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The Impact of Real Traffic from Twitter for 5G Network Deployment

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Abstract*— The utilization of technology, particularly cellular networks, is continuously expanding. This is evident through the increasing number of mobile network operators (MNOs) users, especially in the current era where most things are accomplished online. Consequently, mobile network operators must furnish a comprehensive array of cellular network access services, not just for smartphones but also for other smart devices, to guarantee maximum coverage. With the growing interest in 5G deployment based on low band and millimeter wave communication (mm Wave) for outdoor use scenarios, such as tourist destinations, site design experts are looking for sophisticated real-time traffic data from social media like Twitter to simulate and calculate outdoor radio coverage using 3GPP 38.901 prediction models. This study used the frequencies of 700 MHz and 26 GHz, utilizing Inter-band Carrier Aggregation (CA) to increase data rates while maintaining a wide range and optimizing the number of *gNodeBs*. This research is intended to monitor the Borobudur Temple area, Indonesia, which serves as a tourist destination and one of the world's wonders, thus making it a densely populated area and inevitably requiring good network connectivity. The parameters used are Synchronization Signal Reference Signal Received Power (SS-RSRP), Synchronization Signal to Interference plus Noise Ratio (SS-SINR) and data rate. The simulation revealed that CA SS-RSRP with traffic map increased by 38.88%, SS-SINR increased by 45.05%, and the peak data rate increased from 5884.12 Mbps to 6199.88 Mbps.

***Keywords*— 5G NR planning; inter-band carrier aggregation; 700 MHz; 26 GHz; Twitter social media.**

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I. INTRODUCTION

The frequency will impact resource efficiency as a limited resource with reusable qualities when not in use since unused frequencies should be recycled. To make the most of the frequency spectrum, it is suggested to talk about frequency renting patterns, spectrum pooling, and spectrum sharing. Within the next five years, the concept of shared exclusive used licensing, in which operators can cooperate in the use of frequency licenses, is anticipated to be applied. This needs to be considered since 5G technology can employ carrier aggregation and cognitive radio to improve data speed and capacity. [1].

The fact that there has been an annual rise of cellular network data traffic by more than 50% insinuates that telecommunications services have evolved into a contemporary trend of human requirements that offers swift access to information in helping human activities and improving their quality of life. The path for this technological improvement is an essential topic of discussion at every national and international conference, given the requirement to fulfill the 5G NR technology standard.

A key aspect of 5G technology is using higher frequency bands with bigger bandwidths to boost the attainable data throughput [2]. Due to innate radio propagation characteristics, including increased propagation loss, stronger channel correlation, low diffraction, and poor multipath settings, adding higher frequency bands for mobile cellular services is challenging [3]. Carrier Aggregation (CA) is a key component in modern wireless communication systems because it allows for more transmission capacity (BW) by combining numerous concurrent channels over a fragmented spectrum [4]. This research aimed to obtain a 5G NR network design in the Borobudur tourist area at a frequency of 700 MHz and 26 GHz using CA. This tourist site attracts millions of tourists worldwide and is one of the world's wonders.

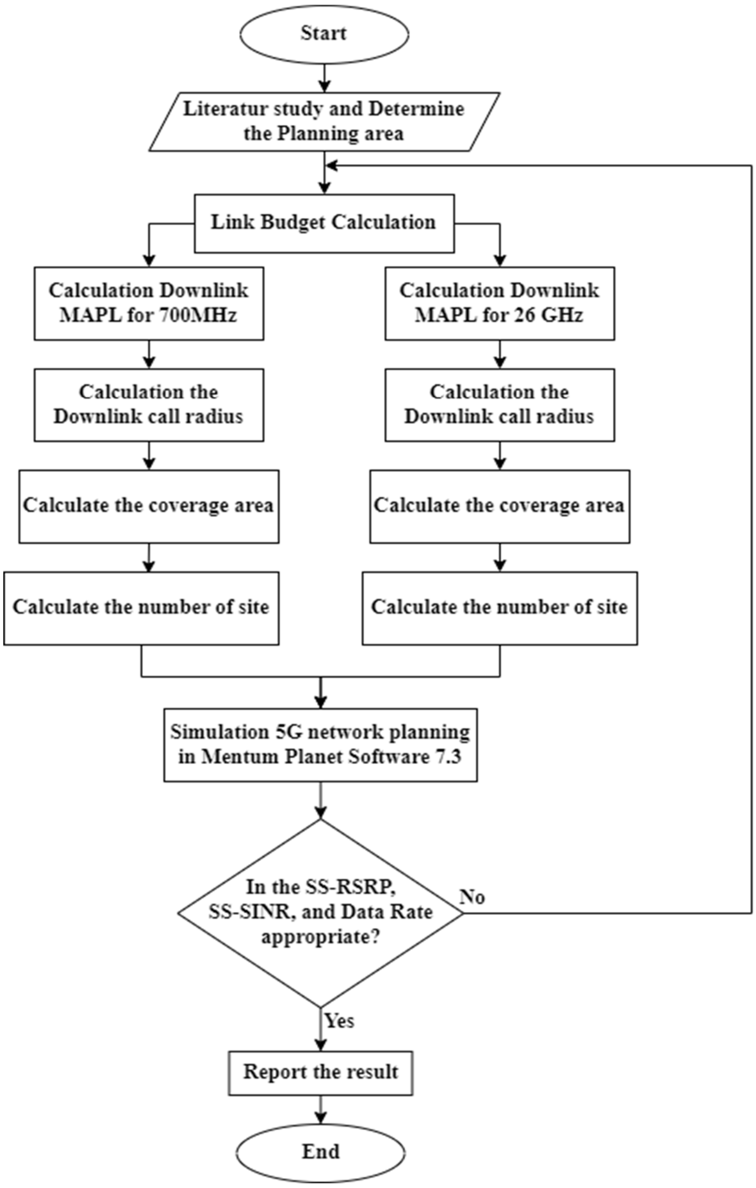


Fig. 1 Calculation flowchart and design model

This study examined the low-band and high-band 5G NR network design in the area around the Borobudur temple, which makes it challenging for operators to select a frequency for 5G. This research chose the 700 MHz and 26 GHz frequency bands since both bands have been proposed in Indonesia and are expected to be used as a template for the rollout of 5G networks in this country. Link budget and propagation model studies determined path loss values, cell radius, and the required number of sites close to the Borobudur temple.

Planning a 5G network with inter-band carrier aggregation scenarios at a frequency of 2300 MHz with a 40 MHz channel bandwidth and frequency of 3500 MHz with a 100 MHz channel bandwidth has been addressed using the Mentum Planet software. It used carrier aggregation methods based on coverage planning and offered a greater data rate [5]. This research contributed to the use of real traffic based on Twitter users to optimize the number of *gNodeB* needed in this field adjusted to the number of user densities in a specific area [6], [7], [8]. With increasingly rapid demand for network traffic, 5G networks deploy more densely packed BTS. Dense cell deployment increases spectral efficiency by shortening the distance between base stations and users, increasing network coverage and system capacity [9], [10]. However, issues with dense cell deployment and convoluted network topology will worsen energy efficiency issues. Additionally, because base stations are responsible for most of the cellular network's energy usage, a considerable increase in base station density and quantity exacerbates the problem. Therefore, to optimize the distribution of cells, a real traffic map is used to determine the traffic needs of users using social media, particularly Twitter, which describes the density in an area [11].

II. Materials and Method

A. Research Method

Coverage planning serves as the basis for the 5G NR planning research in the 700 MHz low-band and 26 GHz high-band. The first step of the research started with finding the locations to set up 5G NR network planning. A good place to start planning for 5G NR technology was the area around the Borobudur temple. With a 35.02 km^2 area and a high tourist density, this tourism site certainly needs geographic information to classify the area and type of area. Propagation model-based link budget calculations were necessary for coverage planning to determine the Maximum Allowable Path Loss (MAPL) value. Before determining the cell radius, as the maximum distance between *gNodeB* and the user terminal, the pathloss value was calculated using the Urban Micro (UMi) and Rural Macro (RMa) propagation models (UT). The cell radius determined the coverage area that *gNodeB* can provide and the required number of sites.

This study utilized the Mentum Planet 7.3 software to process the simulation results, data planning, and calculations. The simulation showcased the coverage area using the SSRSRP, SS-SINR, and data rate parameters. The outcomes of the low-band simulation at 700 MHz and the high-band simulation at 26 GHz were then combined with and without data from Twitter's traffic map.

B. Planning Area

This study was planned to be carried out in the Borobudur tourism area in Indonesia. This location covers about 55.18 km2 of the Borobudur Temple area, which was classified as an urban area. On the other hand, the surrounding area was classified as rural; in 2019, its population reached 62.97 thousand people based on the population data for the Borobudur area [1]. This study determined a planning area of about 35 km2, which functioned as a tourist site with many mobile network users and was considered this research's primary sample and focal point. The 5G network in this area was not only used for communication between humans but was also used for V2x-based transportation modes.

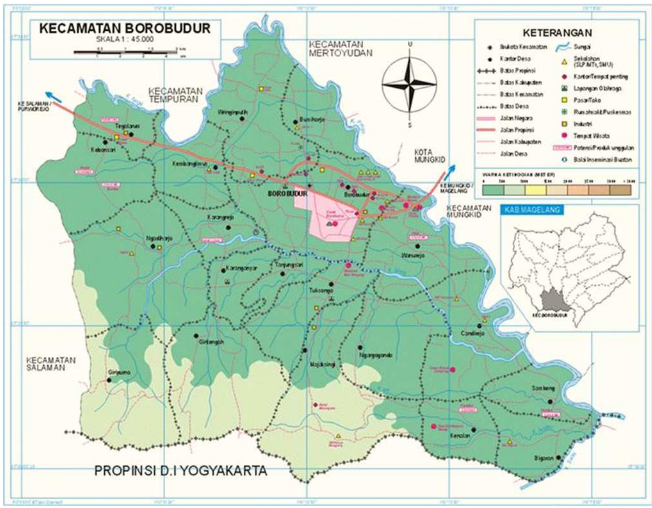


Fig. 2 Planning Area Shown in Mentum Planet [12]

C. Coverage Planning

Cellular network planning, known as "coverage planning, " ensures that the network can deliver service or a signal to everyone under consideration [13]. The network coverage refers to the area surrounding the *gNodeB* or site where a user may submit service requests and connect to the site to obtain services. The radius for the cell is stated as the maximum/limit of cell coverage, and the user will not establish a connection outside of the cell limit [14]. After calculating the range of cells, it is possible to estimate the number of cell sites required to cover the service deployment area.

D. Real Traffic Map from Twitter

A grid-based traffic map was produced using historical traffic data and relevant temporal traffic patterns. [4]. Then the traffic map was used to simplify the population density scheme in an area by optimizing the placement of base stations based on social media users. This process used off-line dense cell base stations on a grid-based traffic map to make it closer to network planning in the field.

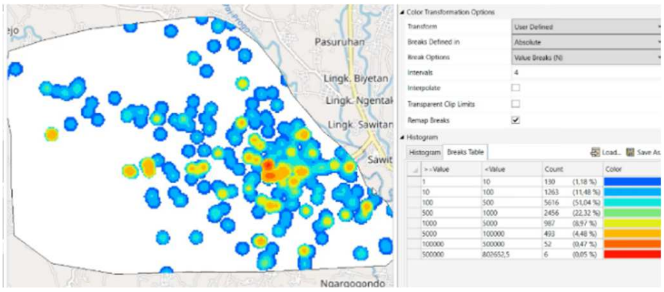


Fig. 3 Real Traffic Map of Twitter using Mentum Planet

Traffic map data were directly retrieved from the menu with the live feature. The traffic map data were taken from the previous three years, namely January 2019 to December 2021, in the Borobudur district area to see the number of users in the area. The data were particularly taken from Twitter, a popular social media where users in the location typed many tweets. The data were grouped by parameters, in which the dark red color indicated the maximum tweet and blue delineated the minimum.

E. Radio Link Budget

A radio link budget totals the revenues and losses of a transmission system. The radio link budget sums the transmitted power, gains, and losses to determine the signal intensity that reaches the receiver input. The Maximum Allowable Pathloss Value (MAPL) was used to assess the mobile and station antenna deterioration. The MAPL value was introduced into the propagation model to determine the cell radius. In this instance, Outdoor to Outdoor (O2O) with Line-of-Sight downlink was the main emphasis of the connection budget (LOS). Two link budget calculation models were used in this study. UMi for the high band (26 GHz) and RMa for the low band (700 MHz). The main parameters in this simulation are summarized in Table 1, while the link budget parameters are shown in Table 2 below.

TABLE I
PARAMETERS SYSTEM 5G NR

Key Parameter	700 Mhz	26 GHz
Technology	NR	NR
Carrier for frequency (MHz)	700	26000
Frequency start (MHz)	758	24250
Frequency end (MHz)	803	27500
Channel Bandwidth (MHz)	40	400
Duplex technique	FDD	TDD
Antenna type	Kathrein	Kathrein

TABLE II
5G NR LINK BUDGET [15][16][17]

Parameter	700 MHz	26 GHz
Power for gNodeB Transmitter (dBm)	46	35
Resource block	106	264
Subcarrier quantity	1272	3168
Antenna gain gNodeB (dBi)	8	0
Cable loss gNodeB (dBi)	0	0
Loss on penetration (dB)	14.5	12.23
Loss on foliage (dB)	8.5	5
Body block loss (dB)	3	15
interference margin (dB)	6	1
Rain/ice margin (dB)	0	3
Slow fading margin (dB)	5	7
Gain antenna UT (dB)	0	0
Temperature (Kelvin)	293°	293°
Thermal noise power (dBm)	-157.911933	-153.9325329
Noise figure UT (dB)	7	7
Demodulation threshold SINR (dB)	22.3	-1.1
Channel Bandwidth (MHz)	40	400
Coverage area	35.02 km^2	35.02 km^2

F. Propagation Models

Based on 3GPP 38.901 standards in network planning, this study used two distinct frequencies: the low band for 700 MHz and the high band for 26 GHz. As a result, two propagation models were used: Rural Macro (RMa) and Urban Micro (UMi). The RMa formula for the LOS scenario is stated below [18]:

$$PL_1 = 20\log_{10}(40\pi d_{3D} f_c/3) + \min(0.03h^{1.72},10)\log_{10}(d_{3D}) - \min(0.044h^{1.72},14.77) + 0.002\log_{10}(h)d_{3D} \quad (1)$$

$$PL_2 = PL_1(d_{BP}) + 40\log_{10}(d_{3D}/d_{BP}) \quad (2)$$

An electromagnetic wave's power density diminishes (attenuated) as it travels over space due to pathloss. There are two path loss values in the RMa propagation model, PL1 and PL2, which can be selected from both of these path loss values according to the desired design [19].

Meanwhile, the RMa formula for the LOS scenario is:

$$PL = 28.0 + 40\log(d_{3D}) + 20\log(fc) - 9\log((d'_{BP})2 + (h'_{BS} - h'_{UT})^2 \quad (3)$$

where d'BP is the breakpoint distance, d3D is the product of the distance between hBS and hUT, and fc is the frequency carrier. The breakpoint distance (d'_{BP}) formula is as follows:

$$d'_{BP} = 4 \times h'_{BS} \times h'_{UT} \times f_c / c \quad (4)$$

The h'BS value is antenna heigh on gNB side, while h'UT is antenna height on UT (User Terminal) side. The propagation model that has been calculated before resulted in the d3D. Following this, the cell radius value (d2D) was obtained using the following calculation:

$$Cell\ Radius\ (d_{2D}) = \sqrt{(d_{3D})^2 - (h_{BS} - h_{UT})^2} \quad (5)$$

After finding the Cell Radius, the next step was to calculate the Site Coverage Area value using the following formula:

$$Site\ Coverage\ area = 2.6 \times d_{2D}{}^2 \quad (6)$$

From the resulting Site Coverage Area value, the number of sites in the planned area can be calculated by:

$$Number\ of\ Sites = \frac{Total\ Large\ of\ Area}{Size\ Coverage\ Area} \quad (7)$$

The Data Rate is the next parameter to examine in this research. The data rate is a metric to measure the speed and extent of sending data through a network. The following is the formula for the 5G data rate, which is based on 3GPP TS 38.306 [5]:

Data Rate (in Mbps) =

$$10^{-6}.\sum_{j=1}^{J}\left(v_{layers}^{(j)}.Q_m^{(j)}.f^{(j)}.R_{max}.\frac{N_{PRB}^{BW(j),\mu}.12}{T_s^{\mu}}.(1-OH^{(j)})\right) \quad (8)$$

In which J stands for the Component Carrier, $v_{layers}^{(j)}$ for the number of layers, $Q_m^{(j)}$ for the Modulation Order, $f^{(j)}$ for the Scaling Factor, N_{PRB} for the Number of RB, and $OH^{(j)}$ represents the Overhead.

III. RESULTS AND DISCUSSIONS

A. Link Budget Calculation Results

Table 3 below shows the outcomes of the link budget estimates for the two frequencies.

TABLE III
LINK BUDGET CALCULATION RESULTS

Parameters	700 MHz	26 GHz
Pathloss (dB)	113.96	107.8
d_{3d} (m)	1663.82	125.82
Cell Radius / d_{2d} (m)	1663.48	125.53
Coverage Area (km^2)	7.19	0.409
Total area Measured (km^2)	35.02	35.02

Since the 700 MHz frequency has a higher coverage area than the 26 GHz frequency, it was selected as the primary cell. The secondary cell in this situation was 26 GHz. As a result, this CA Scenario Simulation plus Traffic map used five sites with two frequencies, 700 MHz and 26 GHz. The frequency of 700 MHz was selected according to the number of sites required in Table 3.

B. SS-RSRP Results

The term "SS-RSRP" refers to the linear average of the wattage contributions provided by the resource elements (REs) that transmit the SSS [21]. SS-RSRP is the equivalent of the RSRP parameter used in LTE systems. The reference range of SS-RSRP is shown in Table 4 below.

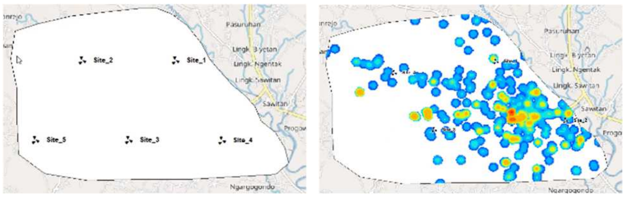
TABLE IV
SS-RSRP REFERENCE RANGE [22]

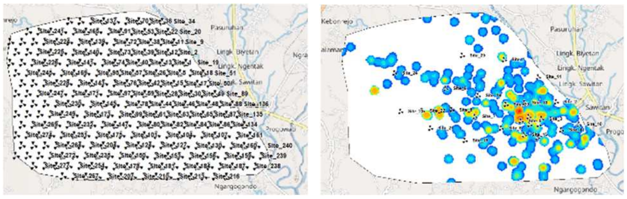
SS-RSRP value (dBm)	Category
≤ -130	Bad
-130 ≤ -110	Poor
-110 ≤ -90	Fair
-90 ≤ -70	Good
≥ -70	Excellent

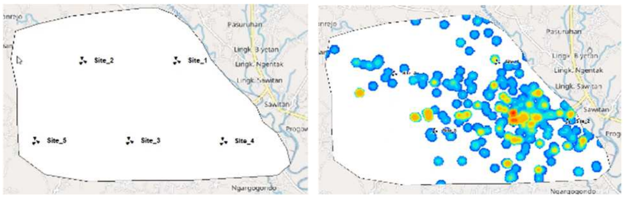
The findings produced for SS-RSRP were compared in three ways using Mentum Planet Planning Software Version 7.3: without traffic map or with 700 MHz non-CA frequency, 26 GHz non-CA frequency, and 700 MHz + 26 GHz when CA was applied. The results are shown in Table 5 and Figure 4 to Figure 9 below.

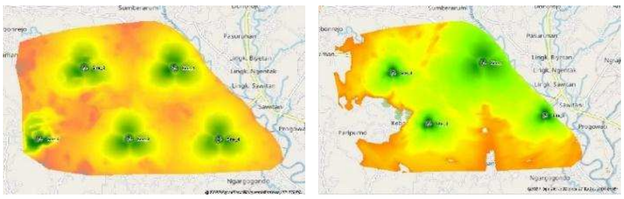
TABLE V
NUMBER OF SITE IN STUDY CASE

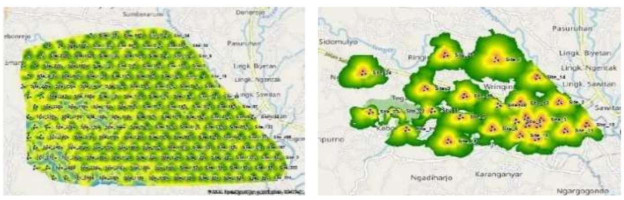
Statistical Scenario	Number of sites		
	700 MHz	26 GHz	700 MHz + 26 GHz
Without Traffic Map	5	251	5
With Traffic Map	4	25	4


(a) Without Traffic Map (b) With Traffic Map
Fig. 4 Comparison of the number of sites 700 MHz


(a) Without Traffic Map (b) With Traffic Map
Fig. 5 Comparison of the number of sites 26 GHz


(a) Without Traffic Map (b) With Traffic Map
Fig. 6 Comparison of the number of sites 700 MHz + 26 GHz


(a) Without Traffic Map (b) With Traffic Map
Fig. 7 Comparison RSRP frequency 700 MHz


(a) Without Traffic Map (b) With Traffic Map
Fig. 8 Comparison RSRP frequency 26 GHz

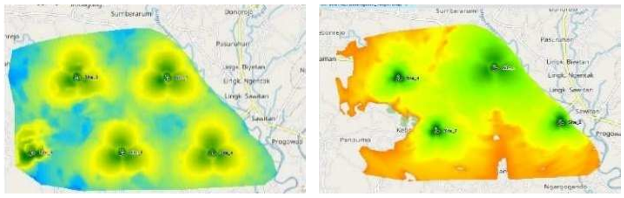

(a) Without Traffic Map (b) With Traffic Map
Fig. 9 Comparison RSRP frequency 700 MHz+26 GHz

TABLE VI
SS-RSRP STATISTICS WITHOUT TRAFFIC MAP

Statistical Parameters	SS-RSRP Without Traffic Map		
	700 MHz non-CA	26 GHz non-CA	700 MHz + 26 GHz CA
Minimum	-119.59	-110.94	-119.59
Maximum	-43.57	-41.51	-43.57
Average	-94.51	-82.18	-94.51

TABLE VII
SS-RSRP STATISTICS WITH TRAFFIC MAP

Statistical Parameters	SS-RSRP With Traffic Maps		
	700 MHz non-CA	26 GHz non-CA	700 MHz + 26 GHz CA
Minimum	-119.99	-110.96	-119.99
Maximum	-28.37	-35.39	-28.37
Average	-105.33	-98.05	-105.33

The simulation results were assessed using the Primary Cell frequency of 700 MHz and the comparative frequency of 26 GHz. The first SS-RSRP minimum value before CA was -119.59 dBm at a 700 MHz frequency based on the information acquired thus far. For 26 GHz, the result was -110.94 dBm. As can be seen, the SS-RSRP value was more significant at a frequency of 26 GHz. After the CA, the SS-RSRP value was close to the SS-RSRP 700 MHz starting value, roughly -119.59 dBm. For RSRP with a Traffic map, the minimum value at a frequency of 700 MHz was -119.99; for 26 GHz, the result was -110.96, and the value in CA was -119.99.

However, at the maximum SS-RSRP, the increase was quite significant. After the CA used the traffic map, the highest SS-RSRP value was -28.37 dBm. This figure was the same at 700 MHz, and -35.39 dBm for 26 GHz. The average value of SS-RSRP after CA with a real traffic map decreased by -105.33 dBm, compared to that without a real traffic map with -94.51 dBm in CA. As a result, Traffic maps increased SS-RSRP by at least a maximum of 38.88% and decreased SS-RSRP by 11.44% on average.

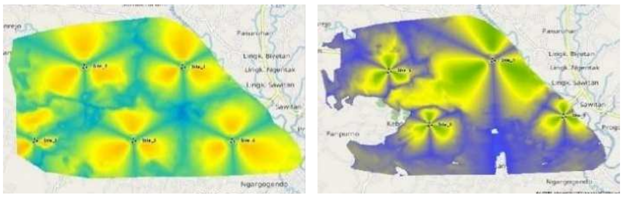
C. SS-SINR Results

The acronym for this ratio is SS-SINR, or signal-to-noise and interference. It was calculated by dividing the number of resources carrying SSS linear average power contributions (in Watt) by the amount of resources carrying SSS linear average power contributions (in Watt) of noise and interference across the same frequency range [23], [25], [26]. These metrics are known as Signal-to-Noise and Interference Ratio Power (SINR) in 4G LTE, and they are essentially the same since they show the signal strength when compared to the amount of noise and interference that the user has received [20], [27], [28].

TABLE VIII
SS-SINR REFERENCE RANGE [24], [29], [30]

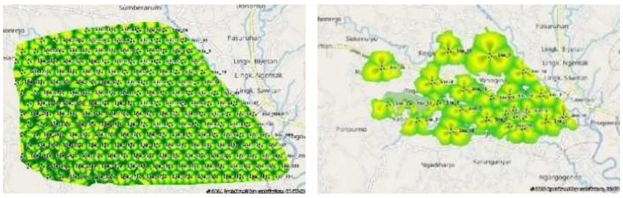
SS-SINR value (dBm)	Category
≤ -10	Bad
-10 ≤ 0	Poor
0 ≤ 15	Fair
15 ≤ 30	Good
≥ 30	Excellent

Figures 10 to Figure 12 display the SS-SINR findings based on the simulation.



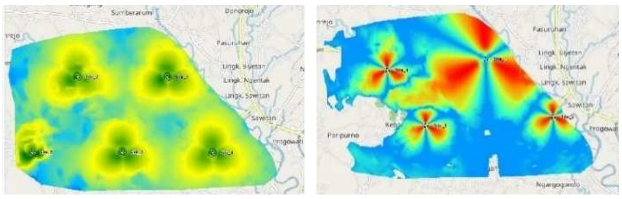
(a) Without Traffic Map (b) With Traffic Map

Fig. 10 Comparison SINR frequency 700 MHz



(a) Without Traffic Map (b) With Traffic Map

Fig. 11 Comparison SINR frequency 26 GHz



(a) Without Traffic Map (b) With Traffic Map

Fig. 12 Comparison SINR frequency 700 MHz + 26 GHz

TABLE IX
SS-SINR WITHOUT TRAFFIC MAP STATISTICS

Statistical Parameters	SS-SINR Without Traffic Map		
	700 MHz non-CA	26 GHz non-CA	700 MHz + 26 GHz CA
Minimum	-3.13	-6.31	-3.13
Maximum	23.39	22.88	23.39
Average	9.82	5.9	9.82

TABLE X
SS-SINR WITH TRAFFIC MAP STATISTICS

Statistical Parameters	SS-SINR With Traffic Maps		
	700 MHz non-CA	26 GHz non-CA	700 MHz + 26 GHz CA
Minimum	-1.72	-2.53	-1.72
Maximum	23.41	22.95	23.41
Average	8.31	8.79	8.31

The frequency of 700 MHz and CA had the same value, possibly because the frequency was 700 MHz as the Primary Cell. This happens both with the traffic map and without the traffic map. However, there was an increase in SS-SINR with a value of -1.72 dBm when using a real traffic map and -3.13 dBm without a real traffic map, thus increasing 45.05% at the minimum. However, on average, there was a decrease in SS-SINR with a real traffic map of 15.37% and no significant difference at the maximum. Our assumption is that the site will be placed in an area with many users, so there are areas that are not covered.

D. Data Rate Results

Data rate is a main feature that sets 5G apart from previous networks. Data rate is greatly influenced by bandwidth. Frequencies running at 700 MHz have the potential to have lower data rates than frequencies operating at 26 GHz due to capacity limitations. As a result, at this 700 MHz frequency, CA was used to get better data throughput while expanding the coverage area.

Tables 11 and 12 below display the finding on data rate computation.

TABLE XI
DATA RATE NON-CA AND CA WITHOUT TRAFFIC MAP STATISTICS

Statistical Parameters	Data Rate (Mbps)		
	700 MHz non-CA	26 GHz non-CA	700 MHz + 26 GHz CA
Minimum	14.08	57.88	14.08
Maximum	797.39	5396.38	5884.12
Average	216.05	727.44	512.36

TABLE XII
DATA RATE NON-CA AND CA WITH TRAFFIC MAP STATISTICS

Statistical Parameters	Data Rate (Mbps)		
	700 MHz non-CA	26 GHz non-CA	700 MHz & 26 GHz CA
Minimum	14.08	57.88	14.08
Maximum	797.62	5402.45	6199.88
Average	231.52	1072.44	494.61

Based on the simulation findings in Table 11 and Table 12, the simulation results with and without the traffic map at the maximum value had a fairly larger value than the theoretical value, which in this case can be stated as Excellent. However, the values obtained from both 700 MHz and 26 GHz at the average data rate were lower than their theoretical values both with and without the traffic map. Furthermore, when it enters the CA value, the results experienced a significant increase at a maximum of 5884.12 Mbps without a real traffic map and 6199.88 Mbps with a real traffic map.

Network performance has improved on several parameters by using the traffic map substantially at this data rate, according to simulation results. The average value increased by 7.16% on the 700 MHz frequency, indicating a significant increase of 47% on the 26 GHz frequency, but the value of CA decreased by 3.46%. There was no significant difference in the maximum parameters for the 700 MHz and 26 GHz frequencies, but the value of CA increased by 5.36% with the traffic map. In this case, the use of a real traffic map plus Carrier Aggregation in the scenario of a frequency of 26 GHz with a bandwidth of 400MHz seems critical in aggregating the 700 MHz frequency to provide the higher data rate.

E. Before and After using Traffic Maps CA Comparison

The main parameters observed for this simulation are summarized in Table 13 below. The figures are derived from the previous results.

TABLE XIII
BEFORE AND AFTER CA SUMMARY

Observed Parameters	CA Before Traffic Maps 700 MHz + 26 GHz	CA After Traffic Maps 700 MHz + 26 GHz
SS-RSRP Value ≥ 70 dBm (%)	0.47	0.51
Max SS-RSRP Value (dBm)	-43.57	-28.37
SS-SINR Value ≥ 15 dB (%)	22.01	4.17
Max SS-SINR Value (dB)	23.29	23.41
Average Data Rate (Mbps)	512.36	494.61
Peak Data Rate (Mbps)	5884.14	6199.88
Sites Needed	5	4

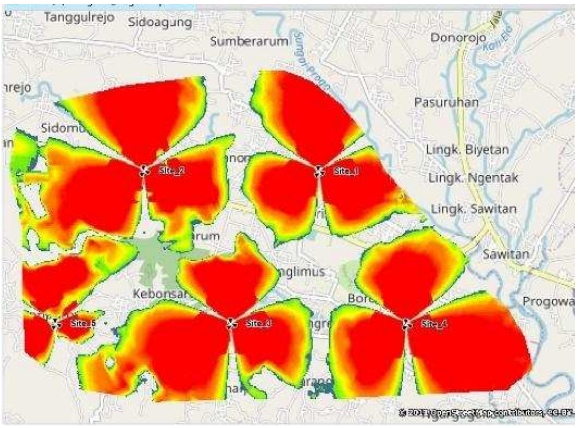


Fig. 13 CA Coverage Map without Traffic Map

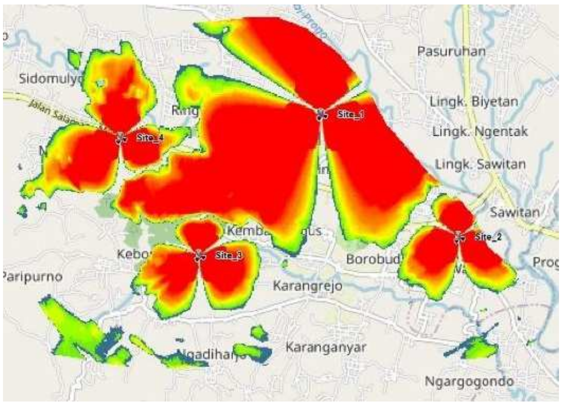


Fig. 14 Coverage Map with Traffic Map

CA using a real traffic map significantly impacts general network conditions. At 700 MHz, the 26 GHz aggregation effect can be observed as an improvement in almost all network characteristics. In the "excellent" category, the percentage value of SS-RSRP increased from 0.47% to 0.51%, and the most significant increase occurred in Max SS-RSRP with a value of -43.57 dBm to -28.37 dBm, with an increase of 34.88%. In the case of SS-SINR, the percentage decreased significantly from 22.01% to 4.17%. However, the highest value of SS-SINR increased slightly from 23.29 dBm to 21.41 dBm. After that, the average data rate decreased from 512.36 Mbps to 494.61 Mbps. However, there was an increase in speed from 5884.14 Mbps to 6199.88 Mbps at its peak. It requires a number of sites with a real traffic map of 4 and without a real traffic map of 5. This happens because the Planet Mentum will place the site based on the existing users, and the area that is not covered by the site means that the area has few or no users, thus making network planning better.

IV. CONCLUSION

The CA 700 MHz and 26 GHz obtained excellent results using a real traffic map from Twitter. Four sites are required in an area of 35.02 km2 with a real traffic map, and five sites are required without a real traffic map from Twitter; this is equal to the number of sites required at 700 MHz with a slight increase in SS-RSRP and SS-SINR and a significant increase in Data Rate. On this basis, it is clear that CA is an innovative approach to obtaining higher data rates and can use a real traffic map from Twitter to precisely position the site according to user presence on the 26 GHz frequency while maintaining an outstanding range of 700 MHz. Although 700 MHz is sufficient for the Borobudur Temple area, Carrier Aggregation and the traffic map, especially with 26 GHz in this scenario, highly increased the Data Rate. As a result, with many existing users, there would be no traffic load. In essence, 5G network planning comprises coverage planning and capacity planning. However, since this research only addressed coverage planning, it is suggested that further research examining capacity planning can be continued.

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