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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 is an access prevention measure taken by the network administrator to limit things that are not permitted and are dangerous to threaten the local network. This is done to keep the network working correctly, and there is no threat from anywhere. The research objective is 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 Universitas Negeri Jakarta. The sampling technique was stratified random sampling by classifying the population into two strata. Data collection techniques used in this study are observation, interviews, and questionnaires. The method used is a mixed-method approach. The subjective test results show that the user interface of the Test ver1.0 hotspot can 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 can meet the satisfaction aspect and is accepted for use by users.*

Keywords *- Wireless Network Roaming Access, PEAP Security System, Internet Access.*

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 is also used as a system that helps various techniques of academic support activities to assist the administrative process. Jakarta State University is 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 is 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 is stored in the browser. If you want to log back in, the authentication token stored in the browser will be called if it is the same as the one stored on the authentication server to get internet access. The I.P. address obtained by the user is obtained from the DHCP server located in each building. With a lest time of 8 hours, the I.P. in each building is different, and this is expected to cause when moving facilities are disconnected due to layer 2 of I.P. Experience from other buildings. Currently, the authentication system is stored on a server located at Pustikom, which will serve all user authentication token requests, and later when it is the same, Internet access will be provided and the token temporarily stored in the browser. At UNJ Hotspot (Lecturers & Employees), users often lost connection problems when they were not doing activities using the Internet for a short time, and 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 is thought to be due to the hotspot's lack of maximum user authentication. To authenticate users at the hotspot, it is necessary to have a server that can 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 BSS (Basic Service Set) topology causes clients to be less effective when using hotspot facilities and moving locations[2], [3]. To overcome this, a hotspot system can 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) that runs at the media-access layer (layer 2 OSI) using IEEE 802.1x authentication with MAC addresses. This mechanism will validate devices such as laptops, cell phones, and other users' devices. Users who are connected to the network will be controlled and more secure. Besides that, it will make it easier for Network Administrators to monitor and investigate when things that are not normal are caused by the user's device [6]. Error making Service Set Identifier (SSID) so that the roaming feature on Access points cannot

work and there are many Access Points and Service Set Identifiers (SSID) in one place and without good management in managing them so that it will cause problems in monitoring Internet networks that are distributed by Access Those points [7]–[9].

Wireless roaming is 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 are connected to form a distribution system (D.S.). Mobile nodes can 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 is supported by roaming features that can 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 are shortcomings, namely in terms of authentication using only single-host mode. In single-host way, only a single MAC or I.P. address can be authenticated by a physical port after the user has established with the IEEE 802.1X protocol [13], [14].

Furthermore, the basis of this research was 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 on 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 results of the preliminary survey is defined.

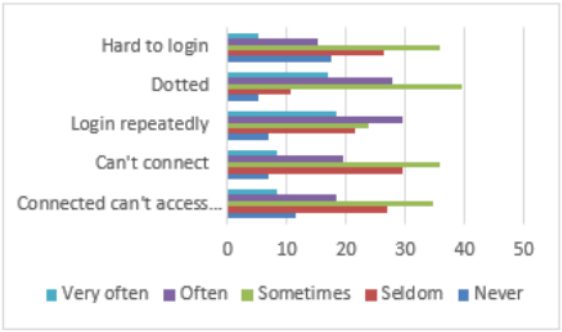

Figure 1. Preliminary Survey Results

From the survey results that have been carried out, it can be concluded that there are still problems that occur when using the UNJ Hotspot for Lecturers and Employees, including difficulty logging in, intermittent connections, repeated logins, unable to connect, and unable to connect to the Internet. In addition, there is also input from users who complain about the difficulty and ineffectiveness of the current hotspot, such as fixing the connection so that it doesn't crash, not re-logging in when changing locations, only needing to log in once a day, expanding network coverage to all areas, and improve the stability of Internet speed because it requires a fast and strong Internet network to support academic activities. Based on the survey results, it can be concluded that there are doubts about the effectiveness of the UNJ Lecturer and Employees hotspot network. Many complain about frequent disconnections and repeated logins that will hinder the mobility and effectiveness of hotspot service users. Based on the background, the problems that will be discussed in this research can be formulated, namely:

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

The purpose of this research is 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. and 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 will combine roaming access point technology which in previous studies was successful in overcoming the disconnection of wireless connections and previous research only focused on layer 2, there was no discussion of the security system, while in this study, aspects of the network security system were included using the PEAP security system method with IEEE 802.1x protocol as a wireless network security system, so that it will ensure data security, besides that it can also monitor users easily so that connections are controlled and more secure, while the controller used is a Wireless LAN Controller so that it can control and manage access point devices more broadly. and a lot[15]. This is expected to increase the stability of the existing hotspot. This study will also look at the effectiveness of using Internet access from the user's point of view, so it is hoped that with the completion of this research, the hotspots for UNJ lecturers and employees will be more stable and can support academic activities at UNJ.

RESEARCH METHODS

A. Participant

This research was conducted at UPT TIK and Campus A, State University of Jakarta. This research targets UNJ lecturers and employees who use the wireless network UNJ 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 UNJ. The sampling technique was stratified random sampling by classifying the population into two strata. The reason is that every day they regularly use the internet network with a very high work target.

B. Data Collecting Techniques

They were collecting data to support developing the UNJ Hotspot wireless network for Lecturers and Employees to improve the user experience in terms of effectiveness when using a wireless network. Data collection techniques used in this study are observation, interviews, and questionnaires. The observation method aims to obtain an overview of the current structure of the UNJ Hotspot for Lecturers and Employees wireless network. Observations were made by observing or observing the existing network structure directly at UPT ICT UNJ. The interview method was conducted to seek further information about the UNJ Hotspot wireless network for Lecturers and Employees by directly asking the interviewees. In the process, the researcher asked the Head of the Division (Kadiv) questions. UPT ICT UNJ 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 UNJ staff to measure the User Interface of UNJ Hotspot Lecturers and Employees using the System Usability Scale (SUS) questionnaire, which is expected to facilitate the use of the user interface that will be developed later. Usability testing is 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 a large number of samples, so it does not require high costs and time[16]. Usability performance will be measured using the System Usability Scale (SUS) questionnaire. SUS is used because of its flexibility that can be used and tested in several interfaces (interfaces). SUS uses ten questions in the questionnaire, which will later be distributed to respondents as a benchmark in testing. The score used is on a scale of 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. The SUS System Usability Scale testing instrument can be seen in Table.1.

Table 1. SUS Testing Instruments

No	*Questions*	*Scale 1-5*
1	I seem to be using UNJ Hotspot 802.1x Lecturers and Employees a lot.	
2	I see the use of UNJ Hotspot 802.1x Lecturers and Employees is quite a hassle.	
3	I think the use of UNJ Hotspot 802.1x Lecturers and Employees is easy to use	
4	I need help from other people or technicians using UNJ Hotspot 802.1x Lecturers and Employees.	
5	I feel that the features of UNJ Hotspot 802.1x Lecturers and Employees are working properly	
6	I feel many things are inconsistent (not compatible with the 802.1x UNJ Hotspot Lecturer and Employee system).	
7	I feel others will understand how to use UNJ Hostpot Lecturers and Employees 802.1x quickly.	
8	I find UNJ Hotspot 802.1x Lecturers and Employees confusing.	
9	There are no obstacles in using UNJ Hotspot 802.1x Lecturers and Employees.	
10	I need to get used to it before using UNJ Hotspot 802.1x Lecturers and Employees.	

Questionnaires are 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 can be applied to calculate how significant the user experience is on interactive products, one of which is 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 will produce as many as 26 UEQ questions to calculate user satisfaction in using the system. UEQ is 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, is broken down into six parts of the scale (aspects) with 26 attributes, namely:

1. Attractiveness, how attractive a product is in overall opinion. Items: annoying / enjoyable, good / bad,

unlikeable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly.

2. Prespicuity, how lightly a product is used. Items: not understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear / confusing.
3. Efficiency, how skilled the user can complete the task. Items: fast / slow, inefficient / efficient, impractical / practical, organized / cluttered.
4. Dependability, whether the user can set the interaction. Item: unpredictable / predictable. Obstructive / supportive, secure / not secure, meets expectations/ does not expectations.
5. Stimulation, how strongly a product can encourage users. Items: valuable / inferior, boring / exciting, not interesting / interesting, motivating / demotivating.
6. Novelty, how innovative the product is. 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 is shown in Table 2.

Table 2. Standard User Experience Questionnaire

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

C. Data analysis technique

The data analysis technique is applied by analyzing system usability and system 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 is done by System Usability Scale (SUS). The SUS contains ten questions where users/respondents are 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 is:

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

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

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

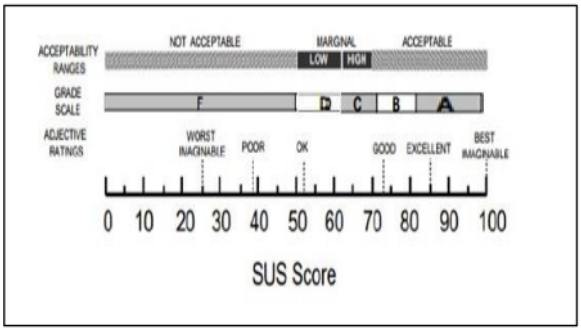

Figure 1. Basis of Assessment of SUS (System Usability Scale)[20]

RESULTS AND DISCUSSION

The results of data analysis based on the questionnaire distributed about the level of user satisfaction with all aspects can 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 measured pattern can make it possible to make some adjustments to get improvements. Suppose that the mean value of the attractiveness aspect in table 3. is 0.60. The results of the hedonic quality in the aspect of attractiveness are below average, so to increase user satisfaction, it is 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% results in processing benchmark data are better than product test results, 25% results are poor
Above average	25% results in processing benchmark data are better than product test results, 50% results are poor
Good	10% of the results in processing benchmark data are better and 75% of the results are bad
Excellent	In the range of 10% best results

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

Table 5. Software Test Results

Process	*Expected results*	*Status*
Open LDAP can run well	When the server is turned on, the Open LDAP application can work normally	Succeed
Login successfully	Users log in using their parent number and password to login to UNJ Hotspot. Open LDAP grant authorization permission	Succeed
Open LDAP monitors user usage (Accounting)	Open LDAP performs the accounting process. The observed data are login time, the amount of bandwidth used, the user's IP address.	Succeed
Can access the messaging app	Users can use the internet to access messaging applications such as WhatsApp, Line etc.	Succeed
Can access browser	Users can use the internet to search for lecture materials	Succeed
Can access email	Users can use the internet to send email	Succeed
Stable connection	The device is connected to the internet through UNJ Hotspot without being disconnected	Succeed
Log out successfully	When finished accessing the internet, users can logout from UNJ Hotspot	Succeed

Table 6. Hardware Test Results

Process	*Expected results*	*Status*
Hardware installed server	The server computer is installed with hardware that meets the specifications so that the server computer can be installed with the server operating system	Succeed
Server computer connected with network device	The server computer is connected to network devices (switches, wireless access points) using a UTP cable	Succeed
Open LDAP can run well	When the server is turned on it can work normally	Succeed
Wireless Access Point can run well	The Wireless Access Point can be accessed from the user's device/laptop	Succeed
Wireless Access Point can run well	The wireless access point relates to a wireless LAN controller for centralized	Succeed

	management of wireless access points	
Wireless LAN Controller configures a wireless access point	Wireless LAN Controller can manage wireless access points centrally	Succeed

Based on Tables 5 and 6 the results of server testing using the Centos Operating System, it can be concluded that the functional testing of Open LDAP using a local area network has been running successfully and can be used by users. The result of the next trial is a login test using various devices and 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, the results are 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 results of the compatibility test for devices and operating systems can still function and run well with a perfect success status and it can be concluded that the Access Point wireless roaming network system with 802.1x security system is 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 can be interpreted as follows:

1. The level of acceptibillity range obtained is in the acceptable category.
2. The grade scale obtained is in category A.
3. The adjective rating obtained is in the Good category.

It can 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 is accepted for used by users in this study can 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 is shown in figure 3.

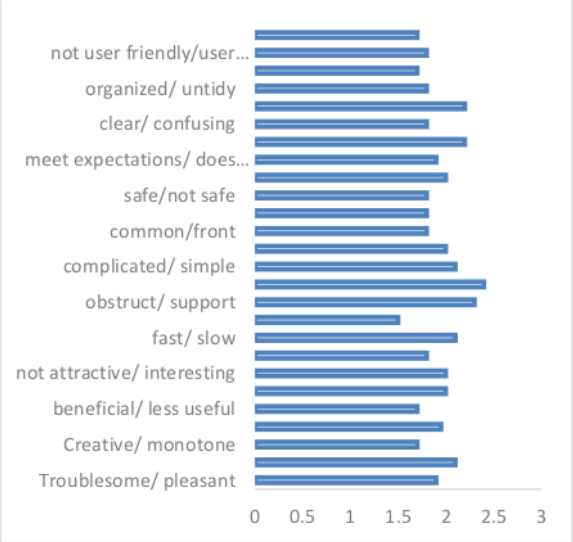

Figure 3. Analysis UEQ Results

The average result obtained is 0.8 and this average is included in the normal rating. Because the average referral value above 0.8 is positive and the average referral value below 0.8 is a negative rating. From the results obtained, it can 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 is 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 is 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. can also be presented by group. 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 can 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 is necessary to compare the user experience of the product as measured by the results of other products. Benchmark tests are 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 can 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 are divided into five categories, namely Excellent, Good, Above Average, Below Average and Bad. Values for each category of the UEQ data analysis tool 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) will be distributed to respondents who have previously completed SUS. The User Experience Questionnaire (UEQ) has five benchmarks, namely very good (excellent), good (good), above average (above average), below average (below average), and bad (bad). The graph of the results of the UEQ test can be seen in Figure 4.

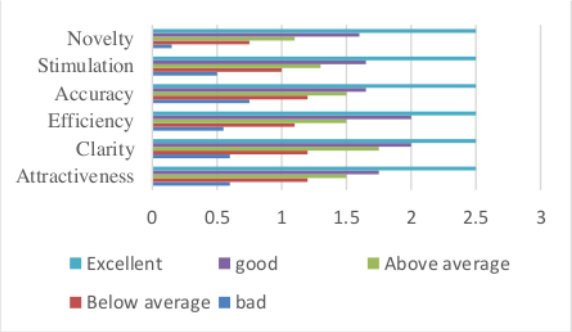

Figure 4. The results of the UEQ test

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 predicate 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 predicate excellent, stimulation with a score 1.92 predicate excellent, and novelty with a score of 1.63 predicate excellent. These results indicate that the six UEQ test scales are in an excellent (very good) position. The subjective test results show that the Ujicobaver1.0hotspot (Doskar) user interface can 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. From the interview results obtained details of the internet and local networks, available bandwidth and servers at the State University of Jakarta.

From the initial data obtained from the results of this interview, the next stage is the planning and integration of a

wireless roaming access point network using a PEAP security system with 802.1x with a pre-existing computer network. Here an open LDAP server is created which will act as a server that controls authentication, authorization, and calculations in the new wireless network. After the open LDAP system was installed, it was then integrated with the WLC which was previously owned by UNJ. 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 will be effective because users no longer need to authenticate wi-fi repeatedly so that when moving from place to place they can still be connected, this is 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 supports previous research which states that in terms of stability for a hotspot network that uses wireless roaming it is quite stable as seen from the test results that clients can move and get the same IP without reconfiguring with the implementation of wireless roaming, the reach of a hotspot network can be expanded and the number of users.

After all the installations went well and the PEAP security system with 802.1x was running, then 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 are running 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]. Development of a roaming network using a Wireless Distribution System (WDS) can reach all campus area. This can be seen from the test coverage of the signal from the roaming network that has been carried out in this study using the concept of a Wireless Distribution System (WDS)[25].

After the functional test was successful, it continued with login compatibility testing for different and varied devices and operating systems aimed at ensuring that the PEAP security system with 802.1x can be used for all devices and all operating systems from the testers using 15 different devices and 12 different operating systems. all of them received a successful login status, which means that the PEAP security system with 802.1x is compatible with all existing devices and operating systems. This is 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 produce roaming feature performance on WDS (Wireless Distribution System) to VoD (Video on Demand) services, are affected by overlapping cells in this study, the registry is fully stored in the operating system.

Subsequently, a small-scale trial was conducted with 15 respondents who ran a series of tests including logging in, opening email, opening applications, opening video streaming, switching places and logging out. From the results of this trial, the success rate was almost entirely successful, meaning that for small-scale trials it was successful and for the system was ready to be used to measure the level of effectiveness and feedback from use, a trial was carried out on 40 users by distributing the System Usability Scale (SUS) and User questionnaires. Experience Questionnaire (UEQ) which is useful for measuring usability aspects, 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 is in the acceptable category. The grade scale obtained is in category A. The adjective rating obtained is in the good category, which means the PEAP security system with 802.1x is accepted.

Subjective testing used a User Experience Questionnaire (UEQ) to calculate user experience in using 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 predicate 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 is 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 can be seen from the average value obtained by the three applications on each UEQ questionnaire scale, which almost all reach even more than 0.8, where this number is the limit value that is considered a normal and positive result in the UEQ questionnaire, and in research This result and predicate also show positive results[21], [28].

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 can be drawn that will answer the problem formulation of this research as follows:

1. The result of this research is that a wireless roaming Access Point network design product has been successfully developed into a ready-to-use product. The results of the tests carried out by wireless authentication went well and can be used for all devices, including computers, laptops, tablets, and smartphones. With this system, users can seamlessly connect to wireless access networks spread across points on the Jakarta State University Campus.
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 is accepted for use by users. For subjective testing, a User Experience Questionnaire (UEQ) was used to calculate user experience in using the system. The results 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 can be put forward are:

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 database or SSO database so that users do not need to remember many accounts to log in to applications and internet access available at the State University of Jakarta.

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