Mobile Networks for Mobile Learning Tools

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Abstract— **Before mobile learning is implemented, network availability factors become one of the key tools that should be provided. Another factor is mobile learning software that must be specifically designed, in accordance with the network performance capabilities that are available. This paper measures the availability of network and service quality for the application of mobile learning tools of the data structure course. Then, the measurement results become the benchmark in the design and development of online learning software. Data usage, material content, access speed and streaming of learning content into a review of the discussion.**

Index Terms— **Mobile; Network; Learning; Data Structures; Performance.**

I. INTRODUCTION

Development of information and communication technology (ICT) has affected the learning system1-5. The rapid advancement of technology makes the ICT on education has become a necessity3-5. Implementation of ICT can be one indicator of the progress of the school's success. Other than that, also considered to support educators in delivering learning materials making it easier for learners to receive material that is conveyed. Given this, the educators should "aware" of the technology.

To implement the learning process with online learning system, certainly needed a network infrastructure and electronic media which will support the use of online learning6-8.

One of the key components that should be provided by the m-Learning learning tool in literature 9 is the ability to connect to other devices. This paper discusses it with case studies on the data structure course as one of the subjects that make many students experience failure in learning.

The results of the discussion have provided conclusions and contributions in terms of designing the model of learning media content framework and application testing model in mobile networks, ensuring network availability in the application of mobile learning applications.

From teaching experience in these years, we strongly feel that the data structure course is very important for students in computer science and technology studies. How to turn this course from a difficult and boring course into an interesting course is becomes an urgent an issue.

The student teaching experience from previous years into an evaluation that this year is much better. This paper has discussed how the implementation of a mobile learning system in the data structures course, various methods and technology approaches used in its development, in this paper focuses on ensuring network availability for mobile learning tools.

This paper is organized as follows. In section 2, the related the architectural design in the development of mobile learning system and QOS. In section 3, Methodology for the network availability and mobile learning application. The experimental results are a measurement of network capabilities in testing mobile learning app also presented in section 4. Finally, our work of this paper is summarized in the last section.

II. RELATED WORK

A. Architecture System

Generally, the architectural design in the development of mobile learning system as in Figure 1, which is divided into three key elements that must be provided, i.e. an availability of the network, smartphone devices, and application software.
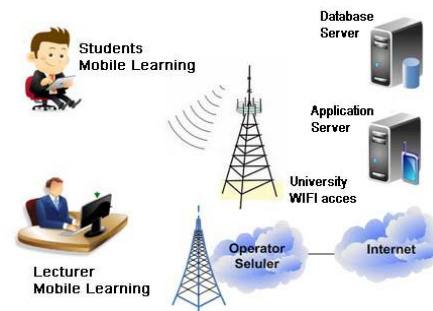

Figure 1: Network architectures for mobile learning

B. An Availability of Mobile Network

One of the research objectives is to ensure the availability of mobile networks before implementing mobile learning system online. Therefore, the initial stage of the study was the field observation with measuring performance mobile networks to multiple locations as the research object, i.e. the residence of the prospective users of the system, which in this case is the residence of students and lecturers.

The measurements model used to measure the mobile network performance refer to illustration model literature 10; that explains model is divided into three subsystems: client, internet service provider (ISP), and server.
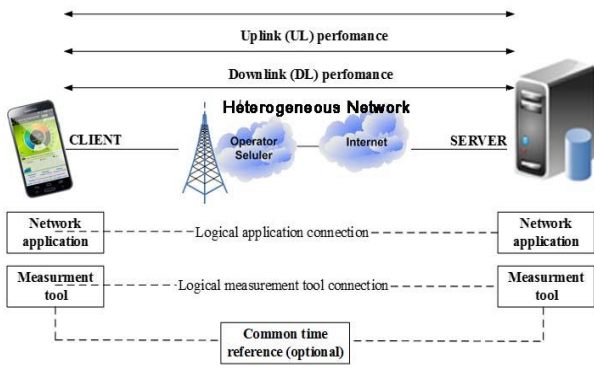
Figure 2: Measurement architecture

The explanation of each section in the measurement model according to literature [10] Figure 2 is as follows:

CLIENT MOBILE DEVICE (Smartphone), the mobile device using a card that supports packet data service communications networks. Mobile connection quality measurement tools using nPerf11 application and 4Gmark12 is a tool offering a comprehensive and reliable benchmark of the quality of service for smartphones. It allows to test and compare smartphones, networks or places on every technologies 2G (Edge, GPRS), 3G (UMTS, HSDPA, H+, Dual-carrier), 4G (LTE) and WIFI. Both applications support for iPhone, iPad, Android devices and Windows Phone12.

The number of internet users and the network connection to use mobile devices in Indonesia is very large and massive13-15. Specifically, for students in the University of MULAWARMAN as potential users, and all students have a smartphone that supports mobile learning system.

INTERNET SERVICE PROVIDER, use the services of some mobile operators that exist in the study area. The application will test some superior packages of each operator with the same standard of access speed (3.5G or above) which can produce download speeds up to 7,2 Mbps.

SERVER, the server has dynamic public IP that is used to serve clients in the reception and delivery of data packets.

C. Quality of Service Experience (QOSE)

According to literature [16 - 18], broadband Quality of Service Experience (QOSE) testing standard from LIRNEASIA, defines a comprehensive set of six performance metrics that should be measured in each experiment, as shown in Table 1.

Table 1
Metric QOSE Standard of LIRNEasia [16 - 18]

Metric	Method	Benchmarks
Download Speed (kbps)	File size 1	
Upload Speed (Kbps)	MB file	
Latency: Round Trip-Time		<300 ms
Jitter (Ms)	The average of 10 pings (each ping provides 3 sets of results.	<50 ms
Packet-Loss (%)		<3%
Availability (%)	Availability = (1 – F/T) x 100%	>98%

DEFINITION 1 [16 – 18]. Download Speed, the maximum rate at which data can be received from the Internet. This is measured by downloading a large file over about 1 minute, in order to average out temporary fluctuations in speed. It is an indicator of the basic browsing experience.

DEFINITION 2 [16 – 18]. Upload Speed, this metric defines the speed at which the subscriber can send data to the Internet. It plays a significant role in responsiveness of real-time applications.

DEFINITION 3 [16 – 18]. Latency (round trip time), Time is taken for a packet to reach the destination and return. This is significant in systems that require two-way interactive communication.

DEFINITION 4 [16 – 18], Jitter, is the variation of end-to-end delay from one packet to the next within the same packet stream/connection/flow.

DEFINITION 5 [16 – 18], Packet-loss, the fraction of packets which do not reach the destination. This can result in noticeable performance degradation with streaming traffic such as video where retransmission is not done.

DEFINITION 6 [16 – 18], Availability, this measures the number of times we are able to access the Broadband services.

THEOREM 1 [16 – 18], for the set Availability = (1 – F/T) x 100%, If T attempts are made to connect to the Internet, and if F attempts fail.

III. METHODOLOGY

A. Methodology for Ensure the Network Availability

Data Sources and Collection Methods, the data source is divided into two, primary and secondary data. Primary data for performance analysis of network availability is a result of measurement quality of service that using mobile network measurement tools, while secondary data is a data packet of internet connection (the card service package featured from ISP), quality of service parameter metric and other references related to research. The field data collection arranged in four session measurement time, i.e. as in Table 2.

Table 2
Session of Measurement Time

Time	Zone UTC+08:00
Morning	06.00 – 11.00
Daylight	11.00 – 15.00
Afternoon	15.00 – 18.00
Night	18.00 – 22.00

The methodology for broadband QOSE testing16-18 defines a comprehensive set of six performance metrics that should be measured in each experiment. The measuring for networks availability uses THEOREM 1.

B. Methodology for Mobile Learning Application

a. Data Structures Course

Data structures is an important subject for 2nd-year students in Dept. of ICT University of MULAWARMAN, but it is difficult to work with them due to their abstract nature [19] the failure to learn [20], and understand this course lead to significantly lower student learning outcomes at the final semester [21].

Based on students learning outcomes in previous years, as in Table 3 shows the percentage of student failure rate the last three years.

Table 3
Percentage of Student Failure Rate of Data Structures Course in
Mulawarman University

Students Year	Number Students	Success	Failed	Success (%)	Failed (%)
2014	153	112	41	73,2	26,79
2015	226	139	87	61,5	38,49
2016	224	161	63	71,88	28,12
Total	603	412	191	68,9	31,13

The best way to understand complex data structures algorithm is to see them in action [22]. Therefore, interactive mobile learning tools are created to make data structures learning easy and interesting, and teaching materials in mobile learning app provide visualization materials for data structures course in accordance with curricula-syllabus and course learning outcomes.

b. Software Analysis and Design

Analysis and design software for development of mobile learning system using object-oriented Unified Modeling Language (UML) [23]. Furthermore, the use case diagram design presented in Figure 3 for students.
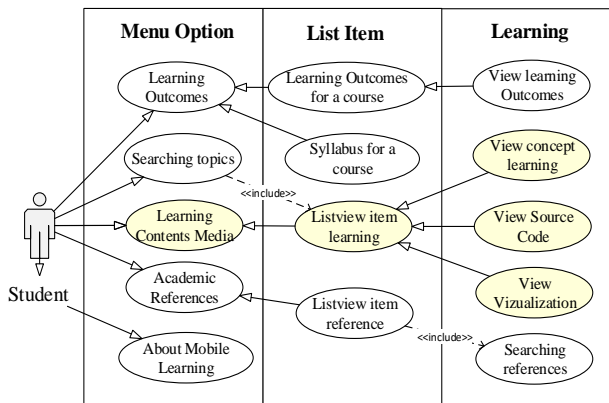

Figure 3: Use case diagram for students

c. Framework for Mobile Learning

In general, the framework architectural design and teaching materials to be presented in the mobile learning applications are shown in Figure 4. The teaching materials will be presented visually in the form of text, images, and moving animations.
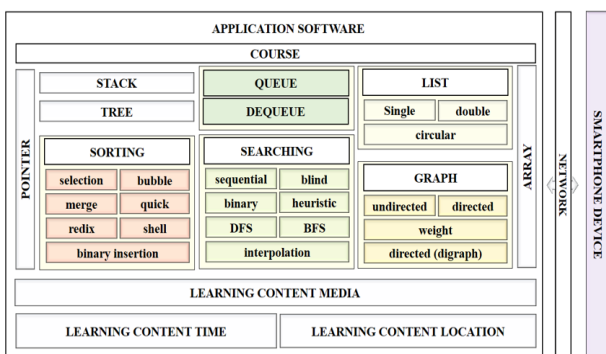

Figure 4: Framework for learning content media

IV. EXPERIMENTAL RESULT

The Measurement Approach is testing from the user experience side in some point where potential users are located. Data clustering is divided into six location of measurement points, with different time sessions.

In each time session, the measurement process is done as much as 10 times test for each the card service packs from ISP. We using data service packs from ISP A and ISP B alternately in one session.

The measurement process is carried out continuously for 21 days (three weeks), this is done to ensure the availability of mobile networks in the location.

Table 3
Network Performance QOSE for ISP A

Area	Speed (kbps)		Sensitivity to			Availability (%)
	Download	Upload	Latency (ms)	Jitter	Packet - loss (%)	
L1	2958	622	69	23,3	0,13	92,86
L2	1270	1032	106	33,7	1,48	72,86
L3	2581	1045	70	58,02	1,02	87,14
L4	1490	1035	108	32,11	1,17	77,14
L5	2960	1628	88	23,82	0,84	88,57
L6	2584	1047	94	18,29	1,33	85,71

According to table 1, the network performance for networks Availability has Benchmarks >98%, based on theorem 1.

From the measurement results of network Availability on ISP A, as shown in Table 3, percentage shows an average of about 84.046% below the reference [16 – 18]. However, the performance of the network service quality measure according to the existing benchmarks with the average value Latency 89.16 ms, jitter 31,54 ms, and packet loss less than 3% or average 0.9%.

Table 4
Network Performance QOSE for ISP B

Area	Speed (kbps)		Sensitivity to			Availability (%)
	Download	Upload	Latency (ms)	Jitter	Packet - loss (%)	
L1	3060	866	269	44,03	1,1	81,43
L2	2849	3100	109	15,67	2,4	78,57
L3	1490	743	243	43,22	1,8	75,71
L4	3052	862	130	12,81	3,1	94,29
L5	2844	3095	119	14	0,9	84,29
L6	1482	3052	318	27,56	4,4	71,43

For ISP B, based on Table 5 the performance measurement results of network availability obtained percentage average value of 80.95% lower than ISP A and existing benchmarks. The average latency value of 198 ms, with an average jitter value of about 26, 21 ms, and packet loss of 2.28%.

Based on the measurement results presented in Tables 3 and 4, it is explained that for the parameter values of network service quality metrics generally have been in accordance with existing benchmarks, except on the network availability level metric that must be with a benchmark >98%, this has not reached the standard presented in Table 1, is still below average, and only 87.025% (9/70), or the internet connection failure rate is 9 times out of 70 attempts to internet connection.

For network speed performance, Figure 5 shows the average graph of download and upload packet data rates from each ISPs at each point of the measurement location.
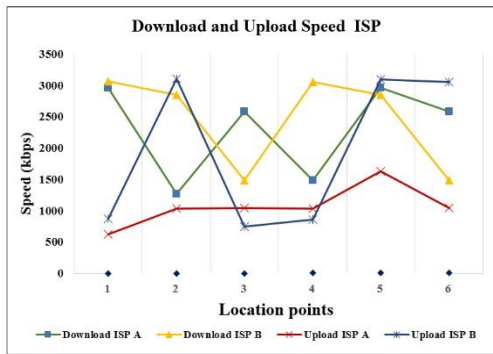

Figure 5: Download and upload speeds of ISPs data packet

In the implementation app phase, the application of mobile learning data structures course is run to see how the system was built and worked in practice.

The mobile learning app which can be installed on Android system was one of the ultimate production of this study. It is conceived as a learning system with a base on mobile android, utilizing smartphone a student's for learning, and organizing the students' learning process anytime and anywhere. In general, hierarchical information the content material of teaching can be seen in the mind map diagram in Figure 6.
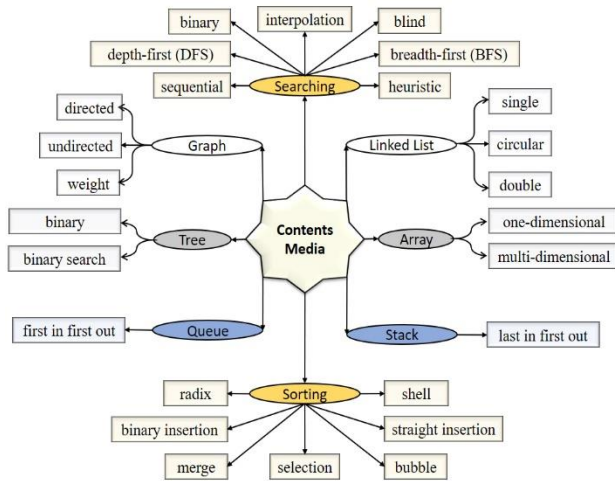

Figure 6: Mind-map diagram of contents media in data structure course in mobile learning app

The main material contained in the teaching module of mobile learning app accord to syllabi literature 24 includes the material learning of arrays, pointer, list, stack, queue, tree, sort, search, and graphs. This material is packed in the form of text, images, and animation visually, each teaching material described its presentation in 3 menus, i.e. theory menu, source code, and visualizations into animation, it's can be setting based on the take value input.

Testing and measurement of mobile learning app in online networks are used directly in the learning of the 2nd-year students Dept. of ICT University of MULAWARMAN.

The location point of the test is done randomly in six districts where mobile learning application users live. To ensure the mobile learning system works well, the test is done on the content of teaching materials divided into 3 test sessions, i.e. browser testing, streaming test, and application speed test.

a. Browsing Test

Browser testing is done on the reference menu, this menu has been linked in some online sources, and can perform other material searches in various reference sources on the internet online. Figure 7 is a reference module used as an example to test the browsing capabilities of a mobile learning application.

Figure 7: Screenshots reference menu for browsing test

The browsing test is done to see the access speed and network availability of the mobile learning application used by the user (Student), the testing scenario is done in the reference search menu, by selecting the reference address site recorded in the application, the testing is site: www.algonet.net and www.google.com. Test results are shown in Table 5.

Table 5
Browsing Test for Submenu References

Area	Google		Availability (%)	Vsualgo.net		Availability (%)
	Time (s)	Weight (kb)		Time (s)	Weight (kb)	
L1	3,21	592	100	7.64	1053	90
L2	7.71	645	100	5.47	1328	80
L3	5,01	700	80	8,47	1978	80
L4	2,98	329	100	7,39	1115	90
L5	3,66	127	90	3,11	1331	80
L6	4,23	163	100	6,57	1965	90

Browsing results in 6 location points obtained an average availability of 85%, or an average 1-2 times connection failure when accessing the reference source (site).

b. Streaming Test

Mobile learning app built containing sub-material that is visualized in moving animations. The test is done based on 2 categories of quality visual resolution, i.e. resolution 240p and 360p. In Figure 8 is a menu app visual animated code and measured the value of performance rate (PR), initial loading and the amount of data packets used.
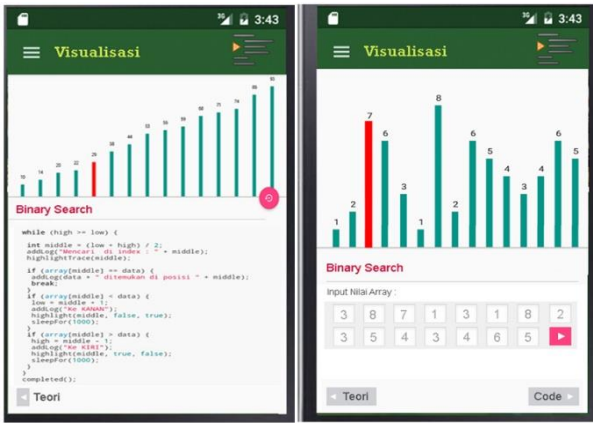
Figure 8: Screenshots visualization menu for streaming test

Table 6 is the result of measurement of network capabilities in the implementation of mobile learning applications for sub-menu material visual running code.

Table 6
Streaming Test for Submenu Visualization

Area	PR (%)	240p Initial Loading (s)	Data Used (kb)	PR (%)	360p Initial Loading (s)	Data Used (kb)
L1	81,70	2,297	3610	83,40	2.116	6586
L2	78,50	1,355	3790	60,90	3.403	5625
L3	69,90	2,337	3016	58,88	4.095	5554
L4	77,80	1,705	5623	62,70	2.516	6012
L5	83,62	3,022	3660	75,40	5.466	6620
L6	93,93	3,287	2784	88,20	6.012	6959

The results of the streaming test in 6 locations obtained the value of performance rate (PR) for 240p quality on average 80.91%, with data used amount 3.7 Mb for 1 minute. The PR value for 360 quality generated an average PR value of 71.58%, with a large amount of data used as much as 6.22 Mb for 1 minute of streaming animation.

c. Speed Test

Speed testing for application performance with metric quality of service parameters is download, upload, latency, jitter, and packet loss, measurement results in Table 7.

Speed test results in 6 locations obtained an average download rate of 3.41 Mb/s with an average of upload data of 0.64 Mb/s. The average maximum latency value is 262.5 ms, minimum 148 ms. For jitter value obtained average 198,16 ms with presentation packet loss 0.8%.

Table 7
Speed Test for Submenu Visualization

Area	Download (Mb/s)		Upload (Mb/s)		Latency (ms)		Jitter (ms)	Packet loss (%)
	Max	Min	Max	Avg	Max	Min		
L1	1,5	0,65	0,54	0,47	214	178	275	1,78
L2	5,01	4,49	1,13	0,39	280	139	126	0,27
L3	3,8	3,13	1,84	1,57	227	112	201	0,63
L4	4,11	3,57	0,61	0,24	205	101	167	0,22
L5	7,26	6,34	0,71	0,32	477	256	328	2,4
L6	4,66	2,28	1,29	0,89	172	102	92	0

Based on measurement results from 3 scenarios of browsing, streaming and speed testing on mobile learning applications, explaining the existence of data behavior in the spotlight of the author, which is related to the amount of data used during the test streaming animation that uses large data.

In general, the average data usage of 3.7 Mb for 240p animated streaming quality, if each student performs simulated learning to the mobile visual media which amounts to 26 teaching materials, then the estimated amount of data packets that must be provided for the learning of 96.2 Mb. And it certainly provides high-cost value for students who will access mobile learning applications with consideration of the amount of data used.

Besides, the amount of data that exist in the media affect the performance of mobile learning applications in mobile networks, moreover, with the problem of network availability is still limited not in accordance with the existing QOSE benchmarks.

V. CONCLUSIONS

From the teaching work in these years, we deeply feel that the data structures course is so important for students in the study of computer science and technology. How to turn this course from a difficult and boring course into an interesting course is becomes an urgent an issue.

The Student teaching experience from previous years into an evaluation that this year is much better. This paper has discussed how the implementation of a mobile learning system in the data structures course, various methods and technology approaches used in its development, in this paper focuses on ensuring network availability for application of mobile learning.

Field findings from the experimental results indicate the use of large data packets in the learning process, this certainly has an impact on the high-cost value for users (students) to access mobile learning applications. Other than, that the amount of data used will affect the performance of quality and access information from mobile learning applications. The availability of networks that have not been optimal also greatly impact on the success of this mobile learning.

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