

Quality Of Service Analysis on LTE Networks Time Division Duplex and Frequency Division Duplex Technology

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Abstract— Quality of service is a method of measuring a network and an attempt to determine the characteristics used to provide good service. The increasing use of mobile technology has a major impact on the development of technology and information. This development relates to the use of information and communication services that are tailored directly, practically, and effectively. In response to these problems, researchers are interested in conducting research by looking at the parameters of Time Division Duplex (TDD) technology at a frequency of 2300 MHz and Frequency Division Duplex (FDD) at a frequency of 900 MHz on download services. The results of service quality measurements on LTE networks are carried out in real-time in the field by comparing each QoS parameter against a predetermined path from the eNodeB point based on RSRP and SINR with different conditions. One of them is PCI 328 when RSRP conditions are measured - 80 dBm, throughput value is 9466.29 Kbps, latency 0.84 ms, jitter 0.028 ms, and packet loss 0%. Conversely, when RSRP conditions are measured - 100 dBm, throughput is 4084.16 Kbps, latency is 1.68 ms, jitter is 0.059 ms, and packet loss is 0.50%. One of them is PCI 328 when the SINR condition is measured at 20 dBm, the throughput value is 9074.99 Kbps, latency 0.86 ms, jitter 0.034 ms, and packet loss 0%. Conversely, when the SINR condition is measured at 12 dB, the throughput is 4239.58 Kbps, latency 0.88 ms, jitter 0.027 ms, and packet loss 0.03%.

Keywords— *Quality of Service, Wireshark, RSRP, SINR*

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I. INTRODUCTION

Wireless telecommunications networks (*wireless*) are currently growing very rapidly. The development of communication is marked by the development of mobile communication system technology starting from the first generation to the next generation, namely the latest technology of 4G or LTE networks (Farida & Hekso Yuniyanto, 2020).

Long Term Evolution (LTE) is a 4th generation (4G) technology invented and launched by the *3rd Generation Partnership Project* (3GPP) which is a combination of seven international telecommunications standardization development organizations. *Long Term Evolution* (LTE) is a representation of previous advances in cellular technology because it has a greater data access speed of up to 10 times compared to 3rd generation (3G) cellular technology. LTE is designed to transmit high-speed data and access multimedia services. Can send and access data in the form of *voice* and *video* at high speed because it has a *downlink speed* reaching 100 Mbps and an *uplink* reaching

50 Mbps (Fabian, 2021). The development of fourth-generation technology (4G) is expected to be enjoyed by all

circles of society, not only in urban communities but also in rural areas (Hardiyanto et al., 2020).

The number of internet users in Indonesia continues to increase from year to year. Based on the survey results of the Indonesian Internet Service Providers Association (APJII), internet users in Indonesia reached 215.63 million people in the 2022-2023 period.

This number increased by 2.67% compared to the previous period of 210.03 million users (*APJII: Indonesian Internet Users 215.63 Million in 2022-2023*, n.d.). Many internet users must be in line with good service quality, but there is a slow cell phone internet speed which is only around 6.8 Mbps.

II. METHOD

2.1 Research Methods

This LTE QoS analysis research uses qualitative, nonparticipator observative methods, namely by comparing each QoS parameter against a predetermined path from the *eNodeB* point. In this study, there were 2 technologies used,

namely LTE TDD (2300 MHz) and LTE FDD (900 MHz). The following is the research flow in Figure 1.

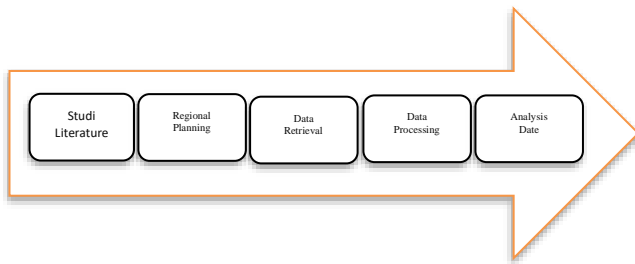


Figure 1 Research Flow.

The following data retrieval flowchart for the study is in Figure 2

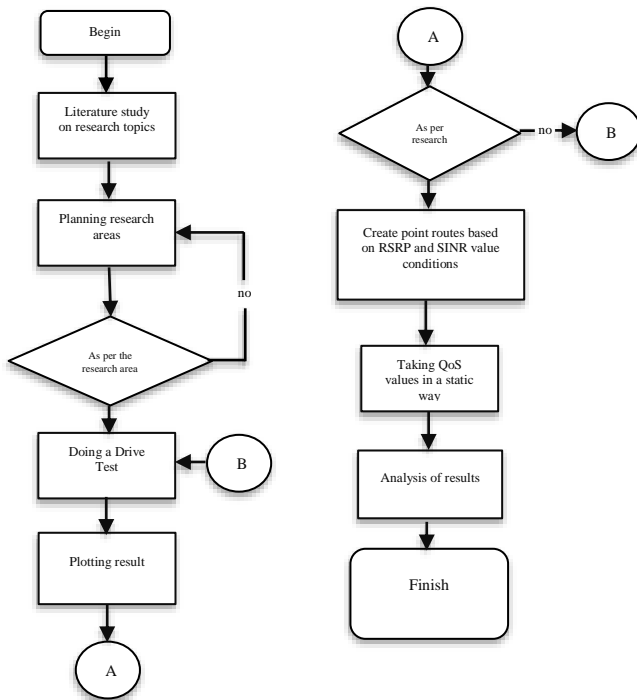


Figure 2 Data Retrieval Flowchart.

2.2 Student literature

In this study, the author first conducted a literature study on the research to be studied. This stage serves as a method to collect theoretical reference data relevant to the case or problem found. At this stage, a search is carried out for journals, descriptions, or Final Projects related to the title to be raised. Data search is also needed to support research, to strengthen existing arguments. This literature study is carried out by researchers after determining the research topic and determining the formulation. The studies obtained were discussed and used as a library in this study.

2.3 District Planning

At the regional planning stage, it serves as a determinant for researchers to examine areas that are by the problems to be studied. This regional planning itself has a function that is very

influential on data collection later because the area must be in accordance with what is studied.

This research needs to be done by taking real data in the field through a *driving test*. In conducting a *drive test*, route design is carried out, to find out how the condition of the research area. This route planning is done using *Google Earth* and *MapInfo Pro* software to see *site information*. This *software* is used in designing routes by paying attention to the condition of the path according to the display on *Google Maps* virtually. This research was conducted in the Jati sub-district, East Padang District, because in that area there is eNodeB which already supports both technologies, namely *Time Division Duplex* (TDD) at a frequency of 2300 MHz and *Frequency Division Duplex* (FDD) at a frequency of 900 MHz. The following is the data processing path in Figure 3.



Figure 3 Data processing path in Google Earth.

After conducting the driving test, based on the results of the plotting that is considered, namely the RSRP and SINR parameters, a location point route will be created for each RSRP and SINR condition on each PCI, to be taken by the author QoS values based on different RSRP and SINR conditions by static means using Wireshark software. Here's the QoS retrieval route in Figure 4.

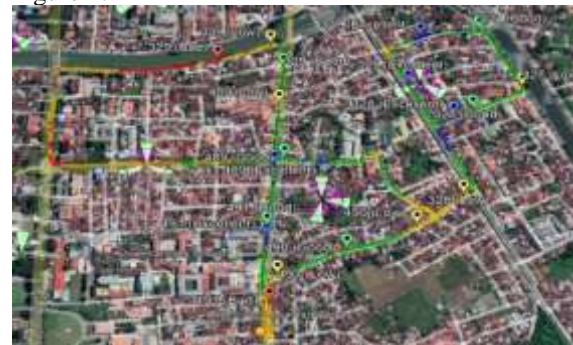


Figure 4 The route of the QoS pickup point at different RSRP conditions.

2.4 Data Retrieval

The data retrieval stage for the problem to be studied uses the *Drive test method*. Drive test data retrieval in this study using a *Samsung Galaxy S5* smartphone that has *TEMS Pocket software* installed serves for quality data retrieval and network determinants. The data that will be captured in the *TEMS Pocket* is RSRP (*Received Signal Reference Power*), and SINR (*Signal to Interference and Noise Ratio*). This data collection uses operators that use LTE FDD and LTE TDD, namely 900 MHz for LTE FDD and 2300 MHz for LTE TDD, operators that have both frequencies are Telkomsel operators. In taking

Quality of Service data using Wireshark the data to be observed is throughput, latency, and packet loss by paying attention to each KPI from RSRP (Received Signal Reference Power) and SINR (Signal to Interference and Noise Ratio).

2.4.1 TEMS Pocket Configuration

In this study using frequencies of 900 MHz and 2300 MHz, a clock frequency is needed on the TEMS Pocket. To lock the frequency of 900 MHz, it is necessary to lock band 8 and for lock frequency 2300 MHz a lock band 40 is needed as Figure 5. Therefore, it is important to survey the location beforehand, to ensure that both frequencies used are available at the research site.

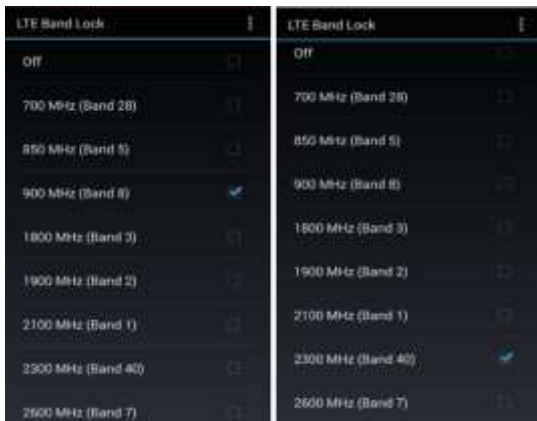


Figure 5 900 MHz and 2300 MHz lock band display.

2.4.2 TEMS Pocket Script Configuration

This study took a test drive using a download service, which was done by downloading data in real. The file used in the download is a file with a large enough size according to the route that has been designed.

Data download activities are carried out first before recording on the TEMS Pocket. This is because so that the data downloaded or uploaded runs well, so that when recording data on TEMS Pocket data has run without any data lacking along the research path. To record data on TEMS Pocket, click Start Logfile Recording, as Figure 6.

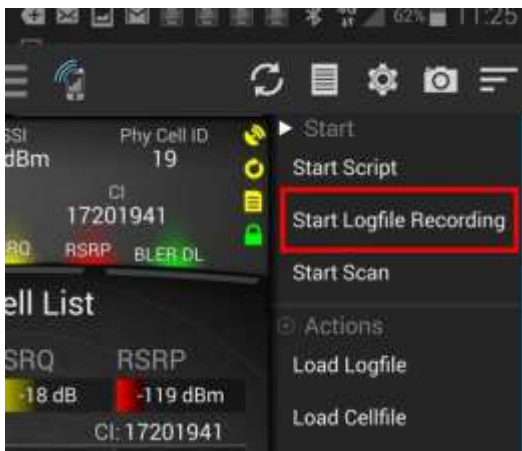


Figure 6 Record data on TEMS Pocket.

The logfile results obtained from the results of drive test data retrieval will be processed using TEMS Discovery software.

2.4.3 QoS Data Retrieval Using Wireshark

In this study, after a drive test, the logfile results will be analyzed for RSRP and SINR values as parameters comparing their effect on QoS parameters. Then the logfile results are imported into Google Earth to create a QoS value retrieval location point, which will be retrieved using Wire Shark software. Wireshark is a Network Packet Analyzer, The Network Packet Analyzer will try to capture network packets and display all the information in those packets in as much detail as possible. Wireshark can analyze data packets in real-time. This means that this Wireshark application will monitor all data packets that go in and out through the interface that has been specified by the user before to then display it (Fitria Rizqi Nurdiana, 2021). The following is a statistical display of one of the QoS capture points in Figure 7.



Figure 7 Capture statistics on Wireshark.

2.5 Data Processing

In the data processing process, the author uses TEMS Discovery software to process the data to be displayed and see the value of network quality and the value of service quality that has been taken. In this data processing process, the author sees the results and compares them with the predetermined performance indicator values. In this study, the parameters that will be processed using TEMS Discovery are RSRP and SINR. Therefore, it takes a range of parameters that become the Key Performance Parameter (KPI) standard for each Parameter.

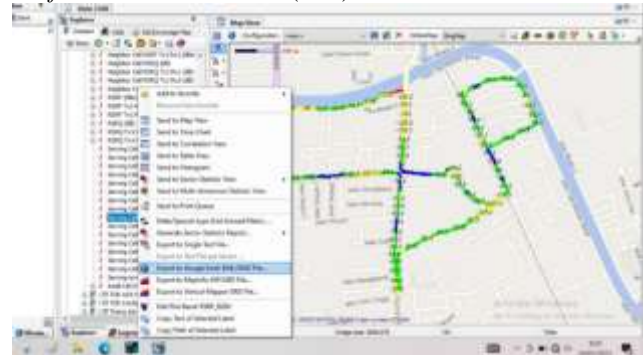


Figure 8 Data processing on TEMS discovery.

Figure 8 is the result of a log file imported into *Google Earth* to create a QoS value retrieval location point, which will be retrieved using *Wireshark software*.

2.6 Results Analysis

In the analysis of the results, a comparison was made between TDD and FDD technology on network quality and *Quality of Service values*, namely *throughput*, *latency*, and *jitter* by paying attention to each KPI value from RSRP and SINR parameters. So that the results of this study are in the form of data and recommendations to related providers to increase the value of their networks in the area.

III. Result and Discussion

Based on the measurement results in both technologies, namely *Time Division Duplex* at a frequency of 2300 and *Frequency Division Duplex* at a frequency of 900 using the *download* method at Telkomsel operators. In this discussion, a maximum of 4 points per sector were taken in 1 test site for each DT parameter, namely RSRP (Reference Signal Received Power) and SINR (Signal to Interference Noise Ratio) on the *Quality of Service value* and the effect of using LTE TDD and LTE FDD on *Quality of Service*.

3.1 The Effect of RSRP on Quality of Service

RSRP (Received Signal Strength Reference Signal Power) is a parameter used in cellular networks, especially in 4G LTE network technology, to measure the signal strength received by mobile devices from base stations (eNodeB in 4G LTE). RSRP is one of many factors that affect QoS in cellular networks. By paying attention to each KPI value of the measured RSRP value, namely in the *Excellent* range ($-80 \leq x$) dBm, *Good range* ($-95 \text{ dBm} \leq x < (-80) \text{ dBm}$), *Bad range* ($-110 \text{ dBm} \leq x < (-95) \text{ dBm}$) and *Bad* ($x < -110 \text{ dBm}$) (Chandra et al., 2021). Taking the QoS value using 2 software, namely *Wireshark software*, is used as a benchmark for the effect of RSRP on *throughput value*.

3.1.1 Effect of RSRP on Throughput at 2300 MHz



Figure 9 Results of RSRP data processing frequency 2300 MHz.

Figure 9 is the result of data processing, it can be seen that the RSRP results have reached 100%. Where *range bad* ($< -110 \text{ dBm}$) has a percentage of 1.09%, *range low* ($(-110) \text{ dBm} \leq x <$

$-95) \text{ dBm}$) has a percentage of 26.78%, *range good* ($-95) \text{ dBm} \leq x < (-80) \text{ dBm}$) has a percentage of 59.56%, and for *range excellent* ($(-80 \leq x) \text{ dBm}$) has a percentage of 12.57%. Each RSRP condition point will be used as a test point taken based on each KPI value from the measured value.

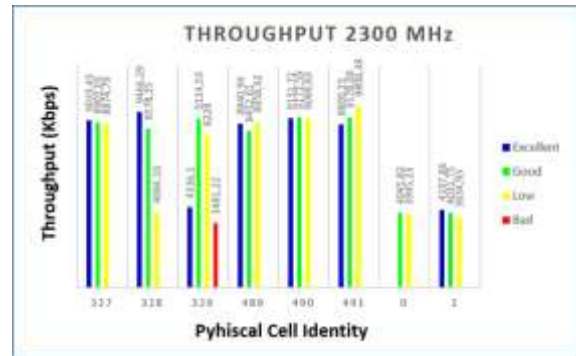


Figure 10 Diagram of how RSRP affects 2300MHz throughput.

In Figure 10 Based on the comparison diagram of the effect of RSRP value on one of the *Quality of Service parameters*, namely *throughput* at a frequency of 2300 MHz. The comparison is based on each test point taken based on each KPI value from the measured RSRP value. It is proven that on PCI 327, 328, 490, and 491 any change in RSRP value whether it is up or down affects the throughput speed.

However, on PCI 329, 489, and 491 some RSRP conditions do not affect throughput speed. In PCI 329 the *throughput* value at RSRP *range excellent* ($-80 \text{ dBm} \leq x$) throughput speed is 4336.1 Kbps. In the *excellent* range, the *throughput* speed is lower than other *ranges* namely *range good*, *low*, and *bad*. In the *good* range the *throughput* value is 9114.53 Kbps, the *low* range throughput value is 8228 Kbps, and in the *bad* range is 3481.22 Kbps. In PCI 489 and PCI 491, it is the same as PCI 329 where some RSRP conditions do not affect throughput speed. A decrease in *low* throughput value in a good RSRP value occurs due to several things, namely interference that can reduce *throughput* even though the RSRP signal is strong. In addition, physical interference such as physical obstacles or weather conditions can interfere with signal and *throughput* speeds.

3.1.2 Effect of RSRP on Throughput at 900 MHz



Figure 11 Results of RSRP data processing frequency 900 MHz.

From Figure 11, namely the results of data processing, it can be seen that the RSRP results have reached 100%. Where *range bad* (< -110 dBm) has a percentage of 7.26%, *range low* (-110 dBm $\leq x < (-95)$ dBm) has a percentage of 34.16%, *range good* (-95 dBm $\leq x < (-80)$ dBm) has a percentage of 51.15%, and for *range excellent* ($-80 \leq x$) dBm) has a percentage of 7.43%.

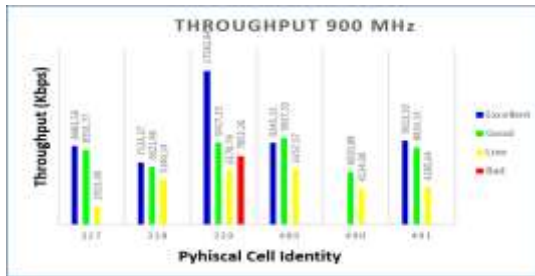


Figure 12 Diagram of how RSRP affects 900MHz throughput.

Based on figure 12 the comparison diagram of the effect of RSRP values on one of the *Quality of Service parameters*, namely *throughput* at a frequency of 900 MHz. The comparison is based on each test point taken based on each KPI value from the measured RSRP value. It is proven that on PCI 327, 328, 490, and 491 any change in RSRP value whether it is up or down affects the throughput speed.

However, in PCI 329 and PCI 489, some RSRP conditions do not affect *throughput speeds*. In PCI 329 the *throughput* value at the RSRP *range low* (-110 dBm $\leq x < -95$ dBm) is 6170.79 Kbps, the *throughput* speed is lower when compared to the *bad range* ($x < -110$ dBm) which is 7853.26 Kbps. In PCI 489, just like PCI 329, some differences in RSRP conditions do not affect throughput speed. PCI 489, at excellent *range* (-80 dBm $\leq x$) throughput speed is 9345.13 Kbps. The *throughput* value in the *excellent range* is lower when compared to the *low range* (-110 dBm $\leq x < -95$ dBm) which is 6357.57 Kbps. Decrease in *throughput* value low RSRP values occur due to several things, namely interference that can reduce *throughput* even though the RSRP signal is strong. In addition, physical interference such as physical obstacles or weather conditions can interfere with signal and *throughput speeds*.

3.1.3 Effect of RSRP on Latency, Jitter, and Packet Loss

Here's a diagram for *Latency*, *Jitter*, and *Packet loss* on the effect of RSRP at 900 MHz.

A. Latency frequency 900 MHz

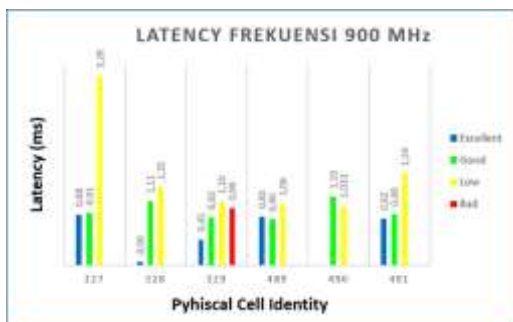


Figure 13 Effect of RSRP on FDD 900 MHz Latency.

Based on Figure 13, a comparison diagram of the effect of RSRP values on one of the *Quality of Service parameters*, namely *latency* at a frequency of 900 MHz. It is proven that in PCI 327, 328 and 491 every change in the RSRP value, both up and down, affects the latency or *delay*.

However, in PCI 329 and PCI 489, some RSRP conditions do not affect *latency*. In PCI 329 the *latency* value in the low RSRP *range* (-110 dBm $\leq x < -95$ dBm) is 1.10 ms, the *latency* is higher when compared to the *bad range* ($x < -110$ dBm) which is 0.99 ms. In PCI 489, just like PCI 329, some differences in RSRP conditions do not affect the size or absence of *latency* that occurs. PCI 489, in the *excellent range* (-80 dBm $\leq x$) *latency* is 0.85 ms. The *latency* value in the *excellent range* is lower when compared to the *low range* (-110 dBm $\leq x < -95$ dBm) which is 0.80 ms.

RSRP measures the strength of the cellular signal received by the device, but latency is the delay in data transmission between your device and the cellular network. Some common causes of high latency in RSRP should either be congested cellular networks or many users being in the same cell at the same time, this can result in network congestion and increased latency. In addition, overall network quality is poor, with a lot of interference or interference that can be the cause of latency.

B. Jitter Frequency 900 MHz

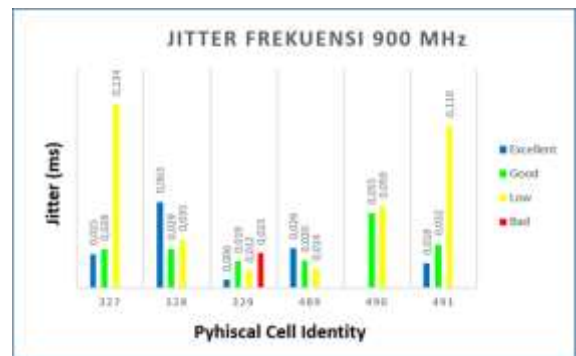


Figure 14 Effect of RSRP on FDD 900 MHz Jitter

Figure 14 is a comparison diagram of the effect of RSRP values on one of the *Quality of Service parameters*, namely *jitter* at a frequency of 900 MHz. From a comparison based on each test point taken based on each KPI value from the measured RSRP value. It is proven that in PCI 327, 490, and 491 any change in the RSRP value both up and down affects the presence of *jitter*.

However, in PCI 328 and PCI 329, some RSRP conditions do not affect *jitter*. In PCI 328 the *jitter* value at the RSRP *range excellent* (-80 dBm $\leq x$) is 0.0627 ms, the *jitter* is higher when compared to the *low range* (-110 dBm $\leq x < -95$ dBm) which is 0.0350 ms. In PCI 329, just like PCI 328, some differences in RSRP conditions do not affect the size or absence of *jitter* that occurs. PCI 329, in the *good range* (-95 dBm $\leq x < -80$ dBm) *jitter* is 0.0193 ms. The *jitter* value in the *excellent range* is lower when compared to the *bad range* ($x < -110$ dBm) which is 0.0252 ms.

A *jitter* is a variation in the delay in sending data packets coming from the network. This could result in instability in voice call quality or data service quality. *Jitter* and RSRP are two different parameters in the context of mobile networks, and

they can affect the quality of your mobile experience, but they have no direct relationship to each other. But *jitter* is very related to *delay* because *the jitter* is a variation of a *delay* that occurs. Although a good RSRP (Reference Signal Received Power) indicates strong signal strength, several factors can cause high jitter on cellular networks. One of the causes is Network Congestion i.e. cellular networks are too crowded with users, high data traffic can cause delays in data transmission and increase jitter.

C. Packet loss Frequency 900 MHz

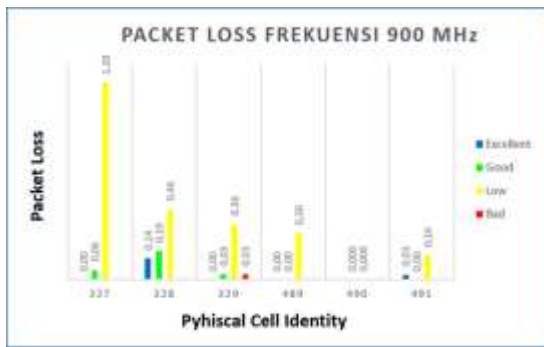


Figure 15 Effect of RSRP on FDD 900 MHz Packet Loss

Figure 15 is a comparison diagram of the effect of RSRP values on one of the *Quality of Service parameters*, namely *packet loss* at a frequency of 900 MHz. Based on each test point each KPI value from the measured RSRP value. It is proven that in PCI 327, 328, 489, 490, and 491 any change in RSRP value both up and down affects *packet loss*. However, in PCI 329, some RSRP conditions do not affect *jitter*. At PCI 329 *the jitter* value at the RSRP range *excellent* ($-80 \text{ dBm} \leq x$) is 0.03 ms, the *jitter* is higher when compared to *the low range* ($-110 \text{ dBm} \leq x < -95 \text{ dBm}$) which is 0.03 ms. The occurrence of signal interference, even though the RSRP signal strength is strong, interference coming from other devices, buildings, or other sources of interference can cause interference with the signal and lost data packets. Then high jitter is the fluctuation in the arrival and exit time of data packets. Although RSRP may be strong, if there is high jitter, packets can arrive late or in the wrong order, which can result in packet loss.

D. Latency Frequency 2300 MHz

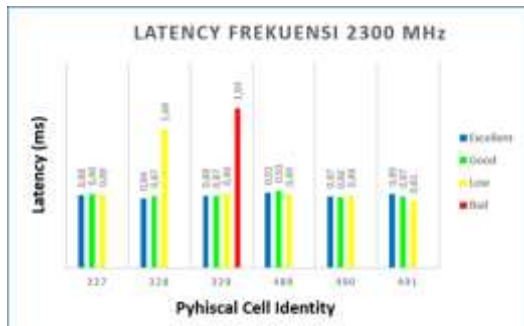


Figure 16 Effect of RSRP on TDD 2300 MHz Latency.

Based on Figure 16, the comparison diagram of the effect of the RSRP value on one of the *Quality of Service parameters*, namely *latency* at a frequency of 2300 MHz. The comparison

is based on each test point taken based on each KPI value from the measured RSRP value. It is proven that in PCI 327, 328, and 491 every change in the RSRP value, both up and down, affects latency or delay.

However, in PCI 489 and PCI 491, some RSRP conditions do not affect the amount or absence of *latency* that occurs. In PCI 489 the *latency value* in the *excellent range* RSRP ($-80 \text{ dBm} \leq x$) *latency* is 0.90 ms. The *latency value* in the *excellent range* is lower when compared to *the low range* ($-110 \text{ dBm} \leq x < -95 \text{ dBm}$) which is 0.89 ms. In PCI 491, just like PCI 489, some differences in RSRP conditions do not affect the amount or absence of *latency* that occurs. PCI 489, at *excellent range* ($-80 \text{ dBm} \leq x$) *latency* is 0.89 ms. The *latency value* in the *excellent range* is lower when compared to *the low range* ($-110 \text{ dBm} \leq x < -95 \text{ dBm}$) which is 0.81 ms.

RSRP measures the strength of the cellular signal received by the device, but latency is the delay in data transmission between your device and the cellular network. Some common causes of high latency in RSRP should either be congested cellular networks or many users being in the same cell at the same time, this can result in network congestion and increased latency. In addition, overall network quality is poor, with a lot of interference or interference that can be the cause of latency.

E. Jitter Frequency 2300 MHz

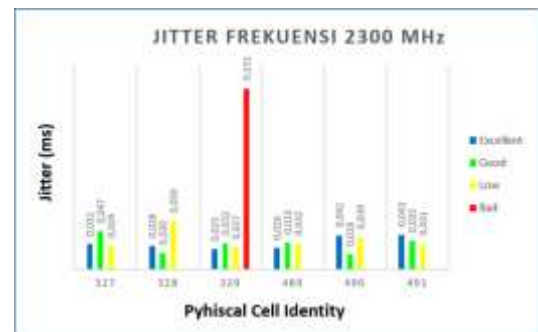


Figure 17 Effect of RSRP on 2300 MHz TDD Jitter

Based on Figure 17, the comparison diagram of the effect of RSRP value on one of the *Quality of Service parameters*, namely *jitter* at a frequency of 2300 MHz. The comparison is based on each test point taken based on each KPI value from the measured RSRP value. The jitter results obtained changes that occur messy or irregular. As in PCI 327, RSRP with *excellent range* ($-80 \text{ dBm} \leq x$) *jitter* is 0.0308 ms. The jitter value in the *excellent range* is lower when compared to *the low range* ($-110 \text{ dBm} \leq x < -95 \text{ dBm}$) which is 0.029 ms. So the jitter results at a frequency of 2300 MHz for changes in RSRP value do not affect the jitter value due to several factors. One of the causes is Network Congestion i.e. cellular networks are too crowded with users, high data traffic can cause delays in data transmission and increase jitter.

1. Packet Loss Frequency 2300 MHz

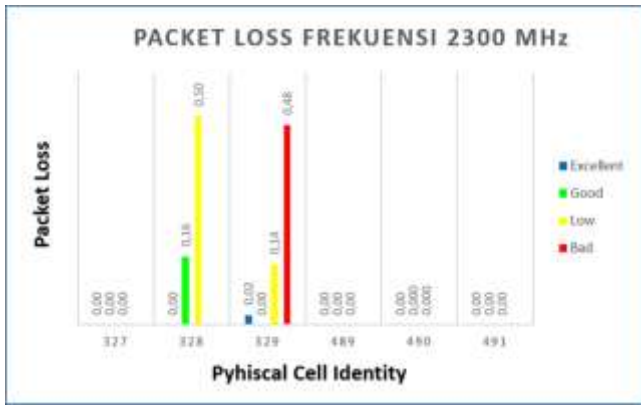


Figure 18. Effect of RSRP on TDD 2300 MHz Packet Loss

Based on figure 18, a comparison diagram of the effect of RSRP values on one of the *Quality of Service parameters*, namely *packet loss* at a frequency of 900 MHz. The comparison is based on each test point taken based on each KPI value from the measured RSRP value. It is proven that in PCI 327, 328, 489, 490, and 491 any change in the RSRP value whether it is up or down affects the presence of *packet loss*.

However, in PCI 329, some RSRP conditions do not affect *packet loss*. At PCI 329 *packet loss* value in the RSRP range *excellent* ($-80 \text{ dBm} \leq x$) which is 0.02%, *packet loss* is higher when compared to the range *good* ($-95 \text{ dBm} \leq x < -80 \text{ dBm}$) which is 0%. The occurrence of signal interference, even if the RSRP signal strength is strong, electromagnetic interference from other devices, buildings, or other sources of interference can cause interference with the signal and lost data packets. Then high jitter is the fluctuation in the arrival and exit time of data packets. Although RSRP may be strong, if there is high jitter, packets can arrive late or in the wrong order, which can result in *packet loss*.

3.1.4 Effect of SINR on Throughput at 2300 MHz



Figure 19 Results of SINR data processing frequency 2300 MHz.

Based on Figure 19, it can be seen that the RSRP results have reached 100%. Where the *range bad* ($x < 0 \text{ dB}$) has a percentage of 5.1%, the *range low* ($0 \text{ dB} \leq x < 13 \text{ dB}$) has a percentage of 41.89%, the *range good* ($13 \text{ dB} \leq x < 20 \text{ dB}$) has a percentage of 34.79%, and for *range excellent* ($20 \leq x \text{ dB}$) has a percentage of 18.21%.

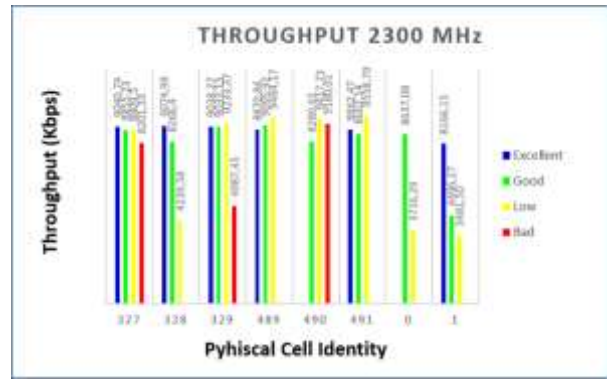


Figure 20. Diagram of the effect of SINR on 2300 MHz throughput

Based on the diagram in Figure 20, the comparison of the effect of the SINR value on one of the *Quality of Service parameters*, namely *throughput* at a frequency of 2300 MHz. The comparison is based on each test point taken based on each KPI value from the measured SINR value. It is proven that every change in the SINR value both up and down affects the *latency* and *packet loss* that occurs during the *download process*.

In both diagrams, it can be seen that if the SINR value decreases, the measured *throughput* value also decreases. As a sample on PCI 327, in the *Excellent* range ($20 \leq x$) dB) throughput value 9040.74 Kbps, *Good* range ($13 \text{ dB} \leq x < 20$) dB) throughput value 8855.23 Kbps and *low* range ($0 \text{ dB} \leq x < 13$) dB) throughput value 8809.3 Kbps. *Range Bad* ($x < 0$ dB)) throughput value 8201.33 Kbps.

The difference and change in *throughput* value at the frequency of 2300 MHz has a considerable difference in value although not significant for each point that occurs in PCI 327. Changes in *throughput* values that fluctuate due to interference or interference with the 4G signal can cause data packets to be retransmitted, which in turn can reduce overall throughput.

3.1.5 Effect of SINR on Throughput at 900 MHz



Figure 21. Results of SINR data processing frequency 900 MHz

From Figure 21, namely the results of data processing, it can be seen that the results of SINR have reached 100%. Where *range bad* ($x < 13 \text{ dB}$) has a percentage of 27.61%, *range low* ($0 \text{ dB} \leq x < 13 \text{ dB}$) has a percentage of 43.54%, *range good*

(13) dB ≤ x < (20) dB) has a percentage of 17.88%, and for range excellent (20 ≤ x) dB) has a percentage of 10.97%.

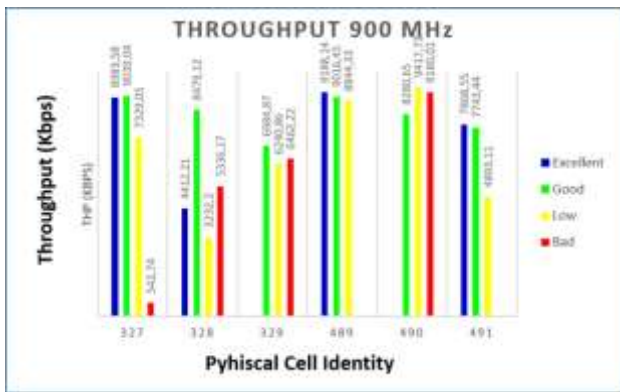


Figure 22 Diagram of the effect of SINR on 900 MHz throughput.

Based on the diagram in Figure 21 comparison diagram of the effect of the SINR value on one of the Quality of Service parameters, namely throughput at a frequency of 900 MHz. The comparison is based on each test point taken based on each KPI value from the measured SINR value. It is proven that on PCI 327, 489, and 491 every change in the SINR value whether it is up or down affects the throughput speed.

But in PCI 328, PCI 329, and PCI 490, some SINR conditions do not affect throughput speed. In PCI 329 the throughput value at the SINR range low (0 dB ≤ x < 13 dB) is 6170.79 Kbps, the throughput speed is lower when compared to the bad range (x < - 110 dBm) which is 7853.26 Kbps. In PCI 489, just like PCI 329, some differences in SINR conditions do not affect throughput speed. PCI 489, at excellent range (20 ≤ x dB) throughput speed is 9345.13 Kbps. The throughput value in the excellent range is lower when compared to the low range (0 dB ≤ x < 13 dB) which is 6357.57 Kbps. A decrease in the low throughput value of a good SINR value occurs due to several things, namely interference that can reduce throughput even though the SINR signal is strong. In addition, physical interference such as physical obstacles or weather conditions can interfere with signal and throughput speeds.

3.1.6 Effect of SINR on Latency and Packet Loss

Here is a diagram for Latency, Jitter, and Packet loss on the effect of SINR at 900 MHz.

A. Latency Frequency 900 MHz

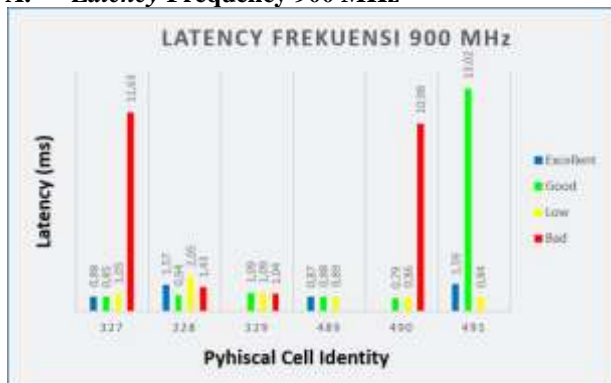


Figure 23 Effect of SINR on FDD 900 MHz Latency

Based on figure 23, the comparison diagram of the effect of the SINR value on one of the Quality of Service parameters, namely latency at a frequency of 900 MHz. The comparison is based on each test point taken based on each KPI value from the measured SINR value. It is proven that in PCI 327, 328, and 491 any change in the SINR value whether it is up or down affects the latency or delay.

However, in PCI 329 and PCI 489, some SINR conditions do not affect latency. In PCI 329 the latency value in the SINR range is low (0 dB ≤ x < 13 dB) which is 1.10 ms, and latency is higher when compared to the bad range (x < - 110 dBm) which is 0.99 ms. In PCI 489, just like PCI 329, some differences in SINR conditions do not affect the amount or absence of latency that occurs. PCI 489, in the excellent range (20 ≤ x dB) latency is 0.85 ms. The latency value in the excellent range is lower when compared to the low range (0 dB ≤ x < 13 dB) which is 0.80 ms.

SINR measures the strength of the cellular signal received by the device, but latency is the delay in data transmission between your device and the mobile network. Some common causes of high latency in SINR that should either congested cellular networks or many users in the same cell at the same time, this can result in network congestion and increased latency. In addition, overall network quality is poor, with a lot of interference or interference that can be the cause of latency.

B. Jitter Frequency 900 MHz

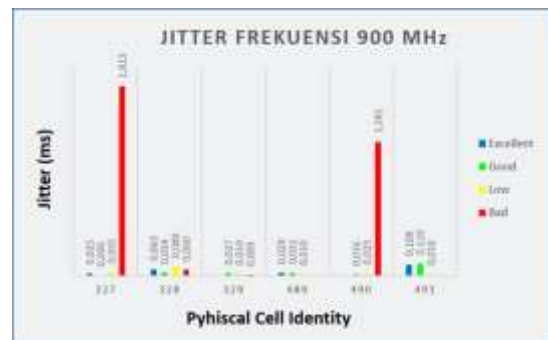


Figure 24. Effect of SINR on FDD 900 MHz Jitter

Based on figure 24, the comparison diagram of the effect of the SINR value on one of the Quality of Service parameters, namely jitter at a frequency of 900 MHz. The comparison is based on each test point taken based on each KPI value from the measured SINR value. It is proven that in PCI 327, 490, and 491 any change in the value of SINR both up and down affects the presence of jitter.

However, in PCI 328 and PCI 329, some SINR conditions do not affect jitter. In PCI 328 the jitter value at the excellent SINR range (20 ≤ x dB) is 0.0627 ms, the jitter is higher when compared to the low range (0 dB ≤ x < 13 dB) which is 0.0350 ms. In PCI 329, just like PCI 328, some differences in SINR conditions do not affect the magnitude or absence of jitter that occurs. PCI 329, at good range (13 dB ≤ x < 20 dB) jitter is 0.0193 ms. The jitter value in the excellent range is lower when compared to the bad range (x < 0 dB) which is 0.0252 ms.

A jitter is a variation in the delay in sending data packets coming from the network. This could result in instability in

voice call quality or data service quality. *Jitter* and SINR are two different parameters in the context of mobile networks, and they can affect the quality of your mobile experience, but they have no direct relationship to each other. But *jitter* is very related to *delay* because *the jitter* is a variation of a *delay* that occurs. Although a good SINR indicates strong signal strength, several factors can cause high *jitter* on cellular networks. One of the causes is Network Congestion i.e. cellular networks are too crowded with users, high data traffic can cause delays in data transmission and increase *jitter*.

C. Packet Loss Frequency 900 MHz

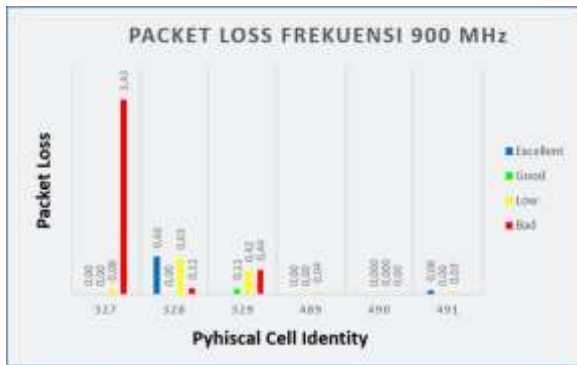


Figure 25 Effect of SINR on FDD 900 MHz Packet Loss

Figure 25 shows a comparison diagram of the effect of the SINR value on *packet loss* at a frequency of 900 MHz. Each test point is taken based on each KPI value from the measured SINR value. It is proven that in PCI 327, 329, 489, 490, and 491 any change in the SINR value both up and down affects the presence of *packet loss*.

However, in PCI 328, some SINR conditions do not affect *packet loss*. In PCI 329 the *packet loss* value at the excellent SINR range ($20 \leq x$ dB) is 0.66, *packet loss* is higher when compared to the *bad* range ($x < 0$ dB) which is 0.11. The cause occurs because high latency can cause *packet loss*. In addition, Network Congestion can also be a cause of *packet loss*, if the network is too dense with data traffic, *the router* or *switch* may not have enough capacity to send all data packets properly, which can cause *packet loss*.

D. Latency Frequency 2300 MHz

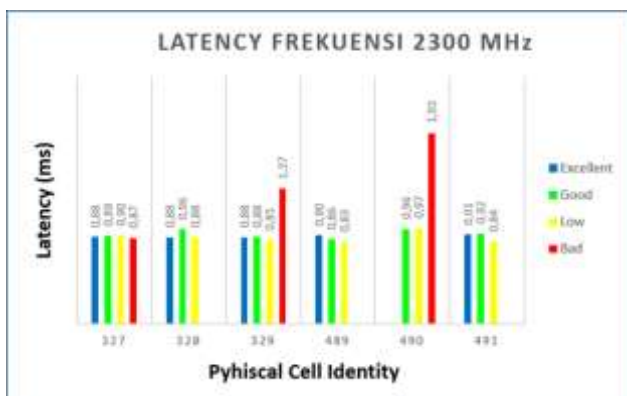


Figure 26 Effect of SINR on TDD 2300 MHz Latency

Based on figure 26, the comparison diagram of the effect of the SINR value on one of the *Quality of Service parameters*, namely *latency* at a frequency of 2300 MHz. From the comparison is based on each test point taken based on each KPI value from the measured SINR value. It is proven that in PCI 329, and 490 every change in the SINR value whether it is up or down affects the *latency* or *delay*.

However, in PCI 327, 328, 489, and 491, some SINR conditions do not affect *latency*. In PCI 327 the *latency* value in the excellent SINR range ($20 \leq x$ dB) is 0.88 ms, the *latency* is higher when compared to the *bad* range ($x < -110$ dBm) which is 0.87 ms. In PCI 489, just like PCI 329, some differences in SINR conditions do not affect the magnitude or absence of *latency* that occurs. PCI 489, in the *good* range ($13 \text{ dB} \leq x < 20 \text{ dB}$) with a *latency* value of 0.90 ms. The *latency* value in the *excellent* range is lower when compared to the *low* range ($0 \text{ dB} \leq x < 13 \text{ dB}$) which is 0.88 ms. Similarly, with data from other PCIs, several SINR conditions do not affect *latency*.

SINR measures the strength of the cellular signal received by the device, but latency is the delay in data transmission between your device and the mobile network. Some common causes of high latency in SINR that should either congested cellular networks or many users in the same cell at the same time, this can result in network congestion and increased latency. In addition, overall network quality is poor, with a lot of interference or interference that can be the cause of latency.

E. Jitter Frequency 2300 MHz

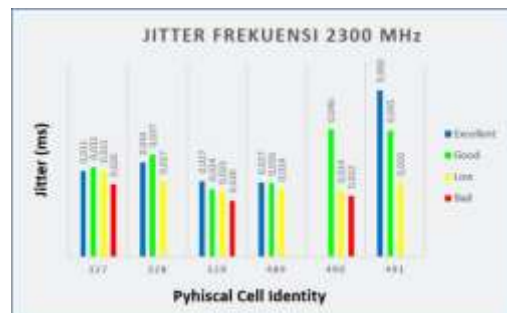


Figure 27 Effect of SINR on 2300 MHz TDD Jitter

Based on figure 3.19, the comparison diagram of the effect of the SINR value on one of the *Quality of Service parameters*, namely *jitter* at a frequency of 2300 MHz. The comparison is based on each test point taken based on each KPI value from the measured SINR value. Based on data at a frequency of 2300 MHz, every change in the SINR value both up and down affects the jitter starting from PCI 327, 328, 329, 489, 490, and 491. This happens because the jitter value does not affect the SINR changes made. The jitter value is very influential on the delay that occurs because the jitter itself is a variation of the delay.

In PCI 327 the *jitter* value in the excellent SINR range ($20 \leq x$ dB) is 0.0309 ms, *the jitter* is higher when compared to the *bad* range ($x < 0$ dB) which is 0.026 ms. In PCI 328, just like PCI 327, some differences in SINR conditions do not affect the magnitude or absence of *jitter* that occurs. PCI 329, at a *good* range ($13 \text{ dB} \leq x < 20 \text{ dB}$) *jitter* is 0.0368 ms. The *jitter* value in the *excellent* range is lower when compared to the *bad* range ($x < 0$ dB) which is 0.0271 ms. Similarly, with data

from other PCIs, several SINR conditions do not affect latency.

Jitter and SINR are two different parameters in the context of mobile networks, and they can affect the quality of your mobile experience, but they have no direct relationship to each other. But jitter is very related to delay because the jitter is a variation of a delay that occurs. Although a good SINR indicates strong signal strength, several factors can cause high jitter on cellular networks. One of the causes is Network Congestion i.e. cellular networks are too crowded with users, high data traffic can cause delays in data transmission and increase jitter.

F. Packet Loss Frequency 2300 MHz

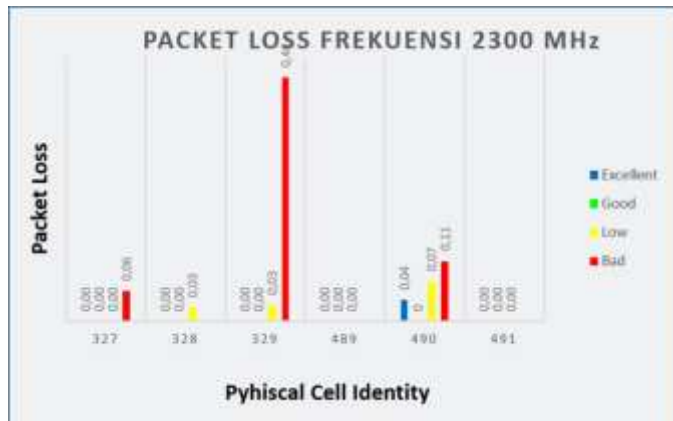


Figure 28 Effect of SINR on TDD 2300 MHz Packet Loss

Based on figure 28, the comparison diagram of the effect of the SINR value on one of the Quality of Service parameters, namely packet loss at a frequency of 2300 MHz. From the comparison is based on each test point taken based on each KPI value from the measured SINR value. It is proven that in PCI 327, 328, 329, 489, and 491 any change in the SINR value both up and down affects the presence of packet loss.

However, in PCI 490, some SINR conditions do not affect packet loss. In PCI 490 the packet loss value in the excellent SINR range ($20 \leq x$ dB) is 0.04, in the excellent range there is packet loss, and when compared with the good range ($13 \text{ dB} \leq x < 20 \text{ dB}$) which is 0 or no packet loss occurs at all. The cause occurs because high latency can cause packet loss. Latency is the time it takes for data to travel from one point to another on the network. Network congestion can also be a cause of packet loss although SINR may be good, if the network is too dense with data traffic, the router or switch may not have enough capacity to send all data packets properly.

3.2 Effect of LTE TDD and LTE FDD on Quality of Service

The effect of LTE TDD (2300 MHz) and LTE FDD (900 MHz) on Quality of Service is seen in the throughput results through drive test results.

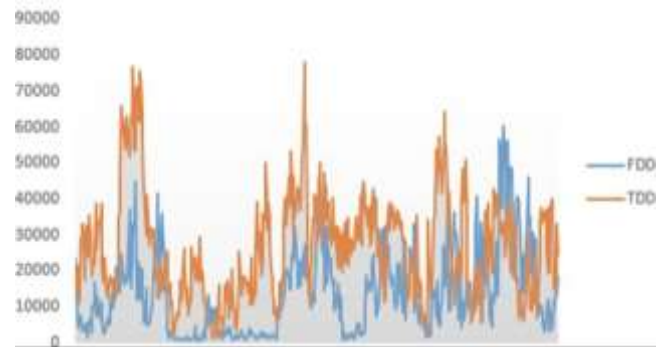


Figure 29. Comparison of FDD 900 MHz and TDD 2300 MHz

Based on Figure 29, which is a comparison graph of FDD and TDD, it can be seen that LTE TDD has a much better performance of download services and has a better probability than the LTE FDD network to maintain service as long as the user is still connected.

IV. CONCLUSION

From the analysis and discussion, the author can draw several conclusions, namely as follows:

The effect of RSRP on Quality of Service parameters in 2 different modulations is seen in each cell measured. One of them is on PCI 328 when the RSRP condition is measured at -80 dBm, the throughput value is 9466.29 Kbps, latency 0.84 MS, jitter 0.028 mms, and packet loss 0%. Conversely, when the RSRP condition is measured -100 dBm, the throughput is 4084.16 Kbps, latency 1.68 mms, jitter 0.059 mms, and packet loss 0.50%.

The effect of SINR on the Quality of Service parameter in 2 different modulations is seen in each cell measured. One of them is on PCI 328 when the SINR condition is measured at 20 dBm, the throughput value is 9074.99 Kbps, latency 0.86 MS, jitter 0.034 MS, and packet loss 0%. Conversely, when the SINR condition is measured at 12 dB, the throughput is 4239.58 Kbps, latency 0.88 MS, jitter 0.027 MS, and packet loss 0.03%. Based on the results obtained, the throughput value of LTE TDD has a better value on the download service. It has a better probability than the LTE FDD network to maintain the service as long as the user is still connected.

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