Operating System Selection For Information System Practicums: A Comparative Study Of Rocky Linux, Centos Stream, And Ubuntu Using The Analytical Hierarchy Process

Dzikri Hisyam
Information System Department
Telkom University
Bandung, Indonesia

Muhammad Fathinuddin
Information System Department
Telkom University
Bandung, Indonesia

Umar Yunan Kurnia Septo Hediyanto
Information System Department
Telkom University
Bandung, Indonesia

***Abstract* — Technology skills development is provided through practicum in the Information Systems Department. But, the fact that various laboratories need varying tools and configurations in their systems makes it highly inconsistent and can affect the experience of practicum for students. Plus, one of the other purposes of this research is to expose students to different operating systems, particularly by exposing them to Linux based systems as part of an approach to expand the students' technical skills beyond what is most commonly used such as Windows. Thus, this study aims to identify which is the most appropriate OS to be used in supporting laboratory practicum activities in the Department of Information Systems. The research adopted the Analytical Hierarchy Process (AHP) method as its experimental methodology. Of these four criteria, the researcher identified four main categories: compatibility of tools, default system configuration, user experience and performance. The assessment consisted of running each of the practicum modules on three operating systems (Ubuntu, Rocky Linux, and CentOS Stream), noting any issues encountered, as well as a penalty for incomplete modules. The results show Rocky Linux at 58.2%, CentOS Stream at 26.1% and Ubuntu at 15.8%. It was determined that Rocky Linux was the best-suited operating system for use during the practicum, because of its compatibility and performance.**

***Keywords*—Operating System, Practicum, AHP, Compatibility, Linux, Laboratory Evaluation**

I. INTRODUCTION

As we enter the Industry 4.0 revolution, stable and scalable computing environments have become essential in higher education, especially in engineering and industrial simulation. The operating systems (OS) needed to run technical applications in academic labs have become significant, as LINUX based operating systems are becoming popular as they are open source, flexible, and manage resources well at the kernel level [1][2][3]. As it provides process scheduling, memory management and hardware interaction among others, the Linux kernel is a perfect platform to perform controlled experiments, and to receive technical training in universities [4].

At the educational level, teaching labs for Information Systems can adopt Linux based operating systems to provide students with experience working with enterprise infrastructure while phasing out dependence on proprietary operating systems like Windows or MacOS [5]. Others, like Ubuntu, CentOS Stream and Rocky Linux, have their merits. Ubuntu provides ease of use and good support, CentOS Stream focuses on reliability and being aligned with enterprise, and Rocky Linux has become a community-based version of CentOS with a promise of better long-term support while maintaining the same compatibility [6][7].

Unfortunately, differences in the compatibility of tools, defaults or the behavior of configurations continue to impact consistency and student learning in a practical environment with these systems. For these reasons, a single deliberate selection of OS should be made so that lab environments are not confusingly fragmented, to minimize mistaken and unnecessary configurations of the OS and the labs that take students' attention away from learning goals, and to ensure that students do not have to spend time unnecessarily learning to work around inconsistent behaviors of their environment.

The focus of this study is to test and provide a comparison between Ubuntu, CentOS Stream and Rocky Linux in order to assess which OS would best suit the practicum activities within the Information Systems Department. A comparison based on four main categories, tool compatibility, configuration, user experiences and performance. The intention is to select one operating system that is optimal for technical training, educational processes and that will create uniformity in the operation of our laboratories.

The results of the study should provide valuable contributions to help teachers and IT administrators determine and implement operating systems that will be used in the educational world. The research is a contribution to curriculum, laboratory setup and student preparation for real life IT environments through better exposure to a Linux based infrastructure, by finding the optimal systems selection.

II. LITERATURE REVIEW

Here will be some explanations and theory, that will backed the whole experiment and research of this thesis:

A. Definition of Operating System

Essentially, an operating system (OS) is software that mediates between the computer hardware and the user. It deals with things like hardware, user interface and running

software. As Akhtar states, the OS is usually regarded as the "heart" of computer systems, like a bridge between hardware and software, allowing them all to work well and safely [8]. Elaborating on this, Akhtar also explain that the OS is a management system that manages memory allocation, process control and networking features that are critical at the nerve center of most modern computing devices such as desktops, servers, and IoT platforms [8].

Goodarzy et al emphasize the versatility of the OS particularly within education and industry, explaining that operating systems manage resources but they also offer possibilities to improve those resources, which is even more true for open-source systems like Linux [9]. They are invaluable for teaching, research, and experimentation in the academy. But contemporary operating systems have evolved beyond that. As Zhao et al. discuss, in contemporary design, AI and machine learning are increasingly incorporated into systems to improve performance, security and user experience [10]. This transformation is especially applicable to the education of industrial engineers, as students are exposed to systems that help the use of advanced applications, such as simulation and lab management.

B. Operating System Category

Operating systems (OS) can be categorized based on their purpose and usage environment, namely Desktop, Server, and Security [11]. Each category is designed to meet specific needs, ranging from personal use to critical infrastructure management, such as:

1) Desktop Operating System

Desktop OS is an operating system type that caters to day-to-day requirements like document processing, web browsing, multimedia, and other productivity applications. These operating systems include (but are not limited to) Windows, macOS, and Linux distributions such as Ubuntu. Desktop OSs have a GUI and hardware support that is familiar to the vast majority of nontechnical users who operate a computer. Desktop OS must be equipped with features like advanced management of graphical applications, compatibility with a wide range of hardware peripheral devices and other software, and periodic improvements based on user feedback to maintain effective performance [12].

2) Server Operating System

Since servers are supposed to host websites, manage networks, and manipulate data, they are specialized types of OSes found in the back-end layer. Examples include CentOS, Rocky Linux, and Windows Server. The space offered by a server OS has generally been renowned for stability, security, and simultaneous multi-user support [13]. In general, desktop OS includes GUI while server OS does not generally possess it in addressing resource management and performance through a single command-line interface (CLI). Server OS are specially designed with virtualization and container-based application management in mind, optimizing resource utilization on a server [14].

3) Security Operating System

Operating systems geared towards security are used to fulfill information security needs, for example by being utilized in threat detection, digital forensic analysis, or penetration testing. Such is the case with Kali Linux, which allows for testing hardware vulnerabilities and evaluation of security systems by penetration testers [15]. These operating systems include additional security tools, like encryption and network monitoring, as well as system auditing functions. Furthermore, security operating systems are generally used in industries where sensitive information must be protected, such as government agencies and financial companies [16].

C. Definition and Evolution of Linux

Linux-based operating systems are software built on the Linux kernel, which is an operating system core first developed in 1991 by Linus Torvalds. Linux evolved from a hobby project to a platform that supports a wide range of modern computing applications, including servers, mobile devices, and embedded systems. As revealed by [17], openness is one of the greatest strengths of Linux. This makes it possible for any developers in the world to contribute towards improving and evolving its functionalities.

Linux has evolved a lot, giving way to so many distributions that are often customized to fit certain needs in various technological fields. For example, the Ubuntu distribution is mainly focused on desktop and educational purposes, with an interface accessible to thousands of packages; on the other hand, distributions like CentOS and Rocky Linux focus more on server applications, with the best stability and constant support for their backend services. According to [18], the evolution of Linux has been strongly determined by modern requirements related to flexibility, safety, and expandability, which make it one of the most popular choices in technological environments needing extended performance.

Furthermore, recent Linux distributions, such as Rocky Linux, have emerged in response to the need to replace distributions like CentOS, which changed their long-term support policies. This confirms the continued agility of the open-source community in responding to the dynamic needs of the industry. Furthermore, [19] point out that the development of Linux does not only include technical dimensions but also cybersecurity issues, which are becoming more complicated in today's time. Integrating state-of-the-art technologies such as containerization and virtualization, Linux has become the very foundation of technological development leading to cloud-based applications, software engineering, and large-scale IT infrastructure [18].

D. Description of Compared Operating System

In the process of selecting the optimal operating system to support practicum activities, it is important to understand the characteristics and uniqueness of each operating system being compared. This chapter describes three major Linux distributions, Ubuntu, CentOS, and Rocky Linux, that have different advantages and disadvantages in meeting the needs of an Information System Department's Practicum. The following explanations will provide a comprehensive overview of the features, advantages, and challenges of each distribution:

1) Ubuntu

Ubuntu is one of the most popular Linux distributions, known for its user-friendly interface and extensive community support. This operating system is specially

designed to be easy to use on a desktop as well as a server, concentrating on stability and software compatibility. Moreover, Ubuntu supports a wide range of educational programs, which makes it especially suitable for use in schools, including computer labs. The advantages of this system include a simple installation process and regular software updates. On the other hand, one prominent weakness is its high resource utilization compared to some other Linux distributions, such as CentOS [20].

2) CentOS Stream

CentOS Stream is a Linux distribution based on Red Hat Enterprise Linux (RHEL), designed for high server stability. In other words, CentOS is widely used in server environments due to its focus on security, reliability, and extensive testing. In addition, it has broad hardware support and is commonly utilized in virtualization-based applications. On the downside, CentOS is more technically demanding than Ubuntu, so for someone without prior knowledge or skills, it would be very difficult to use [21].

3) Rocky Linux

Rocky Linux is one of the relatively new Linux distributions, created to replace CentOS after a change in its support policy. Developed by the open-source community, Rocky Linux aimed to offer an alternative providing stability on par with CentOS and full compatibility with RHEL. Given the efficiency in resource management and the focus on long-term stability, Rocky Linux turned out to be at the top for server needs. Its documentation and community are still developing compared to Ubuntu and CentOS, since it is a relatively new project.

E. Similarities and Differences Between Operating Systems

In each operating system, there are similarities and differences. This chapter will cover the similarities and differences between three operating systems which are Ubuntu, CentOS Stream, and Rocky Linux in four contexts. Those contexts are application context, distros context and the last it system and kernel context. Below is the explanation of each context.

1) Application Context

When comparing them in application context CentOS Linux and Rocky Linux has been the platform of choice for web servers, database solutions and other software that requires a robust, stable system [22]. CentOS Stream and Rocky Linux is also capable of being a desktop OS but is much less likely to be chosen for this role than Ubuntu and doesn't usually have the polished desktop interface and user-friendliness of Ubuntu [23]. Ubuntu is still one of the most popular distributions for servers, especially in cloud, virtualization, and DevOps environments [20]. Ubuntu, on the contrary, is optimized for desktop users, and thus has a more friendly interface, includes more applications, and integrates better in general with desktop tools [20].

2) Distros Context

Ubuntu, CentOS Stream, and Rocky Linux are full Linux distributions based on the Linux kernel and which use systemd as their init system and so, they are all capable and modern operating systems. The important distinction is that they come from different "lineages" and use different package management systems. Ubuntu is a desktop-oriented user-friendly distro that is based on Debian's APT/dpkg toolchain (.deb packages) but has faster release cycles for the software repositories [20]. On the contrary, CentOS Stream and Rocky Linux use DNF/YUM with .rpm packages and are based on Red Hat Enterprise Linux (RHEL) [23].

3) System and Kernel Context

While Ubuntu, CentOS Stream, and Rocky Linux have the same Linux Kernel but they differ in a particular way which explains why they are good in a certain category. Especially in resource usage, CentOS Stream and Rocky Linux have minimal resources usage judging by the advantages of performance, it is minimal because it is optimized for server usage [23]. As for Ubuntu, the resource usage is moderate judging by the performance that is lower than CentOS,

F. Windows Subsystem for Linux (WSL): Overview and Relevance

Windows Subsystem for Linux (WSL) provides a compatibility layer that enables Linux distributions to run on Windows without the need for dual-boot or full virtualization. WSL 2 introduces a real Linux kernel within a lightweight virtual machine, offering near-native performance for most compute tasks, though it still suffers from limited file I/O performance and lacks a native graphical interface [24]. In this study, WSL is considered a practical compromise between native Linux environments and Windows-based systems commonly used by students. Its inclusion allows for Linux tool exposure within familiar Windows workflows, making it a viable transitional solution in environments where full Linux adoption is constrained.

III. METHODOLOGY

This chapter will discuss the methodology that will be used to compare operating systems, also there will be a conceptual framework for this research and at last there will be a systematization of problem solving that will give the flow of the research.

A. Conceptual Framework

This research is being supported by the Analytical Hierarchy Process (AHP). AHP is an organized decision-making framework developed by Thomas L Saaty in the 1970s. By breaking down intricate decision-making challenges into manageable pieces, this approach tackles them head-on. In many fields, AHP is a multi-dimensional decision-making framework that utilizes both qualitative and quantitative criteria. It consists of identifying the problem, creating a hierarchy of objectives and alternatives, conducting pairwise comparisons to determine the weightage for each criteria and alternative, checking for consistency with CR (Consistency Ratio), and then using the results to rank options and select the best option.

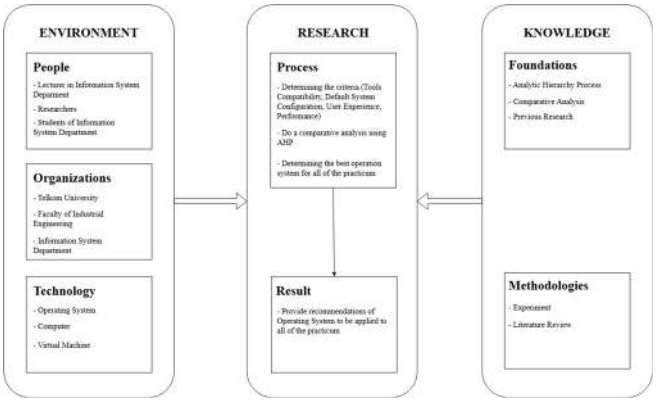

FIGURE 1
Conceptual Model

1) Environment

The Environment outlines the contextual factors that influence the research. It is composed of the primary users of an chosen operating system (OS), which include lecturers in Enterprise Infrastructure Management (EIM), researchers and Information Systems students. Telkom University, the Faculty of Industrial Engineering, and the Enterprise Infrastructure Management Minor are part of the organizational context that contributes to establishing academic objectives, infrastructure, facilities, etc. Technology is incorporated in the evaluation of operating systems (Rocky Linux, CentOS, and Ubuntu), computer hardware for installation, as well as virtual machines used to simulate environments for controlled experiments.

2) Research

The Research component elaborates on the methodology. It identifies the criteria for evaluation: performance, security, stability, compatibility, and ease of use. The AHP methodology is then applied to perform comparative analysis with respect to these criteria in arriving at an informed recommendation of the most appropriate OS for each practicum. This will, therefore, lead to the selection of the best operating system that will address all the needs of that particular lab environment and its users.

3) Knowledge

The Knowledge element supports the study both at the theoretical and empirical levels. It includes the AHP methodology as the central method of selection, integrated with the comparative analysis and certain past studies. Furthermore, it assimilates the properties of the selected operating systems, such as CentOS reputable for stability on enterprise servers, Rocky Linux a more recent poultry with an active community, and Ubuntu because of its ease of use and good documentation. All these elements provide a broad structure that guarantees a sequential mechanism for conducting an evaluation of all possible alternatives and picking the most appropriate operational system that will be effectively implemented in the lab.

B. Systematization of Problem Solving

In this chapter, the author presents how the flow of the comparative analysis in choosing the Operation System to be used in all the practicum in Network System Laboratory will be done. Researchers employ the Analytical Hierarchy Process originally developed by Thomas Saaty. The flowchart shown below portrays a step by step procedure of carrying out the research with the aids of Analytical Hierarchy Process (AHP), in a comparative manner. This paper covers the problem identification stage, goal hierarchy, criteria, and alternatives development, as well as the evaluation of options based on their weighted scores. The flowchart this allows for a smooth working procedure and convinces through rationality so that the researchers can follow the results of qualitative and/or quantitative analysis in order to make informed decisions.

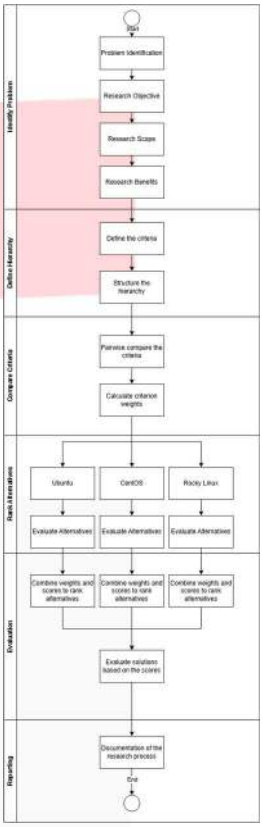

FIGURE 2
Systematization of Problem Solving

1) Identify Problem

The study begins with Identify Problem, which is considered to be the core of the research. This involves the determination of the problem, the specification of the problem that needs to be solved, the intention of setting research objectives providing guidance, the determination of the scope of the research so as to reduce its width, and an identification of expected outcomes in order to demonstrate the contribution of the research to the intended users or the area of research.

2) Define Hierarchy

Next is Define Hierarchy which is the structural approach to the problem in question for a scientific scrutiny. This step starts with defining the criteria to be used for the assessment of the various alternatives and then arranging the goal, criteria and the alternatives into a logical structure so as to make clear their dependencies.

3) Compare Criteria

The process goes on with the Compare Criteria, during which the significance of each criterion is evaluated. Pairwise comparisons are made through various measures and scales, for example the Saaty scale, to find out how important each one of them is and then weights are calculated so as to define the order of the criteria.

4) Rank Alternatives

In the Rank Alternatives phase, the alternatives are evaluated and prioritized. Each alternative is evaluated with respect to the given criteria, and their corresponding scores are summed with the aid of the criterion weights in order to yield a rank of the options in order of suitability.

5) Evaluation

The Evaluation step helps to work out whether the outcomes fit the specified research goals and objectives. The solutions are rated and any disparities or again checked and adjusted as needed so that the selected solution is valid and appropriate.

6) Reporting

Last of all, the Reporting step presents information on the conducted research as well as its results. Every aspect of the process from problem definition to solving the problem and presenting the results is documented and the results are organized in a format that may be presented to the stakeholders or as a journal. Such a systematic approach makes the research rigorous, more credible and useful.

IV. RESULT AND DISCUSSION

This chapter will discuss the result and the analysis of the research.

A. Summary of All Laboratories

TABLE I
SUMMARY OF ALL LABORATORIES

OS	TC	DSC	UX	PN
Ubuntu	11 + 3	11	1	3
Rocky Linux	10 + 1	11	0	1
CentOS Stream	11 + 2	11	0	2

Note:
OS = Operating System
TC = Tools Compatibility
DSC = Default System Configuration
UX = User Experience
PN = Penalty

Above are the summary of issues encountered in all of the laboratories in Information System Department. The table shows that Ubuntu has the most issues in tools compatibility and has the most penalties. In the next section there will be a pairwise comparison and an AHP calculation for all of the laboratory combined which will be the result of this research as a whole.

1) Pairwise Comparison for Tools Compatibility

TABLE II
PAIRWISE COMPARISON TOOLS COMPATIBILITY

OS	Ubuntu	Rocky Linux	CentOS Stream
Ubuntu	1	1/7	1/3
Rocky Linux	7	1	5
CentOS Stream	3	1/5	1

2) Pairwise Comparison for Default System Configuration

TABLE III
PAIRWISE COMPARISON DEFAULT SYSTEM CONFIGURATION

OS	Ubuntu	Rocky Linux	CentOS Stream
Ubuntu	1	1	1
Rocky Linux	1	1	1
CentOS Stream	1	1	1

3) Pairwise Comparison for User Experience

TABLE IV
PAIRWISE COMPARISON USER EXPERIENCE

OS	Ubuntu	Rocky Linux	CentOS Stream
Ubuntu	1	1/3	1/3
Rocky Linux	3	1	1
CentOS Stream	3	1	1

4) Pairwise Comparison for Performance

TABLE V
PAIRWISE COMPARISON PERFORMANCE

OS	Ubuntu	Rocky	CentOS

		Linux	Stream
Ubuntu	1	1/7	1/5
Rocky Linux	7	1	2
CentOS Stream	5	1/2	1

5) Result of the Pairwise in All Laboratories

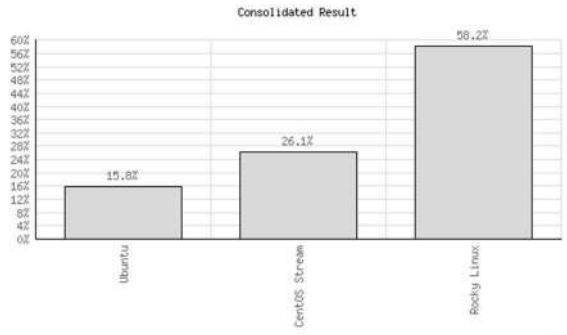

FIGURE 3
Final Result of Pairwise

This is the final result of the pairwise comparison between 3 operating systems in all of the laboratories in information system department combined. As the image shows, Rocky Linux is the most suitable operating system for all of the laboratories combined, followed by CentOS Stream as the second best and for the last or the least suitable for all of the laboratories is Ubuntu. This is the final result for study case based comparison between 3 operating systems namely Ubuntu, Rocky Linux, and CentOS Stream using the Analytical Hierarchy Process (AHP) that was founded By Thomas L Saaty (2004).

V. CONCLUSSION

Rocky Linux was selected as the best operating system fit for most technical practicum activities at the department through AHP comparison based on a criteria assessment of tool compatibility, system defaults, user experience, and performance. It was reliable in all modules, little work around was needed and it was highly compatible with instructional materials and tools. On the other hand, Ubuntu and CentOS Stream had defaults in the system configuration and lack of tools that could not allow completing some of the available modules.

To wrap up of the results, Rocky Linux should be considered a standard operating system for labs, specifically for labs where a RHEL system is necessary. For specific purposes in security or design-centric courses, additional OS like Kali Linux or Windows VMs can also be deployed accordingly. The creation of a custom Linux distribution for the practicum environment of the department is also recommended as it can provide stability, maintenance and ease of use for the students in the long run.

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