Quality of Service of GSM. A Comparative Internet Access Analysis of Provider in Batam

Cosmas Eko Suharyanto, Pastima Simanjuntak, Fergyanto E Gunawan

***Abstract* - The demand for Internet access in Indonesia is very high, followed by telecommunications innovation which is currently growing rapidly. The presence of smartphones has changed the pattern of public communication. There are more consumers access the internet via smartphones. Internet access is provided by the operator cellular. The aim of this study was to perform a comparative analysis of the quality of service (QoS) among GSM providers who provide 4G network in Batam. TIPHON provide a measurement parameters and methodology to conduct QoS analysis. We measure bandwidth, packet loss, delay, and throughput of three mayor GSM providers in Batam. What provider claims about the internet speed sometimes differ from the actual, nevertheless, QoS parameter measurement results provide the fact that it is still in good category.**

***Keywords* : Quality of Service (QOS), GSM, 4G**

I. INTRODUCTION

Telecommunications industry is part of Network Industries, providing voice and data transfer services, such as telephone (fixed and cellular) and Internet. Some industries included in the Network Industries among them are the information technology industry such as software, hardware, multimedia industries such as broadcasting and cable television and industries related to delivery services. The main characteristics generally found in Network Industries is the industry that its components are complementary [1]. Study on telecommunications will lead us mostly to examine the operator providing services, especially data connection.

In Indonesia, according to [2] 9 (nine) licensed operators providing services at national level dominated by three of them; Telkomsel, Indosat and XL. Those three operators are GSM (Global System for Mobile Communication). Compared with CDMA (Code Division Multiple Access), GSM has larger market share, 89% for GSM and just 11% for CDMA [3].

Manuscript received May 2, 2017.

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Along with the growth of technology, such as smartphone, operators compete on internet speed as a strategy to win market. The research on Indonesian Smartphone Utilization brought us a fact, of the 167 million data connection by 2016, 109 million will be on smart phones, while the remaining 22 million will be on tablets and large screen devices [2].

Indonesian's Internet Service Providers Association (APJII) recently released a survey about internet users in Indonesia year 2016. According the survey, number of internet users in Indonesia in 2016 was 132.7 million users, or approximately 51.5% of the total population of Indonesia (256.2 million) [4]. Data of Internet users in Batam in 2013 was 263,000 [5], although we did not get the latest data of internet users in Batam, but we believe the national trend is occurring also in Batam.

Geographically Batam is a very small island, only 415 Km^2 , with 1.1 millions population. As an industrial city, Batam was the destination for jobseekers from all over Indonesia. Then with the rapid growth of the various sectors, it is important to examine how the internet speed in the city, especially areas that have been covered Fourth Generation (4G) network. The aim of this paper is to perform comparison analysis on three mayor GSM provider: Telkomsel, Indosat and XL.

II. THE GSM TECHNOLOGY

As mentioned earlier by Kurronen in [6] The original GSM acronym is 'Group Special Mobile'. This changed afterwards to Global System for Mobile Communication, which is the current official acronym. The standardisation work of GSM-based systems has its roots in the 1980s, when a standardisation body 'Group Special Mobile' (GSM) was created within the *Conference Europeenne des Postes et Telecommunications* (CEPT), whose task was to develop a unique digital radio communication system for Europe, at 900 MHz [6]. The GSM has become the de facto global standard for mobile communications. One of the key features of GSM is the Subscriber Identity Module, commonly known as a SIM card. The SIM is a detachable smart card containing the user's subscription information and phone book. The GSM systems and services are described in a set of standards governed by European Telecommunications Standards Institute (ETSI), where a full list is maintained [7]. According to [8] GSM is a specification of an entire wireless network infrastructure, while CDMA relates only to the air interface — the radio portion of the technology. GSM provides basic to advanced

voice and data services including roaming service. Roaming is the ability to use your GSM phone number in another GSM network.

III. Fourth Generation (4G)

1st generation technology (1G) was solely based on analog technology for its communications. This means that the transmitted signals were analog radio signals. Then came the 2G standards where the radio signals were digital. The short messaging text service (SMS) was also started with the 2G [9]. The demand for improvement led to the launch of the 3G telecommunications. There was a significant improvement in the standards when 3G was launched. 3G technology is the result of research and development work carried out by the International Telecommunication Union (ITU) in the early 1980s [10], [11]. According to [12] one way of gauging the likelihood of 3G's success is to look at one of its closest forerunners: SMS via GSM. Some consider it to be the best indicator of the money-generating potential of the mobile internet, assuming that SMS usage can be easily translated to demand for data on mobile devices. 4G is the fourth generation of wireless mobile telecommunications technology, succeeding 3G.

4th Generation system would be expected to provide support to potential & current applications including mobile web access, IP telephony, gaming service, high-definition mobile TV, video conferencing, 3D television, and cloud computing [13]. As mentioned earlier [13], 4G technology will offer many advancement to the wireless market, including downlink data rates well over 100 Mbps, low latency, very efficient spectrum use and low-cost implementations. With impressive network capabilities, 4G enhancement promise to bring the wireless experience to an entirely new level with impressive user applications, such as sophisticated graphical user interfaces, high-end gaming, high-definition video and high- performance imaging. Based on report by Internet Society conducted in 2014, industry rollout of 4G (and more advanced future generations) serves to further increase the network capacity and bandwidth speeds available. Mobile access technologies are now even more capable of supporting the data-intensive Internet services demanded by users [14].

IV. GSM Provider in Batam

As mentioned above, we focus on three mayor provider of GSM to be examined, Telkomsel, Indosat and XL. Telkomsel started operations in 1995, and within 20 years has established itself as the leading cellular operator in Indonesia, with more than 152 million customers, 103,000 BTS as well as more than 4,900 employees operating in 11 regions across Indonesia [15]. Nationally Telkomsel has more than 1300 BTS 4G with 1.7 million customers are making 4G LTE 4G largest community in Indonesia, Batam became the ninth city that supports 4G LTE service Telkomsel [15]–[17].

Indosat offers communication services for mobile-phone users, both for prepaid and postpaid, under the brands Matrix Ooredoo, Mentari Ooredoo and IM3 Ooredoo [18]. In February 2013, the Qatari telecommunications company at the time known as Qtel, which owned 65% of Indosat's shares, was rebranded as Ooredoo and planned to rebrand all its subsidiaries in the Middle East, Africa, and Southeast Asia in 2013 or 2014 [19]. On November 19, 2015, Indosat was finally renamed to Indosat Ooredoo [20]. Reported in [21] Indosat confirms its position as the second largest operator in Indonesia refers to the performance during the first half 2015. In 2014 Indosat officially launch Super 4G-LTE network commercially to answer the public demand for high speed internet service in Indonesia [22], and in Batam starting on January 2016 custumers can enjoy 4G service plus of IM3 Ooredoo [23].

Began commercial operation since October 8, 1996, XL Axiata being the best in the Asia region, and is majority owned by Axiata Group Berhad with a stake of 66.43%, and the rest belong to the public with a stake of 33.57% [24]. Stated in their annual report, XL Axiata smartphone penetration grew 21% to 63% compared with the same period the previous year. Hence by the end of December 2016, XL Axiata has recorded 29 million smartphone subscribers, increased by 64% YOY from the previous year. In 2016, XL Axiata continued its development of its 4G Network and ended the year with more than 8,200 4G LTE sites in close to 100 cities and areas across Indonesia [25]. At the end of 2015, XL launched 4G networks in Batam [26].

V. Quality of Service

Recommendation of The International Telecommunication Union: ITU-T E.800 provides a set of commonly used terms in the study and management of quality of service (QoS). QoS is totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service. Quality of service terms have been classified into three broad areas; service, network and management [27]. This work focused on network areas examination. The ITU Recommendations was practically described by the European Telecommunications Standards Institute in the project Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON). TIPHON provide a measurement parameters and methodology. TIPHON parameters became basis measurement for further research related to QoS. Based on some research earlier [28]–[31], finally we define four parameters as our matric measurement: bandwidth, delay, jitter, packet loss, and throughput.

When referring to a data connection, bandwidth, communication speed, or connection speed is the total maximum transfer rate of a network cable or device. Bandwidth is typically expressed in bits per second (bps) [32].

Delay or Latency is the time delay caused by the transmission from one point to another point which becomes the goal [30]. Delay time can be increased if the if packets face long queues in the network (congestion), or crosses a less direct route to avoid congestion.

Table 1. Delay Standard

$\frac{packet\ length\ (bit)}{link\ bandwidth\ (bps)}$	***Category***	***Delay***
	Good	0-150 ms
	Medium	150-400 ms
	Poor	>400 ms

ITU-T-G.114

As mentioned before in [30] jitter is the variation of the delay. Jitter is affected by variations in traffic load and the amount of collisions between packets (congestion) on the network. Jitter influence on network performance should be considered in conjunction delay. When large jitter delay is small but the performance of the network can't be said to be bad because of the amount of jitter can be compensated with a small delay value. Jitter will degrade the performance of the network when the value is great and also the value of delay is too large.

Table 2. Jitter Standard

$\frac{\sum variation\ delay}{\sum packet\ received}$	***Category***	***Jitter***
	Good	0-20 ms
	Medium	20-50 ms
	Poor	>50 ms

ITU-T-G.114

Packet loss is percentage of packets lost at an IP test point; this metric does not include any losses due to the end-terminal equipment [33]. According to [29] packet loss happens when one or more packets of data being transported across the internet or a computer network fail to reach their destination. Wireless and IP networks cannot provide a guarantee that packets will be delivered at all, and will fail to deliver (drop) some packets if they arrive when their buffers are already full. This loss of packets can be caused by other factors like signal degradation, high loads on network links, packets that are corrupted being discarded or defect in network elements. This type of damage is detected in the process of "checksum". Checksum is the number of bits that are mathematically calculated by the sender and added to each packet. Recipients also calculate the checksum and comparing the calculated value with the value received by the package. If the received and the calculated checksum do not match, the receiver discards the packet. Regardless of the network topology, there is always a possibility that some level of packet loss can occur due to checksum to detect errors, mainly due to a large number of routers and switches traversed [30].

Table 3. Packet Loss Standard

$\frac{packet\ sent - packet\ received}{packet\ sent}\ x\ 100\%$	***Category***	***Packet Loss***
	Excellent	0%
	Good	3%
	Medium	15%
	Poor	25%

TIPHON

Throughput and actual bandwidth are telecommunication network capacity for accommodating traffic. Throughput can be tracked by actual volumes of time-based full file packets, measured in bit/s, that service networks can carry [34]. This definition re–affirmed by [29], throughput is the amount of data which a network or entity sends or receives data, or the amount of data processed in one determined time space. Throughput standard used in this work follow [30], [34] as shown in **Table 4**.

Table 4. Throughput Standard

$\frac{\sum sent\ data\ (bit)}{time\ data\ delivery\ (s)}$	***Category***	***Throughput***
	Excellent	100%
	Good	75%
	Medium	50%
	Poor	<25%

The signal strength will determine the quality of connectivity of the mobile operator. The real received signal strength is a continuous quantity and measured in *dBm* or *decibel milliwatt*. Mobile phone signal strength is internationally referred to as RSSI (Received Signal Strength Indicator). In an IEEE 802.11 system, RSSI is the relative received signal strength in a wireless environment, in arbitrary units. RSSI is an indication of the power level being received by the receive radio after the antenna and possible cable loss. Therefore, the higher the RSSI number, the stronger the signal. Thus, when an RSSI value is represented in a negative form (e.g. −100), the closer the value is to 0, the stronger the received signal has been.

According to [35] signal strength can be classified into four category as shown in **Table 5**.

Table 5. Signal Strength

RSSI	***Signal Strength***
> -70 dBm	*Excellent*
-70 dBm to -85 dBm	*Good*
-86 dBm to -100 dBm	*Poor*
-110 dBm	*No Signal*

VI. Tool and Procedure

A. Tool

In examining the measurement of QoS above, we use three SIM Card of the provider (Telkomsel, Indosat, XL) with Smartphone Android Samsung Galaxy J5. Smartphone specifications: Lollipop Android OS 5.1, quad-core processor speed of 1.2 GHz, 1.5 GB RAM, 8 GB internal memory, External Memory Up to 128 GB, Internet HSPA 21.1/5.76 Mbps, 4G LTE.

Network Signal Info, this application provides detailed information over the currently used network, whether WiFi or cellular connection [36]. ***Open Signal***, With Open Signal we can see cell towers around us on a map, and the signal compass points us in the direction we need to walk in to improve our connection immediately [37].

Ookla Speedtest, this mobile apps are designed to accurately test the performance of mobile cellular connections including LTE, 4G, 3G, EDGE and EVDO

networks [38]. ***Speedtest Master***, this app can test speed for our mobile cellular connections including WiFi hotspot, LTE, 4G, 3G networks. With just one tap, it will test internet speed through thousands of servers worldwide and show accurate broadband speed test results within 30 seconds [39]. ***Axence netTools*** is a set of ten handy tools for network scanning and monitoring which is popular all over the world. The software is designed both for home and commercial uses [40].

B. Procedure

The first step, we conduct interviews with the management of the GSM network operator. The interviews resulted information about the location of 4G areas. Form the interview we also get information: requirements to be able to enjoy the 4G network is to be in a location that is covered 4G network, have devices that support 4G, have a special 4G SIM card, and activate 4G internet packet.

The next step is to determine the location of 4G base stations of each GSM operator in Batam by using applications such as *Open Signal* and *Network Signal Info.* Tests carried out at a place which is accessible BTS each operator that has the strongest signal. Testing time we follow previous research by [41], 6-8am, 8-10am, 12-14pm, 16-18pm.

VII. RESULT

A. Signal Strength

To run a fairness analysis in this study, we determined the three areas covered 4G network with approximately equal signal strength as shown in the Table 5 which similar with recent work by [42].

Table 6. Signal Strength Test

Provider	***Signal Strength***	***Location***
Telkomsel	-77 dBm	Tiban Indah
Indosat	-85 dBm	Batuaji
XL	-74 dBm	Batuaji

B. Bandwidth Analysis

Bandwidth analysis is our next step in measuring QoS. We conduct this test using scenario devided into four category of time to provide a representative real data. This test resulted bandwidth parameters that we split into three test: download (D) and Upload (U), see Tables 7-9:

Table 7. Bandwidth Test (Telkomsel)

Attemps	***6-8am***		***8-10am***		***12-14pm***		***16-18pm***	
	D	U	D	U	D	U	D	U
1	44.4	4.1	43.1	3.9	40.2	3.9	39.6	3.7
2	47.4	8.5	46.2	7.1	40.1	7.1	42.3	6.1
3	47.6	6.7	45.1	6.2	42.1	8.3	36.9	6.7
4	52.1	12.4	50.2	9.1	45.1	7.2	40.7	6.4
5	53.3	5.3	52.1	5.1	46.4	5.1	45.3	5.4
6	24.1	6.2	25.1	5.2	35.6	5.2	43.1	4.8
7	52.1	12.1	43.2	10.3	39.6	9.5	42.1	7.9
AVG	45.86	7.90	43.57	6.70	41.30	6.61	41.43	5.86
					AVG D =	43.04	(Download/Mbps)	
					AVG U=	6.77	(Upload/Mbps)	

Table 8. Bandwidth Test (Indosat)

Attemps	***6-8am***		***8-10am***		***12-14pm***		***16-18pm***	
	D	U	D	U	D	U	D	U
1	28.6	12.9	25.3	12.4	23.5	12.1	24.2	14.6
2	22.4	14.7	22.1	14.8	23.1	13.4	24.3	14.2
3	22.5	15.7	20.4	14.1	21.3	13.9	26.5	14.7
4	23.3	17.8	24.1	15.5	25.2	15.9	27.2	13.2
5	16.4	17.5	20.1	16.8	24.1	16.4	24.2	17.2
6	28.1	16.6	23.2	16.2	20.3	16.6	25.6	16.9
7	22.5	15.5	21.1	16.4	21.6	17.2	23.8	17.8
AVG	**23.40**	**15.81**	**22.33**	**15.17**	**22.73**	**15.07**	**25.11**	**15.51**
					AVG D =	**23.39**	(Download/Mbps)	
					AVG U=	**15.39**	(Upload/Mbps)	

Table 9. Bandwidth Test (XL)

Attemps	***6-8am***		***8-10am***		***12-14pm***		***16-18pm***	
	D	U	D	U	D	U	D	U
1	19.27	18.51	19.1	19.2	20.1	19.9	20.1	18.02
2	17.8	17.44	18.2	18.1	18.21	17.9	18.9	18.5
3	15.75	20.09	16.1	19.4	16.9	21.7	15.8	21.43
4	24.85	19.25	23.4	18.9	23.13	18.4	23.9	20.3
5	15.73	18.35	16.3	18.3	16.9	17.9	16.1	19.01
6	25.65	21.58	20.9	20.9	24.8	22.9	23.9	19.06
7	28.1	20.7	29.6	18.9	29.9	21.9	29.01	18.03
AVG	**21.02**	**19.42**	**20.51**	**19.10**	**21.42**	**20.09**	**21.10**	**19.19**
					AVG D =	21.01	(Download/Mbps)	
					AVG U=	19.45	(Upload/Mbps)	

Refer to **Tables 7-9** and a clearer **Fig. 1**, the best download speed goes to Telkomses, followed by Indosat and XL which slightly differ. On the other side, Upload speed goes to XL network, followed by Indosat and Telkomsel.

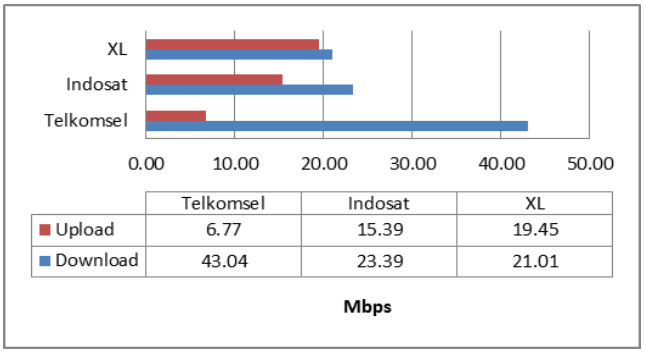

Fig 1. Comparative Bandwidth Test

C. Delay Analysis

We conduct Delay analysis using NetTools, obtained by managing the response time of the monitoring application. We determine five points of destination (server) that most popular site or frequently accessed: yahoo.com, google.com, youtube.com, and facebook.com. Figure 2 describe delay graph of Telkomsel. Overall, the average delay test of Telkomsel is 104.86, still in range of Good as shown in Table 1.

Table 10. Delay Test (Telkomsel)

Server	***6-8am***	***8-10am***	***12-14pm***	***16-18pm***	***AVG***
yahoo.com	200.45	215.09	230.6	250.3	224.11
google.com	24.3	30.65	29.75	30.77	28.87
youtube.com	38.98	48.7	45.54	49.9	45.78
facebook.com	110.76	122.65	120.54	128.8	120.69
AVG	93.62	104.27	106.61	114.94	**104.86**

Table 11. Delay Test (Indosat)

Server	***6-8am***	***8-10am***	***12-14pm***	***16-18pm***	***AVG***
yahoo.com	278.01	277.76	277.05	277.76	277.65
google.com	40.01	39.84	39.9	39.83	39.90
youtube.com	59.51	59.03	58.9	58.92	59.09
facebook.com	54.04	53.98	53.02	52.89	53.48
AVG	107.89	107.65	107.22	107.35	**107.53**

Table 12. Delay Test (XL)

Server	***6-8am***	***8-10am***	***12-14pm***	***16-18pm***	***AVG***
yahoo.com	237.43	236.54	234.01	233.08	235.27

google.com	83.01	82.09	81.09	81.47	81.92
youtube.com	51.99	50.02	49.09	48.04	49.79
facebook.com	45.45	45.76	42.67	41.8	43.92
AVG	104.47	103.60	101.72	101.10	**102.72**

Based on information **Tables 10-12**, the average of delay test of Indosat Network is 107.53, slightly different with the results of the delay test Telkomsel network and also still in the range of Good as shown in Table 1.

XL network is slightly better than Telkomsel and Indosat. If we calculate the average is 102.72, Good range based on delay standard as shown in **Table 1**. See also **Fig. 2**, comparative result of delay test below:

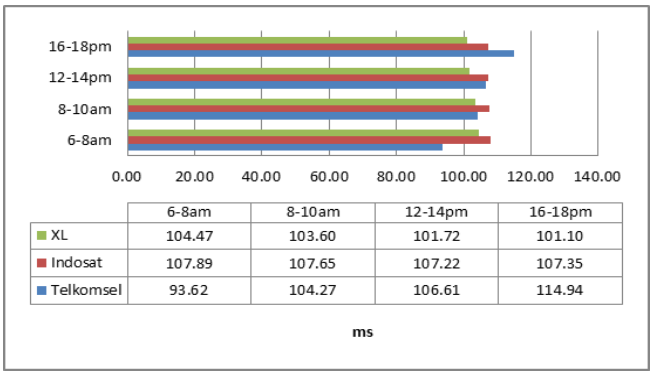

Fig. 2 Comparative Delay Test

D. Packet Loss Analysis

After conducting delay analysis, we run packet loss test using same tool: NetTools. We intentionally did not present data based on time split, since we find the same data: 0%.

Table 13. Packet Loss Test

Server	*Packet Loss (%)*			*TIPHON*
	Telkomsel	**Indosat**	**XL**	
yahoo.com	0	0	0	Excellent
google.com	0	0	0	Excellent
youtube.com	0	0	0	Excellent
facebook.com	0	0	0	Excellent

E. Throughput Analysis

Throughput despite having the same formula unit and the bandwidth, throughput describes the actual bandwidth at a certain time, certain conditions and internet network that is used to download a file with a certain size. Here, we immediately present data in the form of percentage as follows:

Table 14. Throughput Test (Telkomsel)

Server	*6-8am (%)*	*8-10am (%)*	*12-14pm (%)*	*16-18pm (%)*	*AVG*
yahoo.com	80.56	79.97	79.86	80.05	80.11
google.com	87.76	86.06	85.89	85.06	86.19
youtube.com	76.87	77.86	76.54	75.45	76.68
facebook.com	88.89	87.98	86.78	86.07	87.43
AVG	**83.52**	**82.97**	**82.27**	**81.66**	**82.60** **Excellent**

Table 15. Throughput Test (Indosat)

Server	*6-8am (%)*	*8-10am (%)*	*12-14pm (%)*	*16-18pm (%)*	*AVG*
yahoo.com	83.46	83.04	82.87	81.09	82.62
google.com	88.69	88.04	87.92	87.05	87.93
youtube.com	78.04	78.32	77.85	77.54	77.94
facebook.com	89.58	89.06	88.02	81.55	87.05
AVG	**84.94**	**84.62**	**84.17**	**81.81**	**83.88** **Excellent**

Table 16. Throughput Test (XL)

Server	*6-8am (%)*	*8-10am (%)*	*12-14pm (%)*	*16-18pm (%)*	*AVG*
yahoo.com	80.23	80.1	79.89	79.17	79.85
google.com	87.04	86.92	86.81	85.65	86.61
youtube.com	76.55	76.21	76.04	75.12	75.98
facebook.com	88.02	87.76	87.76	87.27	87.70
AVG	**82.65**	**82.75**	**82.63**	**81.80**	**82.53** **Excellent**

Based on the three tables above, we can conclude that the throughput of the three providers are in the range of excellent. See also **Fig. 3**, comparative result of packet loss test.

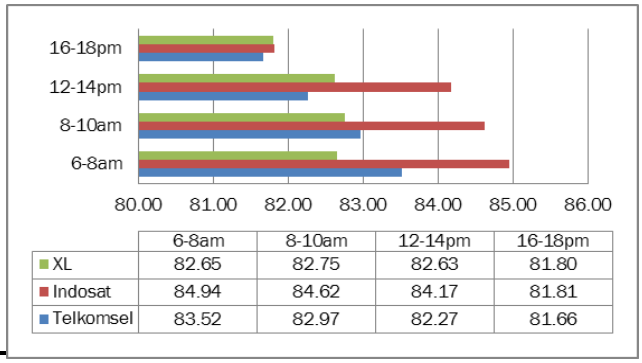

Fig. 3 Comparative Throughput Test

VIII. Comparative Result

After all measurement parameters have been calculated, we provide a comparative result as shown in **Table 17**.

Table 17. Comparative Result

Provider	*AVG Bandwidth*		*AVG Delay*	*AVG Packet Loss*	*AVG Throughput*
	D	**U**			
Telkomsel	43.04	6.77	104.86	0	82.60
Indosat	23.39	15.39	107.53	0	83.88
XL	21.01	19.45	102.72	0	82.53

IX. Conclusion

The following facts are identified as findings of the study. 4G networks can only be enjoyed by users located within the area covered 4G network, with devices that support 4G, and using a special 4G SIM Card. What provider claims about the internet speed sometimes differ from the actual, nevertheless, QoS parameter measurement results provide the fact that it is still in good category. One of the limitations of this study is that we have not included the jitter test in the QoS measurement.

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