2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT)
April 09-11. 2021, ISTTS Surabaya, Indonesia

4G LTE Experience: Reference Signal Received Power, Noise Ratio and Quality

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2021 3rd East Indonesia Conference on Computer and Information Technology (EIConCIT) | 978-1-6654-0514-0/20/$31.00 ©2021 IEEE | DOI: 10.1109/EIConCIT50028.2021.9431853

***Abstract*— Currently, Indonesia has just entered the 4G technology stage so that 5G technology will look very far away, although it cannot be denied that 5G technology will come whether Indonesia is ready or not, therefore this study was held to help describe the current condition of Indonesia's 4G network and is expected to provide input in determining steps and Indonesia's 5G roadmap going forward. This study aims to evaluate the quality of video streaming over the 4G LTE network based on the quality of experience parameters of RSRP, RSRQ and SNR of mobile operators. The walk-test measurement method was used for data collection (morning, evening, night). The performance evaluation results of 4G LTE mobile operators show that the weak value of the RSRP, RSRQ, and SNR values obtained at a point have experienced a decrease in signal strength, this is due to the propagation loss that occurs. The presence of buildings, trees, network density and weather cause propagation such as reflection, diffraction, and scattering. In addition, the distance from the transmitter to the receiver is also a factor that causes a decrease in the signal strength received from the user's device. Therefore, the results of the evaluation serve as a reference for further optimization actions to support the improvement of the 4G LTE network by service providers so that users experience satisfying 4G LTE network services.**

Keywords—4G LTE, RSRP, RSRQ, SNR, QoE

I. INTRODUCTION

Over the past few years, we have seen a remarkable increase in the mobile network experience in Indonesia as part of a significant investment made by operators in Indonesia as part of the transformation to become the largest digital economy in Southeast Asia. With high-speed internet connectivity and mobile networks steadily improving in various places forming a strong foundation for the country's digital economy, we see how mobile operators are performing as important players of this ever-evolving digital ecosystem in our assessment of users' mobile network experiences [1], [2].

The latest report opensignal.com during the lockdown due to the Covid-19 pandemic in 2020 (July and December quarter), as this period includes the introduction of lockdown assessments in relation to the COVID-19 pandemic, this period also indicates to what extent the mobile experience of Indonesian users affects changes in outcomes in the location and data consumption habits of users [3], and because operators offer cheaper or free data plans to provide support for their customers [4]. The need for an internet connection was very important during the Covid-19 pandemic [5], however, there are still many people who are not connected to 4G [6]. On the other hand, initial deployments in several countries (China, South Korea, United States and Japan) are already offering an initial 5G [1]. Telecommunication technology is growing and demands assurance of network availability, continuity, and quality, not only limited to stationary (fixed), but also when moving or mobile. Not only for voice but data communication, image and video streaming demands that makeup multimedia communication [7].

The 4G LTE technology allows users to no longer be limited by space, which is a solution to ensure connection continuity and speed of data access [8]. Until now, service providers are always competing and trying to increase their network coverage in Indonesia. Despite continuing to improve, in practice, the 4G LTE network coverage is still uneven in various cities in Kalimantan. In addition, other problems that have become customer complaints include unstable signal strength, difficult data access to connect [9], and network connection failures [10]. All these problems become user complaints. The performance of the 4G network needs to be explored further so that its utilization is more optimal and does not disappoint network users [11], [12], This study analyses the performance of the 4G LTE network of service providers in Samarinda City, represented by three mobile operators. The parameters quality measured are Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), and Signal to Noise Ratio (SNR). The drive-test method was carried out to measure the quality of the network signal, considering that geographically Kalimantan is a hilly and forest area.

Motivation and research contribution: User satisfaction with the quality of 4G network service greatly affects the financial performance of operator companies [13], if the 4G services are not improved, there is a risk of causing customers to switch to other operators [14]. Currently, Indonesia has just entered the 4G technology stage so that 5G technology will look very far away, even though it cannot be denied that 5G technology will come whether Indonesia is ready or not, therefore this study was held to help describe Indonesia's current condition and it is hoped that it can provide input in determining steps and Indonesia's 5G roadmap going forward. Seeing the experience of implementing mobile technology

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from 1G to 4G in Indonesia, which is always late, so in the face of the era of 5G mobile technology which is expected to be implemented. In addition, Indonesia as one of the most important digital economic powers in the world for 5G deployment in Indonesia [15], [16] and digital Indonesia 4.0 programs towards the development of a new capital city in Kalimantan [1].

II. Related Works

A. Mobile-network Experience

The performance report of the mobile network experience in Indonesia in opensignal.com reveals that telecommunication operators have experienced an increase in users, network traffic density during the Covid-19 pandemic [17]. The experience metrics were evaluated covering download-upload experience, video-voice, gaming experience, coverage and 4G availability [4], [18]. Furthermore, the mobile network experience for the Samarinda city area in the opensignal.com [4] report is shown in "Table I" The most recent OpenSignal.com report for the period August - December 2020 [4], the rating of experience metrics for voice-video apps via video streaming and over-the-top voice services is based on ITU-T recommendations [19]. The download-upload experience represents the user's normal daily speed measured in Mbps, while 4G availability and coverage is a measure of the proportion of time a user has a 4G LTE network connection on a scale of 0-10 [4].

B. Literature Review

The Mobile World Congress 2015 which was attended by representatives from regulators, telecommunication operators and vendors from all over the world, ensures that the current 5G technology is still in the key requirements stage and each one is competing to fulfil the expected vision of 5G technology [15], more than the previous generation. Every technological development requires preparation in implementation both in preparation of regulations, industrial readiness and others [20]. Observing the experience of implementing mobile technology from 1G to 4G in Indonesia, which is always late, so that in facing the era of 5G mobile technology, which is expected to be implemented, an evaluation study of the 4G LTE experience measurement was conducted to see how the performance of the 4G network in Indonesia. The 4G network performance study has been discussed as in the research of Indrawati and U Kedar Priya, which examines the factors that influence the behavioral intentions and customer use towards the adoption of 4G services in Indonesia [21]. The study results reveal that one of the factors that influence Behavioral Intention on 4G service adoption is network performance expectations.

The performance analysis and optimization of LTE networks in the Balikpapan [22] area have been studied by Firdaus Rofiansyah et al., Using the Nemo Analyze software, and research by Maria Ulfah and A. Sri Irtawaty which obtained a direct picture of the conditions around e Node B followed by the plotting process of 126 e Node B sites in the city of Balikpapan [23]. Performance rate for implementation of mobile learning in network [24]. 4G-LTE 1800 MHz coverage and capacity network planning using frequency reuse 1 model for rural area in Indonesia [25], Comparison of TCP variants in Long Term Evolution [26] and Quality of Service Voice over Internet Protocol in Mobile Instant Messaging [27]. Broadband quality of service experience measuring mobile networks from consumer perceived [28], The impact of the reference signal received power to quality of experience for video streaming over LTE network [29], etc.

TABLE I. Mobile Network Experience in Samarinda Region

Metric	Operators (ISP)				
	Telkomsel	*Indosat*	*XL*	*3*	*Smartfren*
Video Experience (0-100 points)	67.9	58.9	61.7	68.1	49.8
Voice-App Exper. (0-100 points)	81.3	73.7	77.7	81.1	76.8
Download Speed Experience(Mbps)	17.9	13.2	16.6	14.2	6.9
Upload Speed Experience(Mbps)	6.9	6.3	6.4	7.5	1.6
4G Availability	91.7	91.7	92	93.5	97.6

TABLE II. Performance Indicator Standards for RSRP [31]

Range (dBm)	Category
-80 to -44	Excellent
-90 to -80	Good
-100 to -90	Fair
-110 to -100	Poor
-140 to -110	Very Poor

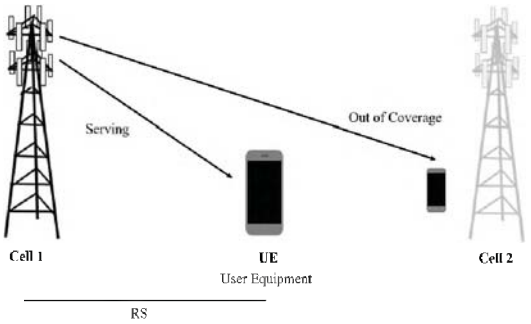

Fig. 1. UE receives signals from site (cell 1)

III. Methodology

This study is to evaluate the experience of the Mobile network operators through measuring the power and quality of the 4G LTE network during the Covid-19 pandemic in the Samarinda city, Kalimantan, Indonesia. The methods and supporting devices are described as follows.

A. Signal Level and Quality for 4G LTE

Reference signal received power is the power of the signal received from eNodeB to User Equipment (UE)[29], shown in Fig. 1. UE receives signal from location in "Fig. 1" explained that the service from a location which is usually analogized by a reference signal, the closer to the presentation location, the better the signal strength received, but if it is far from the location of the coverage service, the worse the signal strength received. The reporting range of RSRP is defined from -140 dBm to -44 dBm with 1 dB resolution [30], Standard RSRP value refers to [31] shown in Table II. The calculation of the RSSP value refers to [32], [33] Eq. (1):

$$\text{RSRP (dBm)} = \text{RSSI (dBm)} - 10 * \log (12 * N)[34] \quad (1)$$

Reference Signal Received Quality is the ratio between RSRP and wideband power. RSRQ represents the signal quality that the UE receives [34]. The RSRQ is also affected by the signal, and the noise as well as interference received by the UE [30], [35]. The calculation of the RSRQ value refers to [36] Eq. (2):

$$\text{RSRQ} = N \times \text{RSRP} / \text{RSSI} \quad (2)$$

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TABLE III. PERFORMANCE INDICATOR STANDARDS FOR RSRQ[31]

Range (dBm)	Category
-10 to -3	Excellent
-12 to -10	Good
-14 to -12	Fair
-17 to -14	Poor
-20 to -17	Very Poor

TABLE IV. PERFORMANCE INDICATOR STANDARDS FOR SNR[31]

Range (dBm)	Category
10 to 30	Excellent
3 to 10	Good
0 to -3	Fair
-20 to -3	Poor

Standard RSRQ value according to [31] in "Table III". Signal To Noise Ratio, is the ratio between the average power received by the average interference and noise. The Key Performance Indicator standards for SNR shown in "Table IV". The calculation of the SNR value refers to [37] Eq. (3):

$$\text{SNR} = \frac{S}{I+N} \quad (3)$$

B. *Variabel and Data Collection Methods*

Data collecting through observations that carry out direct field measurements using the G-Net Track Pro app for network monitoring and walk test at four points as a sample of the measurement location. The research variables are presented in "Table V".

C. *Measurement Methods*

Measurement of 4G LTE network parameters using the walk test method, walking tracing from one sample destination point to another. This measurement method aims to observe, collect data, and analyse the results of measuring the 4G LTE signal quality. Video streaming online via YouTube with a duration of 10 minutes 51 seconds and resolutions: 144p, 240p, 360p, 480p, 720p, and 1080p. The map of the positions of the measurement locations is shown in "Fig. 2".

IV. RESULT AND DISCUSSION

The results of the walk-test measurements at 4 points were tested during August 2020. The "Fig. 3" is an example of the G-Net Track Pro application user interface when collecting field data.

TABLE V. VARIABEL AND PARAMETER

Variabel	Parameter	Description
Key measure 4G LTE	RSRP RSRQ SINR	Reference signal power, quality, and noise ratio.
Location point	start: -0.4689515,117.1550757 end: -0.46939,117.1520991	Coordinate Points tracking with Latitude and Longitude
Mobile operator	Telkomsel XL IM3	Mobile operators covered by the 4G LTE network
Session time	08:00AM - 12:00AM 12:00AM - 15:00PM 15:00PM - 18:00PM	Session time (morning, afternoon and night) data collection activities.

Fig. 2. Location, track and point map of the measurement position.

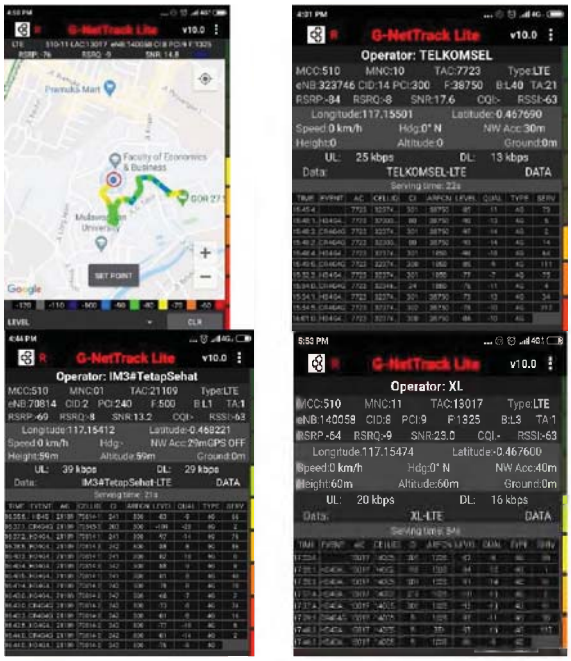

Fig. 3. The G-Net Track Pro application user interface

A. *Measurement Results: Mobile Network*

The measurement results for RSRP, RSRQ and SINR parameters on the mobile operator network starting from location point -0.4689515,117.1550757 to point -0.4683905, 117.1527551, then to point -.4684104,117.151916 and to point -0.46939,117.1520991. Descriptive statistics of the measurement results for 4G LTE parameters on mobile networks are presented in "Table VI".

TABLE VI. DESCRIPTIVE STATISTICS OF THE 4G LTE

	Telkomsel	XL	IM3
N	460	541	866
Mean	-81.8739	-86.7486	-82.9434
Median	-81.0000	-87.00	-82.00
Mode	-78.0000	-86.00	-82.00
Std. Dev.	7.97719	6.20600	9.12015
Variance	63.635	38.514	83.177
Minimum	-114.00	-101.00	-104.00
Maximum	-64.00	-69.00	-64.00

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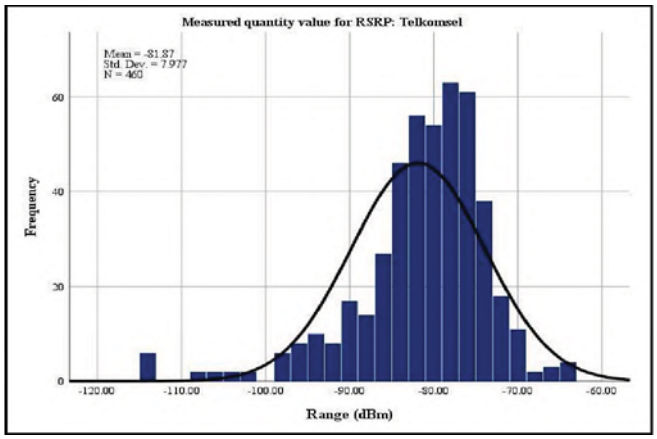

Fig. 4. Measured quantity value for RSRP: Telkomsel network

TABLE VII. MEASUREMENT RESULTS FOR RSRP: TELKOMSEL

Point	RSRP	RSRQ	SNR	RSSI
1	-84	-10	16.4	-63
2	-72	-8	26.2	-63
3	-76	-9	16.6	-63
4	-82	-7	14.6	-66
5	-83	-8	12.2	-65
6	-83	-10	9.4	-65
↓	⋮	…	…	…
459	-90	-12	12.6	-66
460	-78	-10	8	-63

1) Mobile Network: Telkomsel: The parameter measurement results for Telkomsel mobile network operators obtained 460 points. Summary of measurement results in "Table VII". The "Fig. 4" shows the measured quantity value for RSRP on Telkomsel network with minimum value of -114, a maximum of -64, an average of -81.87 Db, standard deviation of 7,977 and mode -78 Db.

2) Mobile Network: XL The parameter measurement results for XL mobile network operators obtained 541 points. Summary of measurement results in "Table VIII". *The "Fig. 5" shows the measured quantity value for RSRP on the XL network with a minimum value of -101, a maximum of -69, an average of -86.74 Db, standard deviation of 6.2 and mode -86 Db.*

3) Mobile Network: IM3 The parameter measurement results for IM3 mobile network operators obtained 866 points. Summary of measurement results in "Table IX". The "Fig. 6" shows the measured quantity value for RSRP on the IM3 network with a minimum value of -104, a maximum of -64, an average of -82.94 Db, standard deviation of 9.12 and mode -82 Db.

TABLE VIII. MEASUREMENT RESULTS FOR RSRP: XL

Point	RSRP	RSRQ	SNR	RSSI
1	-74	-9	17.6	-63
2	-79	-7	17.4	-66
3	-89	-9	12.2	-68
4	-92	-9	9.2	-70
5	-73	-8	13	-63
6	-64	-9	23	-63
↓	⋮	…	…	…
540	-85	-8	16.4	-64
541	-90	-15	-3.4	-65

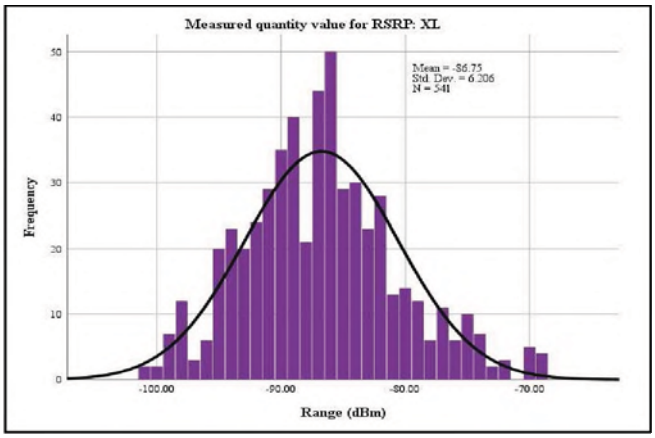

Fig. 5. Measured quantity value for RSRP: XL network

TABLE IX. MEASUREMENT RESULTS FOR RSRP: IM3

Point	RSRP	RSRQ	SNR	RSSI
1	-99	-12	4	-72
2	-93	-13	-1.4	-67
3	-75	-6	19.4	-63
4	-89	-9	15.6	-65
5	-77	-6	11.4	-63
6	-69	-8	13.2	-63
↓	⋮	…	…	…
865	-65	-6	28	-63
866	-74	-5	20.8	-63

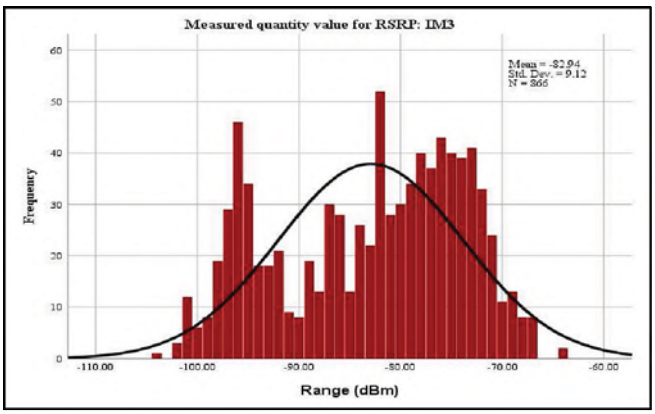

Fig. 6. Measured quantity value for RSRP: IM3 network

B. Discussion

Evaluation of mobile network operator's for RSRP, SNR and RSRQ experiences based on measurement results and adjusted to Standard Key Performance Indicator (KPI), is shown in "Table X" for RSRP performance. Table X shows the KPIs for RSRP for each mobile network operator, obtained of 254 points in the excellent category for Telkomsel, 80 points for XL and 403 points for IM3. The best deviation of Telkomsel operators is -64 dBm and the worst is -114 dBm. The best point of the XL operator is -69 dBm, the worst is -101 dbm, and for the best point of the IM3 operator is -64 dBm, the worst is -104 dbm. From these results, it is explained that IM3 operators have better RSRP performance than the network performance of XL and Telkomsel operators. Evaluation of mobile network operator's for RSRQ experiences based on measurement results and adjusted to KPI, is shown in "Table XI" for RSRQ performance presented in Table XI.

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TABLE X. MEASURED QUANTITY VALUE FOR RSRP

Range (dBm)	Telkomsel	XL	IM3	Category
-80 to -44	254	80	403	Excellent
-90 to -80	155	313	239	Good
-100 to -90	37	146	202	Fair
-110 to -100	8	2	22	Poor
-140 to -110	6	0	0	Very Poor
Sum	460	541	866	

TABLE XI. MEASURED QUANTITY VALUE FOR RSRQ

Range (dBm)	Telkomsel	XL	IM3	Category
-10 to -3	273	457	649	Excellent
-12 to -10	102	43	114	Good
-14 to -12	49	0	103	Fair
-17 to -14	24	41	0	Poor
-20 to -17	12	0	0	Very Poor
Sum	460	541	866	

TABLE XII. MEASURED QUANTITY VALUE FOR SNR

Range (dBm)	Category	Telkomsel	XL	IM3
10 to 30	Excellent	396	384	650
3 to 10	Good	64	146	199
0 to -3	Fair	0	11	17
-20 to -3	Poor	0	0	0
	Sum	460	541	866

The "Table XI" shows the KPIs for RSRQ experience for each mobile network operator, obtained of 273 points in the excellent category for Telkomsel, 457 points for XL and 649 points for IM3. The best deviation of Telkomsel operators is -6 dBm and the worst is -19 dBm. The best point of the XL operator is -7 dBm, the worst is -15 dbm, and for the best point of the IM3 operator is -5 dBm, the worst is -13 dbm. From these results, it is explained that IM3 operators have better RSRQ service coverage performance than the network performance of XL and Telkomsel operators. Evaluation of mobile network operator's for SNR experiences based on measurement results and adjusted to KPI, is shown in "Table XII" for SNR performance value. "Table XII" shows the KPIs for SNR experience for each mobile network operator, obtained of 396 points in the excellent category for Telkomsel, 384 points for XL and 650 points for IM3. The best deviation of Telkomsel operators is 28.60 dBm and the worst is 5.8 dBm. The best point of the XL operator is 23 dBm, the worst is -3.4 dbm, and for the best point of the IM3 operator is 28 dBm, the worst is -1.4 dbm.

Measurement of the 4G LTE signal to 3 mobile network operators generally changes in value during measurement. Changes in the RSRP, RSRQ or SNR values by environmental conditions in the measurement location area such as trees and buildings along the area become an obstacle causing the 4G LTE network performance to change, and including the distance of the enodeB and User Equipment. Another effect is based on observations by network traffic and the number of service users of each operator, we observe that IM3 operators are better than XL and Telkomsel operators because the number of IM3 service users in the area is small when compared to Telkomsel operator users.

The Weak RSRP, RSRQ, and SNR values obtained at a point have experienced a decrease in signal strength, this is due to the propagation loss that occurs. The presence of buildings or buildings, tree heights, network density and weather causes propagation such as reflection, diffraction and scattering. In addition, the distance from the transmitter to the receiver is also a factor that causes a decrease in the signal strength received from the user's device or UE. Therefore, analysis of the performance of the 4G LTE network is needed as an action to monitor the quality of the existing network. The results of the analysis can be used as a reference for further optimization actions and are needed to support the improvement of the 4G LTE network by service providers so that users can experience satisfactory 4G LTE network services.

CONCLUSION

Observing the experience of implementing mobile technology from 1G to 4G in Indonesia which is always late, so that in the face of the era of 5G mobile technology that is expected to be implemented, a 4G LTE experience measurement evaluation study was conducted to see how network performance in the Kalimantan Region, Indonesia. In particular, the evaluation of user experience related to the quality of video streaming against the parameters of RSRP quality, RSRQ quality and noise ratio (SNR) on three mobile network operator services. The evaluation results of user experience on the quality parameters of RSRP, RSRQ and SNR on three mobile network operator services in one city in Kalimantan show differences in performance values. There are differences in the value of the measurement results and analysis of the three operators when viewed from external factors due to the operator's 4G network service coverage, the distribution of BTS positions, the demographics of service users in all areas, as well as the topography of the area around the BTS of each operator. That the quality of service parameter values of mobile operators can be different for each network, even though they are in the same service area. In the future, further action is needed for further planning for development in network optimization in order to improve services, based on field data from service performance analysis.

ACKNOWLEDGMENT

Thanks to the dept. of Informatics Faculty of Engineering for the financial support of research that comes from the Higher Education Operational Assistance Fund (BOPTN) Mulawarman University, Indonesia.

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