Measuring Quality of Service for Mobile Internet Services in Samarinda

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***Abstract*— Quality of Service is an important thing in maintaining the performance of the service to the customer. Not only for marketing purposes, the quality of services can also bridge the gap between the promise given by the service provider and what the customers get. This study aims to get the quality of service for internet data usage of several mobile operators in the city Samarinda. The study was conducted using a mobile device and implemented in seven districts and four points in every district in the city of Samarinda. Measurements using the standard quality of TIPHON with some parameters such end-to-end delay, jitter, packet loss probability and throughput.**

Keywords—quality-of-service; network; mobile; internet; service; provider; tiphon; samarinda.

I. INTRODUCTION

Indonesia is the largest archipelago and home to the world's fourth-largest population, with more than 250 million people spread over 5,069,591 km². Located on the equator between Asia and Australia, just 36 percent of Indonesia's total territory is a land, while the rest is an ocean. It is also geographically varied, with terrain ranging from volcanic mountains to flatlands. Of its more than 17,000 islands, only about 6,000 are inhabited. Most of the population is concentrated on the island of Java, followed by the four other major islands of Sumatra, Kalimantan, Sulawesi and Papua [1].

Indonesia's island structure has made the development of mobile services highly significant ([1], [2]). Not only the deployment of a mobile cellular network relatively easy compared with cable infrastructure, the relatively low cost of adoption and the convenience of mobility has vastly accelerate customer demand, increasing productivity and boosting the economy, as well as contributing valuable tax and non-tax revenues to the government [1].

Mobile cellular service developed rapidly in Indonesia because of strong customer demand [3]. Indonesia's large and highly dynamic telecommunications sector represents the fourth largest mobile telecommunication market in the world, with 308 million mobile subscribers [4]. Of this vast mobile market, which represents a huge potential data market in light of still relatively low smartphone and Internet penetration, approximately 99 percent are prepaid users ([1], [3]). Indonesia is also unique because of the number of phones exceeds the population, which indicates that many people use more than one mobile phones. Customers access the Internet with a variety of devices and technologies both dial-up, leased line, a fiber-optic network, or wireless, using a modem or mobile devices [3]. With the growing extent of Internet use by the public, backbone traffic becomes congested and the quality of the connection to be a challenge to the operator.

The network operators and service providers on a competitive basis to provide services with various Quality of Service (QoS) for network traffic. However, internet access in Indonesia is still relatively slow, poor network coverage and expensive [5]. Some of the justifications for such factors are because of the population is very large, geographical conditions the region, as well as the lack of servers in the country ([1], [2]). In addition, other technical issues also affect the quality of internet access that perceived by customers, among others, the selection of providers and packages subscribed, location or device that is used [3].

With the growing breadth of Internet access services used by the public and the increasing importance of high-speed internet access, the quality of internet access service in Indonesia become an important element to consider. The government policies and legal insurance for the QoS of internet access perceived by consumers actually been arranged in the telecommunications regulation [6]. In the regulation, stated that telecommunications providers shall meet the service standards set by the government and report the implementation of operating performance on a periodic basis to the government [6]. With these regulations, the Internet Service Providers (ISPs) should monitor and report system QoS of networks provided to customers. This will help the government to protect the interests of the public who will access the internet with a good network system and reliable.

Because this paper is intended to determine the extent of QoS performance of ISPs using each service pack featured mobile operator in Samarinda. One of a provincial capital in Indonesia. Measurement/testing using software based tools (dedicated client software) via user traffic, and knowing its comparison using international standards. This study will complement and respond to previous research that has been done to the internet service users and various studies measuring the QoS that has been done.

II. RELATED WORK

A. Internet Quality of Service

Quality of Service has been one of the principal topics of research and development in packet networks for many years by some well-known organization such as IIT Delhi, ITU-T, and Cisco ([7], [8], [9], [10]). Many recent studies have investigated the quality of service from a variety of sources, such as quality of service in the telecommunications industry or ISP as in research in Thailand to discuss the service quality measurement system for mobile telecom service encounter [11]. Research in India that attempts to analyze the gap in service quality of Telecom sector in terms of customers' expectations and perceptions regarding mobile phone services ([10], [12]). Research in Ghana to try to explain why quality customer service plays a major role in the survival of many of the telecommunication companies drawing upon the evidence from the previous literature [13]. Research in Nigeria conducted to Determine the quality of service Provided Evaluate available and the data for quality of service problems using key performance indicators such as call setup, drop rate, and traffic congestion [14]. While research in the UK seeks to measure the performance of the retail 3G and 4G networks of the UK's four national mobile network operators (MNOs): EE, O2, Three and Vodafone [15]. A study again to present the results from a measurement study of both fixed and mobile broadband connections in South Africa [16]. Measurement of performance for Wireless Mobile network already done such an analysis on QoS of network mobility [17], the impact of QoS changes towards network performance [18], and a survey of end-to-end mobile network measurement testbeds, tools, and services [19].

QoS generally describes the assurance of sufficiently low delay and packet loss for certain types of applications or data traffic [20]. The requirements can be given by human factors, e.g., bounds on delay for interactive voice communications, or by business needs, e.g., the need to complete a transaction within a given time. QoS can be described qualitatively (relative) or quantitatively (absolute). Relative QoS definition is related to the treatment received by a class of packets to some other class of packets, while absolute definitions provide metrics such as delay or loss, either as bounds or as statistical indications [20].

The goal of QoS is to provide guarantees on the ability of a network to deliver predictable results. Various parameters can indicate the performance of Internet access networks, such as parameter packet loss, delay, throughput, jitter, latency, etc. ([21], [22]). QoS encompasses all service features determined by network efficiency, resources, provisioning, etc. [14] and it is referred as Network Performance (NP) by ITU [8] and ETSI [23][24]. It is a strictly technical issue which is crucial for quality perceived and assessed by users.

B. QoS Parameters

QoS parameters that affect the performance of mobile internet network to be measured is packet loss, delay (latency), jitter and throughput.

- Packet Loss

Packet Loss is the failure of the transmission of IP packets to its destination. Packet loss is caused by a variety of possibilities [23]. The standard value of packet loss can be seen in TABLE I.

TABLE I. TIPHON TR 101 329 STANDARDS FOR PACKET LOSS

	Category	Packet Loss
Packet Loss standard	Excellent	0 %
	Good	3 %
	Medium	15 %
	Poor	25 %

- Latency Test

Reference to TIPHON ([23], [24]), the standard delay value can be seen in TABLE II.

TABLE II. ITU-T G.114 STANDARDS FOR DELAY

	Category	Delay
Delay (Latency) standard	Good	0 - 150 ms
	Medium	150 - 400 ms
	Poor	> 400 ms

- Throughput Test

Throughput is the actual bandwidth (actual) were measured in a particular time and in certain network conditions that are used to transfer files of a certain size [31]. System throughput is the sum of the speed of data that is sent to all terminals in a network [24]. Reference to TIPHON [24], The standard throughput values can be seen in TABLE III.

TABLE III. QUALITY STANDARDS FOR THROUGHPUT

	Category	Throughput
Throughput standard	Excellent	100 %
	Good	75 %
	Medium	50 %
	Poor	<25 %

III. METHODOLOGY

This research was conducted with a quantitative approach, i.e. measuring the quality of Internet network using the card service package featured mobile operator XL, AON3 and Flash. QoS parameters to be measured is the End-to-End delay, jitter, packet loss probability and throughput.

The scope of the study focused on the state and geographic region as the provincial capital Samarinda East Kalimantan with a total population of 10 districts. In the study selected 7 districts sampled by area calculation factor, population density, public or business area, a school, and community center internet network users.

A. The Measurements Model System

The measurements model used to measure the mobile network performance is illustrated in Fig. 1. This model is divided into three subsystems: client, ISP network, and server.

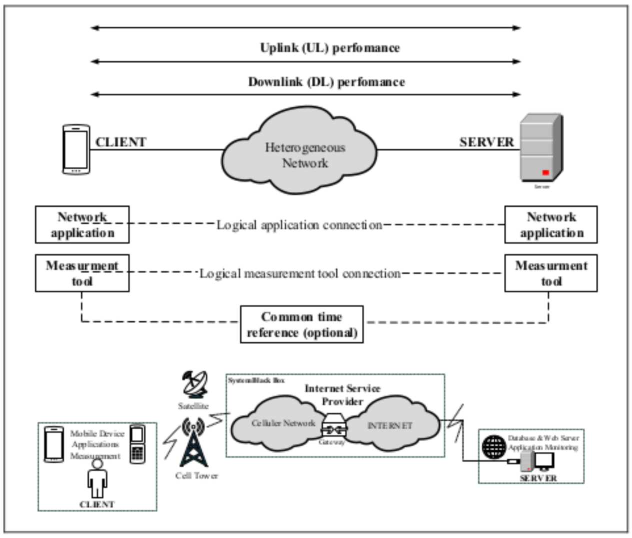

Fig. 1. Measurement Architecture

The explanation of each section in the measurement model according to Fig. 1 is as follows:

1) Client Mobile Device (Smartphone)

The mobile device using a card that supports packet data service communications networks such as GPRS, EDGE, UMTS, HSDPA, or others [10] and has a GPS feature. Measurement application using a specially designed mobile applications, android-based interface with input in the form of QoS parameters such as Server's IP address, the size of data packets to be sent, mobility status, and location of measurement. The point of the GPS coordinates (latitude and longitude), the technology used (TCP / UDP), the information of mobile operators, mobile device (brand and type), date and time, by default is obtained from measurements of the mobile device.

2) Internet Service Provider

Internet service providers 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).

3) Server

The server has one public IP that is used to serve clients in the reception and delivery of data packets. Input data from the client in the form of parameters will be received and stored in the database server. The output parameters on the server side will manage data time offset (the time between the client and server), downlink delay (time data transmission from the server to client), uplink delay (time delivery of data from the client to server), and round time trip (RTT).

Application on the server side is built using web-based applications with MySQL database connection. Monitoring interfaces on the server side will display the results of delivery of the client in the form of tables and graphs based on the existing input parameters.

B. Testing Methods

Measurement activities were carried out in 7 districts, and each district selected 4 different administrative regions, so the number of measurements is 28 measurement points. As for the location of the measurement point in the following TABLE IV.

TABLE IV. LOCATION OF MEASUREMENT

Districts	Area	Latitude	Longitude
Samarinda Ulu	Jl. Juanda 7	-0.4791712	117.1351857
	Jl. S. Parman	-0.4747445	117.1494413
	Jl. L. Soeprapto	-0.4754722	117.1435069
	Jl. Juanda 5	-0.4842306	117.1300089
Samarinda Kota	Jl. K. Bangsa	-0.4917628	117.1503266
	Jl. B. Rahmat	-0.4958087	117.1527366
	Jl. Flores	-0.5026548	117.1500272
	Citra Niaga	-0.5022267	117.1457395
Samarinda Ilir	Jl. Urip Sumoharjo	-0.491015	117.161724
	Jl. M.A. Saleh	-0.4931659	117.160236
	Jl. L.Mangkurat	-0.488477	117.161447
	Jl. Jelawat	-0.50016	117.159902
Samarinda Utara	Alam Segar 3	-0.462297	117.157305
	P. Bumi Sempaja	-0.452939	117.167465
	Terminal Lempake	-0.451211	117.192742
	Citraland	-0.459850	117.187531
Sambutan	Citra Gading	-0.5085206	117.1773618
	Otto Iskandar	-0.5080627	117.1683781
	JL. Pelita	-0.5075708	177.1749739
	Perum. Ariesco	-0.5078874	117.1757699
Sungai Pinang	Jl. D.I Pandjaitan	-0.4686674	117.1695521
	Jl. Gn. Lingai	-0.4610484	117.1713399
	Jl. Mugirejo	-0.4651562	117.1838059
	Jl. Bukit Alaya	-0.4633522	117.1771958
Sungai Kunjang	Jl. Jakarta	-0.531422	117.091415
	Jl. U. Surapati	-0.525333	117.114967
	Jl. Slamet Riyadi	-0.501891	117.123243
	Jl. Banggeris	-0.4929859	117.122040

Measurements were performed repeatedly with different measurement time. Measurements were divided into 3 sessions and 3 variations of the data packet that is 500 bytes, 5000 bytes, and 10000 bytes as in TABLE V.

TABLE V. SESSION OF MEASUREMENT TIME

Time	zone UTC+08:00
Morning	06.00 - 09.00
Daylight	11.00 - 14.00
Night	19.00 - 24.00

IV. MEASUREMENTS AND RESULT

A. Session Testing and Measurements

Tests using PING (Packet Internet Groper) will be done before sending data packets to the server to confirm or check the network connection has been connected to the server. Sessions will be created in the server so that the server can calculate the elapsed time during the session. Fig. 2 illustrates the workflow Mobile Ping (moping).

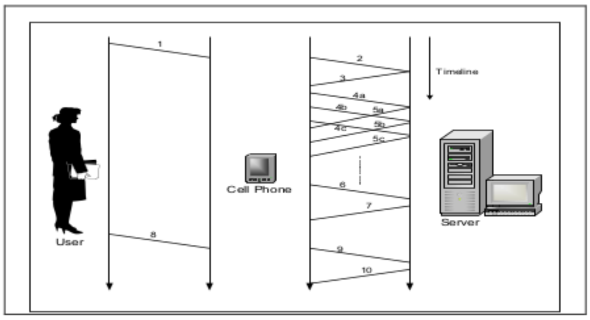

Fig. 2. Mobile Ping (Moping) Session Workflow

The data packets are used for measuring the time offset is made as small as possible, i.e. 1 byte, to reduce Round Trip Time (RTT) of the test. Offset data packets transmitted two times, but the timestamp that is processed is the second. It is made because the second RTT offset data package is smaller than the first due to the offset data package will no longer pass through the opening process of connections.

Having regard to the Fig. 2, inputting of data is done through measurement applications on smartphone devices. These data include the type of test to be performed, the data packet size, the number of test iterations, the time interval between tests, mobility status, test locations as in Fig. 3 and Fig. 4.

Fig. 3. Interface Network Testing

Fig. 4. GUI Moping Test and Measurement

B. Result

The results of measurements have been carried out directly on the site, the handset used in the test was a cell phone Samsung Galaxy Grand Duos SM-G7102 models that support android version 4.4.2.

- Measurement of Packet Loss

The results of measurements of packet loss at every point locations are generally in the range of grades 0-3%, except in Samarinda city to reach a value of 3-5%. The amount of packet loss in the district occurred in the center of very dense commercial activity. The following TABLE VI. shows the average packet of data loss.

TABLE VI. MEASUREMENT OF PACKET LOSS

Districts	Average Packet Loss			Category
	Mobile Operator			
	A	B	C	
Samarinda Ulu	4.4%	2.73%	1%	Good
Samarinda Kota	4%	3.19%	0%	Good
Samarinda Ilir	2.17%	1.58%	0%	Good
Samarinda Utara	0%	0.86%	0%	Good
Sambutan	0%	0%	0%	Excellent
Sungai Pinang	0%	0.74%	0%	Excellent
Sungai Kunjang	0.48%	1.37%	0%	Good

- Delay Measurement (Latency)

Things to note in Fig. 5 is the latency values that tapers at 10000 and 5000 byte packets compared to the 500 byte packets. To find out the cause of this phenomenon, further testing is done to the internal components of the network provider. For reasons of testing limits, the authors could only take the assumption that there is a buffering mechanism that occurs in the service provider. This mechanism causes the packet data in a smaller size than the size of the buffer must wait for a certain time until the buffer is full before it is sent to the network, resulting in increased value of the overall latency.

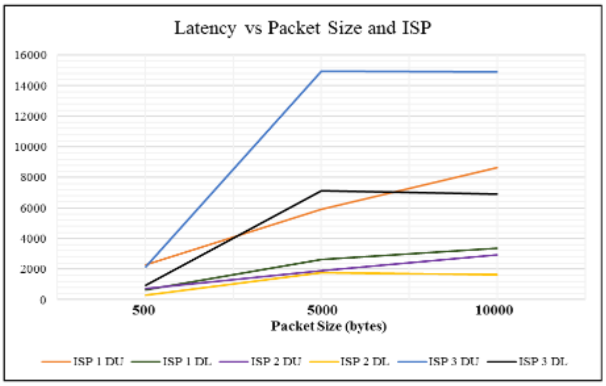

Fig. 5. Latency vs Packet size and ISP

Measurement delay (latency) in the delivery of data packets set by ten times iteration, in Fig. 6 shows the variation of bundling different data from each ISP to reduce the value of latency caused by the buffering process.

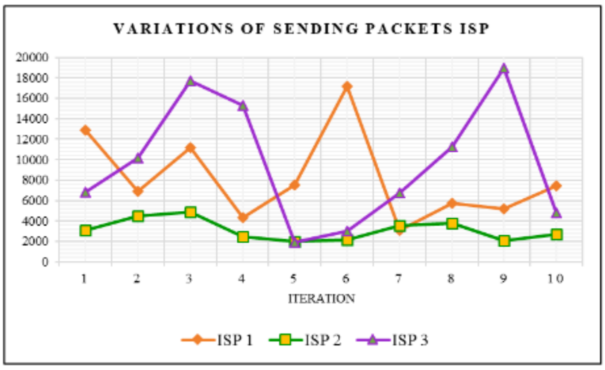

Fig. 6. The Variant of Sending Packets by ISP

- Throughput Measurement

In Fig. 7 is the result of the measurement throughput at one location in the district of North Samarinda shows the throughput. The size of the package used in this test is 10000 bytes. Each test session uses 10 iterations. Test carried out on three mobile network provider initials ISP 1, ISP 2 and ISP 3 are each performed three times a session. Throughput value of ISP 2 is higher than the ISP 1 and 3.

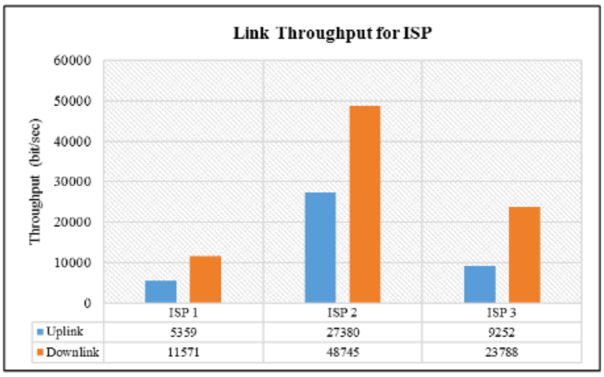

Fig. 7. The Comparison Throughput of each ISP

The interesting things to note in the measurement results shown in Fig. 8 is the value of the downlink compared to the uplink value of each ISP, it seems it is more influenced by the factors of time and location of measurement for other such locations are the downlink value greater than the value of the uplink.

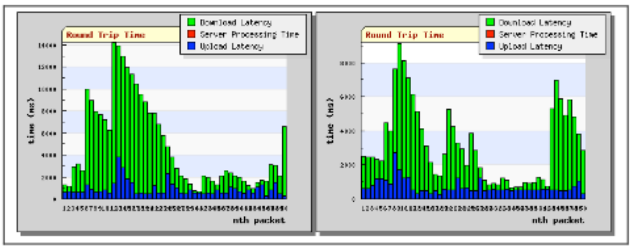

Fig. 8. Uplink and Downlink Throughput

Fig. 8 describe a chart pattern of uplink and downlink throughput. Measurement location was chosen in the area of education and business, that makes a great cause of large downlink data traffic. This can be seen in the pattern of downlink latency, which uplink latency is different from the patterns that tend static. This phenomenon itself, of course, require further research to determine the cause.

Additional testing is done to measuring the time-out. The process of measuring the time-out is done by sending a series of the data size of 1000 bytes and increase the intervals between deliveries. These measurements were performed on two mobile network provider initial ISP 1 and ISP 2 to compare the time-out of both network provider. Each network provider gets two test sessions. Each session uses 20 iterations with the addition of a half-second interval between delivery (500 ms). The results of each session are shown in Fig. 9 and Fig. 10.

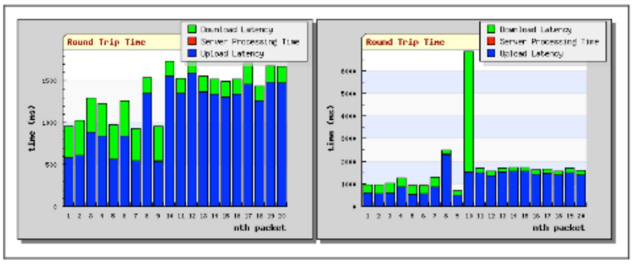

Fig. 9. The Result of Measurement Timeout ISP 1

Based on examination of the Fig. 9 for ISP 1, the value of uplink consistently increased in the 10th iteration. This indicates that the value of the time-out for ISP 1 is 5 seconds, which means if the client using the network for 5 seconds network resources will be diverted to other users.

Fig. 10. The Result of Measurement Timeout ISP 2

The same condition was not seen in testing ISP 2. Until the 20th iteration does not seem to have consistent changes in the uplink. It has been suggested that the time-out value for the ISP 2 is not contained in the range of 1 to 10 seconds. To try further how to determine the time-out value of ISP 2, conducted two additional sessions with the addition of an interval change the value of shipments into the second (1000 ms). It turned out that after adding the value of the interval between deliveries, nothing is changing in the value of a consistent latency uplink. It can be concluded that ISP 2 does not apply the time-out method. During the communication process, network resources continue to be provided to the user.

V. CONCLUSIONS AND DISSCUSSIONS

A. Conclusions

This research conducted to measure the parameters of Quality of Service based on time to the cellular network, using an application running on mobile device. The approach used to measure the end-to-end parameters of the three providers is using the service card package issued by each provider, consider the ISP system in it as a black box. As using PING, this system only accesses network performance in general, without specifically considering the characteristics of a specific application content. Furthermore, measurements have been conducted at 28 locations in the city Samarinda in three sessions (morning, afternoon, and evening). Test cases aimed at providing a general overview of performance each ISP in each region and how mobile ping and other features can be used.

For additional reference, Timeout Interval Test is conducted to measure the round trip delay of a small package amount with increased transmission intervals. With this test will be known round trip delay between packets associated with transmission distance. This test illustrates the cost performance to revive a component that has time-out (reallocation of resources). After measuring the time-out was found one provider that does not apply the time-out method. During the communication process, network resources continue to be provided to the user.

B. Disscussions

During the measurement of mobile network performance, some of the development direction identified for further studies of the process of time synchronization between client and server. The approach used in this study assumes that the time required to transmit a byte from one point to another through cellular network is very small. In reality, it is not always the case. The smallest RTT values for the package measurement time offset is in the range of 500 to 600 ms. Referring to the calculations of D. Mills [27], which states the maximum error generated by the formula Q.1 offset is half of the RTT packet, then the range of measurement error offset of 300 ms still feels quite large. For example, the possibility of future development is the use of embedded systems such as GPS (Global Positioning System).

Perfection Test Tools features is still in progress. One important feature that can be developed is the use of additional features using datagram protocol. With this feature, the ability to identify the characteristics of the network will be increased. The other features that are useful include the automation of the identification of the test site (Base Transmission Station).

Furthermore, through further research can be made a performance index which combines all input and output parameters. This index is useful as a means of comparison between the measurement results of a provider to another provider. More added later, performance index can be used for network control purposes.

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