QUALITATIVE BENCHMARKING STUDY OF SOFTWARE FOR SWITCH PERFORMANCE EVALUATION

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ABSTRACT

The objective of the research was to compare network software technologies to evaluate the performance of switches based on year of inception, countries implemented, versions, type of software, operating system, programming language, features, tools, benefits, and cost range of implementation. It was concluded that OpUtils is the licensed software with more experience in the market in the technological platforms based on the evaluation of the performance of the software to manage the switches being one of the national and international companies that had a great apogee for its low cost and its quality service. On the other hand, Open vSwitch is the software that shows a high-level index in terms of software updates that allow blocking errors in the source code and patches in poorly developed configurations and maintain security in the management of ports and interfaces for switches. This is due to the fact that the software is based on open-source code allowing to optimize its processes. Finally, it is possible to maintain high standards for privileged users, stop anomalies in real time and stop the cause of the problem is necessary to use a licensed software such as Cisco Open SDN Controller for its full functionality. Finally, some recommendations for future studies were indicated, such as: (a) to perform a classification research covering more than 6 switch management software to increase the alternatives for the selection of a complete software that meets the needs of the stakeholders, (b) to increase the number of variables with the aim of taking the research to a deeper study to provide the support to technical network administrators in the security of devices (switches).

KEYWORDS

OpenStack, Open vSwitch, OpenQRM, Cisco Open SDN controller, Ni switch executive, OpUtils.

1. INTRODUCTION

Today, the greatest demand for networking organizations to structure traditional network architectures is for quality services. Therefore, for some time now, software-based networking technology platforms have been developed to evaluate the performance of ICT-enabled tools based on virtualization, enabling communication between devices, and maintaining predictable control between these systems. Also, the virtual switch is the backbone of all data center networks because companies employ tools in order to use software resources and have economical and complete networking solutions (Morillo, 2014; Nicolalde, 2021).

Likewise, hubs or switches can have rules created to avoid collisions or traffic increase through the network channels (Toapanta, 2006; Cujilema, 2011). Similarly, they can work at the same speed as all interconnected ports, facilitating the work of each device (Toapanta, 2006; Cujilema, 2011). However, they can make packet forwarding decisions based on specific addresses providing a higher bandwidth for each computer since their configuration is simple and maintains multiple protocols for data transfer in networks of different segmentation in order to end data congestion in the network (Toapanta, 2006; Cujilema, 2011).

In addition, the switch is a tool that has diverse functionalities to manage networks based on protocols that allow seamless communication between systems (Nicolalde, 2021). Therefore, for the evaluation of software it is necessary to perform stress or performance tests in search of various alternatives that can meet the access, scalability, network flexibility, data processing, security and process automation (Cardona, 2019). Regarding this, the switches are modern equipment and in essence those of CISCO can restrict ports and create security policies this is due to the software of the entity that allows to execute these actions when it detects anomalies within the network (Luna, 2019). In that sense, Valencia (2013) developed a graphical network diagram platform of different wiring systems in telephony headquarters to interact through switches in a LAN network allowing DHCP servers and DNS servers to obtain data from the hosts and display it in real time in the technological network diagram in order to manage

anomalies or connection problems (Valencia, 2013; Cujilema, 2011).

In this research it is proposed to compare software for the evaluation of the performance of switches using free and licensed software based on indicators of previous studies in order to provide relevant information to entities of interest such as those responsible for handling and managing networks allowing them to make a decision based on characteristics that are more suited to the entity, likewise increases the rate of innovation based on software meeting the essential requirements of a software (security, quality of service, routing users, programmable and easy to manipulate) (Morillo, 2014; Valencia, 2013; Luna, 2019; Nicolalde, 2021).

2. MATERIALS AND METHODS

The purpose of this study was to compare free software and licensed software for network switch performance evaluation based on the following indicators: Year of inception, Countries Deployed, Versions, Software Type, Operating System, Programming Language, Features, Tools, Benefits and Implementation Cost Range.

The study was qualitative since it describes and defines software technologies to evaluate the performance of switches based on cross-sectional data mining (Sánchez, Fernández y Díaz, 2021). In this regard, Sanchez, Fernandez and Diaz (2021) mentioned that qualitative research has an important potential before society since it is methodology, processes, procedures of concrete and particular performance when collecting data since being evident that it is a technique of greater depth of search. In addition, the design of the study has been topical, with the objective of reaching the specialists or technical managers who make the decision to opt for optimal and quality systems that meet the requirements for the entity. Several researches were evaluated in Scopus, Dyna, EBSCO, Scielo, Elsevier and the technical data of suppliers of these software's focused on switches (Sánchez, Fernández y Díaz, 2021).

3. RESULTS

After detailing the comparative tables of free software and licensed software for the evaluation of switch performance, the most influential characteristics are compared with the results of previous research in order to obtain a similarity, difference and/or comparison with the present study. Likewise, when carrying out the structure of free software and licensed software, it is possible to identify similarities and/or differences found in the indicators selected in the present study with the results of previous research. Therefore, the comparison of data extracted in the comparative tables is shown, disagreed and/or justified. Likewise, it could be observed in the results, that the OpUtils software shows many years of antiquity in the technological and labor market. In this way, it has approximately 25 years in the dedication and practice to offer solutions to users, network administrators who use software for the management and monitoring of switches, where this result shows the difference in the work of Martinez, Valencia and Osorio (2010) where they justified as a result that the Cacti and Nagios software are those technological platforms that currently predominate the operation of the system in the face of anomalies.

On the other hand, the Open vSwitch software versions prove to be constant developments by performing updates in short periods, with the aim of correcting bugs, errors and bad structure in the source code, to maintain security and information in users, this result shows similarity by Pfaff *et al.* (2015) where they justified as a result that it is advisable to use the Open vSwitch software given the large-scale increase on the variability in the flow and optimization routes to minimize these problems by reducing changes in the software (Pfaff *et al.*, 2015). In addition, OpUtils software is able to adapt to any operating system (Windows and Linux) since its software distributions are easy to install and monitor, this result shows difference to Melwani's work where he mentioned as a result that virtualization is more efficient since its libraries and dependencies, are helpful in creating Docker containers instead of existing as a complete operating system, only including the binaries, necessary libraries and the software we want to virtualize (Melwani, 2018).

Table 1. Comparison of open-source software for switch performance evaluation.

INDICATORS	SOFTWARE		
	OpenStack	**Open vSwitch**	**OpenQRM**
START YEAR	In 2010 the software was released for the first time (OpenStack, 2020).	The foundation of the software is in 2009 (Open vSwitch, 2020).	The founding year of the software was 2004 (OpenQRM, 2021).
COUNTRIES IMPLEMENTED	United States (OpenStack, 2020).	United States (Open vSwitch, 2020).	Australia, Germany (Cardona, 2019).
VERSIONS	Ussuri, Train, Stein, Rocky, Queens, Pike, Ocata, Newton, Mitaka, Liberty, Kilo, Juno, Icehouse, Havana, Grizzly, Folsom, Essex, Diablo, Cactus, Bexar, Austin (OpenStack, 2020).	v2.15.0, v2.14.2, v2.14.1, v2.14.0, v2.13.3, v2.13.2, v2.13.1, v2.13.0, v2.12.3, v2.12.2, v2.12.1, v2.12.0, v2.11.7, v2.11.6, v2.11.5, v2.11.4, v2.11.3, v2.11.2, v2.11.1, v2.11.0, v2.10.7, v2.10.6, v2.10.5, v2.10.4, v2.10.3, v2.10.2, v2.10.1, v2.10.0, v2.9.9, v2.9.8, v2.9.7, v2.9.6, v2.9.5, v2.9.4, v2.9.3, v2.9.2, v2.9.1, v2.9.0, v2.8.11, v2.8.10, v2.8.9, v2.8.8, v2.8.7, v2.8.6, v2.8.5, v2.8.4, v2.8.3, v2.8.2, v2.8.1, v2.8.0, v2.7.13, v2.7.12, v2.7.11, v2.7.10, v2.7.9, v2.7.8, v2.7.7, v2.7.6, v2.7.5, v2.7.4, v2.7.3, v2.7.2, v2.7.1, v2.7.0, v2.6.10, v2.6.9, v2.6.8, v2.6.7, v2.6.6, v2.6.5, v2.6.4, v2.6.3, v2.6.2, v2.6.1, v2.6.0, v2.5.12, v2.5.11, v2.5.10, v2.5.9, v2.5.8, v2.5.7, v2.5.6, v2.5.5, v2.5.4, v2.5.3, v2.5.2, v2.5.1, v2.5.0, v2.4.0, v2.3.2, v2.3.1, v2.3.0, v2.1.2, v2.1.1, v2.1.0, v2.0.0, v1.11.0, v1.10.0, v1.9.0, v1.7.0, v1.6.1, v1.5.0, v1.4.2, v1.4.1, v1.4.0, v1.3.0 (Open vSwitch, 2020).	v.5.3.40, v.5.3.8, v.5.3.5, v.5.3.2, v.5.3.1, v.5.0.2, v.4.7, v.4.6, v.4.5, v.4.4, v.4.3, v.4.2, v.4.1 (OpenQRM, 2021).
TYPE OF SOFTWARE	Free software (Garcia, 2020).	Free Software (Open vSwitch, 2020).	Free software (OpenQRM, 2021).

INDICATORS	SOFTWARE		
	OpenStack	Open vSwitch	OpenQRM
OPERATING SYSTEM	GNU/Linux (OpenStack, 2020).	GNU/Linux BSD (Open vSwitch, 2020).	GNU/ Linux (Gómez, 2013).
PROGRAMMING LANGUAGE	Python (Garcia, 2020).	Python (Melwani, 2018).	C, PHP, JAVA (OpenQRM, 2021).
CHARACTERISTICS	It constitutes a network infrastructure where it is possible to manage IP addresses and generate virtual networks where there is compatibility with neutron. Also, the software has a firewall implementation in the network with neutron (Garcia, 2020).	The database information is protected in new software updates. On the other hand, the control configuration in the kernel module is called. In such a way, it manages the control of data flow between bridges for virtual interfaces. It also has a high level of control for the software service (Open vSwitch, 2020).	It contains different virtualization points for IT support. Also, the software automates the configuration automatically under its entirety (Gómez, 2013).
TOOLS	NetFlow SPAN, RSPAN, LACP, y 802.1q (Garcia, 2020).	The domain configuration is based on the kernel module control. Thus, it is managed in the virtual interfaces of the switches. Likewise, the control of the data flow between bridges (Melwani, 2018).	Virtual machines such as Debian GNU/Linux, Ubuntu Linux, CentOS, SuSE/SLES, Fedora 9 are used to use the tools (OpenQRM, 2021).
BENEFITS	It contains a high level of data security and reliability. In addition, it acquires a high distribution and acceptance in the IP address. Thus, it is possible to have virtualization under IP addresses in Neutron (OpenStack, 2020).	The network functionality is incorporated into the various access points. In this way, the OVS software is constituted in two configurable flow modes in OVSDB and OpensFlow. Also, the software is based on having a compatibility in bridges (Open vSwitch, 2020).	It performs in having variety of plugins in the software functionality such as the basics of a DHCP, TFTP and Local Server. Also, it manages virtual resources in plugin activation where it is mentioned with Xen and Storage-Xen (OpenQRM, 2021).

Source: own elaboration.

Table 2. Comparison of licensed software for switch performance evaluation.

INDICATORS	SOFTWARE		
	Cisco Open SDN Controller (Cisco Open SDN Controller, 2014).	NI Switch Executive.	OpUtils.
START YEAR	In the foundation year of the proposed software was 2014 (Cisco Open SDN Controller, 2014).	The year the software was founded was 2004 (Ni Switch Executive, 2021).	The founding year of the proposed software was 1996 (OpUtils, 2020).
COUNTRIES IMPLEMENTED	United States, Canada (Cisco Open SDN Controller, 2014).	United States, Spain, and Latin America (Ni Switch Executive, 2021).	United States, Japan, Spain, Germany, China (OpUtils, 2020).
VERSIONS	v.1.2, v.1.2.1, v.1.1, v.1.0 (Cisco Open SDN Controller, 2014).	v.3.5, v.3.0, v.2.0 (Ni Switch Executive, 2021)	v.12.3, v.11.0, v.6.0, v.5.0 (OpUtils, 2020).
TYPE OF SOFTWARE	Licensed Paid Software (Cisco Open SDN Controller, 2014).	Licensed Paid Software (Ni Switch Executive, 2021).	Free Software/ Licensed Paid Software (OpUtils, 2020).
OPERATING SYSTEM	Linux (Cisco Open SDN Controller, 2014).	Windows (Ni Switch Executive, 2021).	Windows, Linux (OpUtils, 2020).
PROGRAMMING LANGUAGE	Java (Cisco Open SDN Controller, 2014).	C#, VB .NET, C/C++ y ActiveX, Python (Ni Switch Executive, 2021).	Java (OpUtils, 2020).
CHARACTERISTICS	The software is distributed, enforced, validated, and supported by its commercial distribution. On the other hand, high availability and quality in clustering is maintained. In addition, ease of service is maintained for monitoring, metrics collection and risk management (Cisco Open SDN Controller, 2014).	The integration of several modules can be automated. Likewise, it is identified in the configuration of the deployment of switches from a file or network. Where the configuration of software modules and drivers is guaranteed (Ni Switch Executive, 2021).	IP addresses are managed. Ports are also managed. In this way, the control of unauthorized devices. It is managed in the Configuration Files (OpUtils, 2020).
TOOLS	Allows you to manage Cisco OpensFlow. Thus, it is administered in Cisco PCEP. It also allows to manage Cisco BGPLS (Cisco Open SDN Controller, 2014).	LabVIEW, LabVIEW NXG, LabWindows/CVI (Ni Switch Executive, 2021).	SNMP Tool, CISCO Tools, Diagnostic Tools, Network Monitoring Tools, IP Address Monitoring Tools, Network Tools (OpUtils, 2020).

INDICATORS	SOFTWARE		
	OpenStack	**Open vSwitch**	**OpenQRM**
BENEFITS	Automate standards-based network infrastructure. It also allows optimizing the acceleration in information technology. (Cisco Open SDN Controller, 2014).	Manage network performance on the switch. In this way, it allows to stimulate the values of the network domain. It also enables logging and reporting of performance test failures. It also allows directing switching operations. Where calculations and data manipulation are performed (Ni Switch Executive, 2021).	Monitor packet losses and discards of errors that you have in the network under critical metrics. In such a way, it visualizes the services of the physical servers. It also allows to manage the WAN and VoIP network (OpUtils, 2020).
IMPLEMENTATION COST RANGE	Standard $795.00 - $928.00 Professional $1,031.00 - $5,995.00 Enterprise $6,216.0-$300,000.00 (Cisco Open SDN Controller, 2014).	$ 1,690.00 (Ni Switch Executive, 2021).	$ 195.00 - $ 2,995.00 (Martínez *et al.*, 2010).

Source: own elaboration.

The OpenStack software demonstrates better technological qualities based on the quality of service control for integrated storage management, allowing the automation of modules, port management, IP addresses, configuration files and drivers of the application software, where this result is similar to the study of Garcia when mentioning that the OpenStack software has future possibilities to adapt to new technological changes, achieve constant updates and the possibility of having a distributed IaaS private cloud (Nicolalde, 2021).

On the other hand, OpUtils software then there are different types of tools that have facilitated the user to have network security. Similarly, the OpUtils software is very feasible with its management processes, such as: diagnostics, network monitoring, IP address monitoring, port management and anomaly

detection, this result is different from Ramos when describing the Open vSwitch software maintains a controlled configuration and an organized database scheme given by its tools: Ovs- vsctl, Ovs-ofctl and Ovs-testcontroller which are utilities and drivers to administer, configure, query and manage the ports of the switch interfaces. Next, the Open vSwtich software incorporates functionalities within the network based on the processes of the switches by the use of configurable flows, software compatibility and its high margin in its processing in sending software packages to hardware, this study is different from that of Martinez, Valencia and Osorio (2010) when performing an evaluation of analysis and management tools (Cacti and Nagios) for its ability to identify and analyze functionalities in the ports of the switches in the network, easy configuration, process optimization and meet the needs of the case based on the performance of the default software (Martínez *et al.*, 2010).

Finally, the Open vSwitch open-source software shows to be a good function for medium-sized organizations for its ease of use, modification of the software itself and user domain, in addition to maintaining a phase of installation and management of resources mitigating problems such as ports and interfaces of the switches on the network, in this regard coincides with the work of Martinez, Valencia and Osorio (2010) mentioned that it is necessary to have monitoring tools for network devices to solve problems based on ICT resources, which is why they mention having licensed software to maintain high standards for users on the network and not being able to limit solutions to anomalies with a margin from $195 to $2,995 (Martínez *et al.*, 2010).

4. CONCLUSIONS

The conclusions of the research were as follows: OpUtils is the most experienced licensed software in the market in technology platforms based on the evaluation of the performance of the software to manage switches being one of the national and international companies that had a great heyday for its low cost and quality service (OpUtils, 2020). On the other hand, Open vSwitch is the software that shows a high level of software updates that allow blocking errors in the source code and patches in poorly developed

configurations and maintain security in the management of ports and interfaces for switches. This is due to the fact that the software is based on open-source code allowing to optimize its processes (Open vSwitch, 2020). Thus, OpUtils software is the best option because it can be adapted to the operating systems most commonly used in technological entities (Windows and Linux); since its distributions and dependencies are the easiest way to install and manipulate the software based on the management, administration and monitoring of the switches in the network (OpUtils, 2020).

Next, the OpenStack software shows a great difference compared to the switch software, since it shows technological peculiarities focused on the quality of service control, allowing to manage, automate and optimize port modules and controllers of the application software, adapting to the existing technological changes (OpenStack, 2020; Garcia, 2020). On the other hand, OpUtils is the software that has the most popular and applied options for medium-sized organizations because it is able to facilitate the user in keeping the network secure in the switches given in its management processes (diagnostics, network monitoring, port management and anomaly detection (OpUtils, 2020).

In addition, Open vSwtich software proved to be a good choice for SMEs because it incorporates security functionalities on switch ports in the network due to its simple configurable flow, software compatibility and high processing margin in sending software packages to hardware (OpenStack, 2020). In addition, Open vSwitch software is the only open-source brand suitable for small and medium-sized organizations due to its ease of use, proprietary software modification and user control. In addition, it maintains full resource management by mitigating problems on ports and switch interfaces in the network (Open vSwitch, 2020). Finally, it can maintain high standards for privileged users, real-time anomaly detention and stop the cause of the problem is necessary to employ a licensed software such as Cisco Open SDN Controller for its full functionalities (Cisco Open SDN Controller, 2014).

5. RECOMMENDATIONS

The recommendations of this research are the following: this qualitative study can be continued in a quantitative way by assigning variables, numerical and statistical data to measure the selected and mentioned indicators. To carry out a classification study is a good option to obtain the evaluation software in the performance of switches and which one is the most suitable for specific sectors and network administrators. To develop the research work using the convergent mixed method to obtain qualitative and quantitative data and to compare the information in search of similarity and/or difference. It is recommended to conduct longitudinal studies to analyze and detail technological changes in the evaluation of switch software performance. Perform a classification research covering more than 6 switch management software to increase the alternatives for the selection of a complete software that meets the needs of the stakeholders. Finally increase the number of variables with the objective of taking the research to a more in-depth study to provide support to technical network administrators in the security of ports on switches.

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