The Optimization of PCI Interference in the 4G LTE Network in Padang

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Abstract— With the growth of the customers and the expansion of the 4G LTE network in the area of Padang City, a PCI (Physical cell identity) modulo interference spot has been detected. PCI modulo interference occurs when an area is covered by two or more cells, which have a strong signal, and these cells have the same PCI modulo value. Based on the measurement results by the driving test method, the network conditions were not optimal because the SINR percentage (Signal to Interference Noise Ratio) in the good category was still low, at 9.47%, and the download throughput in the good category was 18.94%. This indicated that the interference in the area was quite high. Thus, it was necessary to do optimization action. The optimization action was taken by rotating the PCI on the site by considering the modulo value of each site so that the PCI with the same modulo did not merely lead to one location. Besides, action was taken to change the azimuth direction of cells that were too dominant. Based on the optimization process that has been carried out and the driving test activities that have been carried out again, the performance in the existing conditions has increased. The SINR percentage in the good category increased by 10%, so it became 19.47%, and the download throughput in the good category increased by 44.74% and became 63.68%.

Keywords—PCI modulo interference; driving test; optimization: LTE; RSRP.

I. INTRODUCTION

The Indonesian Cellular Telecommunications Association (ATSI) noted that the average data usage in 2014 was merely 0.3 gigabytes (GB) per month. This figure grew to 3.5 GB per month in 2018. In 2019, the estimated data consumption in Indonesia reached 4.8 GB, and it will continue to increase to 6 GB in 2021. Regarding these conditions, cellular telecommunications service providers must improve their wireless network capabilities by implementing network optimization and upgrading systems regularly, both software and hardware, for example, by adding eNodeB if customers in the area are too congested. EnodeB is an interface that connects the LTE (Long term Evolution) network with customers [1].

This is undertaken to ensure that all customers can be served properly. However, the addition of eNodeB to the LTE network in the city of Padang has indicated the presence of PCI modulo interference which results in a decrease in the value of KPIs such as SINR and Throughput Download [2]. Thus, it is essential to do optimization, namely the re-

allocation of the identity of the physical layer of the LTE network, namely PCI (Physical Cell Identity). PCI (Physical Cell Identity) has the function to provide identity to the site used to regulate the neighboring system of each cell so that interference does not occur, and the number is limited to 504 so that it is necessary to plan its use [3].

II. MATERIALS AND METHOD

LTE network optimization in Lestari [1] discussed the PCI collision and confusion conflicts. The measurement results showed a decrease in the KPI value, in which the average RSRP was -102 dBm, and the RSRQ was -16.11 dB, indicating a value below the threshold which should be above -100 dBm and -15 dB. Thus, optimization is needed, namely the PCI (Physical Cell Identity). The scenario used was PCI re-allocation based on the reuse distance of 1 km, 2 km, and 3 km according to the provision of Huawei vendor to achieve PCI numbering condition which is collision-free and confusion-free. The simulation results indicated that the optimization scenario for PCI allocation based on the reuse distance affects the quality of the KPI where the scenario of 3

km reuse distance meets the KPI target with a percentage of the RSRP value above -100 dBm of 85.61%, RSRQ above -15 dB of 88.24%, SINR above 10 dB of 83,297% and throughput above 20 Mbps of 85.07%. If the allocation distance is 2 km, which is the standard of vendor provisions to determine the PCI reuse allocation distance based on 2x the maximum radius of coverage, the increase of percentage for RSRP is 77.57%, RSRQ is 80.63%, SINR is 61.16%, and throughput is 73.57% that has not reached the KPI target. Thus, the reuse allocation distance of 3x the maximum radius of coverage is more suitable to be implemented in East Jakarta.

Ulfah [2] discussed PCI (Physical Cell Identity) as Long Term Evolution (LTE), the fourth-generation (4G) technology capable of providing downlink speeds of up to 100 Mbps and uplink of 50 Mbps. Interference is a signal whose presence in a telecommunication network is undesirable, has disturbing properties, and can reduce the performance of telecommunication networks, including 4G LTE technology. In this research, a comparison of the parameter values of a carrier to noise interference ratio (C / N + I) was conducted before and after the use of the Physical Cell Identity (PCI) method. From the research results, it was found that the C / (N + I) value without the PCI method was 5.08 dB and a large 5.14 dB when using PCI, so that there was a difference of 0.06 dB. Thus, it can be concluded that the use of Physical Cell Identity (PCI) increases the value of the C / (N + I) parameter.

PCI is a site identity in the form of a code number 0 to 503 [3]. The parameters observed in this research were the Reference Signal Received Power (RSRP) and Signal to Interference Noise Ratio (SINR). Using coverage prediction, which was a simulation with U-Net planning tools, it was found that 50% of the area covered in Yogyakarta had an RSRP from -99.17 dBm to -98.78 dBm and for Magelang, which was originally -96.51 dBm to -95 dBm. Meanwhile, the SINR in Yogyakarta increased from 1.03 dB to 1.18 dB on average, and in Magelang, it increased from 2.23 dB to 2.55 dB.

The intra-cell interference can be improved by Orthogonal Frequency Division Multiple Access (OFDMA), inter-cell inter-cell (ICI), which can cause throughput degradation and has a significant impact on Signal-to-Noise-Ratio (SINR) in the downlink (DL) [4]. Physical Cell ID (PCI) planning, based on the raw data extracted from the actual SISO system network and MATLAB simulation calculations. The experimental results showed that the Greedy algorithm does not only eliminate conflict and confusion, but it also reduces mod 3 interference by 26.213% more than the baseline schemes and much more than the 4.436% increase ratio given by the classic graph coloring algorithm.

PCI (Physical Cell Identity) is a cell identity configuration used to monitor each cell's neighboring device, corresponding to a special combination of PSS (Primary Synchronization Signals) and SSS (Secondary Synchronization Signals) [5]. To minimize interference and boost network performance, the design of PCI should be well designed. The issue of PCI allocation is poorly designed, leading to the risk of network conflict, suggesting that East Jakarta Collisions and Confusions decreased KPI performance. The KPI elements that affect the effective handover are the RSRP value (above -100 dBm) which is 80 percent, the RSRQ level (above -15 dB) which is 85 percent, the SINR level (above 10 dB) which is 80 percent and the throughput level (above 20 Mbps) which is 85 percent. This paper suggested the method and design of an Automated Physical Cell Identity Distribution that will be implemented in East Jakarta considering the algorithm of reuse distance. In order to achieve optimum efficiency for each cell to prevent collision and misunderstanding and to improve the KPI performance, this method and design has been randomly chosen based on the reuse distance. A simulation was therefore carried out to demonstrate the correlation between PCI re-allocation and KPI calculation, such as RSRP, RSRQ, SINR and Throughput.

Network management and maintenance are facing a number of challenges with the continuous growth of wireless networks, such as large network components, heterogeneous structures, and multi-vendors [6]. In response to this situation, the industry proposed the SON (Self-Organization Network) model, which is designed to make it easier and quicker to schedule, configure, manage, optimize and heal mobile radio access networks. ANR (Automatic Neighbor Relation) is one of the SON's main functions and a key technology for optimizing neighboring LTE cells, but its scope of iANR restricts its scope of implementation. The article proposes a new MR-based LTE automatic neighbor cell optimization (Measure Report), which is simpler and more effective to transmit through user equipment. This suggested technique can precisely classify problems such as missing neighbor cells, misunderstanding of PCI (Physical Cell Identifier), ultra-distant neighbor cells, and redundant neighbor cells. The findings suggest that this approach effectively improves the optimization project for neighboring cells.

The Long Term Evolution (LTE) system's PCI mod3 interference will cause deterioration of radio access, handover, and service quality, significantly reducing user feelings [7]. We propose a new framework that uses the advanced intelligent genetic algorithm to minimize PCI mod3 interference based on Driving test, handover, and Measurement Report data tools. Practical network trials show that our system has significantly reduced the operational complexity and PCI mod3 interference in the LTE system.

The development of the fifth generation has been initiated in another report, the latest being LTE Advanced Pro Release 13 [8]. In this article, we assess how current LTE network implementations perform in comparison with the initial LTE specifications. The aim is to define those primary performance indicators with suboptimal implementations and thus take due note when developing and standardizing wireless technology of the next generation. We examined the latency, handover execution time, and coverage of the user and control plane, which are important parameters for connected mobility use cases such as road vehicle safety and performance.

Two commonly used candidate systems for Connected Vehicle (CV) applications are Dedicated Short-Range Networking (DSRC) and 4G-LTE [9]. Comparing these two most feasible contact criteria and clarifying which one will fulfill the requirements of most V2X scenarios concerning road safety, traffic efficiency, and infotainment are therefore of great necessity. All current studies on comparing the feasibility of DRSC or LTE in V2X applications use software-based simulations to the best of our knowledge, which may

not reflect practical constraints. A Connected Vehicle testbed is created in this paper, incorporating the roadside units of DSRC, 4G-LTE cellular communication stations, and on-board vehicle terminals. Collision Avoidance, Traffic Text Message Broadcast, and Multimedia File Download are designed as three Connected Vehicle application scenarios. A software tool is designed to record the test vehicles' GPS positions/speeds and record certain performance measures of wireless communication. The studies have been carried out under various conditions. This research found that 4G-LTE is more common for non-safety applications, such as transmitting traffic information, downloading files, or accessing the Internet, which does not necessarily involve real-time high-speed communication for security applications, such as Collision Avoidance or electronic traffic sign, DSRC outperforms the 4G-LTE.

In the activity of the Long-Term Evolution Network (LTE/LTE-A), Physical Cell Identity (PCI) has an important function and is primarily used to classify cells in the network [10]. An inappropriate PCI assignment may lead to undesirable consequences of cell conflict. This paper introduces a new graph-coloring algorithm called the Matrix Based Algorithm to overcome the above PCI issues, offering optimized solutions to PCI problems. Its efficiency has been compared to another graph-coloring algorithm, namely DASTUR, in terms of PCI reassignment and re-configuration, to determine the algorithm's robustness. The result indicates the Matrix Dependent algorithm's dominance compared to DASTUR.

The physical cell identity (PCI) assigned to a cell during network planning in Long Term Evolution (LTE) systems specifies the set of sequences used by subscribers as de-modulation reference signals (DM RS) in the uplink (UL) [11]. To avoid interference issues, a sufficient allocation of PCIs must prevent adjacent cells from using the same DM RS, thereby ensuring adequate efficiency in both control and user data channels in the uplink. A detailed review is performed in this paper to measure the effect of PCI preparation on the physical uplink control channel (PUCCH) output in LTE. First, a novel analytical model that reflects the effect of PCI preparation on the likelihood of interruption and outage due to DM RS collisions in PUCCH is provided. Based on this model, with a static system-level simulator implementing a real network scenario, PUCCH performance with several classical PCI planning schemes is assessed. Simulated events protect various PUCCH frame formats, various UL power control (PC) schemes, and normal and abnormal traffic situations. Results show that a PCI plan designed solely on the basis of avoiding PCI collision/confusion and downlink reference signal collisions achieves near-optimal performance in terms of DM RS collisions in PUCCH. However, DM-RS collisions caused by neighboring cells sharing the same sequence could significantly degrade PUCCH performance in extreme cases.

Heterogeneous Networks (HetNets) are Ultra-Dense Networks (UDNs) that deploy a high density of small cells that overlay conventional macrocells [12]. When many Long-Term Evolution (LTE) layers share the available spectrum due to the density and diversity of the network, the assignment of physical cell identities (PCIs) becomes complicated. Since different layers can be handled by different solutions for

Network Management (NM) and Self-Organizing Network (SON), it would also be beneficial to be able to independently distribute the PCIs in each layer. At the same time, it must be ensured that PCI disputes are minimized, even between layers. High cell density raises the possibility that two small cells sharing the same PCI are neighbors of the same macro cell when handling the small cell layer separately, causing a conflict in inter-layer adjacencies, even when PCI conflicts are prevented within the layers. We suggest a methodology that can mitigate these conflicts between layers, while still allowing autonomous allocation between the layers. The solution then utilizes the Automatic Neighbor Connection (ANR) feature to learn the complete multi-layer network topology and optimize the PCI assignment, beginning with an initial intelligent guess for adequate PCI reuse distance. This research found that the proposed strategy retains good output without requiring sharing information across layers compared with state-of-the-art strategy.

Today's mobile network traffic is rising rapidly, and because of the lack of spectrum and other factors, such as the complexity of property coordination and the higher rental cost, the existing cellular infrastructure structure has been altered [13]. Several HetNet interference management strategies are studied in this paper, and the influence of the PCI software on the coverage of LTE is analyzed. The engineering aimed at the train station, which is a typical example of hot network planning simulation scenes and poor coverage areas, is complemented by micro coverage technology. Then the effect on the system's efficiency of micro coverage technology is evaluated. Finally, there are appropriate deployment plans for small base stations.

Veríssimo et al. [14] explored two hypotheses on how well it is possible to detect two distinct Long-Term Evolution (LTE) network issues by supervising near-real-time output techniques. Physical-cell-identity (PCI) conflicts and root-sequence-index (RSI) collisions are the network problems examined. These were labeled through cell relationships that confirmed these two conflicts through trust guard. In addition, a genuine LTE network was used. The results obtained showed that by using each main performance indicator (KPI) measurement as an individual feature, both issues were better identified. For the 800 MHz and 1800 MHz frequency bands, the highest average accuracy for the PCI conflict detection was 31% and 26%, respectively. For the 800 MHz and 1800 MHz frequency bands, the maximum average accuracy obtained for RSI collision detection was 61 percent and 60 percent, respectively.

Mubarok and Putri [15] addressed the LTE-Advanced Network Planning Study of the Effects of Inter-Band Carrier Aggregation. Due to spectrum constraints, the implementation of Long-Term Evolution (LTE) technology in Indonesia was not suitable for spectrum allocation. 3GPP has launched the latest technology to address this issue, namely LTEAdvanced, which supports carrier aggregation (CA) features that enable higher throughput and more efficient spectrum use. This analysis combines two separate frequency bands, namely 5 MHz bandwidth in band 5 (850 MHz) and 10 MHz bandwidth in band 3, LTE-Advanced network planning was carried out using the inter-band CA method (1800 MHz). LTE and LTE-A network preparation is combined with Physical Cell Identity (PCI) and Soft

Frequency Reuse (SFR) schemes to achieve optimum efficiency.

Using PCI increases SINR by 1 dB and increases throughput by 200 KBPS, while using the SFR system increases SINR by 9 dB and increases throughput by 13 Mbps. Due to spectrum constraints, the deployment of Long-Term Evolution (LTE) technology in Indonesia has not been optimal. To solve the problem, 3GPP released the new technology, i.e., LTE-Advanced, to support carrier aggregation (CA) functionality that offers greater throughput with more effective spectrum use. In this research, LTE-Advanced network planning was carried out by combining two distinct band frequencies, namely 5 MHz bandwidth on Band 5 (850 MHz) and 10 MHz bandwidth on Band 3, using the inter-band CA process (1800 MHz). In addition, the planning of the LTE and LTEA networks was coupled with the use of Physical Cell Identity (PCI) and Soft Frequency Reuse (SFR) systems to produce optimum output. The PCI increased SINR by 1 dB and output by 200 Kbps, while the SFR system was able to increase SINR by 9 dB and output by 13 Mbps, respectively.

Evolved Node B, abbreviated to eNodeB, is a telecommunication device that functions as a bridge connecting users of the 4G Long Term Evolution (LTE) network with those of other networks [16]. In general, eNodeB functions as a transceiver, namely the sender and receiver of communication signals from or to a Mobile Station (MS), and connecting the MS with other network elements in a mobile or fixed communication network system [17].

A. LTE (Long Term Evolution)

LTE is a development of previous technologies, namely UMTS (3G) and HSPA (3.5G), in which LTE is mentioned as the 4th generation (4G). UMTS technology has a maximum data transfer rate of 2 Mbps; at HSPA, the data transfer rate reaches 14 Mbps on the downlink side and 5.6 Mbps on the uplink side, while at LTE, the ability to provide speed in terms of data transfer can reach 100 Mbps on the downlink and 50 Mbps on the uplink side with a channel bandwidth of 20 MHz [18].

The capabilities and advantages of LTE compared to previous technologies are the provision of greater coverage and service capacity, reduction of total operational costs, the importance of low delay, and the increase of speed in data transfer [19].
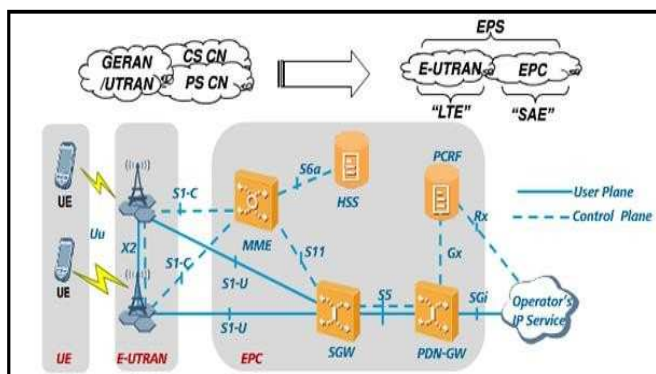

Fig. 1 LTE architecture

As in Figure 1, the LTE architecture is known as SAE, which describes an architectural evolution compared to previous technologies. Overall, LTE adopts the Evolved Packet System (EPS) technology. It contains three important components, namely User Equipment (UE), Evolved UMTS Terrestrial Radio Access Network (E-UTRAN), and Evolved Packet Core (EPC).

B. PCI (Physical cell identity)

PCI (Physical Cell Identity) is a technique of numbering the identity of each cell on a limited number of LTE networks of 504, so there is a need for more efficient usage management to reduce the risk of conflict of high network conflict. The purpose of using PCI is to simplify user search, paging, and handover processes.

C. PCI modulo 3

The shifting frequency plays a very important role during the PCI assignment. PCI provides a change in frequency.
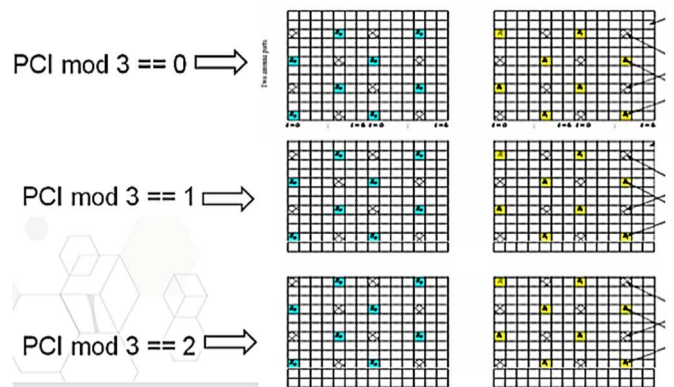

Fig. 2 Implementation of reference signal vs PCI Mod

D. PCI Modulo interference

PCI modulo interference occurs when an area is covered by two or more cells with a strong signal, and these cells have the same PCI modulo value [4].
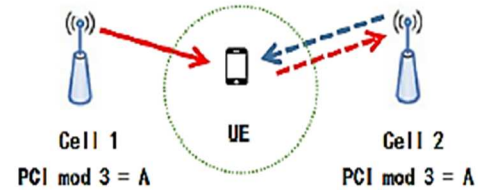

Fig. 3 PCI modulo interference

E. Steps of Placement Pattern of PCI

There are 70 PCI code groups in the outdoor macrocell network allocated for three sectors per site in 1 cluster. If it is necessary, reuse is done to save the allocation provided by the operator, as in Figure 4 below:
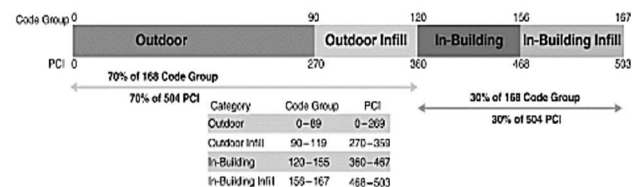

Fig. 4 Allocation of PCI

The requirements for placement pattern to achieve the Collision Free and Confusion Free conditions are as follows:

- The number of code groups provided determines the normal placement pattern, each site in 1 cluster. Cells at each site must belong to one SSS ID group code and a different PSS ID color group.
- The random placement pattern, each site in 1 cluster, is not determined by the code group provided, but in 1 site, the PSS ID must be different to avoid interference.

F. Driving test

Driving test is one part of the job in radio network optimization. Driving test aims to collect real-time network information in the field. The information collected is the actual condition of radio frequency (RF) in an eNodeB. In general, the purpose of the driving test is to collect real radio frequency network information in the field. The information obtained can be used to achieve the following objectives:

- Finding out the actual coverage in the field, whether it is following the coverage prediction during planning.
- Finding out the network parameters in the field whether they are following the planning parameters.
- Finding out the interference from neighboring eNodeB.
- Finding out that there is an RF issue, for example, related to a dropped call or blocked call.
- Finding out the existence of poor coverage.

G. Parameters of PCI Modulo Interference Optimization Performance

The following are the parameters used to discover the success rate of PCI interference modulo optimization:

1) SINR (Signal to Inteference Noise Ratio): SINR is the ratio between the transmitted signal and the interference and noise that arises and mixes with the main signal [20].

TABLE I
SINR RANGE LEVEL

SINR	Color	Strength (dB)
Excellent	Blue	20 =< x
Good	Green	10 =< x < 20
Low	Yellow	0 =< x < 10
Bad	Red	X < -20

2) Throughput download: The frequency used for all transmissions from the Base Station (BS) to the Mobile Station (MS) is known as the downlink frequency, while the download throughput is referred to as transmission speed from the BS to the MS. The following is a table of download throughput ranges.

TABLE II
SINR RANGE LEVEL RANGE THROUGHPUT DOWNLOAD LEVEL

SINR	Color	Strength (kbps)
Excellent	Blue	14000 =< x
Good	Green	7000 =< x < 14000
Fair	Yellow	1000 =< x < 7000
Poor	Pink	512 =< x < 1000
Bad	Red	X < 512

H. Azimuth

The Azimuth in antenna installation is based on the sector/number of antennas installed, and it is determined from the smallest degree. For example, if there are 3 antennas

(sectors) with azimuth 80,160,320, then sector 1 80 °, sector 2 160 ° and sector 3 320 ° and so on [21].

I. GENEX Assistant 3.18

GENEX Assistant is a powerful software for testing radio data that is also used to analyze and process radio network air interface data. GENEX Assistant can help network planning and network optimization engineering to learn and find out the analysis of network performance and reliability problems. This software is used for reporting and analyzing the driving test results called logfile. The logfile can be run directly in this software for reporting based on the previously created route. This software will provide information from the sites that have been undertaken during the driving test process.

J. Map info professional 12.0.02

MapInfo is a Geographical Information System (GIS) application developed by MapInfo Corp since 1986. MapInfo is a GIS software product that allows users to geographically visualize and analyze the inputted data faster and provide the information needed in the decision-making process.
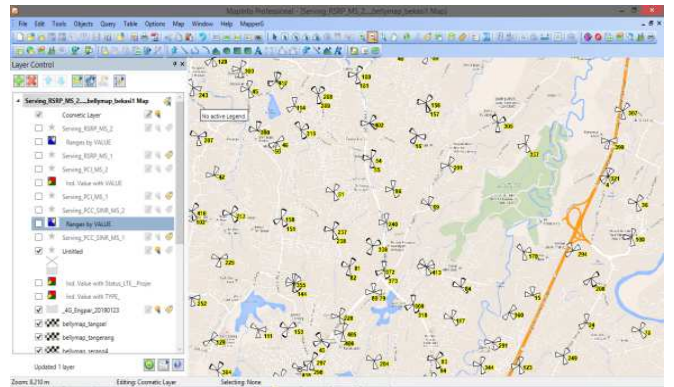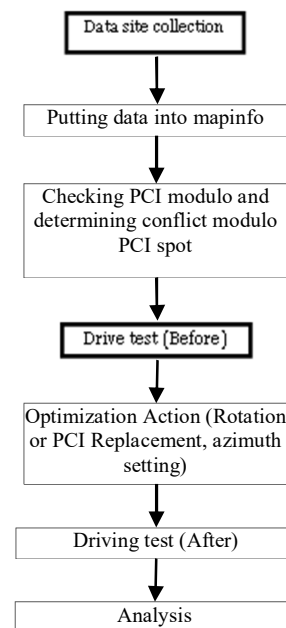

Fig. 5 Map professional info 12.0.02

K. Methodology

Fig. 6 Research flow charts

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The design stage of the PCI modulo interference optimization, as shown in Figure 6, is as follows:

1) Site data collection: Site data are collected in latitude, longitude, Azimuth, cell PCI, and site ID data. The data will be inputted to MapInfo.

2) Entering the site data into MapInfo: Entering the site data into MapInfo that has a function to map site positions. With this mapping, it will be easier to determine the PCI interference modulo spots.

3) Checking the PCI modulo and determining the PCI modulo interference spots: The PCI modulo check functions to find out whether a spot has a PCI modulo conflict or not.

4) Driving test before: The driving test activity is carried out at spots indicated to have PCI modulo interference. The previous driving test is carried out to know the network quality before any optimization action is taken.

5) The action of Optimization: Optimization actions are taken on spots that experience PCI modulo interference can be done by rotating or replacing the PCI and adjusting the cell azimuth.

6) Driving test after A driving test is carried out to determine the quality of the network after the optimization measures are taken.

III. RESULTS AND DISCUSSION

The results of site mapping on the Map info application indicated that the PCI interference modulo spot was in the Pampangan Nan XX area, Sub. district of Lubuk Begalung, Padang. The following Figure 7 is a display of sites that experience PCI modulo interference.

Fig. 7 Spot PCI interference modulo

PCI modulo interference occurs between site 30107 sector two and site 32051 sector 2, which has PCI numbers respectively, namely 193 and 448. Both PCI has the same modulo three value, namely 1.

A. Driving test Result (before)

The following is the result of the driving test that was performed prior to the optimization action.

1) Serving PCI (Before): Figure 8 presents serving PCI. From this figure, it can be seen how many PCI points are served. In this area, it is dominated by PCI 448.
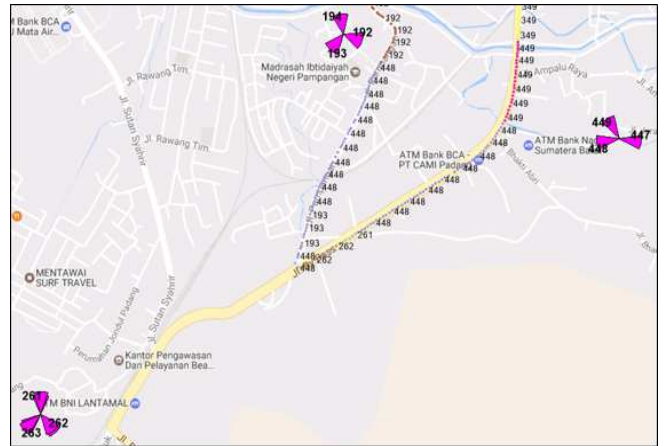

Fig. 8 Serving PCI (Before)

2) SINR (Signal to Interference Noise Ratio) before: In Figure 9, the following displays the SINR results before optimization. Figure 9 shows that the signal quality of the H3I (Tri) operator has poor quality because red and yellow indicators dominate it.
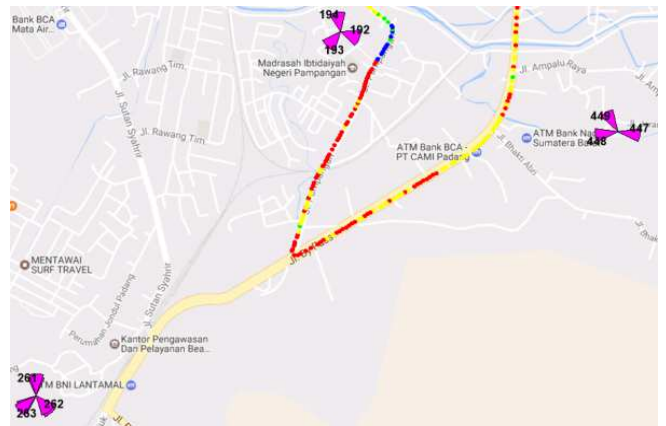

Fig. 9 SINR (Before)

3) Throughput Download (before) In Figure 10, it can be seen that the download speed of the H3I (Tri) operator has a pretty bad quality because it is dominated by yellow indicator.
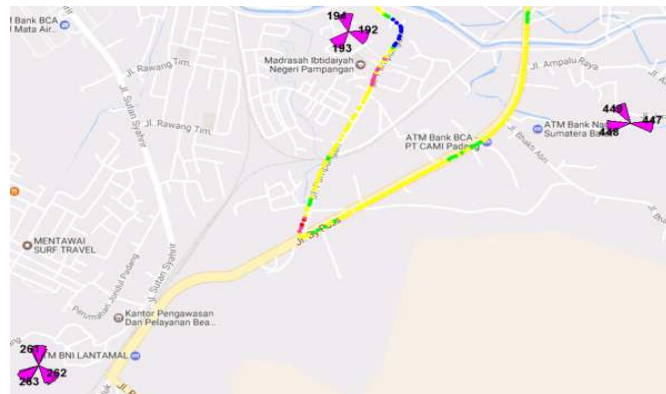

Fig. 10 Throughput download (Before)

B. The Action of Optimization of PCI Modulo Interference

In the case of PCI modulo interference in this study, the researcher takes steps to rotate the PCI at site 30160 and site 30107. On sites 30107, PCI 192 and 193 are rotated so that PCI 193 does not interfere with PCI 448, and on-site 30160 PCI is rotated from 261/262 / 263 to 263/261/262. This is done in order that PCI 192 does not interfere with PCI 261. At site 32051, action is taken to change the direction of sector azimuth 2. Changing the Azimuth is done because, based on the driving test results before, the cell/sector is more dominant than other cells/sectors.

From Table 3, it can be seen that the yellow table is the cell/sector that experiences PCI modulo interference. The table marked in pink represents the change in the azimuth direction. Then the one marked in blue is a PCI with a new formation. Even though the spot that experienced PCI modulo interference was only site 30107 and site 32051, the PCI formation on-site 31060 was also changed because site 31060 also affected the spot.

TABLE III
PCI AND CELL AZIMUTH ON THE INTERFERENCE MODULO PCI SPOT

SID	Sector	Azimuth	PCI	Mod3	Mod6	Mod30	New Azimuth	New PCI	Mod3	Mod6	Mod30
	31060-1	0	261	0	3	21	0	263	2	5	23
31060	31060-2	140	262	1	4	22	140	261	0	3	21
	31060-3	230	263	2	5	23	230	262	1	4	22
	30107-1	110	192	0	0	12	110	193	1	1	13
30107	30107-2	220	193	1	1	13	220	192	0	0	12
	30107-3	350	194	2	2	14	350	194	2	2	14
	32051-1	100	447	0	3	27	100	447	0	3	27
32051	32051-2	260	448	1	4	28	220	448	1	4	28
	32051-3	330	449	2	5	29	330	449	2	5	29

C. Driving test Result (after)

The following is the result of the driving test that was performed before the optimization action.
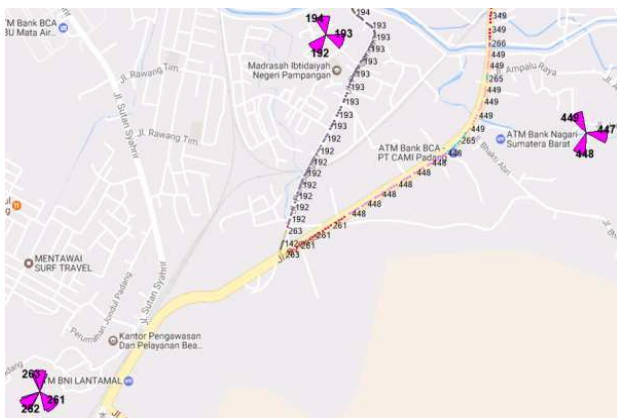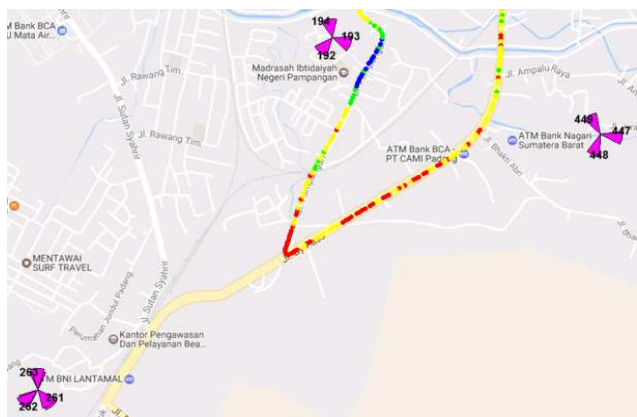

Fig. 11 Serving PCI (After)

Fig. 12 SINR (After)

1) Serving PCI (After): Figure 11 shows that several sectors serve the area. In the western part, the driving test results are dominated by PCI 193 and 192. In the eastern part, it is served dominantly by PCI 448 and 449. Then in the south, it is served by sectors with PCI numbers 261 and 263.

2) SINR (Signal to Interference Noise Ratio) before: Figure 12 shows that the signal quality of the H3I (Tri) operator is sufficient because a yellow indicator dominates it.

3) Throughput download (After): Figure 13 shows that the download speed of the 3 (Tri) operator has a pretty good quality which is dominated by a green indicator.
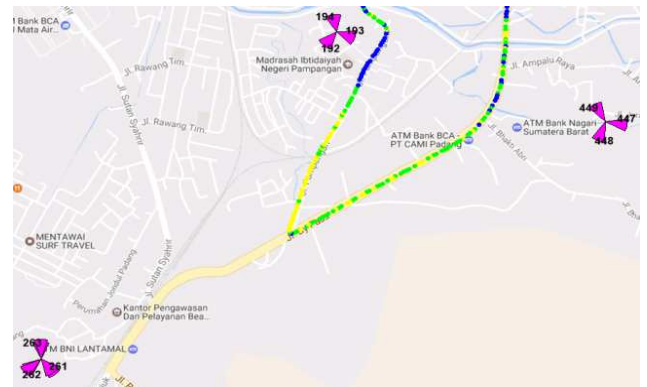

Fig. 13 Throughput download (After)

D. Comparison of SINR Before and After Optimization

Figure 14 is the SINR result before and after optimization. SINR with blue and green indicators is classified as good, while SINR with yellow and red indicators is classified as bad. Before being optimized SINR with the good category is 9.47%, and after being optimized, it is 19.47%. There is an increase in SINR in a good category by 10%.

E. Comparison of the throughput Download Before and After the Optimization

Figure 15 is the result of the download throughput before and after the optimization process. Throughput download with indicators in blue and green is classified as a good

category. Meanwhile, throughput download with yellow, pink, and red indicators is classified as a bad category. Before being optimized, the throughput download in a good category is 18.94%, and after optimization is 63.68%. There is an increase in throughput download in the good category, namely 44.74%.

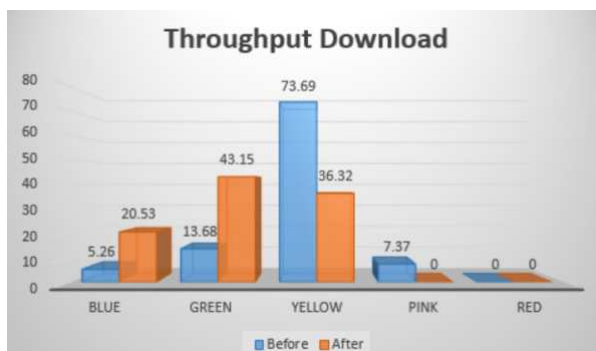Fig. 14 Percentage of SINR before and after the optimization

Fig. 15 Percentage of throughput download before and after the optimization.

IV. CONCLUSION

Regarding the activities of PCI modulo interference optimization that have been carried out, the following conclusions can be taken as follows: PCI modulo interference occurred in the XX Nan Pampangan area, Sub-district. Lubuk Begalung, Padang city between site 30107 sectors 2, and site 32051 sectors 2. PCI modulo interference can be identified by checking the adjacent PCI modulo sites, and the optimization was taken in the case of PCI modulo interference in this study, namely rotating the PCI on-site 30107 from 192/193/194 to 193/192/194, then rotating the PCI on-site of 31060 from 261/262/263 to 263/261/262, and then changing the azimuth sector 2 of site 32051 from 260o to 220o. Based on the optimization process of PCI modulo interference with the driving test method, it was found that RSRP, SINR, and download throughput with good categories increased compared to the one before the optimization. RSRP in the good category was from 81.58% to 92.09%. SINR with good category was from 9.47% to 19.47%, and throughput download in the good category was from 18.94% to 63.68%.

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