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ARTICLE

Radio Network Planning and Optimization for 5G Telecommunication System Based on Physical Constraints

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ABSTRACT

The paper mainly focuses on the network planning and optimization problem in the 5G telecommunication system based on the numerical investigation. There have been two portions of this work, such as network planning for efficient network models and optimization of power allocation in the 5G network. The radio network planning process has been completed based on a specific area. The data rate requirement can be solved by allowing the densification of the system by deploying small cells. The radio network planning scheme is the indispensable platform in arranging a wireless network that encounters convinced coverage method, capacity, and Quality of Service necessities. In this study, the eighty micro base stations and two-hundred mobile stations are deployed in the -15km×15km wide selected area in the Yangon downtown area. The optimization processes were also analyzed based on the source and destination nodes in the 5G network. The base stations' location is minimized and optimized in a selected geographical area with the linear programming technique and analyzed in this study.

1. Introduction

IN recent times, the demands of 5G wireless telecommunications for a substantial increase in throughput of transmission and receiving and the adequate coverage area for a network to preserve an all-embracing range of emerging applications, such as mobile phones, multimedia communication, social network connection, internet gaming, video conferencing, e-learning platforms, e-healthcare system and so on. The 5G systems promise to transfer the improvements of million-fold scheme capacity over present networks while preserving innovative requests with an enormous quantity of low-power devices, identical coverage methods, high dependability, and low-slung latency [1-2].

Network Planning is the interconnection of assorted

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pieces of equipment to allocate resources among abundant users. Radio Network Planning (RNP) plays a noteworthy protagonist in the development of cellular design modeling. It is indispensable for operators to organize wireless cellular networks in a low-cost method. It depends on several inputs such as the environmental zone, the predictable quantity of users, the primary base stations' arrangements, path loss replicas, and the frequency reclaim pattern. Effective radio access network planning is replicated in satisfied subscribers and own infrastructure cost. The main consequence of the Radio Network Planning (RNP) is the location and configuration of base stations, which are desirable to convoke the network coverage model obtaining the concentrated coverage, which means that the mobile is associated with an assumed cell at a maximum conceivable distance at minimum cost. The base stations, the competence of cooperating with the mobile station contained by a convinced coverage area and upholding call superiority standards of radio network planning development, have a radio association through the mobile devices. The Radio Network Planning processes shall have to be painstaking based on the propagation atmospheres, site appearances, essential capacity and coverage, and the antenna conformation at all base stations. The key refurbishment anticipated in the 5G advancement of mobile network standards indicates the foremost issues to the radio network planning practice by comparing with the accessible wireless networks. The 5G system encirclements an innovative core network up to endure obtainable technologies of 3G and 4G, in addition to a new air interface called new radio (N.R.) that compromises considerable data rates and capacity in higher condition by exhausting novel high-frequency bands (millimeter wave mmW). Consequently, 5G is the condensed base station arrangement in a heterogeneous network system that is unruffled of macrocells and dissimilar types of small cells, i.e., microcells, picocells, and femtocells. Small cells are called low-powered radio access nodes, which activate in the licensed and unlicensed spectrum containing a range of 10 meters to a few kilometers and can be utilized in indoor or outdoor public space to expand data capacity and optimize the coverage, reduced latency. Formulation of the base stations nearer to the user with a small cell could moderate the return excursion delay and could intensification numerous obtainable resources for active users in this scheme. The active and sleep modes could be completed to reduce interference and power consumption over and above the enhancement of cellular networks' energy efficiency.

5G millimeter-wave frequencies (mmW) could be utilized for short-range wireless communication, which permits high digital data rates and is beneficial in densely packet networks. The 5G operating bands are divided into two frequency ranges, such as 450-6000MHz for FR1 and 24.25-52.6 GHz for FR2. Most operators continuously custom higher frequency cellular bands (FR2) to afford more capacity to areas with plentiful customers. 5G system yearnings spectrum within the three key frequencies ranges: sub-1GHz, 1-6GHz, and over 6GHz, to deliver prevalent coverage and sustenance to all users. Over the values of 6GHz is needed to bump into the ultra-high broadband speeds intended for 5G, which could not distribute the fastest data speeds without these bands. In this study, the 26GHz and 28GHz bands have the best international band in this range for analyses with numerical studies. The spectrum at 28GHz has irrelevant atmospheric attenuation compared to supplementary GHz frequencies. Besides, the rain attenuation and oxygen could not inhibit intensification suggestively at 28GHz frequency.

The Optimization procedure for Network planning could be appraised of recent research activities in academic societies. The dynamic programming (D.P.) was used to enhance the network nodules' assignment [3]. The convention of clustering and ant-colony algorithms in network planning was reported in [4]. The prosperous application of genetic algorithms to network scheme and planning were articulated in [5]. An optimization technique based on the linear programming whose objective function is the minimization of the complete Wireless Mesh Network fixing cost whereas taking into consideration the coverage of the termination users, the wireless connectivity in the wireless dissemination system and the supervision of the traffic network flows has been enunciated in [6]. A stagnant emulator for the WCDMA network to examine four investigative algorithms to acquire optimized network conformations was described in [7]. In [8], the theoretical general idea of 3G network planning was given. A genetic category algorithm accustomed enhances the number and positions of base stations in place of the cellular network recommended in [9].

This works' objectives are to diminish and optimize the location of base stations in the geographical area, reduce energy disbursement, reduce cell overlap, and improve the Quality of Service (QoS).

The remaining portion of the paper is schematized as follows. Section II presents the proposed network planning model. Section III gives the Analysis of the Power Allocation Problem. Section IV mentions the simulation results and discussion on numerical analysis. Section V concludes the proposed system.

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2. Recommended Network Planning Model

Heterogeneous network planning solutions help from the small base station to boost capacity and coverage under various consequences. The wireless radio network is called a cellular network or mobile network, which is commonly cellular naturally, where coverage is separated keen on innumerable terrestrial coverage areas baptized cells. A Base station (BS) is positioned in each cell, maintaining one or extra cells and reliant on the creators' apparatus. The B.S.s arrange for the radio connection for U.E.s inside the cell to facilitate mobile phones and smartphones to interconnect with the operator's linkage. However, U.E.s are affecting from end to end deferent cells in the course of transmission determinations. Every UE uses a radio connection to converse with the base station using a couple of radio channels, one channel for Downlink (DL), and the other for Uplink (U.L.). The cells (sites) positioned inside the geographical area can be categorized as outdoor and indoor cells. The outdoor cells can be categorized as cellular for macro, cellular for micro, or cellular for pico. The indoor or outdoor small cells can eliminate "bad" users with poor radio circumstances from macrocell conditions.

2.1 Macro-cells

The base station antennas are positioned exceeding the roof-top position; the cell is recognized as a macro. As the antenna's height exceeds the roof-top position's mediocre level, the area that can be concealed is extensive. A macro-cell range might differ from a pair of kilometers to 35 km, the space reliant upon the environment's category and the propagation circumstances. Henceforth, this conception is mostly utilized for residential or countryside milieus.

2.2 Micro-cells

The antennas at the base station are further down the roof-top position's mediocre level, and then the cell is recognized as a micro-cell. The region that can be concealed is minor, so this conception is realistic in metropolitan and residential areas. The assortment of micro-cells is commencing a small number of hundred meters to a twosome of kilometers.

2.3 Pico-cells

Pico-cells are demarcated as the unchanged cover as micro-cells and are customarily utilized for interior coverage. In this study, the recommended system model comprises a prearranged set of contestant base stations B.S.s B which is fashioned B_{micro}. B_{micro} represents the set of contestant micro B.S.s with the fixed locations. In this planning practice, 80 micro base stations are deployed in the 625 km^2 of the Yangon Downtown range. In this analysis, orthogonal frequency division multiple access is a retrieving pattern. The retrieving pattern for the 5G network is not demarcated yet, and the usage of OFDMA is appropriate for enactment estimation and assessment with 4G complexes. The user dissemination ideal in this problem is an approach based on the snapshot. A snapshot epitomizes a pair of users utilizing the physical network at a specified instantaneous time. For a specified snapshot that epitomizes the existing vigorous users, we target to catch the minutest amount of base stations on/off switching approach that quiet promise coverage and capability desires. The downlink signal to interference and noise ratio (*DSINR*) above a subcarrier *N* consigned to the user *A* can be exhibited as follows:

$$DSINR_k = \frac{P_{A,B(A)}}{TNP^2 + I_A} \tag{1}$$

where $P_{a,b(k)}$ as the received power on subcarrier *N* consigned for the user *A* by its serving *BS B(A)*. TNP^2 is the noise power due to thermal , and I_A is the inter-cell interference from neighboring BS_S. $P_{BSmicro}$ is the transmit power of the micro base station. The received power at the mobile station *MS* and base station bs can be expressed as:

$$P_{MS,bs}(dB) = 10\log_{10}\left(\frac{TP_{BS}}{MS_{BS}} - L_{MS,bs}\right) \tag{2}$$

where TP_{BS} is the downlink transmit power of *BS* and MS_{BS} is the number of mobile stations, $L_{MS,bs}$(dB) is the path loss between Mobile Station *MS* and Base Station *bs* can be modeled as:

$$L_{MS,bs}(dB) = 92.4 + 20\log_{10}\left(d_{MS,bs}\right) + 20\log_{10}(f) + \alpha\left(d_{MS,bs}\right) + \gamma(d_{MS,bs}) + \rho + h_{MS,bs} \tag{3}$$

where *f* is the carrier signal frequency in GHz

In this study, the frequency is fixed to 28 GHz. α is the attenuation value in the atmospheric condition is just about negligible at 28 GHz frequency (0.06 dB/km). $h_{MS,bs}$ is a random variable on behalf of the channel gain between Base station and Mobile Station. γ is the rain attenuation, and ρ is the foliage losses.

The path loss is based on the ECC-33 ideal established by Electronic Communication Committee (ECC). It is inferred from Okumura's original quantities and improved its expectations to further meticulously characterize an immovable wireless access system. ECC-33 model to govern the optimal ideal for radio coverage approximation and interference viability could be analyzed during radio network planning based on a multi-transmitter system in the very high-frequency bands (VHF).

$$PL(dB) = Att_{FS} + PL_{BM} + GF_{BS} + GF_{RA} \quad (4)$$

Att_{FS} is the attenuation value in free space, PL_{BM} is the path loss for the basic median, GF_{BS} is the gain factor for base station height, and GF_{RA} is the gain factor for received antenna height.

$$Att_{FS} = 92.4 + 20\log_{10}(d) + 20\log_{10}(f) \quad (5)$$

$$PL_{BM} = 20.41 + 9.83\log_{10}(d) + 7.89\log_{10}(f)$$

$$+9.56 + \left[\log_{10}(f)\right]^2 \quad (6)$$

$$GF_{BS} = \log\left(\frac{h_b}{200}\right)\left[13.98 + 5.8\left(\log\left(d\right)\right)^2\right] \quad (7)$$

For the median city,

$$GF_{RA} = \left[42.57 + 13.7\log\left(f\right)\right]\left[\log\left(h_m\right) - 0.585\right] \quad (8)$$

For a large city,

$$GF_{RA} = 0.759\left(h_m\right) - 1.862 \quad (9)$$

3. Parameters Affecting the Tower Sites

3.1 Rain Attenuation Affecting on the Tower Sites

Rain attenuation is ascribed to the concentration and smattering of electromagnetic waves by rain spots. Rainfall attenuation is a manifestation qualified to the rate of rainfall and frequency, which significances in accumulative path loss, off-putting the coverage region, and accordingly unbecoming the system enactment. At frequencies for high-level value, rain attenuation shall have an outsized effect on the network contingent on the dimension, dissemination, and reduction velocity of the rain spots. When rain falls, phone signals have grinned between towers, which are initiated by lowered signal strength. This occurrence is known as signal attenuation.

At a frequency of above 10 GHz, rainfall and sleet can impact the attenuation enormously; the consequence of attenuation in the atmospheric between source and target over a wireless connection is of main concern, and an appropriate site appointment and appropriate technique are obligatory to govern the level of attenuation. The endorsement of the ITU-R P.838-3 (ITU-R, 2005) establishes the practice of explicit attenuation from the intensity of rain. The explicit attenuation γ (dB/km) is achieved from the rate of rain *R*(mm/h) surpassed at per hundred of the time, expending the power regulation rapport as [10]. Precipitation can include origin ordinary interference above transmitted signals in microwave links [11]. The explicit attenuation *R* (dB/km) is acquired from the rate of rain *R* (mm/h) using the power regulation connection is shown in (10).

$$\gamma_R = kR^{\alpha}\left(2 < R < 50\ mm/hr\right) \quad (10)$$

The values of the coefficients for k and α are considered as the frequency function. *f*(GHz) is the assortment from 1 to 1000GHz.

Table 1. The different frequencies changes of the coefficients k and values (recommended by itu_r p.838-3)

Frequency (Hz)	α	β
2	0.00000847	1.0185
12	0.02386	1.1825
28	0.2051	0.9679
60	0.8606	0.7656

3.2 Foliage Losses Effect on the Tower Sites

The attenuation of radio signals affected by trees barricading the radio connection is labeled as loss of foliage [12]. The loss of foliage is a very convoluted problem that has various constraints and deviations. At millimeter wavelengths, the approximation of foliage initiated attenuation is tremendously momentous for a radio connection arrangement. The dimensions of the shrubberies, brushwood, stems, the concentration and dissemination of shrubberies, and the tree's height compared with the antenna heights that influence the propagation over and done with vegetation. The manifestation of foliage in the broadcast network can central to unembellished signal attenuation. The tree stem, haphazardly disseminated shrubberies, annexes, and brushwood are diverse distributes which origin the attenuation, sprinkling, and deflection on the exuded signal. The foliage argument on wireless connection can be classified as three expressions (a bush, wooded area, and appearances of plants).

Foliage losses ρ for millimeter-wave frequencies are substantial and can mark the enactment of the network. Those losses should be engaged while exhibiting 5G systems at extraordinary frequencies and can be transcribed as follows:

ITU-R model is

$$\rho(dB) = \left(0.2\right)\left(f\right)^{0.3}\left(R\right)^{0.6} \quad (11)$$

where *f* is the frequency in MHz, *R* is the bush of the depth in the meter. (*R*<400m)

Cost 235 model is

$$L_{COST}(dB) = 26.6\left(f\right)^{0.2}\left(d\right)^{0.5} \quad (12)$$

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3.3 Euclidean Expanse Calculation for Base Stations

The Euclidean expanse is the straightforward link expanse between two points in Euclidean space in reality. To calculate the Euclidean distance of nodes in a heterogeneous network system, two types of nodes with different ranges are positioned in the Yangon Downtown area with MATLAB. After deploying these two types of nodes, Type I and Type II nodes' positions, matrixes become visible. Type I nodes' positions are defined as (x_i, y_i) are the coordinates of BS_i in Cartesian expressions where i=1,2,3,...,N and Type II nodes' positions are defined as (u_k, v_k) are the coordinates of MS_k in Cartesian expressions, where k=1,2,3,...,N. If the first Type I base stations B.S.s nodes are located on the point (x_i, y_i), and the second Type II mobile station nodes are positioned on point (u_k, v_k), the Euclidean distance equation between mobile station k and base station i is expressed in (13).

$$d_{k,i} = \sqrt{\left(x_i - u_k\right)^2 + \left(y_i - v_k\right)^2} \tag{13}$$

The interference term depends merely on the inter-cell interfering signals; subsequently, the subcarriers are a cell in orthogonally in an OFDMA-based systems (presumptuous perfect orthogonally condition). For a mobile station to be obliged, it $DSINR$ needs to outstrip the minutest threshold rate $DSINR_{thr}$. The signal to interference plus noise ratio is expressed in (14).

$$DSINR_{th} = \frac{P_{A,B(A)}}{\sum_{i=1, i\neq B(A)}^{N_B} CP_i P_{A,i}} \geq SINR_{thr} \tag{14}$$

where CP_i indicates where BS_i is used or not. The term $\sum_{i=1, i\neq B(A)}^{N_B} CP_i P_{A,i}$ represents the interference power received from neighboring BS_i at MS_k .

4. Analysis and Implementation

Network planning was completed using 28 GHz millimeter wave carrier frequencies that compromise greater transmission capacity due to larger bandwidth associated with the existing frequency ensembles. In this research work, the quantity of overlap base stations is minimized to save energy expenditure, reduce the cell overlap, and reduce cost. Several base stations are switched OFF condition, and the residual active base stations were served the coverage and capacity requirements. The two main parts are considered the base station planning development in this study. The first fragment of base station planning development is considered in the free space path loss condition (attenuation in rainfall condition and foliage losses are zero). The second fragment of planning development is considered in the loss condition.

4.1 Design Parameters for Planning Development

Several eight base stations and nine mobile stations are deployed in the geographical area's fixed locations in this section. Before using the MATLAB tools, this step could be studied and deliberated for the radio network planning development.

Table 2. Test parameters of fixed eight base stations and nine mobile stations

Parameter	Values
Base Station B_{BS}	8
Mobile Station K_{BS}	9
Transmit Power P_{BS}	2 Watt
Atmospheric attenuation α	0.06 dB/km
Rain attenuation λ	0 dB/km
Foliage losses ρ	0 dB/km

The discussions on the results of this fragment are described in the following table. Table 2 shows that the test Parameters of fixed eight base stations and nine mobile stations. Table 3 and Table 4 give the x and y coordinates values for fixed eight base stations and x and y coordinates for fixed nine mobile stations.

Table 3. X and y coordinates values for fixed eight base stations

For Base Station BS_i	x coordinate of BS_i	y coordinate of BS_i
1	25	25
2	-25	25
3	-25	-25
4	25	-25
5	-25	0
6	25	0
7	0	25
8	0	-25

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4.2 Distance Calculation Results

Among the quantity of eight base stations to nine mobile stations, the distance calculation results are described for the quantity of eight base stations to the mobile station four.

Table 4. X and y coordinates values for fixed nine mobile stations

For Mobile Stations MS_k	u is the coordinate of MS_k	v is the coordinate of MS_k
1	30	5
2	20	30
3	-15	40
4	-30	-15
5	-30	-15
6	-15	-10
7	-15	-40
8	15	-15
9	30	-40
1	30	5

The Euclidean expanse between Base Station BS_i and Mobile Station MS_k is evaluated using (13) with k is 1 to 9 and i is 1 to 8. Table 5 shows that the distance calculation results between the mobile station k and the base station i.

Table 5. Distance calculation results between base station i and mobile station k

Mobile Station MS_k	Base station BS_i	Euclidean distance d_{ki} (km)
4	1	55.9×10^{-3}
4	2	11.18×10^{-3}
4	3	40.3113×10^{-3}
4	4	68×10^{-3}
4	5	15.8114×10^{-3}
4	6	57×10^{-3}
4	7	31.62277×10^{-3}
4	8	50×10^{-3}

4.3 Calculation Outcomes of Path Loss

To calculate the values of path loss between Mobile Station 4 and 8 Base Stations using (3). The evaluated Euclidean distance between mobile stations 4 and 8 base stations results is replaced in this path loss equation. The calculations results of path loss between mobile station k and base station i is listed in Table 6.

Table 6. Calculation results of path loss between mobile station k and base station i

Mobile Station MS_k	Base station BS_i	Path loss $L_{k,i}$ (dB)
4	1	96.99
4	2	82.523
4	3	93.61
4	4	98.525
4	5	85.866
4	6	96.974
4	7	91.859
4	8	95.6374

The value of f is the GHz values for millimeter-wave frequency. The very high frequency (HF) and ultra-high frequency (UHF) are required to implement the 5G millimeter wave path loss model. In this study, the frequency is established to 28 GHz. α is the attenuation in atmospheric (0.06 dB/km), which is negligible at 28 GHz frequency. $h_{k,i}$ is the random variable signifying the channel gain between base station i and mobile station k. In free space loss condition, attenuation values in rain condition γ and foliage loss ρ are zero.

4.4 Calculation Outcomes of Received Power

To calculate the received power between mobile station 4 and the number of 8 base stations using (2).

The evaluated path loss between mobile station 4 and the number of 8 base stations results are replaced in this received power equation. The intention consequences of the received power between mobile station k and base station i are listed in Table 7.

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Table 7. Calculation results of received power between mobile station k and base station i

Mobile Station MS_k	Base station BS_i	Received Power $P_{k,i}$ Watt
4	1	4.443×10^{-11}
4	2	1.2431×10^{-11}
4	3	9.67832×10^{-11}
4	4	3.121×10^{-11}
4	5	5.757×10^{-11}
4	6	4.46066×10^{-11}
4	7	1.4484×10^{-11}
4	8	6.0681×10^{-11}

4.5 Calculation Outcomes for SINR

Finally, calculate the *SINR* between mobile station 4 and 8 base stations using (14). These *SINR* values need to exceed the threshold value of *SINR*. The threshold value of *SINR* is -9dB. It is used to detect the data easily. CP_i represents Base station i is used or not. The evaluated values of received power between mobile station 4 and the number of 8 base stations are replaced in this equation. The calculation results of *SINR* (dB) between mobile station k and base station i are listed in Table 8.

Table 8. Calculation results of sinr (db) between mobile station k and base station i

Mobile Station MS_k	Base station BS_i	$SINR_k$(dB)
4	1	-16.944
4	2	0.9527
4	3	-13.468
4	4	-18.5
4	5	-4.614
4	6	-16.92
4	7	-11.6
4	8	-15.67

Among the number of 8 base stations and a quantity of 9 mobile stations, the calculation results are expressed for the quantity of 8 base stations to 4 mobile stations. According to the calculation results, the greater than or equal SINR threshold (dB) are the active base stations and otherwise are the dead base stations.

5. Numerical Results

The numerical results are analyzed established on various conditions for the real-world situation in a specific capacity.

5. 1 Numerical Results with Fixed Base Stations and Random Mobile Stations

In this section, the fixed number of 9 base stations and random 20 mobile stations are deployed in -4km×4km area, defined in Figure 1.

The first iteration outcome is designated in Figure 2. In this result, the number of five life nodes covered the twenty mobile stations within the -4km×4km range of geographical area. The second iteration result is revealed in Figure 3. The quantity of active five base stations covered the twenty mobile stations within -4km×4km area.

The tenth iteration result is described in Figure 4. The numbers of five nodes are switched on among the 9 micro base stations in the -4km×4km coverage area in these results.

Table 9. Test parameters of a fixed number of eight base stations and a random number of twenty mobile stations

Parameter	Values
Base Stations B_{BS}	9
Mobile Station K_{BS}	20
Transmit Power P_{BS}	2 Watt
Atmospheric attenuation α	0.06 dB/km
$SINR_{th}$	-9 dB
Rain attenuation γ &Foliage losses ρ	0

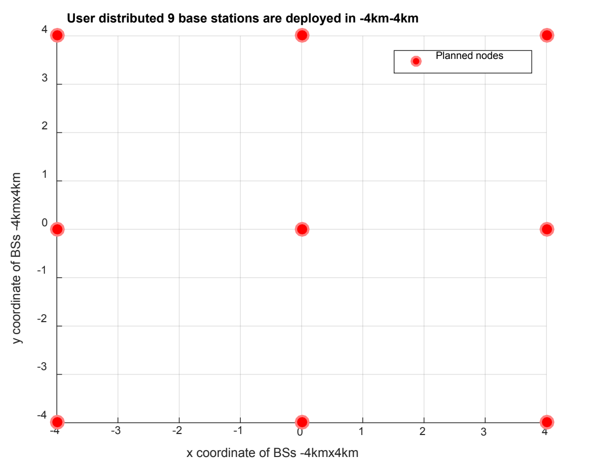

Figure 1. User Distributed 9 Nodes are deployed in -4km × 4km area

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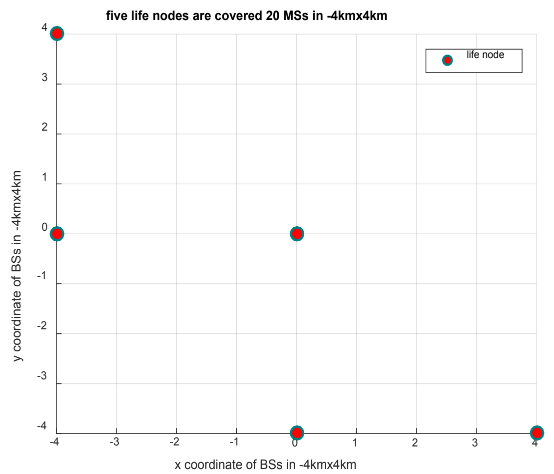

Figure 2. Five Life Nodes covered 20 Mobile Stations in -4km×4km area

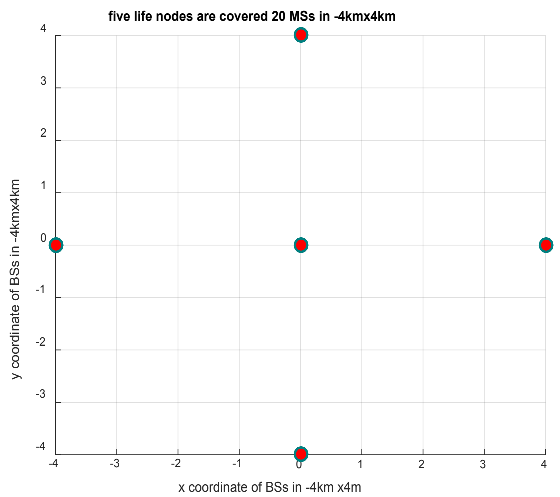

Figure 3. Five Life Nodes are covered 20 Mobile Stations in -4km×4km area

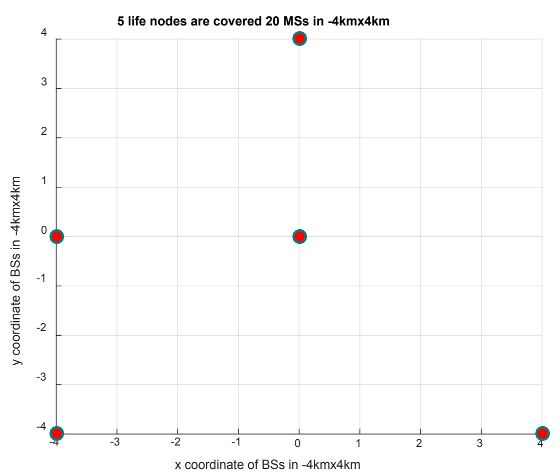

Figure 4. Five Life Nodes are covered 20 Mobile Stations in -4km×4km area

The results from several iterations indicate that there is a minimum number of the base station, which has five from this simulation with limited *SINR* greater than -9dB. Table 9 shows the test parameters of a fixed number of eight base stations and a random number of twenty mobile stations in the -4km×4km range.

5.2 Numerical Results with Random Base Stations and Random Mobile Stations

In this section, the number of 9 base stations and 20 mobile stations are randomly deployed in -4km × 4km range of geographical area, shown in Figure 5. The first iteration result for the minimum number of base stations is shown in Figure 6. The numbers of 4 base stations are switched on, and the numbers of 5 base stations are switched off among the 9 micro base stations. In the second time iteration process, the locations of base stations and mobile stations are changed within the geographical area shown in Figure 7 through Figure 8.

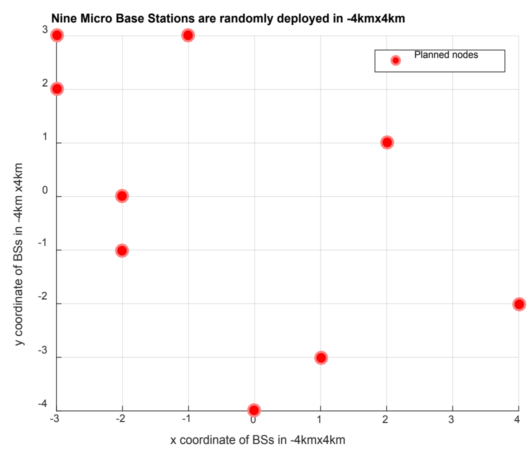

Figure 5. Nine micro base Stations and 20 Mobile Stations are randomly deployed in -4km × 4km area.

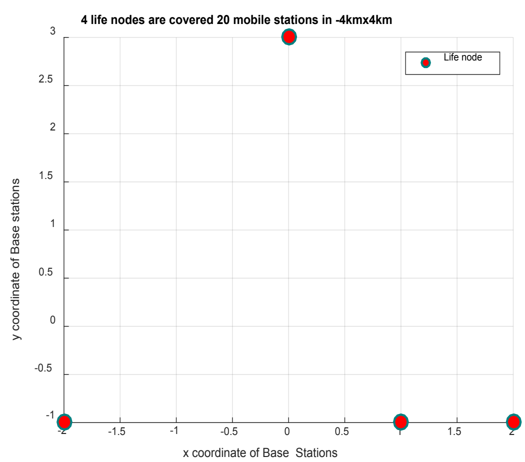

Figure 6. Four Life Nodes are covered the 20 Mobile Stations -4km × 4km area.

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In the second iteration result, the numbers of three base stations are switched on, and the numbers of six base stations are switched off among the 9 micro base stations, which result is shown in Figure 8. The numbers of four nodes are switched on in the tenth iteration, and five nodes are switched off among the nine micro base stations in -4km × 4km area. Several iterations show a minimum number of the base station, which has three from this simulation with limited *SINR* greater than -9dB.

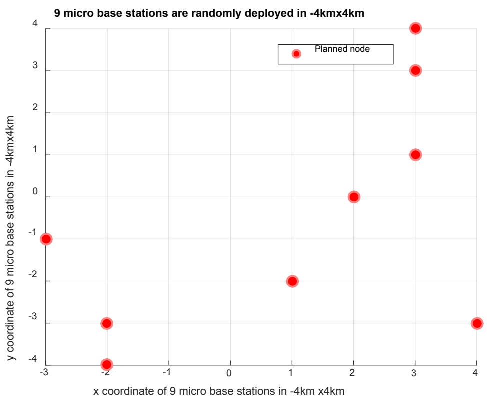

Figure 7. Nine Micro Base Stations and 200 Mobile Stations are randomly deployed in -4km × 4km area.

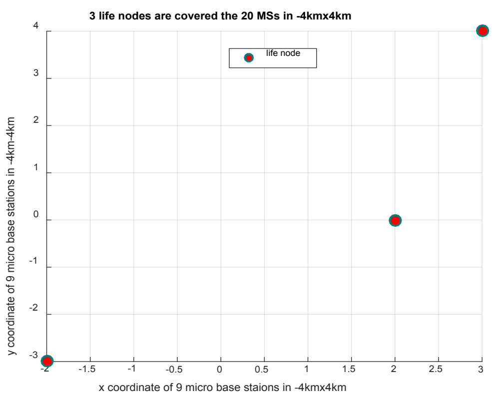

Figure 8. Three Life Nodes are covered the 20 Mobile Stations -4km ×4km area.

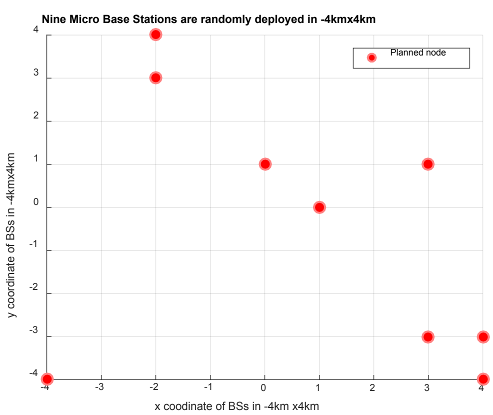

Figure 9. Nine Micro Base Stations are randomly deployed in -4km × 4km area.

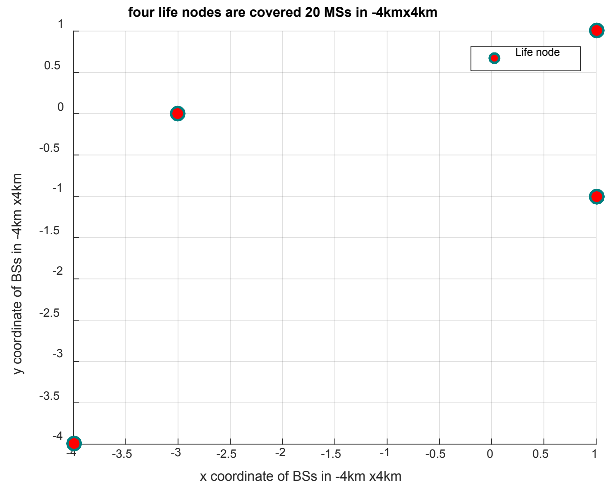

Figure 10. Four life nodes covered the 20 mobile Stations -4km × 4km area.

5.3 Numerical Results with Fixed Base Stations Planning for Yangon Downtown Region

In this section, the fixed number of 80 base stations in micro condition and 200 mobile stations are randomly deployed in the -15km × 15km of Yangon Downtown district, and these results are shown in Figure 11.

Table 10. Test parameters of fixed number of 80 base stations in micro condition and random number of 200 mobile stations

Parameter	Values
Base Stations B_{BS}	9
Mobile Station K_{BS}	20
Transmit Power P_{BS}	2 Watt
Atmospheric attenuation α	0.06 dB/km
$SINR_{th}$	-9 dB
Rain attenuation γ & Foliage losses ρ	0

This planning process is considered only free space path loss. The first iteration result is shown in Figure 12. In this result, 51 base stations in micro condition are switched on, and 29 base stations in micro condition are switched OFF among the 80 micro base stations in the -15km × 15km of Yangon Downtown district.

Table 11. X and y coordinates of fixed number of eighty base stations in micro condition

Number of Base Stations	x coordinate	y coordinate
1	-12500	0
2	-12500	3125
3	-12500	6250
4	-12500	9375
5	-12500	12500
6	-12500	-3125
7	-12500	-6250
8	-12500	-9375
9	-12500	-12500
10	-9375	0
11	-9375	3125
12	-9375	6250
13	-9375	9375
14	-9375	12500
15	-9375	-3125
16	-9375	-6250
17	-9375	-9375
18	-9375	-12500
19	-6250	0
20	-6250	3125
21	-6250	6250
22	-6250	9375
23	-6250	12500
24	-6250	-3125
25	-6250	-6250
26	-6250	-9375
27	-6250	-12500
28	-3125	0
29	-3125	3125
30	-3125	6250
31	-3125	9375
32	-3125	12500
33	-3125	-3125
34	-3125	-6250
35	-3125	-9375
36	-3125	-12500
37	0	0
38	0	3125
39	0	6250
40	0	9375
41	0	12500
42	0	-3125
43	0	-6250
44	0	-9375
45	0	-12500
46	0	0
47	3125	3125
48	3125	6250
49	3125	9375
50	3125	12500
51	3125	-3125
52	3125	-6250
53	3125	-9375
54	6250	0
55	6250	3125
56	6250	6250
57	6250	9375
58	6250	12500
59	6250	-3125
60	6250	-6250
61	6250	-9375
62	6250	-12500
63	9375	0
64	9375	3125
65	9375	6250
66	9375	9375
67	9375	12500
68	9375	-3125
69	9375	-6250
70	9375	-9375
71	9375	-12500
72	12500	0
73	12500	3125
74	12500	6250
75	12500	9375
76	12500	12500
77	12500	-3125
78	12500	-6250
79	12500	-9375
80	12500	-12500

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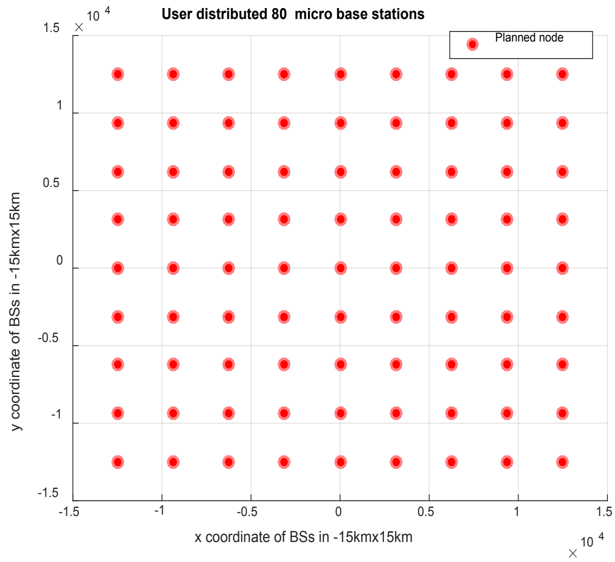

Figure 11. User Distributed Number of 80 Micro Base Stations and 200 random mobile stations are deployed in -15km × 15km

In the second iteration result, the numbers of 54 base stations in micro condition are switched ON, and 26 base stations in micro condition are switched off among the 80 base stations in the micro condition, shown in Figure 13.

The tenth iteration result is presented in Figure 14. In these results, the numbers of active nodes are 55 among the 80 micro base stations in the -15 km × 15 km coverage area of the Yangon Downtown region.

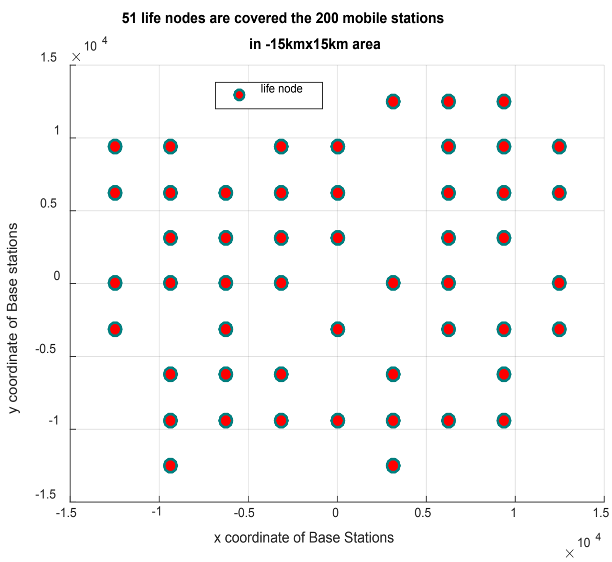

Figure 12. 51 Life Nodes are covered 200 Mobile Stations in -15km × 15km area

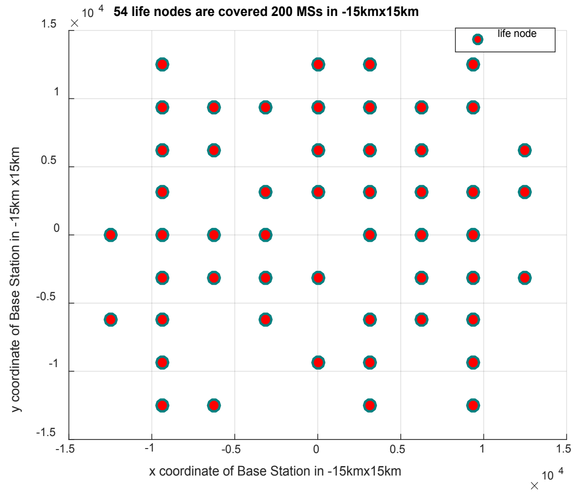

Figure 13. 54 Life Nodes are Covered 200 Mobile Stations in the -15km × 15km

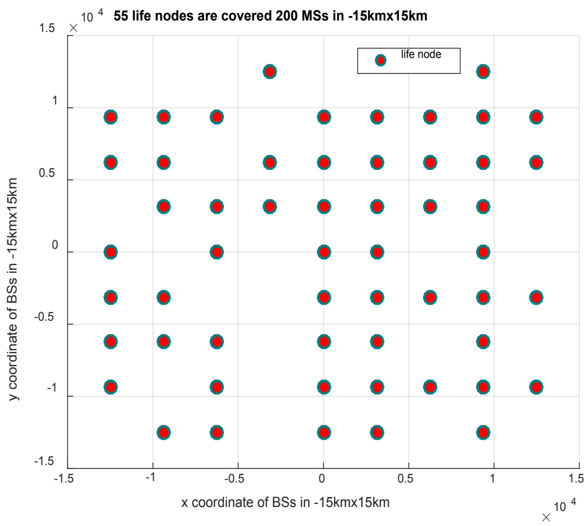

Figure 14. 55 Life Nodes are covered 200 Mobile Stations in -15km × 15km area

Several iterations show a minimum number of the base station, which has fifty-one from this simulation with limited *SINR* greater than -9dB. Test parameters of a fixed number of 80 micro base stations and a random number of 200 mobile stations are shown in Table 10. The locations of x and y coordinates for fixed eighty micro base stations are listed in Table 11.

5.4 Numerical Results of Random Base Station Planning in Yangon Downtown Area

In this section, the number of 80 micro base stations and 200 mobile stations is randomly deployed in the -15 km ×15 km range of the Yangon Downtown region, shown in Figure 15.

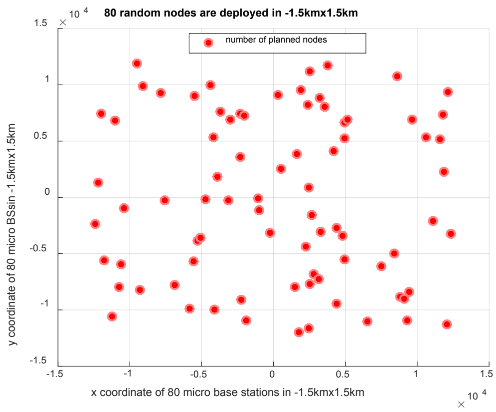

Figure 15. Random Number of 80 nodes and 200 mobile Stations are deployed in -1.5km × 1.5km

After running the simulation, the numbers of 51 nodes are active base stations, and 29 nodes are dead base stations among the 80 micro base stations, shown in Figure 16. In the second iteration, the number of fifty-three life nodes is covered the 200 mobile stations in the -15 km × 15 km area is shown in Figure 18.

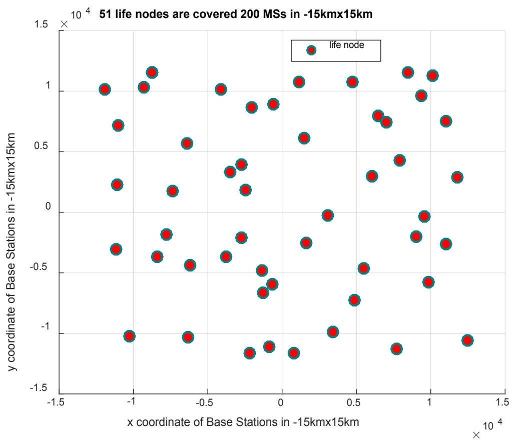

Figure 16. Fifty-one life nodes are covered 200 mobile stations in -15km × 15km area

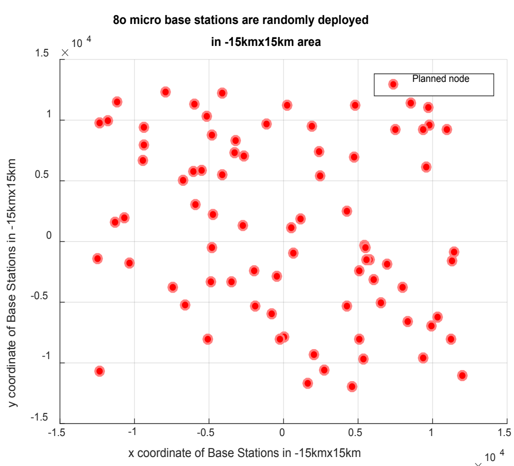

Figure 17. Random Number of 80 nodes and 200 mobile Stations are deployed in -1.5km × 1.5km

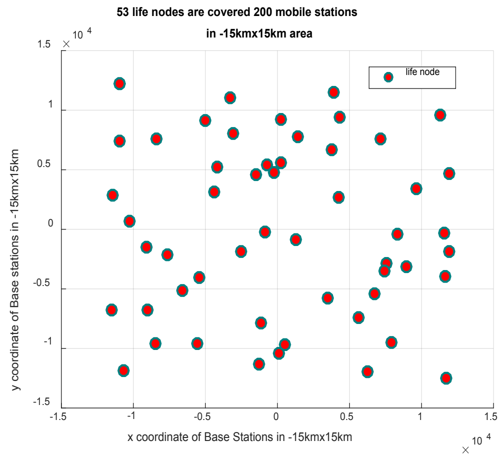

Figure 18. Fifty-three life nodes covered 200 mobile stations in -15km ×15km area

In the tenth iteration, fifty-five life nodes are covered; the 200 mobile stations in the -15 km × 15 km area is shown in Figure 20. Several iterations show that a minimum number of the base station is around fifty-one from this simulation with a limited number *SINR* is less than -9dB.

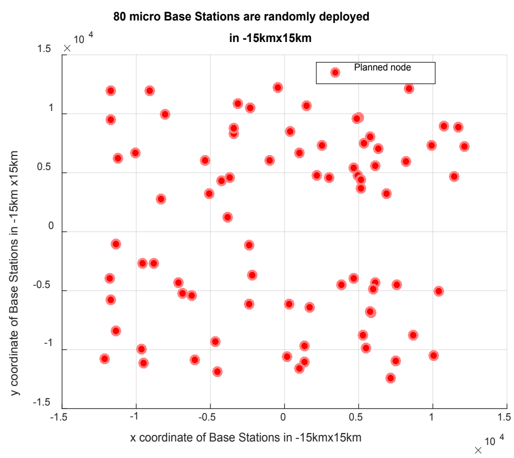

Figure 19. A random number of 80 nodes and 200 mobile Stations are deployed in -1.5km ×1.5km

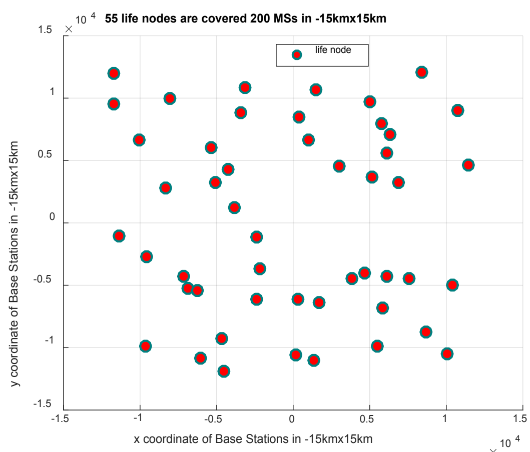

Figure 20. Fifty-five life nodes covered 200 mobile stations in -15km ×15km area

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5.5 Numerical Results of Attenuation in Rain Fall Condition and Losses in Foliage Condition

In this section, the attenuation in rainfall conditions for three different intensity levels for rain is shown in Figure 21. For these analyses, the value of γ is diverged between 0.5 (dB/km) for light rain (2.5mm/hr) up to 9 (dB/km) for heavy shower rain (50 mm/hr) at the selected 28 GHz frequency.

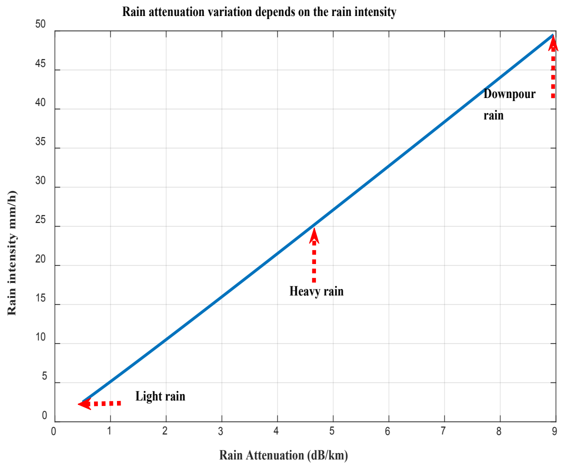

Figure 21. Attenuation in Rain Fall Condition Variation Hang on the Rain Intensity

These figures demonstrate that this supplementary attenuation at high frequencies affects the network's performance, prominent to a noteworthy surge in the linkage outage. Subsequently, this aspect is significant in the Radio Network Planning progression as encountering network necessities concerning the outage threshold, which hangs on the environmental circumstances in the designated zone of concentration. When the rain intensity increases, rain attenuation also increases.

Table 12. Foliage losses (db) variation depends on the depth of the foliage (meter)

R(depth of the foliage in meter)	ρ(foliage losses dB)
1	4.3170
2	6.5433
3	8.3455
4	9.9178
5	11.3386

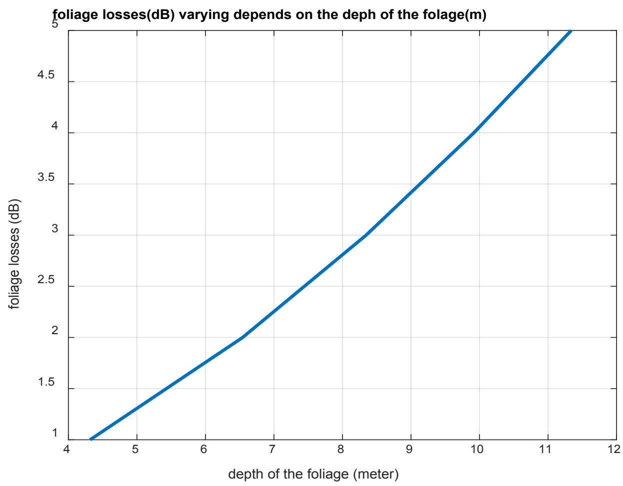

Figure 22. Foliage Losses (dB) variation Depends on the Depth of the Foliage in Meter

Figure 22 shows that the foliage losses (dB) for the different foliage depth (meter). In this study, losses in foliage conditions are realized to the pretend network by changing the parameter ρ. The foliage depth value R was increased from 1m to 5m to create diverse foliage depths prominent to a deviation in the rate of ρ from 4.31 dB to 11.33 dB. If the depth of the foliage increases, the foliage losses will increase. Table 12 shows that the foliage losses (dB) variation depends on the foliage depth.

5.6 Numerical Results of Rain Attenuation and Foliage Losses Affecting on Base Station

In this section, the results of foliage losses and rain attenuation affecting the base stations are discussed in Figure 23 through 26.

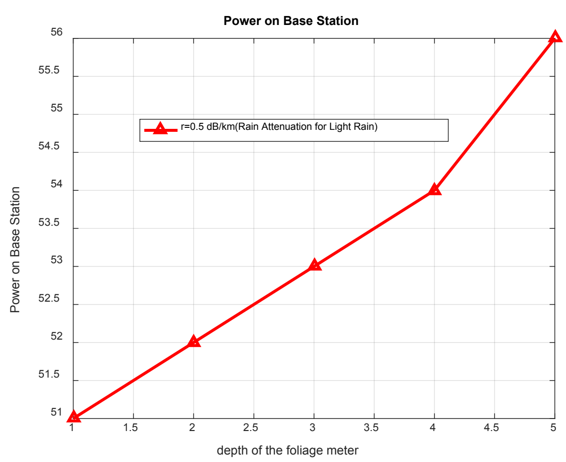

Figure 23. Active Base Stations for Depth of the Foliage (1~5) Meter and Light Rain

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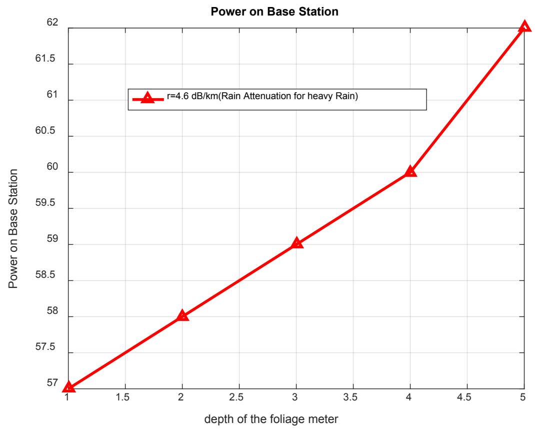

Figure 24. Active Base Stations for Depth of the Foliage (1~5) Meter and Heavy Rain

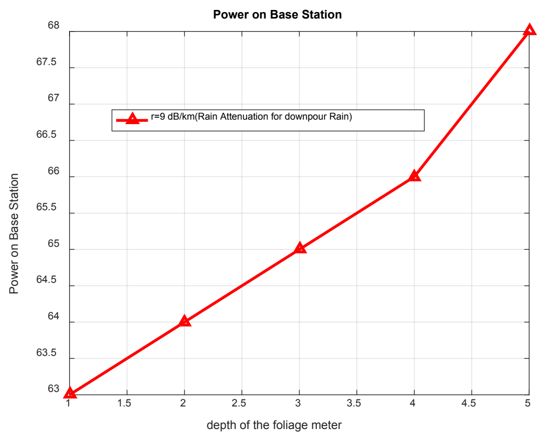

Figure 25. Active Base Stations for Depth of the foliage (1~5) Meter and Downpour Rain

According to light rain conditions, fifty-one base stations are switched on in one-meter foliage depth, and fifty-six base stations are switched on in five-meter foliage depth. This result is shown in Figure 23. According to heavy rain conditions, fifty-seven base stations are switched on in one-meter foliage depth, and sixty-two base stations are switched on in five-meter foliage depth.

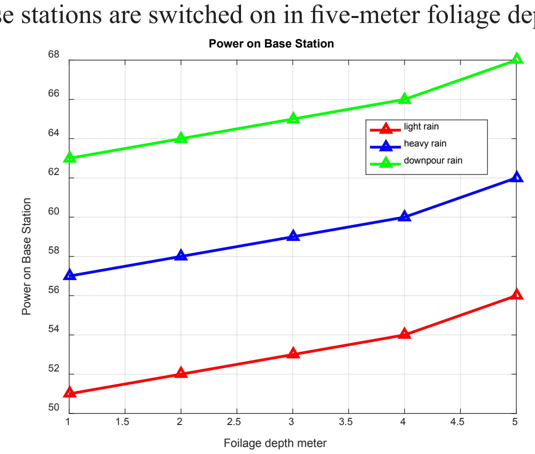

Figure 26. Comparison Results of Active Base Stations for Light Rain, Heavy Rain, and Downpour Rain

The result on Active Base Stations for Depth of the Foliage (1~5) Meter and Heavy Rain is shown in Figure 24. According to downpour rain conditions, sixty-eight base stations are switched on in one-meter foliage depth, and sixty-eight base stations are switched on in five-meter foliage depth. This result is shown in Figure 25. The comparison result of active base stations for light rain, heavy rain, and downpour rain is shown in Figure 26.

6. Discussions And Conclusion

This study's main contribution is to enhance the quantity and base station locations for a geographical region. The base station cannot be switched off if the received *SINR* ratio is less than the *SINR* threshold value and if not, these nodes are said to be active base stations. Firstly, the base station planning process is tested in the free space path loss condition. In the -4km × 4km coverage area, the numbers of 9 micro base stations are fixed locations, and the numbers of 20 mobile stations are deployed the random locations. The first iteration result is the five life nodes covering the 20 mobile stations after running the simulation. The second iteration result is the five life nodes that covered the 20 mobile stations. The tenth iteration result is the five life nodes which covered the 20 mobile stations. The simulation tests the same coverage area; the number of 9 micro base stations and 20 mobile stations are randomly deployed in that coverage area. After running the simulation, the first iteration result is the four active base stations covering the 20 mobile stations. The second iteration result is the three base stations that covered the 20 mobile stations. The tenth iteration result is the four life nodes which covered the 20 mobile stations. In -15km × 15km coverage area, the numbers of 80 micro base stations are fixed locations, and the numbers of 200 mobile stations are deployed the random locations. Minimum fifty -one micro base stations can support to 200 mobile stations in this coverage area. Secondly, the base station planning process is tested in the shadowing effect, rain attenuation, and foliage losses condition stage. Attenuation in rain conditions depends on the rain intensity. If the rate of rain intensity increases, the rain attenuation will increase. And then, the foliage losses depend on the depth of the foliage. The number of fifty-six base stations covered the 200 mobile stations in -15km × 15km in light rain. In downpour rain, the numbers of sixty-eight base stations covered the 200 mobile stations within the geographical area. Radio network planning was accomplished in the impending 5G mobile networks framework to enhance base stations' quantity and positions within the geographical area. Planning was done using the millimeter-wave carrier frequencies that compromise higher

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transmission capability because of the great bandwidth associated with the contemporary frequency bands. In the first part of the base station planning process, the minimum number of base stations is considered in free space loss conditions. In the second part base station planning process, the minimum number of base stations is considered in loss condition (rain attenuation and foliage losses). According to the loss condition, the numbers of base stations are more switched on to cover the subscribers within the downpour rain network than the light rain condition. The numbers of base stations in free space loss condition make more planning process optimized and minimized than the loss condition. Minimizing the base stations on/off switching can reduce the energy expenditure, reduce cell overlap, and reduce cost.

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