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Effectiveness of Wireless Network Roaming Access Point using PEAP Security System to Improve Internet Access

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ABSTRACT

Network security was an access prevention measure taken by the network administrator to limit things that were not permitted and were dangerous to threaten the local network. This was done to keep the network working correctly, and there was no threat from anywhere. The research objective was to determine the effectiveness of wireless access point roaming networks with 802.1x security systems in increasing Internet access. The sample number in the study was 40 respondents, with details of 20 respondents from lecturers and 20 respondents from employees at university. The sampling technique was stratified random sampling by classifying the population into two strata. This study's data collection techniques were observation, interviews, and questionnaires. The method used was a mixed-method approach. The subjective test results show that the user interface of the Test ver1.0 hotspot could provide the best experience for users. The effectiveness of an Access Point roaming wireless network with an 802.1x security system as measured on the satisfaction aspect gets an average System Usability Scale score of 81.38, meaning that it could meet the satisfaction aspect and was accepted for use by users.

1. Introduction

Information and Communication Technology, especially computer networks, has become one of the primary things in the industry, education, banking, and government. Apart from being a tool in supporting the learning process, the application of Information and Communication Technology in education was also used as a system that helps various techniques of academic support activities to assist the administrative process. Jakarta State University was one of the higher education institutions in Jakarta which has 33,786 students consisting of the D-3 level with a total of 2,476 students, S-1 with a total of 23,562 students, S-2 with a total of 3,330 students, S-3 with a total of 2,419 students, and also has 1,131 lecturers and 840 teaching staff. This data was obtained from observations and interviews with the Head of UPT ICT UNJ. Internet network technology was needed to support academic activities such as learning activities searching for lecture material modules. Searching for journals online, lecturer information system (SIDOS), personnel information system (SIPEG), UKT determination system (SIUKAT), test-ver1.1-Hotspot (Doskar) (SIAKAD), and library information system[1].

From the results of initial observations, it was found that the UNJ Hotspot authentication system for lecturers and employees uses a web system. The authentication token was stored in the browser. If you want to log back in, the authentication token stored in the browser would be called if it was the same as the one stored on the authentication server to get internet access. The I.P. address obtained by the user was obtained from the DHCP server located in each building. With a lest time of 8 hours, the I.P. in each building was different, and this was expected to cause when moving facilities were disconnected due to layer 2 of I.P. Experience from other buildings. Currently, the authentication system was stored on a server located at Pustikom, which would serve all user authentication token requests, and later when it was the same, Internet access would be provided and the token temporarily stored in the browser. At UNJ Hotspot (Lecturers & Employees), users often lose connection problems when not using the internet for a short time. Users were asked to re-enter their username and password to reconnect. Loss of connection occurs when the user moves to another place within the Jakarta State University campus. This was thought to be due to the hotspot's lack of

maximum user authentication. To authenticate users at the hotspot, it was necessary to have a server that could perform the authentication process to check whether the username and password data entered by the user match those in the database or not.

Several previous studies said that the problem of developing hotspots using the Basic Service Set (BSS) topology causes clients to be less effective when using hotspot facilities and moving locations[2], [3]. To overcome this, a hotspot system could be applied with an Extended Service Set (ESS) topology that uses more than one Access Point and makes the Access Point-Access Point into a single network[4], [5]. Implementation of authentication on the web (Network Access Control) runs at the media-access layer (layer 2 OSI) using IEEE 802.1x authentication with MAC addresses. This mechanism would validate laptops, cell phones, and other users' devices. Users who were connected to the network would be controlled and more secure. Besides that, it would make it easier for Network Adminwastrators to monitor and investigate when things that were not normal were caused by the user's device [6]. Error making Service Set Identifier (SSID) so that the roaming feature on Access points cannot work. There were many Access Points and Service Set Identifiers (SSID) in one place and without good management in managing them so that it would cause problems in monitoring Internet networks that were distributed by Access Those points [7]–[9].

Wireless roaming was one way to increase the reliability of a hotspot network that still uses the Basic Service Set (BSS) topology[10]. Thus, the BSS configuration uses an A.P. as a liaison between clients, 3) The Extended Service Set (ESS) consists of a series of overlapping BSS (each has an A.P.), which were connected to form a distribution system (D.S.). Mobile nodes could roam between A.P.s to cover a wide area[11]. A wireless distribution system that interconnects several Access Points without connecting them to a wired network system was supported by roaming features that could ensure wireless clients do not lose their connection[12]. The implementation of network user authentication aims to prevent and reduce crime on the network. However, there were shortcomings, namely in authentication using only single-host mode. In a single-host way, only a single MAC or I.P. address could be authenticated by a physical port after the user has established with the IEEE 802.1X protocol [13], [14].

Furthermore, the bases of this research were also strengthened from the survey data of the UNJ Two-Year Evaluation of Lecturer and Employee Hotspots researched by UPT ICT UNJ on January 20, 2020, with 190 respondents from lecturers and employees at UNJ. The eighth question related to the problems encountered when using UNJ Wi-Fi Hotspot for Lecturers and Employees. In Figure 1, the distribution of the preliminary survey results was defined.

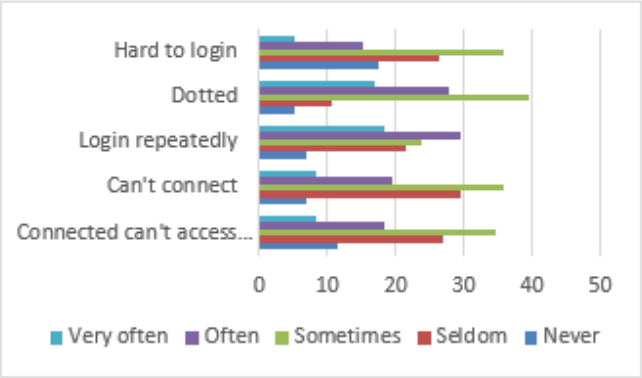

Figure 1. Preliminary Survey Results

From the survey results, it could be concluded that problems still occur when using the UNJ Hotspot for Lecturers and Employees. Including difficulty logging in, intermittent connections, repeated logins, inability to connect, and inability to connect to the internet. In addition, there was also input from users. Who complains about the difficulty and effectiveness of hotspots today? Like fixing the connection, so it doesn't get stuck. No re-entry was required when changing location, and it only needs to enter once a day. To expand network coverage to all areas to improve internet speed stability. Fast and powerful internet network thus supporting academic activities. Based on the survey results, it could be concluded that there were doubts about the effectiveness of the UNJ Lecturer and Employees hotspot network. Many complain about frequent disconnections and repeated logins that would hinder the mobility and effectiveness of hotspot service users. Based on the background, the problems that would be discussed in that research could be formulated, namely:

1. How was the design and product development of a wireless roaming Access Point network with an 802.1x security system to increase the effectiveness of used Internet access for lecturers and employees at the State University of Jakarta?
2. Was the result of developing an Access Point wireless roaming network with an 802.1x security system effective?

The purpose of this research was to know the process of developing and implementing a wireless roaming Access Point network using the Protected Extensible Authentication Protocol (PEAP) security system with 802.1x. The effectiveness of using Internet access for UNJ lecturers and employees after a wireless roaming Access Point network was created using the PEAP security system with 802.1x. In this study, we would combine roaming access point technology. Which in previous studies was successful in overcoming the disconnection of wireless

connections. Previous research has focused only on layer 2. There was no discussion about security systems. While in that study, aspects of network security systems were included used the PEAP security system method with the IEEE 802.1x protocol as a wireless network security system. The advantages of this research would ensure data security and monitor users easily so that connections were controlled and more secure. The controller used was a Wireless LAN Controller that could control and manage access point devices more widely[15]. This was expected to increase the stability of the existing hotspot. This study would also look at the effectiveness of used Internet access from the user's point of view, so it was hoped that with the completion of this research, the hotspots for UNJ lecturers and employees would be more stable and support academic activities at UNJ.

2. Research Methods

2.1 Participant

This research was conducted at UPT TIK, and Campus A. Thwas research targets lecturers and employees who use the wireless network Hotspot Lecturers and Employees. The implementation time of this research starts from May to October 2021. The number of samples in the study was 40 respondents with details of 20 respondents from lecturers and 20 respondents from employees at university. The sampling technique was stratified random sampling by classifying the population into two strata. The reason was that every day they regularly use the internet network with a very high work target.

2.2 Data Collecting Techniques

They collected data to support the development of the hotspot wireless network for Lecturers and Employees to improve the user experience in terms of effectiveness when using a wireless network. This study's data collection techniques were observation, interviews, and questionnaires. The observation method aims to obtain an overview of the current structure of the hotspot for Lecturers and Employees' wireless networks. Observations were made by directly observing the existing network structure at UPT ICT. The interview method was conducted to seek further information about the Hotspot wireless network for Lecturers and Employees by directly asking the interviewees. The researcher asked the Head of the division (Kadiv) questions in the process. UPT ICT Infrastructure. Then the data from the interviews were collected to be analyzed according to the research needs.

Usability Testing was carried out on UPT ICT staff to measure the User Interface of Hotspot Lecturers and Employees used the System Usability Scale (SUS) questionnaire, which was expected to facilitate the use of the user interface that would be developed later. Usability testing was given to users who have been interviewed so that they have an estimate of the user interface to be tested. This SUS method does not require many samples, so it does not require high costs and time[16]. Usability performance would be measured used the System Usability Scale (SUS) questionnaire. SU Swas used because of its flexibility that could be used and tested in several interfaces (interfaces). SUS uses ten questions in the questionnaire, which would later be distributed to respondents as a benchmark in testing. The score used was on a scale of 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. The SUS System Usability Scale testing instrument could be seen in Table.1.

Table 1. SUS Test Instruments

No	*Questions*	*Scale 1-5*
1	I seem to be using Hotspot 802.1x Lecturers and Employees a lot.	
2	I see that using Hotspot 802.1x Lecturers and Employees was quite a hassle.	
3	I think the use of Hotspot 802.1x Lecturers and Employees was easy to use	
4	I need help from other people or technicians using Hotspot 802.1x Lecturers and	
5	Employees. I feel that the features of Hotspot 802.1x Lecturers and	
6	Employees were working properly	
7	Many things were inconsistent (the 802.1x Hotspot Lecturer and Employee system).	
8	I feel others would understand how to use Hotspot Lecturers and Employees 802.1x quickly.	
9	I find Hotspot 802.1x Lecturers and Employees confusing.	
10	There were no obstacles in used Hotspot 802.1x Lecturers and Employees.	
	I need to get used to it before used Hotspot 802.1x Lecturers and Employees.	

Questionnaires were some written questions used in obtaining information and respondents in the sense of personal reports or things they know. The questionnaire in this study refers to the User Experience Questionnaire (UEQ). UEQ could be applied to calculate how significant the user

experience was on interactive products, one of which was a web-themed application [17]. The UEQ questionnaire consists of six aspects, namely attractiveness, clarity, efficiency, accuracy, stimulation, and novelty. Of the six aspects, that would produce as many as 26 UEQ questions to calculate user satisfaction using the system. UEQ was usually applied for several purposes, namely estimating the level of user experience between two products, evaluating the user experience of a product, and ensuring areas of improvement [18]. Each UEQ question, including measurement evaluation, was broken down into six parts of the scale (aspects) with 26 attributes, namely:

1. Attractiveness, how attractive a product was in overall opinion. Items: annoying / enjoyable, good / bad, unlikeable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly.
2. Prespiculity, how lightly a product was used. Items: not understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear / confusing.
3. Efficiency, how skilled the user could complete the task. Items: fast / slow, inefficient / efficient, impractical / practical, organized / cluttered.
4. Dependability, whether the user could set the interaction. Item: unpredictable / predictable. Obstructive / supportive, secure / not secure, meets expectations/ does not expectations.
5. Stimulation, how strongly a product could encourage users. Items: valuable / inferior, boring / excited, not interested / interested, motivation / demotivated.
6. Novelty, how innovative the product . Items: creative / dull, inventive / conventional, usual / leading-edge, conservative / innovative.

Based on the scale score 1=strongly disagree, 2=disagree, 3= less agree, 4=agree, and 5=strongly agree that has been described, the UEQ instrument was shown in Table 2.

Table 2. Standard User Experience Questionnaire

Indicator	*1*	*2*	*3*	*4*	*5*	*Indicator*
troublesome						pleasant
incomprehen						understandable
sible						monotone
creative						hard to learn
easy to learn						less useful
beneficial						exciting
boring						interesting
not attractive						predictable
unpredictabl						slow
e						conventional
fast						support
inventive						bad
obstruct						simple
good						exhilarating
complicated						front
dislike						comfortable
common						not safe
uncomfortab						not motivating
le						does not meet
safe						expectations
motivate						efficient
meet						confusing
expectations						practical
not efficient						untidy
clear						not attractive
impractical						not user
organized						friendly
attractive						
user friendly						
conservative						

2.3 Data Analysis Techniques

The data analysis technique was applied by analyzed system usability and user experience. To measure usability using the System Usability Scale (SUS) questionnaire while measuring user experience using the User Experience Questionnaire (UEQ). Usability aspect analysis was done by System Usability Scale (SUS). The SUS contains ten questions where users/respondents were given a choice of a scale of one to five to answer based on whether the respondents agree or disagree with each question about the system being tested. The score of one for strongly disagree and five for strongly agree. The formula for calculating SUS was:

$$\bar{x} = \frac{\sum x}{n} \quad (1)$$

Where:
x= Average score
∑x = Total SUS Score
n = Number of Respondents

The average SUS score from several other studies was 68, so if the SUS score was above 68 [19]. However, the previous research determined the SUS score, as shown in Figure 2.

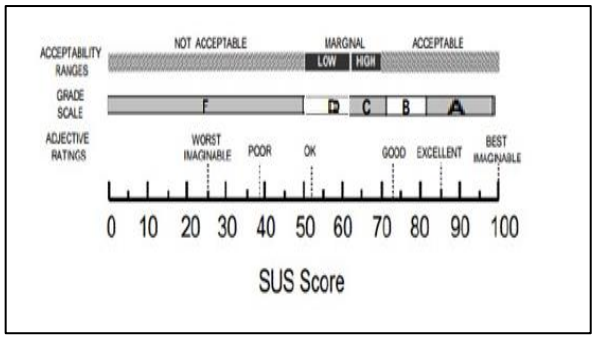

Figure 1. Basis of Assessment of SUS (System Usability Scale)[20]

3. Results and Discussion

The results of the data analysis based on the questionnaire distributed about the level of user satisfaction with all aspects could be seen in table 3.

Table 3. Reference table of User Satisfaction Levels Based on the Value of Each Aspect [21]

	bad	*Below average*	*Above average*	*good*	*Excellent*
Attractiveness	< 0,65	≥ 0,65 < 1,09	≥ 1,09 < 1,50	≥ 1,5 < 1,72	≥ 1,72
Clarity	< 0,50	≥ 0,50 < 0,84	≥ 0,84 < 1,31	≥ 1,31 < 1,64	≥ 1,64
Efficiency	< 0,53	≥ 0,53 < 0,90	≥ 1,90 < 1,37	≥ 1,37 < 1,82	≥ 1,82
Accuracy	< 0,70	≥ 0,70 < 1,06	≥ 1,06 < 1,40	≥ 1,4 < 1,6	≥ 1,6
Stimulation	< 0,52	≥ 0,52 < 1,00	≥ 1,00 < 1,31	≥ 1,31 < 1,5	≥ 1,5
Novelty	< 0,24	≥ 0,24 < 0,63	≥ 0,63 < 0,96	≥ 0,96 < 1,34	≥ 1,34

The UEQ questionnaire makes estimates of the locations where improvements have the highest impact. UEQ shows the pattern of the tested products based on the 6 quality aspects measured. This rhythmic pattern could make it possible to make some improvements. Suppose that the mean value of the attractiveness aspect in table 3. was 0.60. The results of the hedonic quality in the aspect of attractiveness were below average, so to increase user satisfaction, it was quite clear to increase the use of more attractive. For an explanation of the interpretation of the benchmarks shown in Table 4.

Table 4. Benchmark comparison interpretation

Benchmark Comparison	*Interpretation*
bad	In the range of 10% worst results
Below average	50% of results in processing benchmark data ware better than product test results, 25% of results ware poor
Above average	25% results in processing benchmark data ware better than product test results, 50% of results ware poor
Good	10% of the results in processing benchmark data ware better, and 75% of the results were bad
Excellent	In the range of 10% best results

Functional test results to see whether the software and system hardware features work as expected. Functional test results were shown in Table 5 and Table 6.

Table 5. Software Test Results

Process	*Expected results*	*Status*
Open LDAP could run well	When the server was turned on, the Open LDAP application could work normally	Succeed
Login successfully	Users log in used their parent number and password to log in to the hotspot. Open LDAP grant authorization permission	Succeed
Open LDAP monitors user usage (Accounting)	Open LDAP performs the accounting process. The observed data ware login time, bandwidth used, the user's I.P. address.	Succeed
Could access the messaging app	Users could use the internet to access messaging applications such as WhatsApp, Line, etc.	Succeed
Could access browser	Users could use the internet to search for lecture materials	Succeed
Could access email	Users could use the internet to send email	Succeed
Stable connection	The device was connected to the internet through a hotspot without being disconnected	Succeed
Log out successfully	When find washed accessing the internet, users could log out from the hotspot	Succeed

Table 6. Hardware Test Results

Process	*Expected results*	*Status*
Hardware installed server	The server computer was installed with hardware that meets the specifications so that the server computer could be installed with the server operating	Succeed

	system	
Server computer connected with a network device	The server computer was connected to network devices (switches, wireless access points) using a UTP cable	Succeed
Open LDAP could run well	When the server was turned on, it could work normally	Succeed
Wireless Access Point could run well	The Wireless Access Point could be accessed from the user's device/laptop	Succeed
Wireless Access Point could run well	The wireless access point relates to a wireless LAN controller for centralized management of wireless access points	Succeed
Wireless LAN Controller configures a wireless access point	Wireless LAN Controller could manage wireless access points centrally	Succeed

Based on Tables 5 and 6, the results of server testing using the Centos Operating System show that the functional testing of Open LDAP used in a local area network has been running successfully and could be used by users. The result of the next trial was a login test that used various devices. Operating systems to test the reliability of the Access Point roaming wireless network system with an 802.1x security system against all various devices, both types of devices and operating systems, and the results ware shown in Table 7.

Table 7. Standard User Experience Questionnaire

Device	*Merk*	*Mac Address*	*OS*	*Status*
Laptop	Lenovo idea pad 5i	08:5B: D6:B4:60: FE	Win 10	Success
Laptop	ThinkPad Ultrabook T460S	E4-B3-18-E6-C6-93	Win 7	Success
Smartphone	Poco f3	8C: AA: CE: 20:2B:78	Andr 11	Success
Laptop	Asus Vivo book TP412FA	04: EA:56: B7:8F:BD	Win 10	Success
Laptop	ASUS A456U i7	F0:03:8C:85: E3:4D	Win 8	Success
Smartphone	ASUS Zenfone 5Q	B0:6E:BF:8A:54: CB	Andr Pie	Success
Laptop	Lenovo IdeaPad 5	38:68:93: 6B:E1:76	Win 10	Success
Smartphone	Redmi Note 9 Pro	E0:1F: 88:7E:5F:AC	Andr 11	Success
Tablet	Samsung Tab S6	E2:47: E5:89:78: A2	Andr 11	Success
Laptop	Lenovo Idea pad 3 Slim 3	02:45: E2:70:6D: B7	Win 11	Success
Smartphone	iPhone XR	A8:91:3D: B5:61:C6	IOS 15.2	Success
Laptop	MacBook pro M1	3C: 06:30:46: 2C:A7	Mac	Success
Smartphone	iPhone 8 Plus	6C:4D: 73:52:C8:04	IOS 14.8	Success
Laptop	MacBook Air	38: F9:D3:70: E4:5E	Mac	Success
Smartphone	Real me 7	EE: 36:9FL0D:A5:1B	Andr oreo	Success

From table 7, the compatibility test results for devices and operating systems could still function and run well with a perfect success status. It could be concluded that the Access Point wireless roaming network system with 802.1x security system was compatible with all devices. The results of the analysis of the System Usability Scale questionnaire distributed to 40 respondents "Test-Ver1.0-Hotspot (Doskar)" obtained an average System Usability Scale score of 81.38 where the score could be interpreted as follows:

1. The level of acceptability range obtained was in a good category.

2. The grading scale obtained was in category A.

3. The adjective rate obtained was in a Good category.

It could be concluded from the results of the average score of the System Usability Scale that a Test-Ver1.0-Hotspot (Doskar) system from the point of view of the satisfaction aspect uses a usability testing tool with tools using a questionnaire distribution System Usability Scale has been able to meet the satisfaction aspect and was accepted for used by users in this study could be used by lecturers and employees within the scope of the Jakarta State University. The results of the analysis of the UEQ instrument on the mean, variance, and standard deviation for each question on each scale: attractiveness, accuracy, clarity, efficiency, stimulus, and novelty. The result was shown in figure 3.

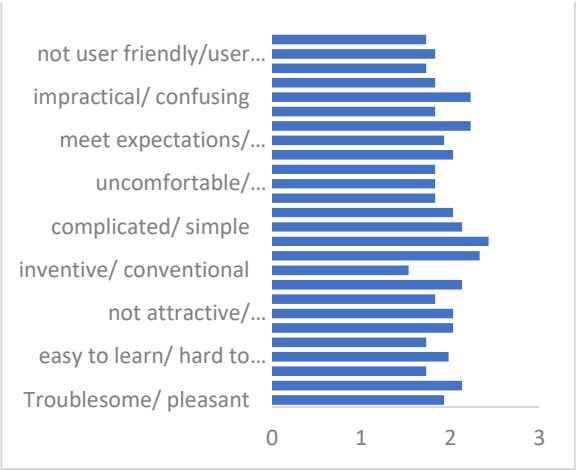

Figure 3. Analyses UEQ Results

The average result obtained was 0.8, and the average was included in the average rating. Because the average referral value above 0.8 was positive, and the average referral value below 0.8 was a negative rating. The results obtained could be concluded that the Test-ver1.1-Hotspot (Doskar) left a positive impression on all scales, including attractiveness, clarity, efficiency, accuracy, stimulation, and novelty. This was shown in Table 8.

Table 8. Average Results Based on Scale

	Mean	*Variance*
Attractiveness	1.946	0.94
Clarity	2.029	1.14
Efficiency	2.031	0.91
Accuracy	1.931	1.08
Stimulation	1.921	1.35
Novelty	1.629	1.29

The results of the analysis have three aspects: attractiveness, which was a dimension of pure valence, pragmatic quality, which describes the quality of interactions related to the tasks or goals performed by the user; and hedonic quality, which describes the aspects- relevant aspects. The group could also present it for the joy or excitement of using the product. This resulted in an evaluation of the UEQ from the attractiveness aspect with a value of 1.95; pragmatic quality with a value of 2.00; and 1.78 for hedonic quality. The results could be seen in table 9.

Table 9. UEQ Group Mean Results

Pragmatic and Hedonic Quality	*Mean*
Attractiveness	1.95
Pragmatic quality	2.00
Hedonic quality	1.78

To better understand the quality of a product, it was necessary to compare the product's user experience as measured by the results of other products. Benchmark tests were carried out using the User Experience Questionnaire (UEQ). Analytical data tool by comparing the value of each aspect with respondent data collection to evaluate different products (business software, web pages, web shops, social networks). Benchmark tests could represent the relative quality of Test-ver1.1-Hotspot (Doskar) compared to other products in the User Experience Questionnaire (UEQ). Analytical data tool (version 10) benchmark test results were divided into five categories: Excellent, Good, Above Average, Below Average, and Bad. Values for each UEQ data analysis tool category are shown in Table 10.

Table 10. Categories on the UEQ Analytical Data Tool

	bad	*Below average*	*Above average*	*good*	*Excellent*
Attractiveness	<0,7	>0,7	>1,19	>1,6	>1,86
Clarity	<0.75	>0,75	>1,25	>1,77	>2,03
Efficiency	<0,6	>0,6	>1,06	>1,5	>1,9
Accuracy	<0,78	>0,78	>1,15	>1,47	>1,7
Stimulation	<0,5	>0,5	>1	>1,35	>1,7
Novelty	<0,25	>0,25	>0,75	>1,14	>1,61

The User Experience Questionnaire (UEQ) would be distributed to respondents who have previously completed SUS. The User Experience Questionnaire (UEQ) has five benchmarks: excellent, good, above average, below average, and bad. The graph of the UEQ test could be seen in Figure 4.

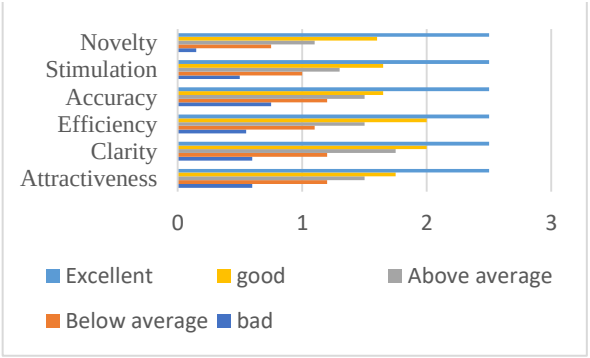

Figure 4. The results of the UEQ test

The results of the UEQ evaluation questionnaire were determined using the data analysis tool provided by UEQ. Figure 4. shows that of the six scales, attractiveness with a score of 1.95 predicates excellent, clarity with a score of 2.03 predicate excellent, efficiency with a score of 2.03 predicate excellent, accuracy with a score of 1.93 predicates excellent, stimulation with a score of 1.92 predicates excellent, and novelty with a score of 1.63 predicates excellent. These results indicate that the six UEQ test scales were in an excellent (very good) position. The subjective test results show that the

Ujicobaver1.0hotspot (Doskar) user interface could provide the best experience for users. The development of a wireless roaming access point network using the PEAP security system with 802.1x was initiated by interviewing the Network Technician Coordinator of UPT ICT, Adipurwa, and staff of the Infrastructure Division of UPT ICT UNJ Pramana. The interview results obtained the internet and local networks, available bandwidth, and servers at the State University of Jakarta.

From the initial data obtained from this interview, the next stage was the planned and integrated wireless roaming access point network using a PEAP security system with 802.1x with a pre-existing computer network. Here an open LDAP server was created, which would act as a server that controls authentication, authorization, and calculations in the new wireless network. After the open LDAP system was installed, it was integrated with the WLC that UNJ previously owned. For this integration, a new WLAN SSID named test-ver1.0-Hotspot was created as a temporary WLAN during the trial process.

This new WLAN uses an 802.1x system that performs login authentication stored on registration in each operating system. This would be effective because users no longer need to authenticate Wi-Fi repeatedly so that when moving from place to place, they could still be connected. This was in line with the research of Sofyan, Abdillah, Syahputra, entitled Analysis and Design of Wireless Roaming (Case Study). Baturaja University from these results obtained the same results and supported previous research, which states that in terms of stability for a hotspot network that uses wireless roaming, it was quite stable as seen from the test results that clients could move and get the same I.P. without reconfiguring with the implementation of wireless roaming, the reach of a hotspot network could be expanded and the number of users.

After all the installations went well, and the PEAP security system with 802.1x was running, the software and hardware functional tests were carried out. This functional test aims to ensure that all software and hardware of PEAP security systems with 802.1x were run well, hardware testing includes open LDAP and others, hardware testing includes ping and others. This functional application was accompanied and verified by the network and infrastructure staff of UPT ICT UNJ. The results of this study support research with the title Implementation of internal wireless roaming using a Mirotic Wireless Distribution System (WDS)[22]–[24]. Developing a roaming network using a Wireless Distribution System (WDS) could reach all campus areas. This could be seen from the test coverage of the signal from the roaming network carried out in that study used the concept of a Wireless Distribution System (WDS)[25].

After the functional test was successful, it continued with login compatibility testing for various devices. Operating systems to ensure that the PEAP security system with 802.1x could be used for all devices and operating systems from the testers using 15 different devices and 12 different operating systems. They all received a successful login status, which means that the PEAP security system with 802.1x was compatible with all existing devices and operating systems. This was in line with Busran's research, Teddy Eka Wira Saputra, entitled Analysis of Roaming Feature Performance in Wireless Distribution System (WDS) Against Video On Demand (VOD) services. That performance of roaming on WDS (Wireless Distribution System) to VoD (Video on Demand) services were affected by overlapping cells in this study. The registry was fully stored in the operating system.

Subsequently, a small-scale trial was conducted with 15 respondents who ran several tests, including logging in, opening an email, opening applications, opening video streaming, switching places, and logging out. From the trial results, the success rate was almost entirely successful. It was successful for small-scale trials, and the system was ready to measure the level of effectiveness and feedback from users. A trial was carried out on 40 users by distributing the System Usability Scale (SUS) and User questionnaires. Experience Questionnaire (UEQ) was useful for measuring usability, namely: effectiveness, efficiency, and user satisfaction. In the aspect of satisfaction, the PEAP security system (SUS) Questionnaire System Usability Scale (SUS) with 802.1x got an average of 40 respondents who got 8.1 which means that the acceptability range obtained was in a good category. The grade scale obtained was in category A. The adjective rating obtained was in a good category, which means the PEAP security system with 802.1x was accepted.

Subjective testing used a User Experience Questionnaire (UEQ) to calculate user experience used the PEAP security system with 802.1x. The results were obtained in the Test-Ver1.0-Hotspot (Doskar) UPT ICT, which got results on the attractiveness scale with a score of 1.95 predicates excellent. Clarity with a score of 2.03 excellent predicate, efficiency with a score of 2.03 excellent predicate, accuracy with a score of 1.93 predicates excellent, stimulation with a score of 1.92 predicates excellent novelty with a score of 1.63 predicates excellent, which means the PEAP security system with 802.1x was accepted. This supports the research of Surahman, Widiyasono, Gunawan entitled Usability and User Analysis Experience the Online Health Consultation Application Using the Usability Scale System and the User Experience Questionnaire in this study. The UEQ results showed that respondents gave positive perceptions of the three applications tested[21], [26], [27]. This could be seen

from the average value obtained by the three applications on each UEQ questionnaire scale. Almost all reach even more than 0.8, where this number was the limit value considered normal. The positive result in the UEQ questionnaire and research This result and predicate also show positive results[21], [28].

4. Conclusions and Suggestions

Based on the results of the analysis, the results of product development, the results of testing and product revisions, as well as the discussions that have been described previously, conclusions could be drawn that would answer the problem formulation of the research as follows:

1. The result of the research was that a wireless roaming Access Point network design product had been successfully developed into a ready-to-use product. The tests carried out by wireless authentication went well and could be used for all devices, including computers, laptops, tablets, and smartphones. Users could seamlessly connect to wireless access networks spread across Jakarta State University Campus points with this system.
2. The effectiveness of the Access Point wireless roaming network with an 802.1x security system measured on the satisfaction aspect used the System Usability Scale (SUS) questionnaire, which got an average System Usability Scale score of 81.38. This has met the satisfaction aspect and was accepted for use by users. For subjective testing, a User Experience Questionnaire (UEQ) was used to calculate user experience in used the system. The results were obtained on a wireless roaming Access Point network with an 802.1x security system that obtained results on a scale of attractiveness, efficiency, accuracy, stimulation, novelty, and clarity at an excellent position (excellent).

For the sake of the continuation of future research, suggestions that could be put forward were:

1. Development of additional features such as notification to network administrators in case of problems with the Open LDAP server.
2. Development of interface features to perform user management on the Open LDAP server.
3. A centralized user or SSO database does not need to remember many accounts to log in to applications and access the internet at the State University of Jakarta.

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