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Analysis of 2G and 4G Network Quality in Solok City

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ABSTRACT

Gunung Talang, Twin Lake, Gumanti Valley, Hiliran Gumanti and Pantai Cermin sub-districts in Solok Regency, which are dominated by hills and trees, are the cause of unstable signal quality, causing complaints from the public regarding this. So this study is to determine the network quality in Gunung Talang District, Twin Lakes, Gumanti Valley, Hiliran Gumanti, and Pantai Cermin on Telkomsel, XL and Indosat Operators. Checking is carried out using the *drive test* method using TEMS *Pocket* on 2G and 4G networks.

The quality of the 2G network from the measurement results was obtained for RxLevel all operators was bad and for RxQual was good except for Telkomsel operators. Meanwhile,on the 4G network, measurement results for RSRP and SINR for all operators are bad. Some areas that have problems are recommended for optimization, site passenger and site addition. All of this happens because of obstacles in the form of hills, cliffs, and tall trees at some point. From the results of the study, the quality of the Telkomsel operator's 4G network has an RSRP value of 46.16% and SINR of 61.06%. XL operators have an RSRP value of 42.7% and SINR which is 60.74%.Meanwhile, Indosat Ooredoo has an RSRP value of 43.2% and SINR of 74.6%. As for the 2G network, the quality of Telkomsel's 2G network operator has an RxLevel value of 47.8% and RxQual of 89.49%. XL operators have an RxLevel value of 58.34% and RxQual of 77.62%.Meanwhile,Indosat Ooredoo has an RxLevel value of 46.16% and RxQual is 80.56%.

INTRODUCTION

Gunung Talang, Twin Lake, Gumanti Valley, Hiliran Gumanti and Pantai Cermin sub-districts are 5 sub-districts out of 14 sub-districts located in Solok Regency. Judging from the geographical location and current condition of the region, these 5 districts are included in rural areas, because the area is dominated by hills and trees. This will be the cause of weak signals in the 5 sub-districts.From rural characteristics, adequate network connectivity is needed in the area. For this reason, testing is needed to determine the quality of the network in the area. So in this problem the author conducted field testing using *TEMS pocket. TEMS Pocket* is a mobile network diagnostic tool embedded into a mobile phone. *TEMS Pocket* can measure the performance of data transmission during downlink and uplink.

This research uses 2G and 4G networks on Telkomsel, XL and Indosat operators by focusing on *coverage* and *quality* parameters. According to the Ministry of Technology, 2G is a digital cellular communication technology. GSM technology is widely applied to mobile communications, especially mobile phones. 4G technology will allow an individual to have direct access to specific location services that offer information about demand at high speed and low cost.In this regard, the proposed research and study needs are expected to be facilitated by the Padang State Polytechnic according to the available areas of expertise.

LITERATURE REVIEW

Second Generation Technology (2G)

The second generation (2G) of cellular systems was developed to correct the weaknesses found in 1G cellular systems. In 2G this system has used digital modulation, multiple access techniques, and power control (*power control*) which can improve system performance. GSM system architecture consists of three subsystems that interconnect and interact with each other, as well as with their users, through network interfaces. Each of these subsystems is the *Base Station System (BSS)*, Network Switching *System (NSS), and* Operation & Maintenance System *(OMS)*. (Lingga Wardhana, 2011).

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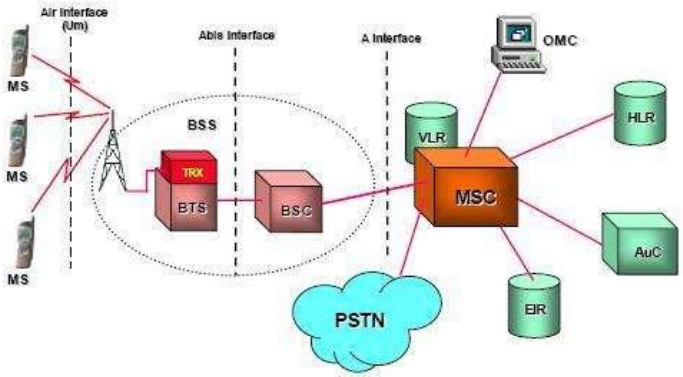

Figure 1. 2G GSM architecture

Base Station System (BSS)

BSS is part of the network that provides interconnection from MS to basic switching equipment. BSS consists of three devices, namely:

1. Base Station Controller (BSC)
   BSC oversees one or more BTS and manages traffic coming and going from BSC to MSC or BTS. BSC also regulates radio source management in assigning frequencies to each base station and regulates handover.
2. Base Transceiver Station (BTS)
   BTS is a transmitting and receiving device that provides radio services to MS. In BTS there are traffic channels used for communication.
3. Transcoder
   Transcoder serves for MSC translation from 64 Kbps to 16 Kbps and also traffic channel efficiency.

***Network Switching System* (NSS)**

NSS functions as *switching* on GSM networks, network management and as *an interface* between GSM networks and other networks. NSS components on GSM networks consist of:

1) *Mobile Switching Center* (MSC)
   The MSC is designed as *an Integrated Service Digital Network* (ISDN) switch modified to work for cellular networks. MSCs can also connect cellular networks with *fixed networks*.
2) *Home Location Register* (HLR)
   HLR is a *database* that contains fixed customer data. These data include: customer service, additional services, and information about the latest customer location (*update*).
3) *Visitor Location Register* (VLR)
   VLR is a *database* that contains temporary information about customers, especially about the location of customers in the network coverage area.
4) *Authentication Center* (AuC)
   AuC contains *a database* that stores confidential information stored in code format. AuC is used to control legitimate network usage and prevent fraudulent customers.
5) *Equipment Identity Register* (EIR)
   EIR is a centralized *database* that functions for International *Mobile Equipment Identity* (IMEI) validation.
6) *Inter Working Function*
   Inter Working Function functions as *an interface* between GSM networks and ISDN networks.
7) *Echo Canceller*
   Echo Canceller is used for connection with PSTN, serves to reduce echo

***Operation & Maintenance Centre* (OMS)**

This section of the OMS allows *network* providers to establish and maintain networks from a central location.

1) *Operation and Maintenance Centre* (OMC)
   OMC as a network operation and maintenance control center. Its main function is to supervise device alarms and repair of operating errors.
2) *Network Management Centre* (NMC)
   NMC serves to control the operation and maintenance of networks larger than OMC.

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***Fourth Generation Technology*(4G)**

Long Term Evolution (LTE) is the name given to a project within The Third Generation Partnership Project (3GPP). This technology is a pre-4G technology defined in the 3GPP standard release 8. LTE supports speeds of up to 100 Mbps for downlink and 50 Mbps for uplink on 20 MHz bandwidth channel . Based on its advantages, LTE is supported by OFDMA (Orthogonal Frequency Division Multiple Access) technology for downlink direction, then SC-FDMA (Single Carrier Frequency Division Multiple Access) technology for uplink direction to achieve higher data rates and maximum and efficient bandwidth usage. The development of cellular telecommunications technology has grown from the first generation (1G) to the third generation (3G), even now it has been developed into the fourth generation (4G). (Efriyendro &; Rahayu, 2017)

LTE architecture is known as SAE (System Architecture Evolution) which describes an architectural evolution compared to previous technologies. Overall, LTE adopts EPS (Evolved Packed System) technology. Inside there are three important components, namely UE (User Equipment), E-UTRAN (Evolved UMTS Terrestial Radio Access Network), and EPC (Evolved Packed Core). LTE architecture consists of two main parts, namely LTE itself which is also known as E-UTRAN (Evolved UMTS Terrestial Radio Access Network), and SAE (System Architecture Evolution) (Ramadianty, 2018).

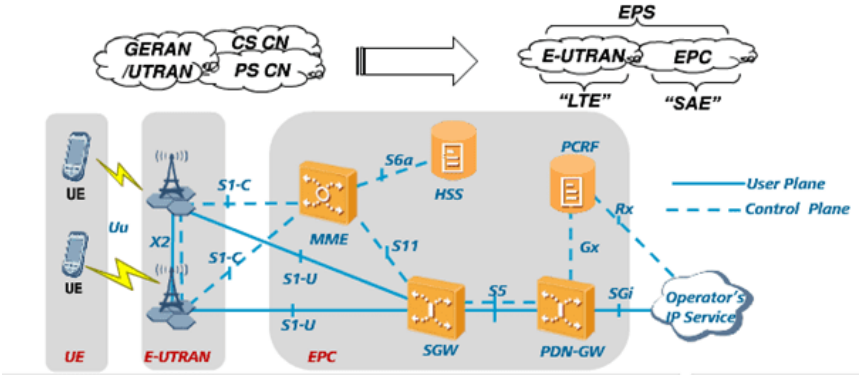

Figure 2. *4G LTE architecture*

Overall, LTE adopts EPS (Evolved Packet System) technology which is divided into three parts, namely: (Syaza Ibra Harlin, 2021)

1) ***User Equipment*** **(UE)**
   User Equipment (EU) is a user communication device. This device can be a mobile phone, computer, tablet, or smart device that can connect to the internet.
2) ***Evolved UMTS Terrestrial Radio Access Network*** **(E-UTRAN)**
   Evolved UMTS Terrestrial Radio Access Network or E-UTRAN is an LTE architecture with the ability to handle the radio access side of the EU to the core network, unlike traditional technology that separates *Node* B and RNC into separate elements in the LTE system. System. E-UTRAN is available with only one component, Evolved Node B (*eNodeB*), which combines both capabilities. Physically, *ENodeB* is an above-ground base station (*greenfield base station*) or on top of a building (rooftop base station). Each *eNodeB* is connected to the EPC via the S1 interface and can also connect to nearby base stations via the X2 interface. The X2 interface is mainly used for signaling and forwarding packets during handover. E-UTRAN systems can use OFDMA for *downlink*, SC-FDMA for uplink, and MIMO for up to four antennas per station per site.
3) ***Evolved Packet Core*** **(EPC)**
   Evolved Packet Core or EPC is a system where the core network uses All-IP. EPC provides core cellular functionality that in previous generations (2G, 3G) had two separate parts: *Circuit Switched (*CS) for voice and *Packet Switched* (PS) for data. EPC is essential for end-to-end IP delivery services over LTE. EPC consists of MME (*Mobility Management Element*), S-GW (Serving *Gateway), HSS (*Home Subscription Service*), PCRF (*Policy and Charging Rules Function*), and PDN-GW (*Packet Data Network Gateway*).*

Drive Test

Drive Test is a measurement of transmitter / BTS signal quality to MS / *mobile or* vice versa. *Drive Test* is a signal quality measurement carried out using vehicles in a relatively large area (*outdoor*). *Drive Test* aims to collect network information and measure signal quality in real time in the field. Measurement data from the desired area is collected using special *software* where *engineers* get RF *coverage* or identify problems that occur in the field and determine the solution of these problems (Ramadianty, 2018).

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Parameter Drive Test

Each 2G, 3G, and 4G network has its own parameters, there are several network quality parameters in the *drive test* , namely:

1. Parameters on 2G

In retrieving 2G network *drive test* data, the parameters are as follows:

a. Rx Level

Rx Level is the power level of signal strength received by MS in units (-dBm). The Rx Level value can be seen in the *drive test* when used when the test is used when MS is *idle* or *dedicated* (Widyastoro, 2015).

Signal Strength - Rx Level (dBm)		
Excellent		>= -70 and < 0
Very Good		>= -80 and < -70
Good		>= -90 and < -80
Fair		>= -95 and < -90
Poor		< -95

Figure 3. Reference Value Rx Level

b. Rx *Quality*

Rx Quality is the level of signal quality of the receiver at the Mobile Station. The greater the Rx Quality value indicates a bad value and indicates the bit error rate value of the signal in dedicated conditions is also very large. As a result, there is a disruption of cellular communication links. The Rx Quality value can only be known when MS is used in a dedicated method or in conditions of accessing communication needs (Widyastoro, 2015).

Quality - Rx Qual (dB)		
Excellent		<= 2 and >= 0
Good		<= 4 and > 2
Fair		<= 6 and > 4
Poor		> 6

Figure 4. Reference Value Rx Quality

2. Parameterson 4G

In retrieving 4G network *drive test* data, the parameters are as follows:

a. RSRP (*Reference Signal Received Power*)

RSRP is a parameter of the strength level of the received signal. *Power* from the *reference signal* or signal strength received in units of dBm. The longer the distance between *the site* and *the user, the smaller the RSRP received by the* user (Nuari,Usman& Hanuranto, 2021).

Signal Strength - RSRP (dBm)		
Excellent		>= -75 and < 0
Very Good		>= -85 and < -75
Good		>= -100 and < -85
Fair		>= -110 and < -100
Poor		<-110

Figure 5. Reference Value RSRP

b. SINR (*Signal to Interference Noise Ratio*)

SINR (*Signal to Interference Noise Ratio*) is a ratio of comparison between the main signal emitted with interference and *noise* arising or mixed with the main signal. The greater the SINR value, the better the signal quality

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(Yusnita, Saputra, & Chandra, 2019).

Figure 6. Reference Value SINR

***Key Performance Indicator* (KPI)**

KPI is a standard value that must be achieved from the results of data retrieval during the *drive test* so that it can be used as a guideline to determine whether network quality is as expected or still needs to be improved network quality. (Hikmaturokhman, 2013) (Kominfo, 2022)

Tabel 1. KPI Target dan Persamaan 2G dan 4G

Network	Parameters	Standart Parameter	Target	Equation
2G	RxLevel	≥ -85 dBm	80%	$\frac{Sample \geq -85}{Total\ Sample} \times 100\%$
	RxQual	≤ 3 dB	80%	$\frac{Sample \leq 3}{Total\ Sample} \times 100\%$
4G	RSRP	≥ -100 dBm	90%	$\frac{Sample \geq -100}{Total\ Sample} \times 100\%$
	SINR	≥ 5 dB	90%	$\frac{Sample \geq 5}{Total\ Sample} \times 100\%$

METHOD

The research was conducted in Gunung Talang District, Twin Lakes, Gumanti Valley, Hiliran Gumanti and Pantai Cermin District, Solok City, West Sumatra Province using the drive test method. Drive test measurement using TEMS Pocket application and drive test measurement mode with Drive *Test Dedicated Mode*. *Dedicated Mode* is a measurement of signal quality during the *upload/download* process. Measure and identify data quality. Custom mode is used to get RSRP, SINR, and *throughput values*.

Drive Test Device

In carrying out *the drive test* , several supporting applications are needed. Devices used in the form of *hardware* and *software* such as: Google Earth, Tems Pocket, and Tems Discovery.

Data Measurement

Before measuring the quality of 2G and 4G signals in Solok Regency, first design a Drive Test *for mapping the area to facilitate writing in the measurement process, after that the Drive Test data retrieval process* is carried out using TEMS *Pocket*, then measure Drive Test data using TEMS *Discoverry*, Here in figure 3.1 are the stages and research in measurement.

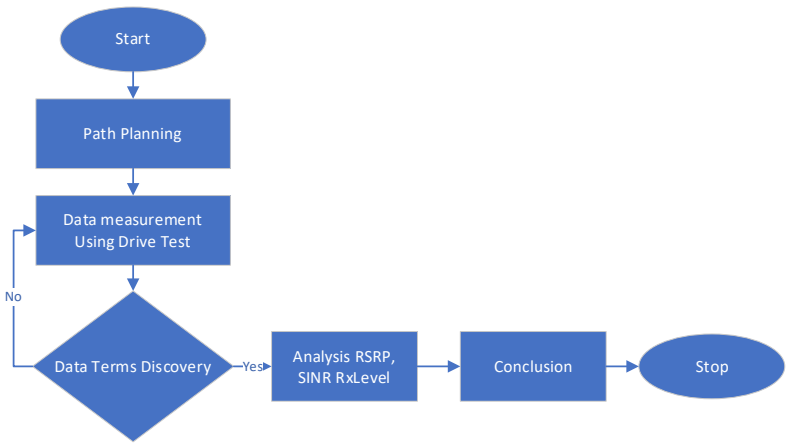

Figure 7. Measurement Stage

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Checking the quality of 2G and 4G signals on Telkomsel, XL and Indosat operators using the *Drive Test* method is carried out data collection starting from 09.35 – 22.10 WIB on August 27, 2022 in Solok Regency. The data generated from the measurements made can be in the form *of plotting* results or images.

Before taking *Drive Test* data, what must be done first is to plan the path that will be passed when doing a *drivetest*. In path planning using *Google Earth software*. *Google Earth* serves as a support for the existence of settlements in the area. The path taken is the area of Gunung Talang District, Twin Lake, Gumanti Valley, Hiliran Gumanti and Cermin Beach seen in figure 7 with a total path length of 82.4 km.

Figure 8. Alur Drive Test

RESULT

2G Measurement Results

1) Telkomsel

a. RxLevel

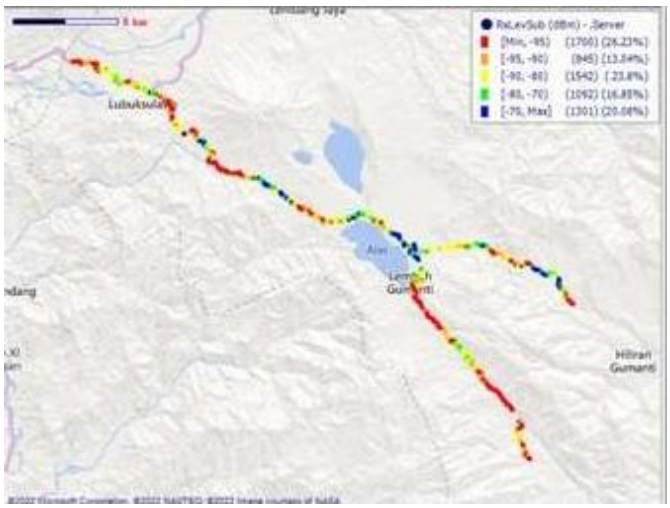

Figure 9. Plotting RxLevel Telkomsel

$$KPI\ RxLevel = \frac{3101}{6480} \times 100\% = 47{,}86\% \qquad (1)$$

From the calculation of the KPI target above, a sample standard of 3,101 was obtained with a percentage of 47.86% from 80%. This result certainly has not met the target set by Telkomsel operators and it can be said that this signal level is still categorized as poor.

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b. RxQual

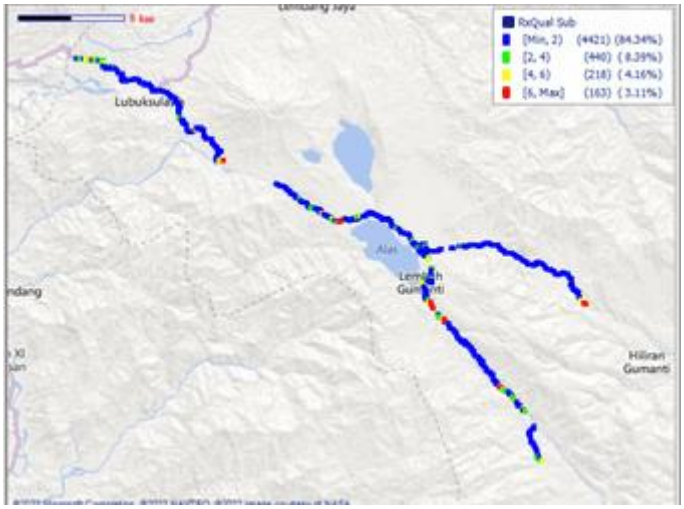

Figure 10. Plotting RxQual Telkomsel

$$KPI\ RxQual = \frac{4691}{5242} \times 100\% = 89{,}49\% \qquad (2)$$

From the calculation of the KPI target above, a sample standard of 4,691 was obtained with a percentage of 89.49% from 80%. This result certainly meets the target set by Telkomsel operators and it can be said that this signal level is categorized as very good.

2) XL

a. RxLevel

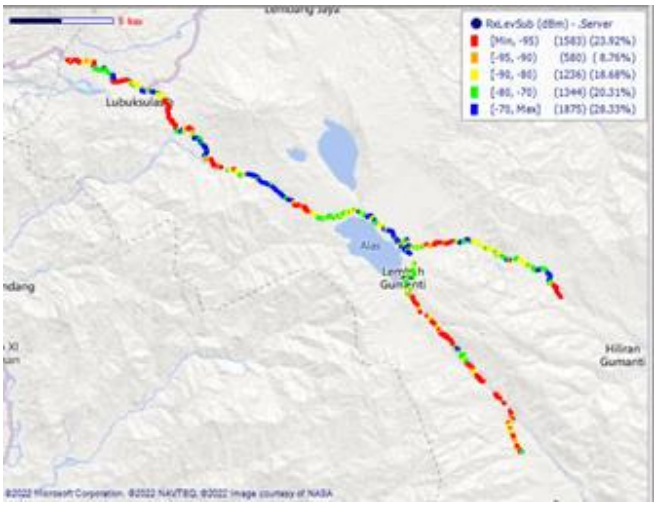

Figure 11. Plotting RxLevel XL

$$KPI\ RxLevel = \frac{3861}{6618} \times 100\% = 58{,}34\% \qquad (3)$$

From the calculation of the KPI target above, a sample standard of 3,861 was obtained with a percentage of 58.34% from 80%. This result certainly has not met the target set by XL operators and it can be said that this signal level is still categorized as poor.

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b. RxQual

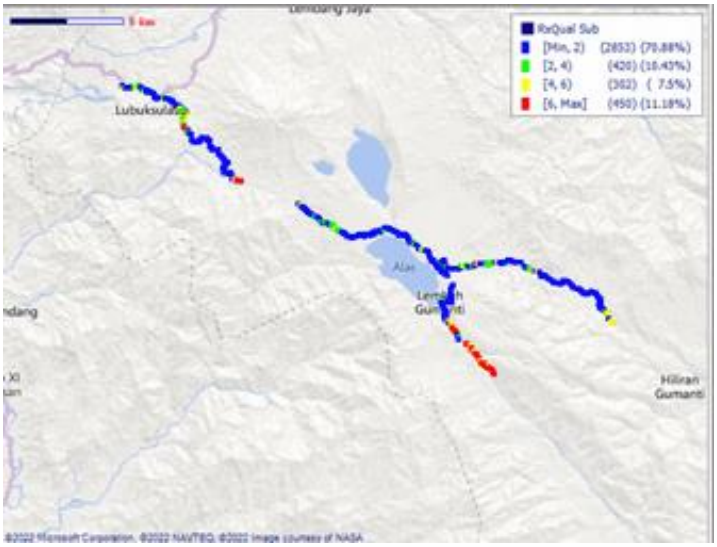

Figure 12. Plotting RxQual XL

$$KPI\ RxQual = \frac{3124}{4025} \times 100\% = 77{,}62\% \quad (4)$$

From the target KPI calculation above, a standard sample of 3,124 was obtained with a percentage of 77.62% out of 80%. This result certainly does not meet the target set by the XL operator and it can be said that this signal level is categorized as quite good.

3) Indosat

a. RxLevel

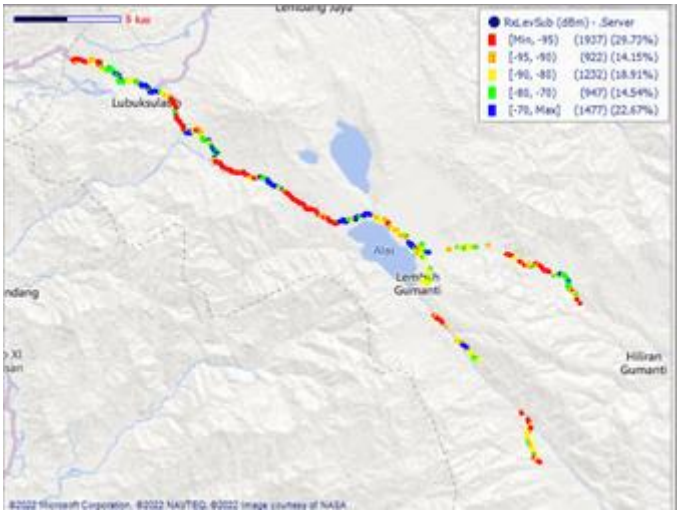

Figure 13. Plotting RxLevel Indosat

$$Nilai\ KPI\ RxLevel = \frac{3007}{6515} \times 100\% = 46{,}16\% \quad (5)$$

The KPI target calculation above obtained a sample standard of 3,007 with a percentage of 46.16% from 80%. This result certainly has not met the target set by Indosat operator and it can be said that this signal level is still categorized as poor.

b. RxQual

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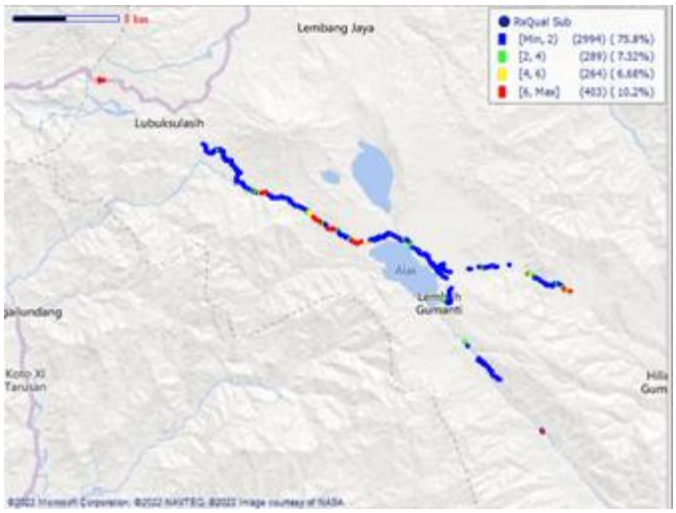

Figure 14. Plotting RxQual Indosat

$$Nilai\ KPI\ RxQual = \frac{3182}{3950} \times 100\% = 80{,}56\% \quad (5)$$

The calculation of the KPI target above obtained a sample standard of 3,182 with a percentage of 80.56% from 80%. This result certainly meets the target set by Indosat operator and it can be said that this signal level is categorized as good.

4G Measurement Results

1) Telkomsel

a. RSRP

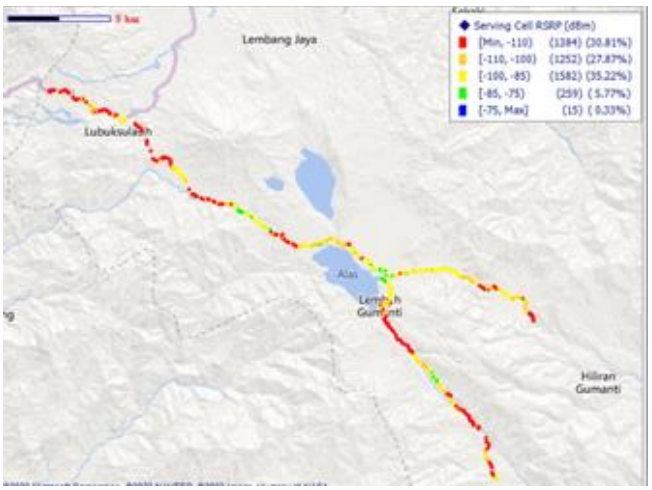

Figure 15. *Plotting* RSRP Telkomsel

$$Nilai\ KPI\ RSRP = \frac{1856}{4492} \times 100\% = 46{,}16\% \quad (6)$$

The calculation of the KPI target above obtained a sample standard of 1,856 with a percentage of 46.16% from 90%. This result certainly has not met the target set by Telkomsel operators and it can be said that this signal level is still categorized as poor.

b. SINR

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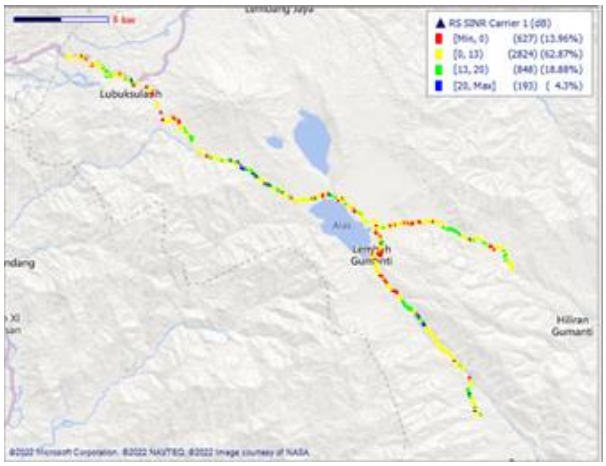

Figure 15. Plotting SINR Telkomsel

$$Nilai\ KPI\ SINR = \frac{2743}{4492} \times 100\% = 61{,}06\% \quad (7)$$

The calculation of the KPI target above obtained a sample standard of 2,743 with a percentage of 61.06% from 90%. This result certainly meets the target set by Telkomsel operators and it can be said that this signal level is categorized as poor.

2) XL

a. RSRP

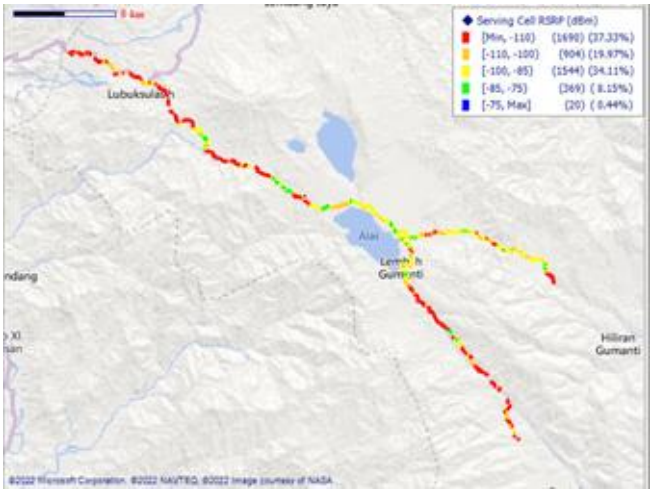

Figure 16. *Plotting* RSRP XL

$$Nilai\ KPI\ RSRP = \frac{1933}{4527} \times 100\% = 42{,}7\% \quad (8)$$

The KPI target calculation above obtained a sample standard of 1,933 with a percentage of 42.7% from 90%. This result certainly has not met the target set by XL operators and it can be said that this signal level is still categorized as very bad.

b. SINR

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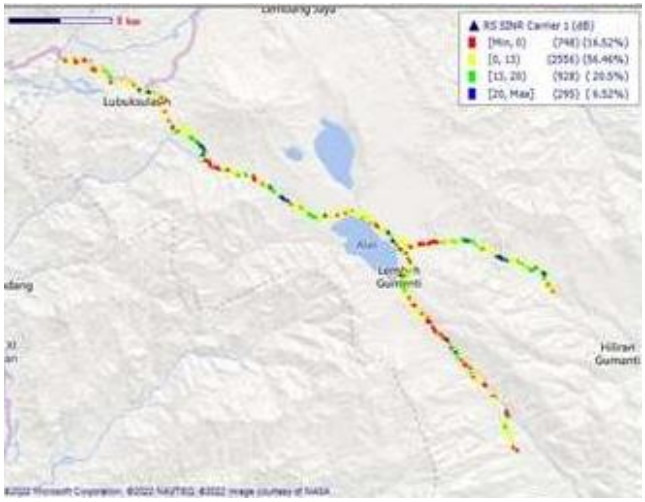

Figure17. Plotting SINR XL

$$Nilai\ KPI\ SINR = \frac{2750}{4527} \times 100\% = 60{,}74\% \quad (9)$$

The calculation of the KPI target above obtained a sample standard of 2,750 with a percentage of 60.74% from 90%. This result certainly meets the target set by the XL operator and it can be said that this signal level is categorized as bad.

3) Indosat

a. RSRP

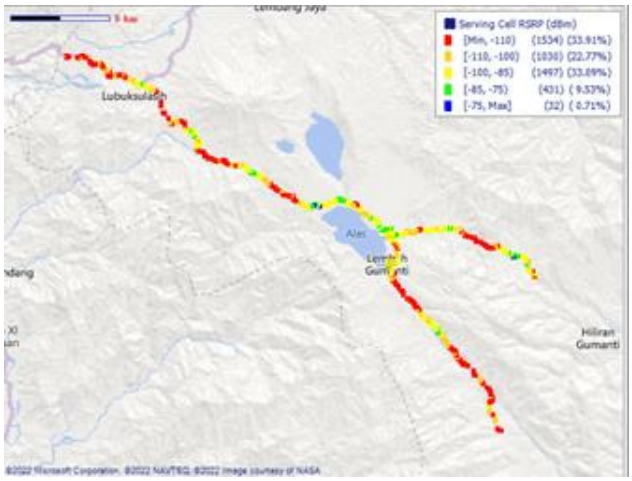

Figure18. *Plotting* RSRP Indosat

$$Nilai\ KPI\ RSRP = \frac{1960}{4524} \times 100\% = 43{,}32\% \quad (10)$$

The calculation of the KPI target above obtained a sample standard of 1,960 with a percentage of 43.32% from 90%. This result certainly has not met the target set by Indosat operator and it can be said that this signal level is still categorized as very bad.

b. SINR

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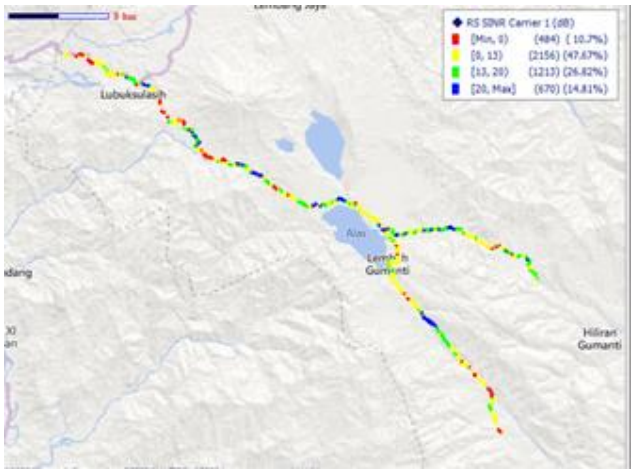


Figure 19. Plotting SINR Indosat

$$Nilai\ KPI\ SINR = \frac{3374}{4523} \times 100\% = 74{,}6\% \quad (11)$$

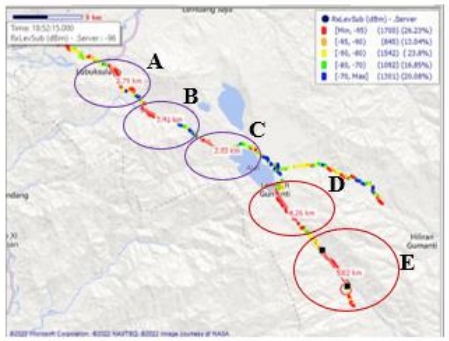
The KPI target calculation above obtained a sample standard of 3,374 with a percentage of 74.6% from 90%. This result certainly meets the target set by Indosat operator and it can be said that this signal level is categorized as poor.

DISCUSSION

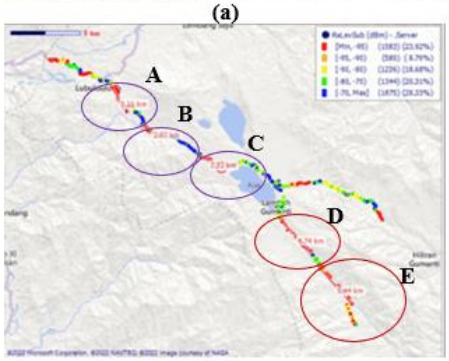
2G and 4G Network Analysis

1) 2G Network

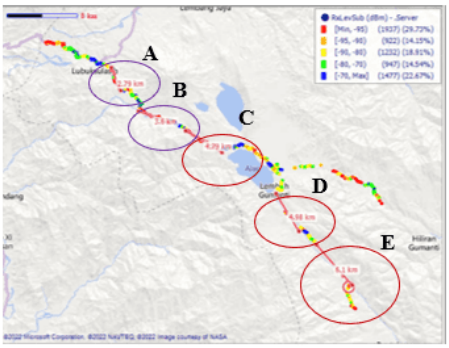
The results of plotting and calculations from RxLevel and RxQual based on KPI show that the three operators, namely Telkomsel, XL and Indosat, have poor signal strength power levels. As for the parameters describing the value of BER on these three operators are excellent. Here's figure 20 where the areas have poor RxLevels :



(a)



(b)



(c)

Figure20. (a) *Bad signal* 2G Telkomsel (b) *Bad signal* 2G XL (c) *Bad signal* 2G Indosat

Here are the new site recommendation coordinates for points D and E.

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Figure 21. RecommendedNew Site Position 2G

Table 2. Recommended New Site Position 2G

Site	Longitude	Latitude
D	100.786079°	-1.119992°
E	100.836646°	-1.172900°

2) 4G Network

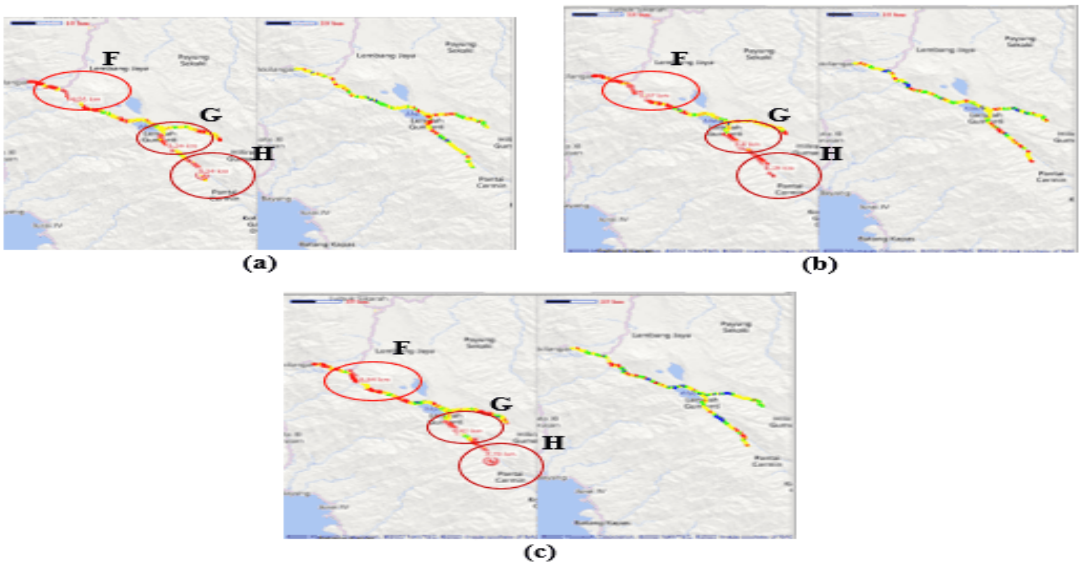

Figure 22. (a) *Bad signal* 4G Telkomsel (b) *Bad signal* 4G XL (c) *Bad signal* 4G Indosat

The results of plotting and calculations from RSRP and SINR based on KPI show that the three operators, namely Telkomsel, XL and Indosat, have weak signal strength, especially on XL and Indosat operators. As for the ratio of the ratio between the main signal emitted with interference and *noise* arising is bad. Figure 4.15 where the area has poor RSRP and SINR.

The new site is built based on *the bad signal* of 3 operators at the same point or region. The compared data are RSRP and SINR parameter values for 4G. For bad *signal* distances use a minimum limit of 2 km. The length of the *bad signal* area of the five regions found has a length above 2 km. Based on 3 bad *signal* points on Telkomsel, XL and Indosat operators, figure 23 allows the point to be built a new *site* with the following coordinate points:

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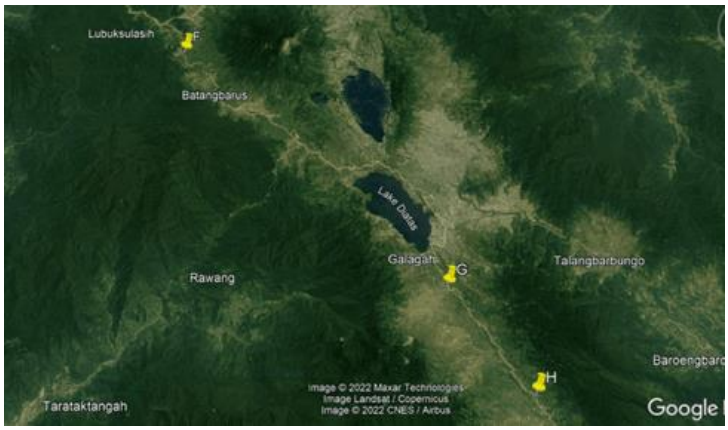

Figure 23. Recommended *New 4G* Site Position

Table 3 shows that points G and H on the new site recommendations for 4G networks are the same as the position of the new sites for 2G networks, namely at points D and E. This new *site* recommendation is only built one at one point of *recommendation sites* for Telkomsel, XL and Indosat operators as well as on 2G and *4G networks.*

Tabel 3. Rekomendasi Posisi *Site* Baru 4G

Site	**Longitude**	**Latitude**
F	100.615284°	-0.987741°
D/G	100.786079°	-1.119992°
E/H	100.836646°	-1.172900°

CONCLUSION

From the research entitled checking the quality of 2G and 4G networks in Solok Regency, the following conclusions can be obtained:

1. The quality of Telkomsel's 2G network operator has an RxLevel value of 47.8% and RxQual which is 89.49%. XL operators have an RxLevel value of 58.34% and RxQual of 77.62%. Meanwhile, Indosat Ooredoo has an RxLevel value of 46.16% and RxQual is 80.56%.
2. The quality of Telkomsel's 4G network has an RSRP value of 46.16% and SINR of 61.06%. XL operators have an RSRP value of 42.7% and SINR which is 60.74%. Meanwhile, Indosat Ooredoo has an RSRP value of 43.2% and SINR of 74.6%.
3. It is recommended for 2G networks to optimize points A, B and C on Telkomsel and XL operators, for point C on Indosat operators, site passengers are carried out on Telkomsel or XL operator sites. Points D and E on these three operators were added new *sites.* As for the 4G network, points F, G and H are added *new sites with points G and H equal to points D and E on the 2G network. The addition of* other sites is at points I and J. Where the coordinates for each point are sites D/G (100.786079°, -1.119992°), *site* E/H (100.836646°), *site* F (100.615284°, -0.987741°), *site* I (100.899716°, -1.121880°), dan *site* J (100.920848°, -1.136059°)

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