

Challenges and Opportunities for Enterprise Computer Networks: a case study

Adis Rahmanović¹

University of Travnik, Faculty of
Technical Studies, Travnik,
Bosnia and Herzegovina,
adis.r@rmub.ba

Azra Čatović²

University of Novi Pazar,
Department of economic sciences,
Serbia,
a.catovic@uninp.edu.rs

Halid Žigić³

European university Brcko, Faculty
of Technical Studies Brcko,
Bosnia and Herzegovina
halid_zigic@outlook.com

Abstract – *Computer network enterprises represent a complex structure of ICT infrastructure in enterprises, subject to continuous development, deployment, updating, improvement, but also maintenance. The challenges arising from the planning, implementation, updating, implementation of new services processes are constantly present, and in the context of ever-expanding development and deployment, the deployment of new ICT network services is becoming more sensitive, and challenges are becoming more important. On the other hand, the opportunities provided by the implementation of this type of network are increasing, and companies in the corporate business domain are increasingly dependent on prompt and accurate information in all management domains. New platforms, ICT services are leading to the automation of the entire business of information systems and associated infrastructure, which products have to deploy to all complex enterprise computer networks. Business is increasingly dependent on information management and security infrastructure, so it intends to invest in a platform for greater security and reliability of network infrastructure.*

Keywords – *Computer network, Enterprise computer networks, LAN, VLAN, Switch L3, Switch, SAR Journal.*

I. INTRODUCTION

The application of new technologies in the field of local computer networks in enterprises is mostly related to the field of increasing bandwidth, implementation of virtualization and platform for new services, increasing reliability, service quality and security. Enterprise computer networks are usually composed of optical, wired, wireless and possibly GPS, ie. satellite as well as mobile networks. This architecture is needed both because of the conditions associated with the constraints of the location for implementation, and because of the characteristics of the ICT service, budget constraints, time, legal constraints and the like. Challenges in the process of implementation and operation of such networks are manifested in ensuring compatibility of standards, avoidance of bottlenecks, data protection and ICT infrastructure, as well as in the domain of optimal work and greater reliability in the field of availability and protection of information and ICT services. The capabilities that the Enterprise Computer Network needs to meet are the automation and management of companies through computer resources in a secure, reliable, mobile and flexible way, with access to information of authorized persons from identified locations in a secure and prescribed manner.

II. IMPLEMENTATION AND APPLICATION OF ENTERPRISE COMPUTER NETWORKS

Enterprise computer network in the modern way of doing business is the "backbone" of ICT infrastructure, in which we have wired and optical infrastructure, various forms of GPS and mobile communications, so we often use wireless network of different standards and domains of protection with all the challenges ways of corporate ICT infrastructure. We are often in a situation where we have already existing network infrastructure, subnets or networks with different standards, because it is a very intensive process of development of these areas, development of new standards, and previous ones implemented in the company are not surpassed and in some parts they are still functioning, so the challenge is to provide an optimal, appropriate level of security in such networks. Therefore, when investing in upgrades and new ICT infrastructure, the analysis of existing resources, the possibility of upgrading and possible renewal is performed, taking into account compatibility, compliance with new standards, levels of security and reliability, quality of service and protection, and avoiding bottlenecks in the exploitation process... Therefore, it is best to show on the example of application, implementation of new, upgrade of the old network infrastructure and communication with the old standards on the example of application in one company, in this case it is RMU Banovići. Consolidation of the network has increased the overall security and reliability of the complete system. The implemented solution needs to ensure that the best that each of the devices provides is used. The backbone of the network consists of five HPE 5510 48G 4SFP + HI switches connected in a stack, while Cisco SG 200 and HPE 5510 48G 4SFP + HI and Cisco 2960 switches are used as access switches. Network topology can be represented in physical and logical topology. The physical topology shows the physical interconnections, the equipment used, the ports that are connected, and the speeds and modes of operation of the ports. The logical topology shows the logical flow of communication on the physical infrastructure. Communication between the equipment located in the server room of the Directorate RMU Banovići is realized

primarily through single mode optical infrastructure. The network infrastructure between individual facilities was realized by laying optical-cable distribution, while the network infrastructure within buildings and in production segments was mainly created by wired and wireless infrastructure. The figure below shows the physical interconnections of the installed equipment.

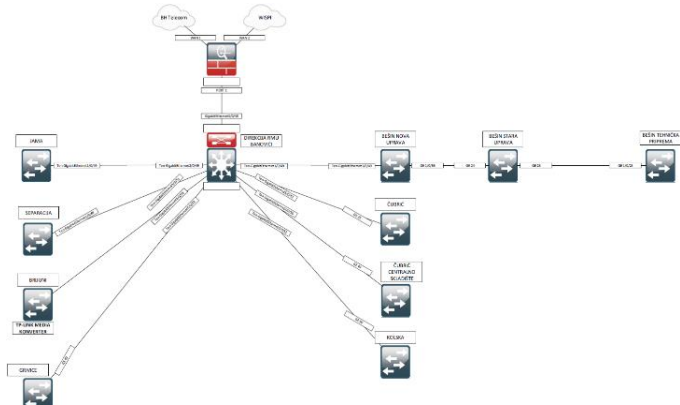


Figure 1. Display of network infrastructure between buildings and towards the Internet

The interconnection of the server infrastructure located in the server room of the RMU Banovići Directorate is shown in the figure below.

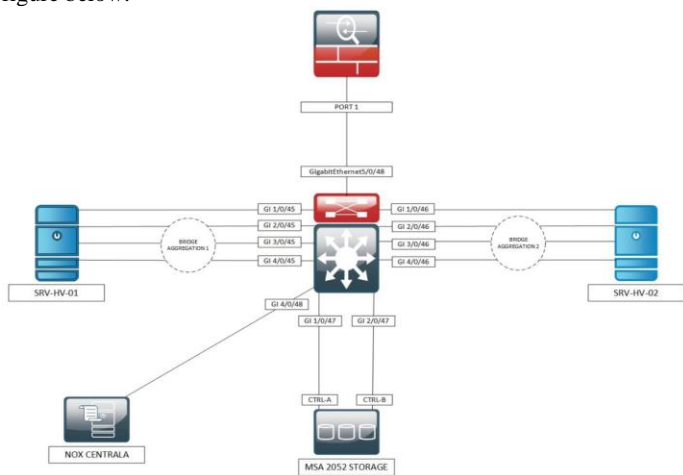


Figure 2. Display server, storage and network infrastructure interconnections

As can be seen in the figure, link aggregation (LAG) was used according to the server infrastructure in such a way that from each server, three network interfaces are connected to the central switch, thus increasing the capacity to 30Gbps, significantly increased reliability. By connecting the NOx control panel that controls a number of sensors, access doors, the physical security of such infrastructure is increased, as well as defined rules of access to such infrastructure, both at the physical and logical level, and through the access authorization matrix at the application layer. Based on the logical topology and network design, an IP address scheme was applied, which allows granular definition of security settings and routing and enables scalable and simple extension of the IP address space.

For the needs of IP address distribution for user networks, a DHCP service has been implemented with a separate address range for individual network segments on existing servers. Access to an individual device is done via the management IP address from the management VLAN.

From the aspect of infrastructure in this network, the central role is played by the central switch, which is L3 manageable, composed of modules and represents the core of the computer network. There was already a computer network in RMU Banovići, so some segments needed to be replaced, some upgraded, as well as expanded in a certain part.

The previous L3 central switch has been in operation for over 13 years, so due to reduced reliability, insufficient capacity and not supporting new security concepts and support for new services, the existing Cisco WS-C4506 switch was replaced, which included 4x WS line cards. -X4148 and 1x line card WS-X4424-GB-RJ45 with HPE 5510 switches connected in a stack on which 10G uplinks were used using appropriate single mode transceivers and 10Gbps transfer rate was achieved according to locations where HPE 5510 switches were also installed, which is a significant increase compared to the previous 1Gbps transfer rate. In addition, according to the majority of user computers located in the Directorate of RMU Banovići, a transfer speed of 1Gbps is enabled, which is a significant increase compared to previous transfer speeds of 100Mbps. Five HPE 5510 switches are configured in the stack. The switches are interconnected by DAC cables via a 40 Gigabit interface and as such form one unit or one logic switch. Taking into account the redundancy of power supply, communication through redundant cables, as well as modularity and hot swap maintenance capabilities, as well as fast reactions and content redirection in case of failure of one of the switches, one switch from central switch configured to compact switch.

Due to possible greater needs, the introduction of new projects, they can be upgraded, but in this phase a spare redundant part is provided, to increase reliability and security and ensure business continuity. The figure below shows how to connect the switches to the stack.

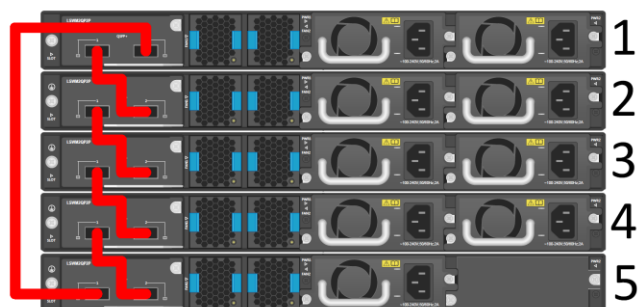


Figure 3. Display the central switch in the connected stack

LAN virtualization is optimized so that the number of users, quality, sensitivity, complexity and security of services to be provided at the specified location is taken into account, so remote locations are created as one VLAN, respectively, while the central location is the Directorate.

RMU, optimized and 5 VLANs were created at this location. At remote locations, 1 to 3 VLANs are created depending on the need. To configure VLANs, it was necessary to perform the following steps, as well as know some of the features of virtualization, which is described below.

For the purpose of configuring the additional VLAN on the switch, and as shown in the figure below, you need to click on VLAN Management and then on Create VLAN and then on Add ...

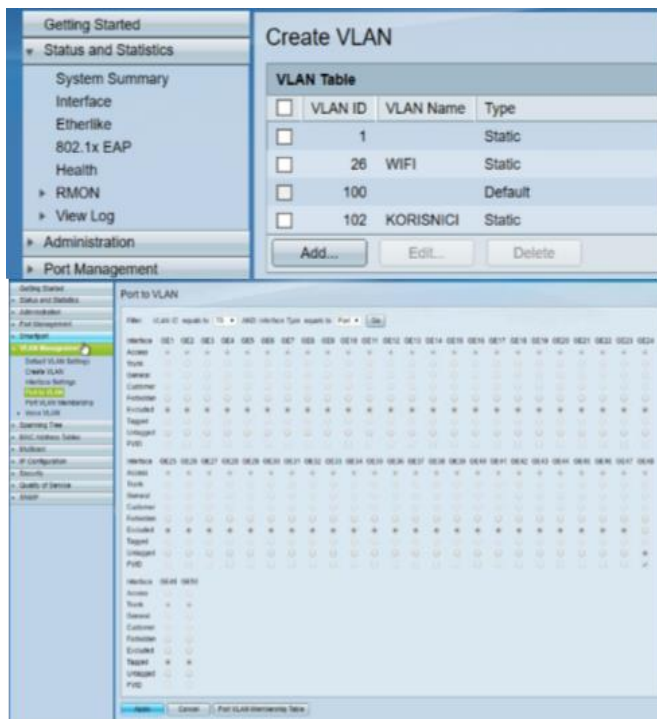


Figure 4. Creating and configuring VLANs

Then a window appears as in the setup image above, in which we enter the VLAN ID and VLAN Name. VLAN ID is a number that identifies a VLAN and can have a value of 0 - 4095 while VLAN Name represents an arbitrary name or description that can be assigned. After entering the required data, it is necessary to click on Apply and in this way we created a new VLAN on the SG200 switch.

Then it is necessary to add a port on the switch to a specific VLAN (in our case VLAN 70). It is necessary to click on VLAN Management and then on Port to VLAN and then in the drop-down menu next to "VLAN ID equals to", select the desired VLAN and then click "Go". To add a port to VLAN 70 we will select the "Untagged" option on the port we want to assign to the corresponding VLAN (in our case port GE48).

Since the ports through which access switches are connected to the RMU Banovići Directorate are configured as trunks or collection ports, in order to pass VLAN 70 through trunk, it is necessary to select the "Tagged" option on trunk ports (in our case ports GE49 and GE50). In this way, we add the appropriate port to the created VLAN and pass the VLAN through the trunk, after which it is necessary to save the configuration. Virtualization will provide logical division and creation of LANs that have minimal

interaction, which increases the level of security, and thus functionality and reliability. After this, it is necessary to save the created and configured VLANs.

The Switched Network is part of a network structure or Layer 2 network consisting of five Cisco SG200s, three HPE 5510s and one Cisco 2960 switch, and they connect users' computers and printers to individual locations. Layer 3 switch, which consists of five HPE switches connected in a stack, has the function of a central switch that performs the function of routing and is also used as an access switch for user computers in the Directorate of RMU Banovići.

The network is segmented into virtual LANs (VLANs) that allow network segmentation on Layer 2 while allowing the use of shared infrastructure. All access switches are connected by TRUNK ports to the central switch and, as mentioned earlier, a single optical infrastructure was used to connect the central and access switches, with appropriate, 1G or 10G single mode SFP transceivers built into the switches.

There are 9 access switches in the network that connect end stations (workstations, servers, printers, etc.). All access switches are identically configured. Access switches are connected to the central switch via fiber media 10 Gigabit and 1Gigabit trunk links. Depending on the switch location, access ports are configured in previously defined VLANs. At the location Bešin – "Nova uprava", the existing Cisco SG200 switch was replaced with a new HPE 5510 switch on which 10G uplinks were used using appropriate single mode transceivers and 10Gbps transfer speed was achieved according to the RMU Banovići Directorate, which is a significant increase compared to the previous 1Gbps transfer rate.

The increase in transmission speed at this location is especially pronounced if we take into account the fact that through this location, the locations Bešin - Old Administration and Bešin - Technical Preparation also communicate with the Directorate of RMU Banovići. In addition to replacing the switch, two Cat6 patch panels were installed that were used to terminate existing network cables that had previously been terminated using RJ45 connectors. By installing new patch panels, on all user computers connected with Cat5e network cable or better and in accordance with the rules of the profession, a transfer speed of 1Gbps is enabled, which is a significant increase compared to previous transfer speeds of 100 Mbps.

A Ubiquiti switch was installed on the site together with 4 new access points, i.g., to support and distribute wireless signal and network. For the needs of users and printers, VLAN 102 is created on the central switch and the network segment is assigned in the specified IP address interval, while for the needs of the wireless system VLAN 26 with network segment is used in the assigned second IP address interval or VLAN 20 with network segment IP address interval for server equipment needs.

The picture below shows the current layout of the network cabinet in which the above equipment is installed.



Figure 5. Example of a network cabinet with equipment at a remote location Bešin - Old Administration

The existing cabinet was removed, as it was not intended to accommodate communication equipment, and a new 6U height communication cabinet was installed. Instead of the existing Allied Telesis switch, one of the existing Cisco SG200 switches with corresponding single mode and multimode transceivers was installed in the mentioned closet in order to establish a connection, on the one hand to the location Bešin - New Administration or RMU Banovići Directorate and on the other hand to the location Bešin - Technical preparation, and without the use of existing optical media converters. In addition to the switch, a new optical patch panel was installed with a multimode optical cable for connection to the Bešin location - Technical preparation, as well as a new patch panel Cat6 which was used to terminate existing network cables previously terminated using RJ45 connectors. By installing the above switch and patch panel Cat6, on all user computers connected by Cat5e network cable, or better, and in accordance with the rules of the profession, a transfer speed of 1Gbps is enabled, which is a significant increase compared to previous transfer speeds of 100 Mbps. In addition, one access point has been installed on the site to cover this location with a wireless signal, as well as an APC UPS for uninterruptible power supply, filtering and stabilization of voltage conditions. For the needs of user computers and printers at this location, a special VLAN was created on the central switch, while for the needs of the wireless system, another VLAN is used.

At the Bešin - Technical Preparation location, the existing Cisco WS-CE500 switch was replaced with a Cisco 2960 switch with an additional single mode transceiver installed in order to establish a connection to the Bešin - Old Administration location, and then further to the Bešin - New Administration location. RMU Banovići, without using the existing optical media converter. In addition to the switch, a new optical patch panel was installed with a multimode optical cable for connection to the Bešin - Old Administration location, as well as a new patch panel Cat6 which

was used to terminate existing network cables previously terminated using RJ45 connectors. By installing the above switch and patch panel Cat6, on all user computers connected with Cat5e network cable or better, and in accordance with the rules of the profession, a transfer speed of 1Gbps is enabled, which is a significant increase compared to previous transfer speeds of 100 Mbps.

At the Čubrić location, a 9U cabinet was installed, and the equipment from the 6U cabinet was replaced with the existing Cisco WS-CE500 switch with the existing Cisco SG200 switch, which included an additional single mode transceiver in order to connect to the RMU Banovići Directorate, without using the existing optical media converter. In addition to the switch, a new Cat6 patch panel was installed that was used to terminate existing network cables that were previously terminated using RJ45 connectors. By installing the above switch and patch panel Cat6, on all user computers connected by Cat5e network cable, or better, and in accordance with the rules of the profession, a transfer speed of 1Gbps is enabled, which is a significant increase over previous transfer speeds of 100Mbps. Additionally, an APC UPS for uninterruptible power supply is installed on site. At the locations of Grivice, the central warehouse Čubrić, Kolska and Brijuni, similar activities were performed as at the location Čubrić.

At the Jama and Separacija locations, the existing Cisco SG200 switch was replaced with a new HPE 5510 switch in which an additional single mode transceiver was installed in order to establish a connection with the RMU Banovići Directorate without using the existing optical media converter. On the HPE 5510 switch, 10G uplinks were used and a 10Gbps transfer rate was achieved according to the RMU Banovići Directorate, which is a significant increase compared to the previous transfer rate of 1Gbps. Additionally, an APC UPS uninterruptible power supply is installed on site. For the needs of user computers and printers at this location, a special VLAN was created on the central switch, as well as a VLAN for Wi-fi.

III. CHALLENGES AND OPPORTUNITIES OF ENTERPRISE COMPUTER NETWORKS

The task of the Enterprise Computer Network is to be the basic infrastructure for the application and use of various ICT services, which are growing in number, and which are increasingly demanding in terms of resources speed, quality, reliability, security, data protection and all resources that have access to such infrastructure. Today, corporations realize the management of business through computers and computer resources, so the integration of intranet and internet infrastructure is extremely important, and thus the application of the most compact and up-to-date solutions in the field of security. The specificity of the corporate network is that it is complex, large, composed of different segments at almost all layers, so the challenge is to ensure compliance and compactness of standards, optimize it in the field of bottleneck avoidance, minimize security risks through authentication rules, virtualization, application various

software and hardware tools, defining and strictly adhering to procedures and rules.

The informatization of companies is increasing, the number of information that is continuously transmitted through the network, the dependence on prompt and accurate information in an adequate place, is increasing, and therefore requires greater security and reliability, demanding in terms of new services, which are more demanding such as video teleconferencing, 8k video transmission, smart technologies with compact solutions, IoT, application of integrated information systems with integration of ERP, production, Internet access, mobility, ability to upgrade and transfer large amounts of data faster and more reliable. The realization of these requirements has given new opportunities, but also produced new challenges, mostly in the field of security. Opportunities that were realized through a more promptly response, implementation of new technologies, a platform for further safer and more reliable development were achieved through improvements in the new computer network, analyzing the same in relation to the previous situation.

Improvements over the previous situation in terms of active and passive network infrastructure, through this case study improvements were made in various segments. One of the key improvements is to increase the access speed from 100 Mbps to 1 Gbps for user computers both in the Directorate of RMU Banovići and in locations where structured cabling is done in accordance with the rules of the profession. In addition to increasing the speed for user computers at locations (Bešin - Nova uprava, Jama and Separacija) where HPE 5510 switches are installed, 10Gbps transfer speed was achieved according to the RMU Banovići Directorate, which is a significant increase compared to the previous transfer speed of 1Gbps. The central switch is able to process and transmit tens of times more information than the previous one. Security has been increased through the application of enhanced authentication, encryption, virtualization, and physical access control. Using the "display interface brief" command on the central core switch, the speeds on the switch ports can be displayed. The figure below shows only the speeds according to remote locations that are connected using the optical infrastructure since the central core switch has a total of 260 ports.

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RMU-BANOVICI-DIREKCIJA>display interface brief | include XGE
XGE1/0/49 UP 10G(a) F(a) T 100 TRUNK-BESINNDPR
XGE1/0/50 DOWN auto A A 100 TRUNK
XGE1/0/51 DOWN auto A A T 100 TRUNK-BRIJUNI
XGE1/0/52 DOWN auto A A 7 TRUNK
XGE2/0/49 UP 10G(a) F(a) T 100 TRUNK-JAMA
XGE2/0/50 UP 1G(a) F(a) T 100 TRUNK-C.SMLADISTE
XGE2/0/51 DOWN auto A T 100 TRUNK
XGE2/0/52 DOWN auto A T 100 TRUNK
XGE3/0/49 DOWN auto A T 100 TRUNK
XGE3/0/50 DOWN auto A T 100 TRUNK
XGE3/0/51 UP 10G(a) F(a) T 100 TRUNK-SEPARACIJA
XGE3/0/52 UP 1G(a) F(a) T 100 TRUNK-KOLSKA
XGE4/0/49 DOWN auto A T 100 TRUNKSEA
XGE4/0/50 DOWN auto A T 100 TRUNK
XGE4/0/51 DOWN auto A T 100 TRUNK-DIREKCIJA
XGE4/0/52 UP 1G F(a) A 109 TRUNK-BRIJUNI
XGE5/0/49 DOWN auto A A 1
XGE5/0/50 DOWN auto A A 1
XGE5/0/51 UP 1G(a) F(a) T 100 TRUNK-CUBRIC
XGE5/0/52 UP 1G(a) F(a) T 100 TRUNK-GRIVICE

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Figure 5. Display of link speeds to remote locations on the central core switch

IV. CONCLUSION

Challenges facing corporations in the information age, with the characteristics and needs of intensive change management, cost, product introduction, quality management, time, budget, risks, the need for continuous improvement of intellectual capital, adequate measurement and stimulation can be realized only by intensive and adequate introduction and application of new technologies in the field of smart solutions, IoT, artificial and business intelligence, automation and appropriate information system, modern ways of data protection, information systems and ICT infrastructure. In order to ensure this and to have accurate and timely information available, it is necessary to provide infrastructure in locations where wired and optical infrastructure has certain limitations for implementation. In such situations, regardless of all the challenges in the implementation and use that are most pronounced in the field of security, which need to work continuously, and which are expressed not only because of the application and compatibility of different technologies, but also due to accumulation of knowledge, development of different hacker tools, greater importance of ICT services, information and ICT infrastructure, as well as the above benefits and upcoming technologies in the field of mobility, flexibility and adaptability, it is necessary to increasingly explore and intensify upgrades, because it will play a significant role within corporate ICT infrastructure. Of course, in the coming period it will be imperative to find adequate answers to the challenges posed by the use of these technologies, and the topic of security among other things and such infrastructure will be increasingly important,) but also because of the growing number of services that are distributed through them, but also the importance of technologies that will be in use using this type of infrastructure, but also the characteristics of modern corporate business and market conditions.

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