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Mutual Impact of High Computer Network Utilization and Business Processes

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Abstract

Computer network is a telecommunication system for data transmission that allows for number of independent devices to communicate with each other. With tolerance for computer network system faults close to zero, it is necessary to manage local computer network (LAN) as very important recourse in every enterprise. Mutual impact between investments in information and communication technologies and business performance has been in focus of research in information systems. In this paper tools for monitoring status of information and communication infrastructure are used for detection of possible problems in business processes. Reasons for those problems are analyzed and possibilities for corrections through use of LAN and administrator tools are proposed. Implementation of proposed corrections would result in reduced loss of labor hours.

Key words: *information and communication Infrastructure, local area network, MRTG, business processes*

1. INTRODUCTION

Main purpose of Enterprise Information Systems (EIS) is to manage information flow within organization and in that way to allow managers to make decisions based on most recent and relevant information [1]. It is almost impossible to imagine either small or large companies without some kind of EIS. Markus and Tcanis in [2] split reasons for adopting of EIS into two different categories, technical and business, and list separately reasons for small and large companies. Some of these reasons are integration of applications' cross-functionality, elimination of redundant data entries, improvement of information technology (IT) architecture, business growth, and reduction of business operating and administrative expenses.

Main components of EIS are communication and software infrastructure, databases, applications, project and user documentation, development, exploitation and maintenance teams as well as EIS users.

Architecture of communication infrastructure of EIS should be able to support business processes. Since enterprises represent dynamic systems it is necessary for communication infrastructure to grow and change with an enterprise, so it can continue to fulfill its role as a component of EIS.

Mutual impact between information and communication technologies investments and business performance has been one of most researched topics in information systems (IS) for significant amount of time [3]. Organizations rely on IS, which require a reliable computer network infrastructure [4].

This correlation is used as a foundation for research conducted in this paper. Focus is on possibility of using

information gathered by monitoring status of information and communication infrastructure (ICI), especially local computer network, as an indication of possible problems in business processes.

In this paper term high computer network utilization (HCNU) is used to represent cases in which either network capacity reaches maximum or it represents cases in which significant change, called peak, in computer network utilization occurs.

HCNU, if it lasts for significant amount of time, could create bottlenecks and delays in business processes. In that way it influences effective capacity and thus a productivity of an enterprise. It could be caused by the problems within computer network itself. This can happen due to faulty computer network architecture or due to valid limitation. Also it could be caused by events in business processes.

In the paper, problems in business processes are detected and reasons for their appearance explained. Also, solutions are proposed that are founded on LAN (Wake on LAN) and administrator tools.

Apart from Introduction and Conclusion, this paper is organized as follows. In Section 2 a short review of related work concerning effects of ICT on productivity and LAN monitoring tools is given. In Section 3 case study is presented, starting with system setup, followed by analysis of collected data in Section 3.1 and possible implementations of solutions for detected problems in sections 3.2 and 3.3.

2. RELATED WORK

As a result of early research on effects of ICT on productivity, term “productivity paradox” was coined. This term represents early findings that increase of computer power in 1970s and 1980s in USA was not followed by increase in productivity [5]. In late 1990s slow productivity increase in USA was still a problem [6].

During the same time researchers focused on trying to explain this paradox. Brook in [7] offers explanation that there was a rise in production of indirect (unmeasured) service outputs. In [8] the way productivity is measured is questioned since in modern economy product value depends on quality, timeliness, customization, convenience, variety and other intangibles and it is claimed that computerization does not directly increase productivity, but that it represents a necessary component of change in organization which then increases productivity.

Later research has shown that computers do contribute in significant amount to company output [9] and that IT expenditure had a significant impact on productivity measured on common financial or market based measure [10].

Since in this paper focus is on mutual influence of high computer network utilization and business processes, work related to measuring network traffic will be presented also.

Enterprise networks represent corporate computer network that are composed of network devices and systems that support various corporate applications. Providing an efficient, reliable and secure computer network is one of the most challenging tasks for network administrators [11].

Network traffic monitoring should provide information about collected data and analysis of those data. Monitoring tools gain raw status data by probing network packets. Network administrators need to obtain accurate and reliable information such as how much traffic is transferred, what type of traffic is transferred, how much traffic is generated from which system, which system or application is causing bottlenecks and how high is peak traffic and when does it occure [12].
Various tools for network monitoring and analysis are available. These tools can be grouped into three categories based on their data acquisition techniques. The first group contains tools that use traffic flow information from network devices like Cisco NetFlow and sFlow. The second group of tools represents tools that are based on Simple Network Management Protocol (SNMP), such as Multi Router Traffic Grapher (MRTG) and Cricket. The third group consists of packet sniffer tools such as snoop, tcpdump, WinDump (command line tools) and Wireshark that has graphical user interface (GUI) [13]. In case study that is presented in Section 3, MRTG is used. It represents graphic presentation for SNMP data queries. SNMP is defined by Internet Engineering Task Force (IETF) and it is an application layer protocol that is used to monitor network devices [13].

3. CASE STUDY

As mentioned before, in case of high computer network utilization some sort of bottleneck might appear in business processes. Those bottlenecks can cause delays that can transfer through entire business process, thus causing loss of labor hours.

Loss of labor hours has a direct influence on efficency that figures in effective capacity of a system as indicated in (1),

$$C_e = d_e * s_e * h_e * \eta_e \quad (1)$$

where C_e stands for efective capacity, d_e represents number of workdays in a year, s_e number of shifts in a day, h_e workhours in a shift and η_e efficency.

Peaks in computer network utilization can be reduced either on business or on ICT side. For example in case of peaks reaching maximum computer network capacity, link agregation within LAN or expansion of link toward internet service provider (ISP) could be a solution. If those solutions are not possible, then solutions could be searched by analizing and making changes in business processes.

In this case study an enterprise LAN with more then 2000 devices, mostly computers running some version of Microsoft Windows operating systems, is observed. Majority of those computers belong to Windows

Domain. Work is organized in two shifts, with first shift starting the workday at 7:00 and working until 14:30 and with second shift from 12:30 until 19:30. Majority of empoyees are permanently working in the first shift.Majority of users have their profiles saved on domain controllers. Domain controllers are hosting Active Directory and are responsible for domain users logons. During their workday employes spend most of their time using services provided through local computer network.

EIS and common network services, such as domain controller, domain name server (DNS), proxy, gateway, firewall and Windows Server Update Service (WSUS) are running on virtual machines hosted by 5 Fujitsu servers (RX300S7, RX300S6, RX2540, RX200S7 and RX200S6) running under VMware ESXi hypervisor. Two virtual network switches runing on VMWare ESXi, among other roles, take up role of network load balancers, balancing network traffic originating on these 5 servers between two Cisco 2960 switches.

MRTG version 2.17.4 was used to record data over a period of 12 months, starting from July 2016 until June 2017 with routers2.cgi software as generic web-based frontend. LAN usage was monitored at three points. Port (Uplink) on Cisco 3750 switch that is used for connection toward internet service provider (ISP) and two previously mentioned Cisco 2960 switches on which Fujitsu servers are connected.

3.1. Analysis

In this section data provided by MRTG on yearly, monthly, weekly and daily level will be presented and analized. High computer network utilization events of interest, those that last for significant amount of time, are indentified and if possible, explained.

MRTG is used to provide informations about inbound and outbound traffic on three previously mentioned points. Inbound traffic on a certain point referres to traffic that originated elsewhere on computer network and arives to that specific point in computer network, while outbound traffic represents traffic leaving specific point in computer network.

Yearly data for Uplink towards ISP shows that, during monitored 12 months period, maximum inbound trafic was at 43% and maximum outbout traffic at 21% of 1 Gbps link. Average inbound and outbound traffic over the year was at 5% and 1%.

For two Cisco 2960 switches, their combained graphic would represent total traffic between EIS and common network servers and the rest of LAN and internet.Yearly data, over the same period, maximum inbound and outbound traffics were at 98% and 97% of 1Gbps link for first and 99% and 98% of 1Gbps for second switch, while average was at 4% and 2% for first and 2% for second Cisco switch.

Monthly, weekly and daily reports show the same pattern of usage towards ISP throughout the year.

Daily traffic for Uplink towards ISP is shown in figure 1. Similar patterns can be found in reports for weekly, monthly and daily usage on two Cisco 2960 switches. Daily report for these switches are shown in figures 2 and 3 respectively.

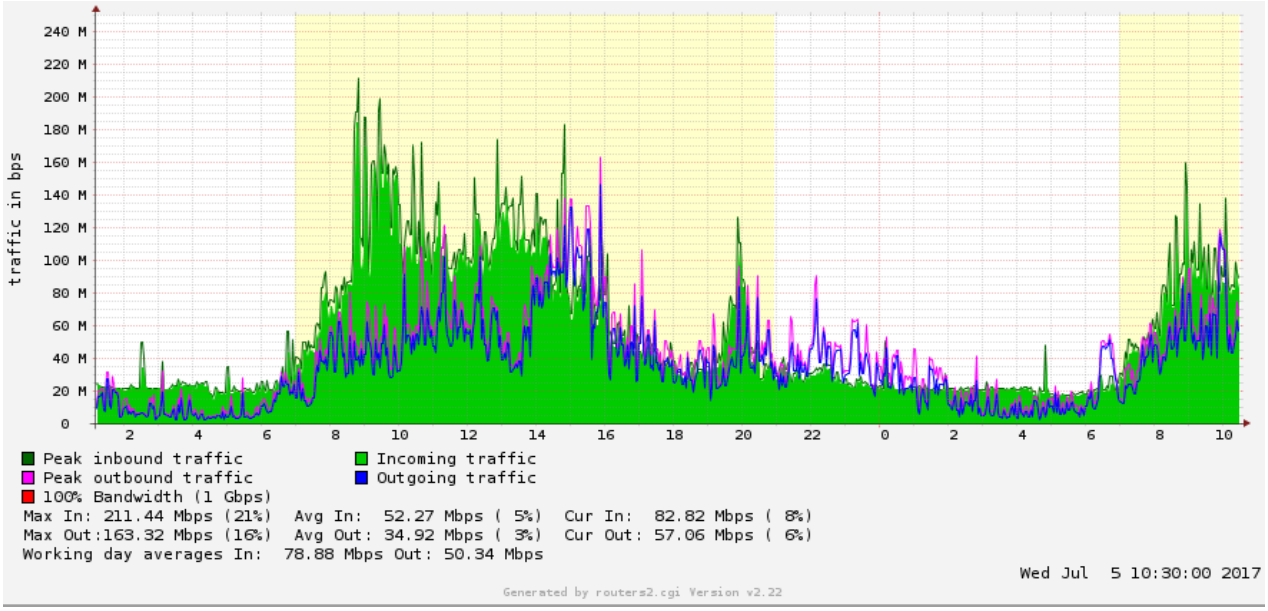

Figure 1. Daily traffic towards ISP

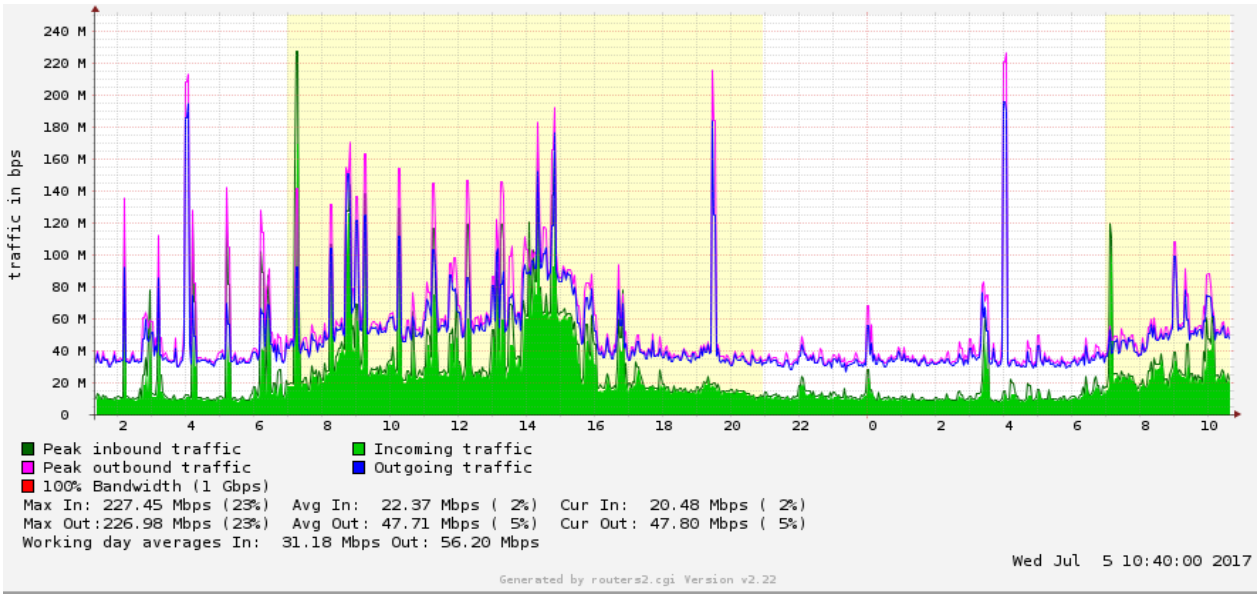

Figure 2. Daily traffic towards Switch 1

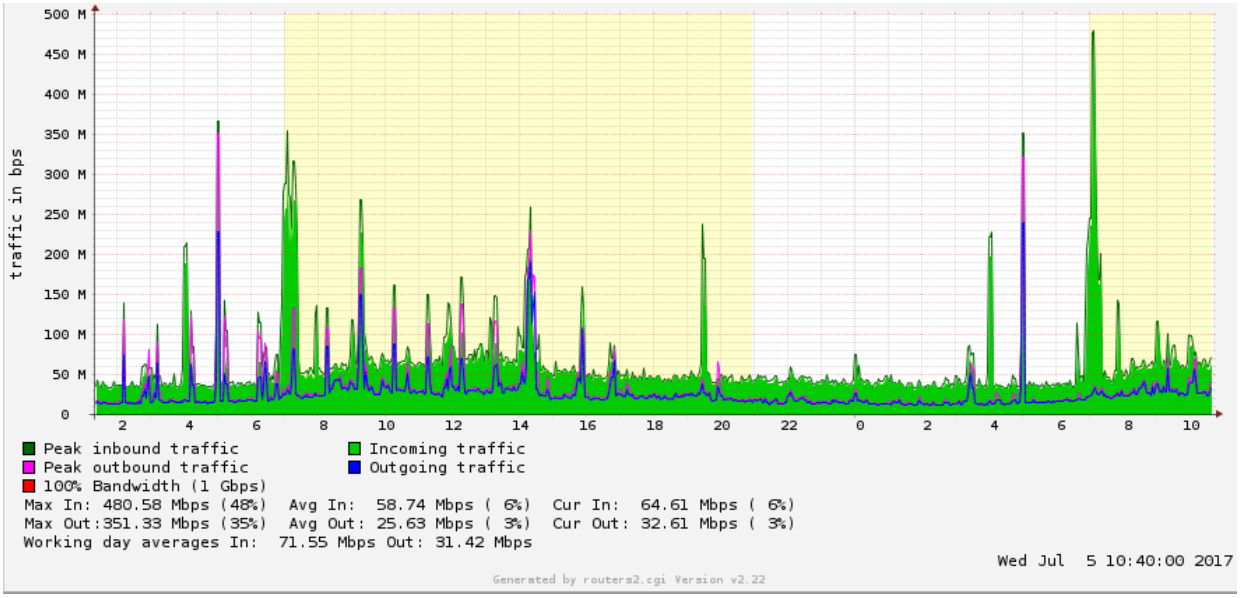

Figure 3. Daily traffic towards Switch 2

Analisis of data for Uplink towards ISP, shows no extreme peak usage times. As expected, peak usage can be represented by rather flat line and it is spread over regular business hours with peak usage at around 9am.

Analisis of two Cisco Switches, more extreme peak usage time was detected at 7am regularly on workdays that last for about 30 minutes. Although this peak reaches only 48% of bandwidth it is still several times higher than average usage over other working hours. Also, these peaks last for around 30 minutes every workday. These two facts can signal a possible problem in business processes.

Next step in this research is identifying reasons for these peaks.

Starting point for identifying reasons for these peaks is time of their occurrences and that is around 7am every workday. This time coincides with beginning of business hours in the enterprise.

At that time of day, the largest number of computers in this LAN are powered on. After powering on following events occur: i) Microsoft Windows update is run (if there is a schedule update); ii) user profiles are transferred from Windows Domain; iii) Microsoft Windows updates are downloaded (if any).

Microsoft Windows update is of relevance since it could require computer system restart, too. In that case it could be said that Microsoft Windows update takes place in two stages, first stage is initiated after shutdown or restart command is given and the second stage is initiated after computer is powered up or restarted. So, in case that first stage of Microsoft Windows update process was started before shutdown/restart of a computer, second stage of update starts when computers are powered on at the beginning

of a workday and it is necessary for it to be finished before employee can use his workstation.

As mentioned before, majority of computers in this enterprise belong to Windows Domain, so after Microsoft Windows update is done, these computers contact domain controller and user profiles are transferred over enterprise LAN. Finally, WSUS is contacted and if any, new Microsoft Windows updates are downloaded to local computers.

Needless to say that these three process can take some time. Second stage of Microsoft Windows update can take up to 10 minutes depending on update. In some cases, transfer of profiles from domain controller can also take up to 20 minutes. These two events directly influence business processes since employees are unable to use computers at their workstations during that time.

Process of downloading new Microsoft Windows updates from WSUS can also take significant time but it does not influence business processes since during that time employees can use their workstations.

Since peak LAN usage at this time does not go over 50%, it should not take that long to transfer profiles from domain controllers to local computers. This indicate a problem with domain controller that administrators should look into. Similarly, time needed for computers to finish second stage of Microsoft Windows update is not linked to LAN usage.

With all this in mind it is safe to assume that problem of lost labor hours, which of course has influence on business processes, is caused by the fact that users power on their computers upon starting their work day and that only then second stage of Microsoft Windows update and transfer of user profile from Windows Domain occur. As mentioned before, solutions could be looked for both in business processes and within ICT.

4. SOLUTION PROPOSAL

In this specific case, peak computer usage could be reduced by spreading start of workday for first shift from 7:00 to different times between, for example 6:30 and 7:30. This would reduce peak in computer network usage, but labor hours would still be lost. Therefore two possible examples of implementation of solution for this problem, using ICT technology, mainly using LAN and administrator tools, are proposed.

First step is that computers need to be turned on so if second stage of Microsoft Update is pending, it could be finished. Once computer is turned on, automatic login to domain controller and transfers of profiles can be started. Enabling automatic logins for computers that have only one domain user is not addressed in this paper. It is important to mention that it raises the question of security of data stored in profile.

To power on computers on enterprise LAN, Wake On LAN (WoL) technology could be used. WoL standard provides a possibility for remote devices to be turned on by sending specially formatted packet on Ethernet network. Computer on LAN that were shut down, have its network cards still active and they keep monitoring communication traffic and checking for WoL packets (magic packets) addressed to it. If valid packet is detected, computer will be turned on [14]. Once computer is turned on, second stage of Microsoft Windows update, if any, will be finished. After that auto login and transfer of user profiles can be initiated and by the time employees arrive, their workstations can be ready and time from their workday will be saved.

In following section two possible implementations of WoL will be shown, one implemented on Microsoft Windows 10 operating system and the other on Fedora 25. In both cases, prerequisites are that WoL is enabled on target computers and that MAC addresses of target computers are known.

4.1 Microsoft Windows implementation

For example, of implementation in Microsoft Windows 10, Send-WOL PowerShell script will be used. This script is licensed under MS-LPL (Microsoft Limited Public License version 1.1). Send-WOL PowerShell script code is shown in listing 1.

Listing 1. Send-WOL PowerShell script code

```
function Send-WOL
{
<#
  .SYNOPSIS
    Send a WOL packet to a broadcast address
  .PARAMETER mac
   The MAC address of the device that need to wake up
  .PARAMETER ip
   The IP address where the WOL packet will be sent to
  .EXAMPLE
   Send-WOL -mac 00:11:32:21:2D:11 -ip 192.168.8.255
#>
[CmdletBinding()]
param(
[Parameter(Mandatory=$True,Position=1)]
[string]$mac,
[string]$ip="255.255.255.255",
[int]$port=9
)
$broadcast = [Net.IPAddress]::Parse($ip)

$mac=(($mac.replace(":","")).replace("-",""))
.replace(".","")
$target=0,2,4,6,8,10 |
% {[convert]::ToByte($mac.substring($_,2),16)}
$packet = (,[byte]255 * 6) + ($target * 16)

$UDPclient = new-Object System.Net.Sockets.UdpClient
$UDPclient.Connect($broadcast,$port)
[void]$UDPclient.Send($packet, 102)
}
```

Microsoft Windows batch file named wol.bat is created as shown in Listing 2.

Listing 2. Wol.bat batch file

```
Send-WOL -mac 5D-D7-FB-E3-0F-78
Send-WOL -mac DE-BE-4B-F2-C9-5E
Send-WOL -mac C3-0D-B1-10-EC-16
…
Send-WOL -mac 37-E3-EF-7A-5A-20
wait 600
Send-WOL -mac 47-13-0B-70-E3-58
```

```
Send-WOL -mac 8F-FD-6D-12-AF-92
…
Send-WOL -mac F2-82-1A-DC-F0-07
…
wait 600
…
```

All computers within network are split into groups so WoL signal can be sent to one group followed by wait period of 600s, then second group and so on. Microsoft Task Scheduler version 1.0 is then used to achieve that this batch file is run at desired times, starting at 05:00am and finishing by 07:00am.

4.2 Fedora implementation

For example, of implementation in Fedora 25, command `ether-wake` will be used. Using these command magic packets can be send as shown in listing 3.

Listing 3. Ether-wake WoL command

```
ether-wake [mac_address]
```

Analog to Microsoft Windows implementation, shell script named WoL is created with individual commands as shown in listing 4.

Listing 4. WoL.sh shell scrip

```
#!/bin/sh
ether-wake 5D-D7-FB-E3-0F-78
ether-wake DE-BE-4B-F2-C9-5E
ether-wake C3-0D-B1-10-EC-16
…
ether-wake 37-E3-EF-7A-5A-20
sleep 600
ether-wake 47-13-0B-70-E3-58
ether-wake 8F-FD-6D-12-AF-92
…
ether-wake F2-82-1A-DC-F0-07
…
sleep 600
…
```

For running shell script at desired times Cron job scheduler can be used. Cron job is created as shown in listing 5.

Listing 5. Command of creation of Cron job

```
crontab 0 5 * * 1-5 /usr/bin/WoL
```

Parameters `0` and `5` represent that shell script will be run at 05:00am, Parameters `1-5` represent that shell script will be run on every workday, While `/usr/bin/Wol` represents the path to the shell script.

Problems with both of these possible solutions is that they are based on WoL and as such WoL raises some security considerations. In general, possibility for magic packets can be abused by anyone within the same LAN and therefore computers can be power on by unauthorized personnel.

5. CONCLUSION

In this paper, possibilities of mutual impacts of high network utilization and business processes are described. In case study data collected from MRTG was used to detect problem in business processes. Sources of that problem are detected and one possible implementation of solution is proposed. Proposed solutions is on ICT side and implementation of such solution should result in less loss of labor hours at the beginning of workday and thus influence the total effectiveness of business processes. Causes for slow transfer time of user profiles from domain controller to workstations remains an issue and should be addressed. In presented case study, status of information and communication infrastructure is used to detect just one problem, but it is important to mention that it could be used for detection of various other problems in business processes.

Further research could be focused on how these kind of problems could be solved by changes in business processes, as well as attempting to find reasons for other high computer network usages that were not covered by this specific research.

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