches and routers. Consequently, that congestion impairs the traffic of the network services that also share these intersections (e.g. the Internet service, access to the Web server, access to the file server, etc.). The Bandwidth / Traffic Control (BWTC) was developed to minimize this problem. The BWTC is part of the NMSIS and enables a dynamic bandwidth control of the transmission between the images server and its clients, according to the traffic congestion of the network intersection points in the path.

This paper is organized in four sections. Section I introduces the paper. Section II introduces the NMSIS. Section III presents the BWTC. Section IV describes the tests realized during the evaluation of the BWTC as well as the results obtained. Section V concludes the paper.

II. NMSIS

The NMSIS result from the integration between the tools Network Administration Visualized (NAV) and Free Open Source Ghost (FOG) [2]. The NMSIS is based on the protocol Simple Network Management Protocol (SNMP) and, follows the guidelines of the network management functional model FCAPS (Fault, Configuration, Account, Performance, Security), defined by the International Organization of Standardization (ISO).

There are several open source tools for network management and monitoring, like the OpenNMS and the Clonezilla. These tools focus specifically on the management tasks. The OpenNMS focus the network management and monitoring, while the Clonezilla focus on image management.

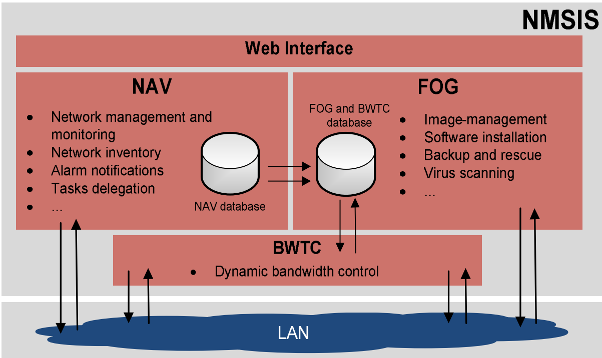

Fig. 1. NMSIS architecture [2]

The main advantage of the NMSIS is that it facilitates the network management and monitoring, providing image

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management, and achieves it by integrating the most relevant features of existing tools in one single system.

Among the various aspects of NMSIS a few can be highlight, such as, the Web interface with tasks delegation to different administrators; the network search and localization of equipment; the inventory of devices on the network; performance graphics for network equipment; tools for maintenance support; monitoring equipment (e.g. switches, routers, servers) and services (e.g. the web pages service, the e-mail service); alarm notifications and logging; the image-management tools with network QoS preservation, among many others [2]. To preserve network QoS, during remote image-management procedures, the NMSIS uses the BWTC. The BWTC optimizes the traffic load in the interception points, by controlling the flow of transmissions from the images server.

II. BWTC – BANDWIDTH / TRAFFIC CONTROL

The Bandwidth / Traffic Control (BWTC) was developed in order to tone down the negative impact of software installation through the network. The BWTC works only in the images server, modulating the amount of traffic send from this server to each system in the network, optimizing to the *ceil* value (maximum traffic load, set by the administrator) the traffic load in every interception point of the network.

The main procedures of BWTC comprise three different phases: 1) to collect the traffic statistics of each interface port of the devices, 2) to identify and match the IP addresses associated to each active port and marked in a database as targets of the image-management, and 3) to control the bandwidth of traffic transfers between the images server and the client systems according the traffic load and port availability in the network devices.

The BWTC is composed of three modular components: the BWTC_ARP, the BWTC_CALC and BWTC_STATISTICS.

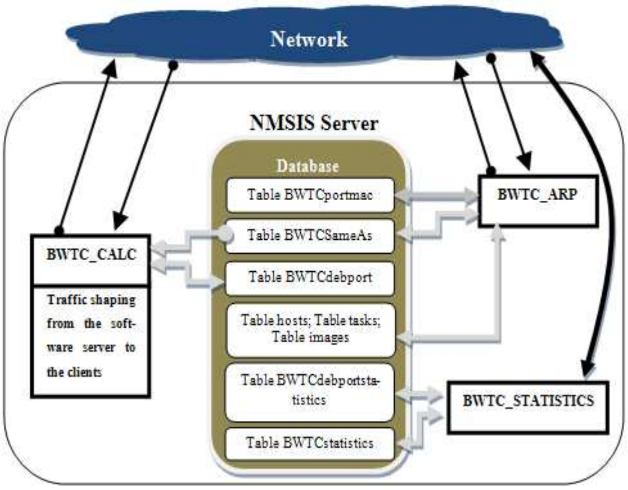

Fig. 2. BWTC architecture [2].

Each of these components interacts via SNMP with the network devices in the path. Figure 2 depicts the architecture of BWTC [2].

A. BWTC_ARP

The BWTC_ARP - BandWidth / Traffic Control-Address Resolution Protocol was developed to identify the ports of the active network equipment (e.g. switches supporting the SNMP protocol) in which the clients of the images server are connected. The BWTC_ARP accesses the MIBs of those switches and collects the list of MAC addresses of computers in communication with each of its ports. The collected information is stored in table BWTCportmac of the database. The collected MAC addresses are used to index a search in the hosts table of the NMSIS database in order to obtain the corresponding IPs. The IP <-> MAC relationship and the port ID to which they are connected is then inserted in table BWTCSameAs of database. The BWTC_CALC component uses the information entered by the BWTC_ARP to model the traffic to the clients [2].

B. BWTC_CALC - BandWidth / Traffic Control Calculate

The BWTC_CALC module is the most important of the BWTC. This module is responsible for shaping (modeling) the flow of software traffic (or system images), from the images server to its clients, depending on the load of the network.

The BWTC_CALC collects information from the MIBs of the active network devices in the data transfer path, calculates the traffic load for each port and stores the information in the database. Based on the traffic load of each port and the location of each client (information obtained by BWTC_ARP), the BWTC_CALC shapes the flow of software going to each port, so that the load does not exceed a *ceil* value.

By adopting a ceil value on each port, the remaining bandwidth, available but not used for transferring images, can be used to accommodate burst of bandwidth demands from other network services sharing the same device port.

The centerpiece for modeling the traffic flow of data transfers from the images server to the target clients is the controller. A proportional controller in closed loop with memory was used. The traffic controller constrains the data rate transmitted from the images server through each port of the network device (e.g. switches and routers) in the path, so that the network traffic load (images traffic plus other services traffic) in each port is optimized to the *ceil* value, and not exceeding it.

The fact that the controller has memory is very important, because the output traffic load of any port of the active network equipment, in the instant N, can include the traffic introduced by the images server in the instant N-1 [2].

C. BWTC_STATISTICS - BandWidth / Traffic Control Statistics

The BWTC_STATISTICS was developed to allow a detailed analysis of the traffic flow through the active network equipment (discrete values) [2].

With a period of 36 seconds, this module access the MIBs of the active network equipment (e.g. switches, routers), download the number of bytes sent and received from each port, calculates the load and saves it in the database (along with the instant when it happened). Later, the administrator can access the database of BWTC_STATISTICS, collect information and create discrete graphics (e.g. in Excel). All modules of the BWTC can be activated remotely through the Web interface of NMSIS. The BWTC works over time, independently and dynamically.

III. BWTC PERFORMANCE EVALUATION

In order to evaluate the BWTC application, several tests were designed and conducted in different scenarios. Those tests focused on:

1) the performance of the BWTC when traffic congestion is detected in the intersection points, while the images server transfers its data to the remote computers;

2) the ability of the BWTC to optimize the use of network to a ceiling value smaller than the maximum link capacity;

3) the impact on other network services, resulting from the installation of software on remote computers without the BWTC;

4) the impact of BWTC behavior on other network services, during image-management procedures.

In order to setup BWTC the ceil value must be defined. The ceil value is defined as a percentage of link capacity and its value determines the efficiency of the network. At the time this contribution is being written, studies are also in progress to optimize the ceil value, that shall be published in the future. Nevertheless, since a ceil value is necessary to illustrate the benefits of BWTC behavior, a ceil value of 72% will be considered as an example in the tests described in this paper.

Figure 3 illustrates the test scenario common to all tests. This scenario consists of two rooms, the servers room “Sala_A” and the client PCs room “Sala_B”. Sala_A contains 3 servers: 1 web server (SW), 1 file server (SF) and 1 images server (SIMG). In Sala_B several clients for the previous servers were installed: the SW client (CSW), SF client (CSF), and 2 SIMG clients (CSIMG). For the SW and SF clients test tasks for downloading data from the servers were created to load the network interception points. The interception points are identified in Figure 3 by the ports of the switches that are shared by multiple systems (port 1 and port 24).

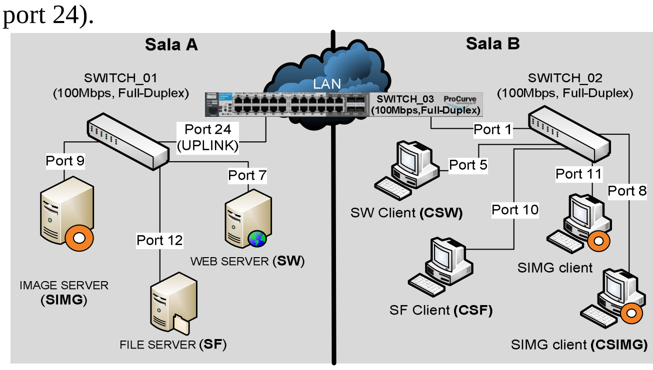

Fig. 3. Schematic of the test scenarios [2].

In order to simplify the result analysis, files with constant sizes were downloaded from the servers in different test scenarios; Table I summarizes the size of the used files.

Table I
Size of test files

Client ID	File Size
SW Client	58Gbits
SF Client	59Gbits
SIMG client1	60,8Gbits
SIMG client2	60,8Gbits

During the tests the BWTC_STATISTICS measures the input and output traffic of each network equipment. The collected results are summarized in Tables II to IV and presented in the following sections.

The BWTC evaluation was realized in several steps, each one associated to a specific test scenario. The first scenario is assumed to be a reference for the second one; the results measured in this test represent the network traffic conditions without any interference of images-management traffic or BWTC control.

In the second scenario, image-management is introduced and its effect on the network QoS is measured and compared with first scenario. Also in this case the BWTC is disabled.

In the third scenario, the conditions of the previous tests are reproduced but, in this case the BWTC is enabled. The obtained results are then compared with results of previous scenarios.

A. Reference Scenario

This scenario aims to evaluate the performance of servers SW and SF while supporting single sessions with their clients, the SW Client and SF Client, respectively. The servers and clients are connected to different switches. The traffic load measured in this test results from the files download initiated in both clients.

The results presented in Table II show that the maximum data transfer rate from the SW and SF are 28.5Mbps and 32Mbps, respectively. These bandwidth limitations are justified not only by the servers configurations, but are also related with the hardware characteristics of servers and clients, the effective capacity of network interfaces [3], the mechanisms for flow control and congestion control in the TCP protocol [4], the TCP state machine that introduces some delay in data processing, among other issues.

Table II
Maximum and average data rates

Server / Port	Port Number	Maximum data rate (Mbps)		Average data rate (Mbps)	
		SW	SF	SW	SF
SW	07	28.5		18.2	
SF	12		32		19
UPLINK	24	59.5		36.3	

B. Scenario-Remote images install without BWTC

This scenario is composed of 3 servers (SIMG, SW and SF) and four clients (1 CSW, 1 CSF and 2 CSIMG) connected as illustrated in Figure 3. This scenario aims to evaluate the impact of remote images installation in the network QoS.

Results presented in Table III show that the network traffic produced by the software installation over the network produces a negative impact on downloads associated to the services of SW and SF. The negative impact is expressed by a reduction on average data rates of servers downloads, which decrease from 18.2Mbps to 14.2Mbps in the SW and form 19Mbps to 15.6Mbps in the SF, corresponding to reductions of 22% and 18% in SW and SF, respectively [2].

Table III

Maximum and average data rates

Server/ Port	Port Num.	Maximum Data Rate (Mbps)			Average Data Rate (Mbps)		
		SW	SIMG	SF	SW	SIMG	SF
SW	07	30			14.2		
SIMG	09		76			25.6	
SF	12			27			15.6
UPLINK	24	90			57.2		

The results in this table also illustrate that the images server has best data rate performance in the network, with the average data rate of 25.6Mbps and a maximum of 76Mbps. This is due to the amount of network bandwidth spend on the two simultaneous sessions of the images server.

As expected, the average data rate measured in the UPLINK port increased, from the 36.3Mbps in the previous scenario to 57.2Mbps in this scenario.

Considering that network connections operate at 100Mbps (full-duplex), the previous results also illustrate that the quality of service of other active applications is reduced, even when the images server does not use all the available bandwidth.

C. Scenario-Remote images install with BWTC

This scenario is similar to the previous one, but the BWTC is added to control the traffic transmitted by the images server. The BWTC models the SIMG traffic flow according measures of network load collected in the ports of the interception points in the path.

The results of tests realized in this scenario present several improvements in quality of active services. The negative impact caused by the images server traffic, in other active services is minimized by the BWTC. Table IV resumes the values average and maximum data rate values measured in the ports of corresponding servers and in the uplink port. Using the BWTC, the average data rates of SW flows increased from 14.2Mbps to 17.5Mbps (23%), the SIMG flows increased from 25.6Mbps to 31.8Mbps (24%) and for SF the average data rates increased from 15.6Mbps to 17.7Mbps (14%).

Thus, most of data rate losses caused by remote images installation in the network services were minimized.

Table IV

Maximum and average data rates

Server/ Port	Port Numb.	Maximum Data Rate (Mbps)			Average Data Rate (Mbps)		
		SW	SIMG	SF	SW	SIMG	SF
SW	07	21			17.5		
SIMG	09		40			31.8	
SF	12			21.5			17.7
UPLINK	24	72.5			64.9		

The maximum data rate of 90Mbps measured at the UPLINK port in the previous test, decreased to 72.5Mbps in this test, due to the ceil value defined in BWTC. Since a ceil value of 72% was assumed, the results obtained reflect the BWTC behavior.

IV. CONCLUSIONS

This paper presents the NMSIS component responsible for controlling the traffic flow in images servers: the BWTC. This component assumes special relevance in remote image installation procedures, during a normal network operation, i. e. when other services are also supported over that network.

The BWTC consists of several modules (BWTC_ARP, BWTC_CALC and BWTC_STATISTICS) that identify and interact (via SNMP) with the network devices in the installation path, in order to collect information about the traffic load at their ports. Based on such values, BWTC modulates the traffic transmitted by the server to the remote devices.

Given the results of the BWTC evaluation, it was demonstrated that this software tool tunes down the negative impact of remote images installation through the network. With the BWTC, the NMSIS enables image-management procedures during the normal operations of remaining network services without interfering in their quality.

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