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Base Station Switch off Methods for Mobile Communication without Effecting QoS

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Abstract: During low traffic hours, switching off base stations is an effective way of saving energy in mobile communication networks. To serve increased traffic and to fulfill large and high-speed data demands, operators are deploying more base stations. This leads to more energy consumption in the mobile communication network. Therefore, minimizing energy consumption in mobile communication has become a primary concern. In a communication system, the maximum energy is consumed at the base stations. Hence, by switching off some of the base stations during low traffic hours, energy can be saved. In this work, we developed static and dynamic base station switch-off methods to minimize energy consumption during low-traffic conditions. Using these base-station switch-off methods, we are able to reduce the power use by 12.63%, 10.81% and 12.66% for the three different traffic scenarios.

Keywords: *Adjacent Base Station, Adaptive Switch off, Possible Switch off Base Station, Handover, Maximum Allocating Limit.*

1. Introduction

Due to technology advancements, smart mobile usage has increased [1]. The number of mobile devices is increasing day by day, and the data demand is also increasing drastically [2-5]. Earlier desktop and laptop devices were used for internet access, but now there has been a shift from conventional computer internet access to mobile internet access [6]. Additionally, earlier information exchange was performed by using paper and letters; now information exchange has shifted to digital circulars and letters. Smartphone and information exchange applications such as WhatsApp and Twitter have become integral parts of daily life. Several users access videos by live streaming applications such as YouTube, and Amazon Prime.

5G and 6G in several industry and home appliances are being controlled/monitored using smart mobile devices. Due to this number of users, the data and data rate demand is increasing. To fulfill these requirements, cell splitting and frequency reuse are promising solutions [7] [8]. The concepts cell splitting and frequency reuse are increasing the density of base stations. Due to greater number of base stations, energy consumption and radiation are increasing drastically [9]-[11].

GREEN NETWORK stands for the Globally Resource Optimized Energy Efficient Network; this research focuses on optimal resource allocation, for an energy efficient cellular network with improved performance [12]. In 5G and 6G, minimizing the energy consumption and radiation, i.e., green wireless/mobile communication is the primary concern [13]. This can be achieved by switching off some of the base stations in the network. Mobile traffic is not the same, and varies with time and place [14]. It is low during night and nonpeak hours. Therefore, during peak hours, by keeping all the base stations in an active state, all users can be served, and energy consumption can be minimized by switching off some base stations during night and nonpeak hours [15]-[17]. It is a challenging to select a base station for switch-off, and reallocate the switch-off base station traffic to adjacent active base stations without affecting the QoS of mobile devices or coverage areas. In this work, we propose base station switch-off methods for low-traffic conditions without compromising the QoS of mobile devices or coverage areas.

2. Related work and Research Goal

J. Wu et al. developed base station sleeping methods. They proposed three sleeping schemes: an isolated scheme, a cooperative scheme and a hybrid scheme. In the isolated scheme, base stations enter into the short-term sleep mode. In this mode, the base station switches between active and sleep modes, and the use of a femto base station/cell was suggested. In the cooperative scheme, the base station enters into the long-term sleep mode. Base station traffic is adjusted to nearby base stations, and macro base stations are suggested for this purpose. In a hybrid scheme based on traffic conditions, some base stations enter into long-term sleep, and the remaining base stations enter short-term sleep [18]. B. Shen et al. considered a heterogeneous network. The network consists of macro base stations and small cells.

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The macro base stations which are used to cover a wide area and track mobile devices, operate below 2.5 GHz. Small cells operating above 3.5 GHz which are used for high-speed data transfer. Based on traffic conditions, small cells enter into on and off modes [19].

Z. Tong et al. developed a base station on/off method for dense base station networks. They tried to monitor traffic, and based on traffic conditions, some base stations were kept in off mode during low-traffic conditions [20]. N. Yu et al. considered a heterogeneous network. In this work, macro base stations are used for transferring control signals and tracking purposes, and the remaining small base stations, such as micro, pico and femto base stations, are used for data transfer. These base stations are responsible for saving energy, and are switched between on/off modes based on traffic conditions [21].

The base stations need to switched-off carefully, and the traffic associated with switched-off base station should be adjusted to the best possible adjacent base stations. In this work, we propose static and dynamic base station switch-off methods and present a switching-off base station selection procedure and traffic handoff strategies.

3. Methodology

During low traffic hours by switching off some of the base stations in the cellular network, energy consumption can be minimized. To develop base station switch-off methods, we considered a cluster of 49 base stations arranged row and column wise as shown in matrix equation(1). The bolded base stations shown in matrix equation (1) have adjacent/cooperative base stations and are named "**Inner Matrix**" base stations. These bolded base stations (i.e. inner matrix base stations) can choose to switch-off if the traffic associated with these base stations is less than the threshold traffic level.

BSs=

$$\begin{bmatrix} BS1 & BS2 & BS3 & BS4 & BS5 & BS6 & BS7 \\ BS8 & \boldsymbol{BS9} & \boldsymbol{BS10} & \boldsymbol{BS11} & \boldsymbol{BS12} & \boldsymbol{BS13} & BS14 \\ BS15 & \boldsymbol{BS16} & \boldsymbol{BS17} & \boldsymbol{BS18} & \boldsymbol{BS19} & \boldsymbol{BS20} & BS21 \\ BS22 & \boldsymbol{BS23} & \boldsymbol{BS24} & \boldsymbol{BS25} & \boldsymbol{BS26} & \boldsymbol{BS27} & BS28 \\ BS29 & \boldsymbol{BS30} & \boldsymbol{BS31} & \boldsymbol{BS32} & \boldsymbol{BS33} & \boldsymbol{BS34} & BS35 \\ BS36 & \boldsymbol{BS37} & \boldsymbol{BS38} & \boldsymbol{BS39} & \boldsymbol{BS40} & \boldsymbol{BS41} & BS42 \\ BS43 & BS44 & BS45 & BS46 & BS47 & BS48 & BS49 \end{bmatrix} \ldots(1)$$

During low traffic hours, to minimize the energy consumption in the cellular network, we propose an adaptive base station switch-off algorithm that selects a static switch-off or dynamic switch-off method, which can switch off large number of base stations for a given traffic condition. To illustrate these methods, an example traffic distribution BSsMDs (base stations mobile devices) matrix is generated as shown in Equation (2). The number of mobile devices (MDs) connected to each base station (BS) at a particular instant in time is indicated. For each base station (BS), the number of MDs connected/communicating at a given instant in time is randomly generated (as shown in Equation-2), and the various steps in the static and dynamic base station switch off methods are explained below.

BSsMDs=

$$\begin{bmatrix} 24 & 58 & 91 & 55 & 133 & 99 & 13 \\ 29 & 17 & 125 & 64 & 79 & 36 & 70 \\ 23 & 132 & 130 & 44 & 44 & 149 & 48 \\ 100 & 95 & 132 & 46 & 121 & 137 & 56 \\ 139 & 26 & 28 & 42 & 67 & 73 & 125 \\ 59 & 67 & 22 & 70 & 145 & 26 & 17 \\ 36 & 123 & 134 & 49 & 87 & 114 & 51 \end{bmatrix} \ldots(2)$$

3.1 The criteria for selecting a switch-off base station (BS) were as follows:

A base station (BS) can be chosen for switching off if it satisfies the following conditions.

i. The base station should have a lower traffic distribution than the threshold level (we considered the threshold traffic for switching off the BS to be 70).
ii. The base station should have cooperative base stations.

All adjacent base stations are called cooperative base stations. A cluster of 9 base stations is shown in Figure 1. Only BS5 has cooperative base stations; thus, it can be chosen for switching off if it has less traffic than the threshold traffic.

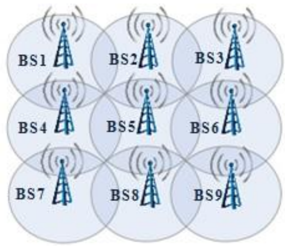

Fig. 1:BS5 Cooperative base stations

3.2 Procedure to generate a possible switch-off BS matrix:

The BSsMDs matrix shows the current existing mobile traffic distribution in the network. Using BSsMDs traffic distribution inner matrix, the algorithm generates a possible switch-off BS matrix. The algorithm identifies the low-traffic inner matrix base stations that have threshold value less than 70 MDs and considers possible switch off base stations. From the inner matrix of the BSsMDs shown in equation (3), the possible switch-off base stations with traffic less than the threshold value are BS09, BS11, BS13, BS18, BS19, BS25, BS30, BS31, BS32, BS33, BS37, BS38 and BS41. Using the inner matrix of BSsMDs, the generated possible switch-off base station matrix is shown in the matrix equation (4).

BSsMDs=

$$\begin{bmatrix} 24 & 58 & 91 & 55 & 133 & 99 & 13 \\ 29 & 17 & 125 & 64 & 79 & 36 & 70 \\ 23 & 132 & 130 & 44 & 44 & 149 & 48 \\ 100 & 95 & 132 & 46 & 121 & 137 & 56 \\ 139 & 26 & 28 & 42 & 67 & 73 & 125 \\ 59 & 67 & 22 & 70 & 145 & 26 & 17 \\ 36 & 123 & 134 & 49 & 87 & 114 & 51 \end{bmatrix} \ldots(3)$$

Possible Switch-off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(4)$$

3.3 Static and Dynamic Switch-off BSs matrix generation:

Using ‘Possible Switch-off BSs’ matrix, the algorithm generates ‘Static Switch off BSs’ matrix and ‘Dynamic Switch off BSs’ matrix. The matrix element ‘1’ in the ‘Static Switch off BSs’ matrix indicates the static switch off base station, and the switch-off method is called the “Static Switch off Method”. The matrix element ‘1’ in the ‘Dynamic Switch off BSs’ matrix indicates the dynamic switch off base station, and the switch off method is called the “Dynamic Switch off Method”.

To generate the ‘Static Switch-off BSs’ matrix, the algorithm scans the ‘Possible Switch off BSs’ matrix from the beginning, and whenever matrix element ‘1’ is found, the corresponding base station is considered to be a static switch-off base station and all the adjacent base stations are removed from the possible switch off base stations list; all adjacent matrix elements are made ‘0’. Similarly using ‘Possible Switch-off BSs’ matrix, the algorithm finds all the remaining static switch-off base stations and generates the ‘Static Switch off BSs’ matrix. For the given traffic condition, using ‘Possible Switch off BSs’ shown in equation (4), the generated ‘Static Switch-off BSs’ matrix is shown in equation (5).

Static Switch-off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(5)$$

To generate the ‘Dynamic Switch-off BSs’ matrix, using the ‘Possible Switch off BSs’ matrix and the traffic distribution matrix ‘BSsMDs’, the algorithm finds the lowest traffic base station, which is considered a dynamic switch-off base station, and all its adjacent base stations are removed from possible switch off base stations, i.e., all adjacent elements in the ‘Possible Switch-off BSs’ matrix are set to ‘0’. Similarly, using the ‘Possible Switch off BSs’ matrix and the traffic distribution matrix ‘BSsMDs’, the algorithm identifies all remaining dynamic switch base stations and generates the ‘Dynamic Switch-off BSs’ matrix. For a given traffic condition, the generated ‘Dynamic Switch off BSs’ matrix is shown in equation (6).

Dynamic Switch-off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(6)$$

With the ‘Dynamic Switch-off’ method, fewer MDs were disrobed due to the handoff process since while generating the ‘Dynamic Switch-off BSs’ matrix, base stations with less traffic were chosen for switching off.

3.4 Procedure to handover the switch-off BS MDs to adjacent BSs:

If in the ‘Static/Dynamic Switch off BSs’ matrix, the element is ‘1’, which indicates that the corresponding base station has lover MDs than the threshold value and can be switched off and that associated MDs can be transferred to adjacent BSs. While handover/allocating switching off base station mobile devices to adjacent base stations, the considered factors are the received power (Pr_max) from neighboring BSs and the present MDs connected to these neighboring BSs. Switching off base station, MD-received power from neighboring base stations is calculated as given in equation (7).

$$\mathrm{Pr(m)} = \mathrm{e(i)} * \mathrm{Pt(i)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The neighboring base station transmitted power attenuation factor (e) with respect to allocating MDs is randomly generated, and is between -∞ to -53 dBm; this factor depends on various factors, such as distance between the BS and MD, environmental conditions, and obstacles such as buildings and trees. As the distance of the mobile device (MD) from the base station increases, the signal path loss or path attenuation also increases.

The algorithm calculates the received power Pr(m) from all adjacent base stations, and selects the base station for which maximum power is received. The power considered to be Pr_max, where Pr(m) is the received power of the m^{th} mobile device from the i^{th} cooperative base station, and Pt(i) and e(i) are the i^{th} base station’s transmitted power and attenuation factor, respectively. Since attenuation increases as the distance increases; the MD receives the maximum transmitted power from the base station when it is nearer to the BS, and it cannot receive power from the base station when it is very far from the BS. Since MDs from switching off base stations cannot receive maximum transmitted power from adjacent base stations, i.e., signals more attenuated and attenuation factors (e) randomly generated between

-∞ to -53 dBm. While allocating MDs to cooperative base stations, in algorithm, we also consider the upper limit **(**Maximum Allocating Limit-MAL) to 100, i.e., the number of MDs allocated to cooperative base stations. The algorithm verifies whether the workload of adjacent BSs is less than the maximum allocating limit (MAL) of the BS. [Depending on the network operating area and traffic distribution, an appropriate value of MAL needs to be assigned. If there is no MAL criterion, all the switching-off BS MDs may be allocated to one BS. Due to this allocation, a BS may lose (unable to serve) a new request from its own MDs, which are in its own coverage area due to the maximum service MD limit. In this work, the maximum service MD limit is considered to be 150 for each BS**]**.

If these two conditions are satisfied, then the mobile devices of selected switching-off BS is allocated and modified load is calculated using equation (8);

$$\left.\begin{aligned} MDs\ of\ BS(r,c) &= MDs\ of\ BS(r,c)+1 \\ MDs\ of\ BS(p,p) &= MDs\ of\ BS(p,q)-1 \end{aligned}\right\} \\ if\ MDs\ of\ BS(r,c) < \mathrm{BS.MaxAllocat\ Lim}\ \&\&\ \mathrm{Pr}\ \_max > Pr\_th \ldots (8)$$

Where BS(r,c) is neighboring BS, BS(p,q) is the being switched off BS, r, p = row, c, q = column and Pr_threshold power chosen as -50 dBm.

This procedure is repeated until all MDs are removed from the selected switch-off base station and all switch-off base stations in the switch-off BSs matrix.

3.5 Cell zooming:

To increase the coverage area, the base station transmission power levels are increase; this concept is called cell zooming or cell scaling. During the handover of switching off base station mobile devices to adjacent/cooperative base stations, if any mobile device/devices are not allocated due to low received signal strength from adjacent base stations, then the required adjacent base station power levels increase and the leftover switching off base station mobile devices are allocated to these increased power level (cell zoomed) base stations.

3.6 Procedure to calculate the power consumed by the network:

The Power consumed by the network is calculated using given equation (9) [3],

$$\mathrm{P_{\_consumption}} = \eta * \mathrm{Pt} + \mathrm{Pc} + \mathrm{LPl} \ldots \ldots \ldots (9)$$

Where $P_{\_consumption}$ = total power consumed by the network, η = transmission power efficiency, Pt = BS transmission signal power, Pc = constant operational power, and L = number of radio links in the network (the number of mobile devices is equal to the number of radio links, i.e., for each MD, one radio link (channel) is allocated), Pl = radio link serving power. The terms η*Pt and Pc are constant powers where LPl is variable since the number of radio links (number of mobile devices) is dynamic with respect to time and place.

Below Table 1 shows the simulation parameters used in the network simulation.

TABLE 1 SIMULATION PARAMETERS

S.No.	Parameter	Value
1.	Constant operational power (Pc)	130 W
2.	Transmission power efficiency (η)	0.32
3.	BS transmission signal power (Pt)	46 dBm
4.	Radio link serving power (Pl)	250 mW
5.	Pr_threshold	-50 dBm
6.	Cooperative BS Maximum Allocating Limit	100 MD
7.	Lower limit to switch off a BS	70 MD
8.	Maximum MDs Limit in each BS	150

3.7 Steps in the Network Simulation:

STEP-1: The algorithm takes network traffic distribution matrix BSsMDs as input and as explained in the sections 3.1 and 3.2, the algorithm generates 'possible switch-off BSs' matrix as shown in matrix equation (4).

STEP-2: Using the 'Possible Switch off BSs' matrix and section 3.3 algorithm generates, the 'Static Switch off BSs' and 'Dynamic Switch off BSs' matrices, respectively, as shown in matrix equations (5) and (6).

STEP-3: Then it compare the 'Static Switch off BSs' and 'Dynamic Switch off BSs' matrices if

i. The number base stations switched off in the 'Static Switch off BSs' matrix > 'Dynamic Switch off BSs' matrix then, the 'Static Switch off BSs' matrix is chosen for switching off the base stations.

ii. Otherwise the 'Dynamic Switch off BSs' matrix is chosen for switching off the base stations.

STEP-4: The chosen switching-off base stations are either from 'Static Switch-off BSs' or' from the 'Dynamic Switch-off BSs' matrix, mobile devices are handed over/reallocated to adjacent/cooperative base stations as explained in the section 3.4.

STEP-5: If any base station switches off, mobile devices are not handed over due to less received signal strength; using the cell zooming concept, the leftover mobile devices are handed over to increased-power-level (cell scaled) adjacent base stations, as explained in section 3.5.

STEP-6: After the handover process, using section 3.6 and simulation parameters specified in Table 1, the algorithm calculates and displays, the power consumed by the network, with and without switching off base stations in the network, and the traffic distribution in the network before and after switching off the base stations.

The steps in the simulation are represented using a flowchart, as shown in figure 3.

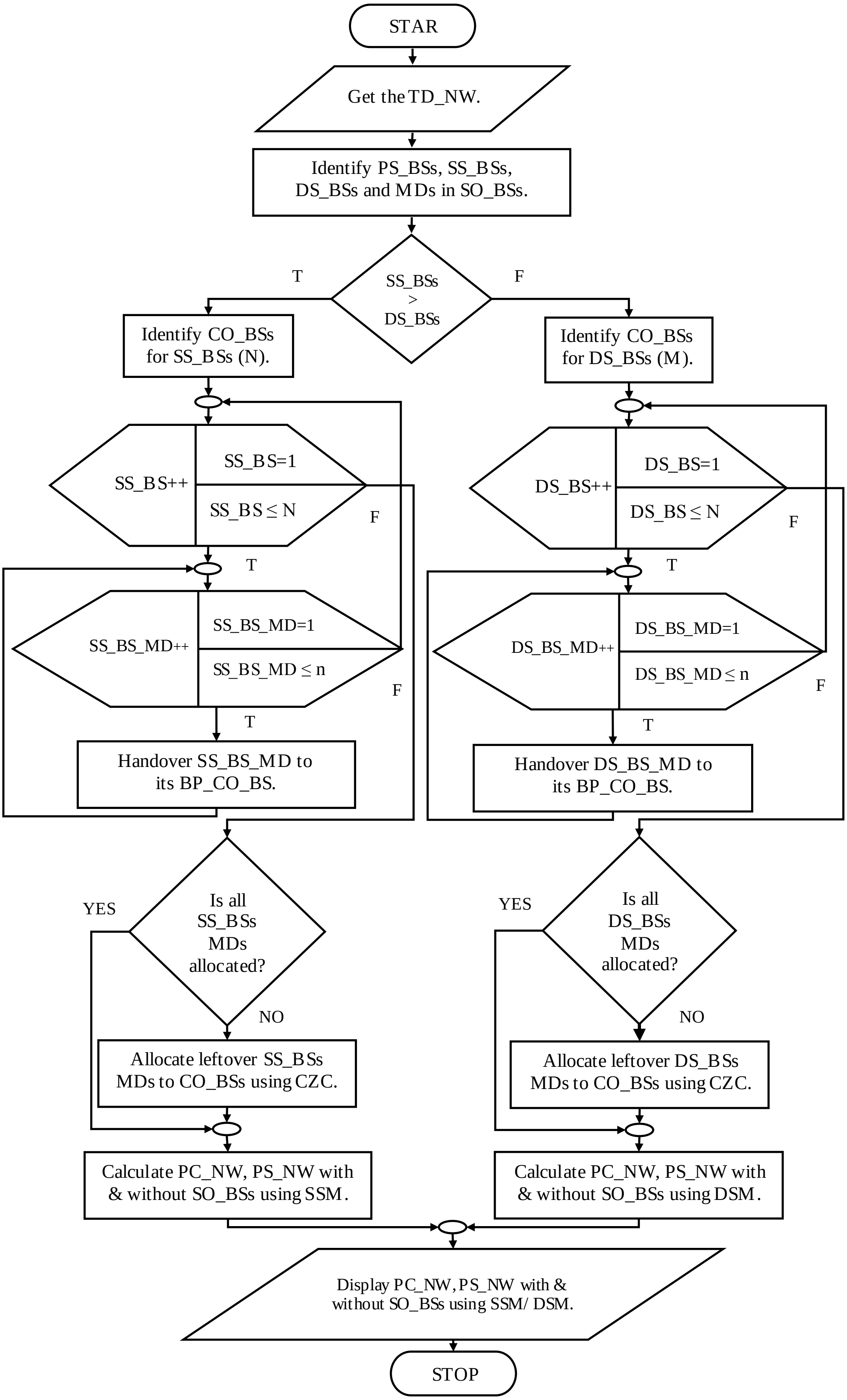

Fig2: Static and Dynamic Base Station Switch off method flow chart.

TD_NW:	Traffic Distribution from the Network;
PS_BS:	Possible Switch_off Base Station;
SS_BS:	Static Switch_off Base Station;
DS_BS:	Dynamic Switch_off Base Station;
MD:	Mobile Device;
SO_BS:	Switch_off Base Station;
CO_BS:	Co-Operative Base Station;
SS_BS_MD:	Static Switch_off Base Station Mobile Device;
DS_BS_MD:	Dynamic Switch_off Base Station Mobile Device;
BP_CO_BS:	Best Possible CO_Operative Base station;
CZC:	Cell Zooming Concept;
PC_NW:	Power Consumed in the Network;
PS_NW:	Power Saved in the Network;
SSM:	Static Switch_off Method;
DSM:	DnamicSwitch_off Method;

4. Results and Discussion

CASE-I: Switching off base stations in the "Static Switch off Method" > "Dynamic Switch off Method".

When switching off base stations in 'static switch off BSs' matrix > 'dynamic switch off' matrix, the algorithm chooses the 'static switch off BSs' matrix and the method is called the "static switch off method". Matrix equation (10) shows, the traffic distribution in the network at a particular instant in time. The matrix has 49 base stations and 3708 mobile devices. Given the inner matrix of the BSsMDs shown in the matrix equation (10), the traffic of base stations BS09, BS12, BS16, BS17, BS18, BS19, BS23, BS27, BS33, BS37, BS39 and BS41 is less than the threshold value 70 and these 12 are 'possible switch-off base stations'. Using matrix equation (10), the generated 'possible switch off BSs' matrix is shown in equation (11). The position of matrix element '1' shows a possible switch-off base station to which the connected mobile devices are less than the threshold value 70.

BSsMDs=

$$\begin{bmatrix} 88 & 20 & 122 & 147 & 22 & 90 & 140 \\ 29 & \mathbf{63} & 81 & 112 & \mathbf{67} & 96 & 20 \\ 132 & \mathbf{3} & \mathbf{52} & \mathbf{68} & \mathbf{30} & 88 & 127 \\ 106 & \mathbf{12} & 118 & 135 & 124 & \mathbf{22} & 99 \\ 38 & 129 & 132 & 95 & \mathbf{26} & 147 & 22 \\ 27 & \mathbf{9} & 142 & \mathbf{21} & 114 & \mathbf{19} & 69 \\ 27 & 50 & 106 & 34 & 97 & 102 & 89 \end{bmatrix} \ldots(10)$$

Possible Switch off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \mathbf{1} & 0 & 0 & \mathbf{1} & 0 & 0 \\ 0 & \mathbf{1} & \mathbf{1} & \mathbf{1} & \mathbf{1} & 0 & 0 \\ 0 & \mathbf{1} & 0 & 0 & 0 & \mathbf{1} & 0 \\ 0 & 0 & 0 & 0 & \mathbf{1} & 0 & 0 \\ 0 & \mathbf{1} & 0 & \mathbf{1} & 0 & \mathbf{1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(11)$$

Using matrix equation (11) and the section 3.3, the generated 'static switching off BSs', and 'dynamic switching off BSs' matrices are shown in equation (12) and (13) respectively. For the given traffic distribution shown in the BSsMDs matrix (10), the "static switch off method" algorithm can switch off 7 base stations and the "dynamic switch off method" can switch off 6 base stations as shown in the 'static switching off BSs' matrix equation (12) and the 'dynamic switching off BSs' matrix equation (13), respectively. For the example traffic distribution shown in the BSsMDs matrix (10), to reduce radiation effects and power consumption, the algorithm chooses the "static switch off method" and tries to reallocates 7 switching off base station mobile devices to cooperative/adjacent base stations, as explained in the section 3.3.

Static Switching off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \mathbf{1} & 0 & 0 & \mathbf{1} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \mathbf{1} & 0 & 0 & 0 & \mathbf{1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \mathbf{1} & 0 & \mathbf{1} & 0 & \mathbf{1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(12)$$

Dynamic Switching off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \mathbf{1} & 0 & 0 \\ 0 & \mathbf{1} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \mathbf{1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & \mathbf{1} & 0 & \mathbf{1} & 0 & \mathbf{1} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(13)$$

The cooperative base stations for the first and all static switching-off base stations are shown in matrix equations (14) and (15), respectively.

COP BSs for Static Switch-off base station_1 =

$$\begin{bmatrix} \mathbf{1} & \mathbf{1} & \mathbf{1} & 0 & 0 & 0 & 0 \\ \mathbf{1} & \mathbf{1} & \mathbf{1} & 0 & 0 & 0 & 0 \\ \mathbf{1} & \mathbf{1} & \mathbf{1} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(14)$$

COP_SET for Static Switch-off base stations=

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 2 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 3 & 1 & 0 & 1 & 4 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 5 & 1 & 6 & 1 & 7 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \ldots(15)$$

Matrix equation (16) shows the first switching-off base station (BS9) traffic reallocation to neighboring base stations. The BS9 cooperative base stations are BS1, BS2, BS3, BS8, BS10, BS15, BS16 and BS17, and the current associated traffic is 88, 20, 122, 29, 81, 132, 03 and 52, respectively. The base stations BS3 and BS15 already had more than the maximum allocating limit (MAL=100); thus, no mobile device was allocated to these two cooperating base stations. Sixty-three mobile devices of switching off base station BS9, based on received signal strength and MAL, mobile devices (12, 17, 10, 12, 03 and 09) that were handover/allocated to cooperative base stations BS1, BS2, BS8, BS10, BS16 and BS17, respectively.

Switch off base station1 MDs allocation to adjacent BSs=

$$\begin{bmatrix} 12 & 17 & 0 & 0 & 0 & 0 & 0 \\ 10 & 63 & 12 & 0 & 0 & 0 & 0 \\ 0 & 3 & 9 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(16)$$

Similarly, along with BS9, all 7 switching off base stations, mobile device allocation before cell zooming is shown in the matrix equation (17). With the exception of 6th switching off base station (BS39), all the switching off base station traffic/mobile devices are adjusted to their adjacent/cooperative base stations. Before applying cell zooming, out of 21 mobile devices from BS39, 20 mobile devices are allocated to cooperative BSs. Due to maximum allocating limit (MAL=100) and received signal strength, the BS39 21st mobile device is not allocated to any of its adjacent base stations.

The BS39 cooperative base stations are BS31, BS32, BS33, BS38, BS40, BS45, BS46 and BS47, and their associated traffic levels are 132, 95, 26, 142, 114, 106, 34 and 97, respectively. The traffic conditions of the BS31, BS39, BS40, and BS45 cooperative base stations are more than the maximum allocation limit (MAL), and from the matrix equation (18), the BS32, and BS46 attenuation factors i.e., the received signal strength for the 21st mobile device, are very low, therefore, the BS39 21st mobile device cannot be allocated to these base stations. The attenuation factors of the BS39, 21st mobile device are shown in matrix equation (18). The cooperative base station 33 (BS33) traffic is less than the maximum allocation limit, and by increasing its power level (using cell zooming), the base station BS39 21st unallocated mobile device is allocated to BS33, as shown in matrix equations (19) and (20).

Allocation_MatrixBeforeZooming=

$$\begin{bmatrix} 12 & 17 & 0 & 0 & 8 & 10 & 0 \\ 10 & 63 & 12 & 0 & 67 & 4 & 0 \\ 0 & 6 & 15 & 18 & 21 & 12 & 0 \\ 0 & 12 & 0 & 0 & 0 & 22 & 1 \\ 4 & 0 & 0 & 3 & 16 & 0 & 10 \\ 2 & 9 & 0 & 20 & 0 & 19 & 4 \\ 4 & 2 & 0 & 9 & 3 & 0 & 9 \end{bmatrix} \ldots(17)$$

Switching off BS6 21st MD Attenuation factors (e)=

$$1.0e-08 * \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.02 & 0.085 & 0.235 & 0 & 0 \\ 0 & 0 & 0.235 & 0 & 0.32 & 0 & 0 \\ 0 & 0 & 0.245 & 0.03 & 0.465 & 0 & 0 \end{bmatrix} \ldots(18)$$

Allocation_MatrixWithZooming =

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(19)$$

Allocation_MatrixAfterZooming=

$$\begin{bmatrix} 12 & 17 & 0 & 0 & 8 & 10 & 0 \\ 10 & 63 & 12 & 0 & 67 & 4 & 0 \\ 0 & 6 & 15 & 18 & 21 & 12 & 0 \\ 0 & 12 & 0 & 0 & 0 & 22 & 1 \\ 4 & 0 & 0 & 3 & 17 & 0 & 10 \\ 2 & 9 & 0 & 21 & 0 & 19 & 4 \\ 4 & 2 & 0 & 9 & 3 & 0 & 9 \end{bmatrix} \ldots(20)$$

After the switching off base stations mobile device allocation to adjacent base stations, the traffic distribution in the network, before and after the cell zooming concept are shown in matrix equations (21) and (22), respectively.

BSsMDs_Post_AllocationBeforeZooming=

$$\begin{bmatrix} 100 & 37 & 122 & 147 & 30 & 100 & 140 \\ 39 & 0 & 93 & 112 & 0 & 100 & 20 \\ 132 & 9 & 67 & 86 & 51 & 100 & 127 \\ 106 & 0 & 118 & 135 & 124 & 0 & 100 \\ 42 & 129 & 132 & 98 & 42 & 147 & 32 \\ 29 & 0 & 142 & 1 & 114 & 0 & 73 \\ 31 & 52 & 106 & 43 & 100 & 102 & 98 \end{bmatrix} ..(21)$$

From equation (21), except for one mobile device from BS39, mobile devices from all the switching-off base stations are allocated to the adjacent base station, and from equation (22), with cell zooming, the leftover mobile device is allocated to the adjacent base station BS33. Equation (22) shows that all the switching-off base station traffic is allocated/handed over to adjacent base stations.

BSsMDs_Post_AllocationAfterCellZooming=

$$\begin{bmatrix} 100 & 37 & 122 & 147 & 30 & 100 & 140 \\ 39 & 0 & 93 & 112 & 0 & 100 & 20 \\ 132 & 9 & 67 & 86 & 51 & 100 & 127 \\ 106 & 0 & 118 & 135 & 124 & 0 & 100 \\ 42 & 129 & 132 & 98 & 43 & 147 & 32 \\ 29 & 0 & 142 & 0 & 114 & 0 & 73 \\ 31 & 52 & 106 & 43 & 100 & 102 & 98 \end{bmatrix} \ldots(22)$$

CASE-II: Switching off base stations in the "Static Switch off Method" < "Dynamic Switch off Method".

When switching off base stations in the 'static switch off BSs' matrix < 'dynamic switch off' matrix, the algorithm chooses the 'dynamic switch off BSs' matrix; this method is called the "dynamic switch off method". The matrix equation (23) shows, the traffic distribution in the network. It has 49 base stations and 3690 mobile devices. The traffic density of inner matrix base stations BS12, BS13, BS16, BS23, BS24, BS26, BS27, BS31, BS33, BS37, BS39 and BS4 is less than the threshold value. These are the possible switch-off base stations, and are shown in equation (24).

BSsMDs=

$$\begin{bmatrix} 63 & 45 & 75 & 119 & 73 & 1 & 77 \\ 2 & 132 & 142 & 116 & 47 & 7 & 24 \\ 145 & 29 & 104 & 132 & 138 & 90 & 89 \\ 9 & 40 & 55 & 100 & 45 & 14 & 120 \\ 133 & 133 & 35 & 126 & 52 & 147 & 21 \\ 3 & 12 & 93 & 16 & 134 & 57 & 66 \\ 74 & 31 & 137 & 116 & 42 & 117 & 112 \end{bmatrix} \ldots(23)$$

Possible Switch off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(24)$$

Using the matrix equation (24), the generated 'static Switching off BSs' and 'dynamic switching off BSs' matrices are shown in the equations (25) and (26), respectively.

Static Switching off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(25)$$

Dynamic Switching off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(26)$$

For the given traffic distribution shown in the BSsMDs matrix (23), using the "static switch off method" algorithm can deactivate five base stations, while the 'dynamic switch off method' can deactivate six base stations, as detailed in matrix equation (25) for static switching off BSs and matrix equation (26) for dynamic switching off BSs. For the given example traffic distribution, to switch off more base stations, the algorithm chooses the "dynamic switch off method" and reallocate six switching off base stations mobile devices to cooperative/adjacent base stations.

From the matrix equation (26), the switching-off base stations cooperative base stations are shown in matrix equation (27). The mobile device allocation before cell magnification and the traffic distribution in the network are shown in matrix equations (28) and (29), respectively.

COP_SET for dynamic switch-off base stations=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 \\ 1 & 2 & 1 & 0 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 3 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 4 & 1 & 5 & 1 & 6 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \ldots(27)$$

Allocation_MatrixBeforeZooming=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 1 & 1 & 1 \\ 8 & 0 & 0 & 0 & 1 & 7 & 0 \\ 0 & 29 & 0 & 0 & 0 & 8 & 5 \\ 7 & 8 & 6 & 0 & 1 & 14 & 0 \\ 0 & 0 & 4 & 0 & 24 & 0 & 16 \\ 3 & 12 & 6 & 16 & 0 & 57 & 9 \\ 3 & 2 & 0 & 0 & 21 & 0 & 0 \end{bmatrix} \ldots(28)$$

BSsMDs_Post_AllocationBeforeZooming=

$$\begin{bmatrix} 63 & 45 & 75 & 119 & 74 & 2 & 78 \\ 10 & 132 & 142 & 116 & 48 & 0 & 24 \\ 145 & 0 & 104 & 132 & 138 & 98 & 94 \\ 16 & 48 & 61 & 100 & 46 & 0 & 120 \\ 133 & 133 & 39 & 126 & 76 & 147 & 37 \\ 6 & 0 & 99 & 0 & 134 & 0 & 75 \\ 77 & 33 & 137 & 116 & 63 & 117 & 112 \end{bmatrix} \ldots(29)$$

From equation (29), all the six dynamic switching-off base stations mobile devices are allocated to adjacent base stations without using the cell zooming concept.

CASE-III: Switching off base stations in "Static Switch off Method" = "Dynamic Switch off Method".

When the switched off base stations in the 'static switch off BSs' matrix = 'dynamic switch off BSs' matrix, the algorithm chooses the 'dynamic switch off BSs' matrix, since the same number of base stations can be switched-off with fever mobile handovers.

Matrix equation (30) shows, the traffic distribution in the network. It has 49 base stations and 3581 mobile devices. The traffic density of inner matrix base stations BS09, BS11, BS13, BS19, BS24, BS25, BS27, BS31, BS33, BS34, BS37 and BS39 is less than the threshold value. These are the possible switch-off base stations and are shown in equation (31).

BSsMDs=

$$\begin{bmatrix} 18 & 99 & 51 & 129 & 1 & 26 & 33 \\ 144 & 7 & 71 & 63 & 109 & 42 & 54 \\ 149 & 72 & 71 & 113 & 36 & 136 & 148 \\ 140 & 120 & 14 & 8 & 123 & 66 & 28 \\ 48 & 113 & 52 & 105 & 54 & 15 & 94 \\ 36 & 13 & 89 & 25 & 87 & 144 & 137 \\ 27 & 85 & 41 & 64 & 149 & 55 & 77 \end{bmatrix} \ldots(30)$$

Possible Switch off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(31)$$

Using possible switch off BSs matrix equation (31), the generated 'static switching off BSs' and the 'dynamic switching off BSs' matrices are shown in matrix equations (32) and (33), respectively. From these equations, the algorithm can switch off same 7 base stations using the 'static switching off method' and the 'dynamic switching off method'. However using the "static switching off" method, 230 mobile devices, and "dynamic switching off" method 173 mobile devices to be handed over. To reduce the number of mobile devices handovers, the algorithm selects the "dynamic switching off" method.

Static Switching off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(32)$$

Dynamic Switching off BSs=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(33)$$

Matrix equation (34) shows the cooperative base stations for dynamic switching-off base stations. Matrix equations (35) and (36) show the allocation of mobile devices without and with zooming, respectively.

COP_SET for Dynamic Switch off base stations=

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 7 & 1 & 6 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 2 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 4 & 1 \\ 1 & 3 & 1 & 5 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0 & 0 \end{bmatrix} \ldots(34)$$

Allocation_MatrixBeforeZooming=

$$\begin{bmatrix} 1 & 1 & 15 & 0 & 20 & 9 & 10 \\ 0 & 7 & 18 & 62 & 0 & 42 & 5 \\ 0 & 0 & 16 & 0 & 19 & 0 & 0 \\ 0 & 0 & 1 & 8 & 0 & 1 & 3 \\ 1 & 0 & 8 & 0 & 9 & 15 & 3 \\ 2 & 13 & 6 & 25 & 6 & 0 & 0 \\ 4 & 3 & 5 & 6 & 0 & 0 & 0 \end{bmatrix} \ldots(35)$$

Allocation_MatrixWithZooming=

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(36)$$

From equation (35), except for switching off base station 7, i.e., BS11 12th MD, all the switching-off base stations MDs are allocated to adjacent base stations. For the switching off base station BS11, the cooperative base stations are BS03, BS04, BS05, BS10, BS12, BS17, BS18 and BS19. However, cooperative base stations BS04, BS12, and BS18 have more than the maximum allocation limit (MAL); therefore, these base stations cannot cooperate and according to equation (37), for the BS11, 12th mobile device, the received signal strength from the remaining cooperative base stations BS03, BS05, BS10, BS17 and BS19 is less than the threshold value due to lower attenuation factor (e). Therefore, before applying cell zooming concept, the BS11, 12th mobile device is not allocated to any cooperative base station. With the cell zooming concept, by increasing the BS17 cooperative base station signal strength, the 12th mobile device of BS11 is allocated to it, as shown in matrix equation (36). The matrix equation (38), shows the switching-off base stations traffic allocation to adjacent base stations.

Switching off BS7 12th MD Attenuation factor (e)=

$$1.0e\text{-}08 * \begin{bmatrix} 0 & 0 & 0.02 & 0.26 & 0.025 & 0 & 0 \\ 0 & 0 & 0.025 & 0 & 0.11 & 0 & 0 \\ 0 & 0 & 0.055 & 0.41 & 0.06 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \ldots(37)$$

Allocation_MatrixAfterZooming=

$$\begin{bmatrix} 1 & 1 & 15 & 0 & 20 & 9 & 10 \\ 0 & 7 & 18 & 63 & 0 & 42 & 5 \\ 0 & 0 & 17 & 0 & 19 & 0 & 0 \\ 0 & 0 & 1 & 8 & 0 & 1 & 3 \\ 1 & 0 & 8 & 0 & 9 & 15 & 3 \\ 2 & 13 & 6 & 25 & 6 & 0 & 0 \\ 4 & 3 & 5 & 6 & 0 & 0 & 0 \end{bmatrix} \ldots(38)$$

The traffic distribution in the network before and after cell zooming are shown in matrix equations (39) and (40), respectively.

Post_allocation_Before_Zooming=

$$\begin{bmatrix} 19 & 100 & 66 & 129 & 21 & 35 & 43 \\ 144 & 0 & 89 & 1 & 109 & 0 & 59 \\ 149 & 72 & 87 & 113 & 55 & 136 & 148 \\ 140 & 120 & 15 & 0 & 123 & 67 & 31 \\ 49 & 113 & 60 & 105 & 63 & 0 & 97 \\ 38 & 0 & 95 & 0 & 93 & 144 & 137 \\ 31 & 88 & 46 & 70 & 149 & 55 & 77 \end{bmatrix} \ldots (39)$$

Post_allocation_After_Zooming=

$$\begin{bmatrix} 19 & 100 & 66 & 129 & 21 & 35 & 43 \\ 144 & 0 & 89 & 0 & 109 & 0 & 59 \\ 149 & 72 & 88 & 113 & 55 & 136 & 148 \\ 140 & 120 & 15 & 0 & 123 & 67 & 31 \\ 49 & 113 & 60 & 105 & 63 & 0 & 97 \\ 38 & 0 & 95 & 0 & 93 & 144 & 137 \\ 31 & 88 & 46 & 70 & 149 & 55 & 77 \end{bmatrix} \ldots (40)$$

Case-I (Static switch off BSs > Dynamic switch off BSs): In this case, for the given traffic distribution, the "static switch off method" can switch more base stations (7 BSs) than can the "dynamic switch off method" (it is able to switch off 6 BSs). Therefore, the algorithm selects the "static switch off method" to minimize more energy consumption. In this case for the given traffic distribution, the power consumed by the network without switching off any base station is 7.921 KW, and the power consumed by the network using the static switch off method by switching off 7 base stations is 6.92 KW, and that using dynamic switch off method by switching off 6 base stations, is 7.064 KW. Therefore, adaptive switch off method selects static switch off method and able to save 1001 Watts of power.

Case-II (Static switch off BSs < Dynamic switch off BSs): In this case, for the given traffic distribution, the dynamic switch off method can switch-off more base stations (6 BSs) than to the static switch off method (it able to switch off 5 BSs). Therefore, the adaptive switch off algorithm selects the dynamic switch off method to save more power. In this case, for the given traffic condition, the power consumed by the network without switching off any base station is 7.916 KW, the power consumed by the network using the dynamic switch off method by switching off 6 base stations is 7.06 KW, and by using static switch off BSs method by switching off 5 base stations, the power consumed by the network is 7.202 KW. Therefore, the adaptive switch-off algorithm selects dynamic switch-off method and able to save 856 Watts of power.

Case-III (Static switch off BSs = Dynamic switch off BSs): In this case for the given traffic distribution, the static switch-off method and dynamic switch-off method can be used to switch off an equal number of base stations (6 BSs). However, the dynamic switch-off method selects switch off base stations with less traffic. Therefore, the dynamic switch off method need to handover fewer mobile devices (173 MDs for the given traffic distribution) to the adjacent base stations than does the static switch off method (230 MDs). Therefore, the dynamic switch-off method is selected to reduce number of mobile devices used in the handover process. In this case, the power consumed by the network without switching off any base station is 7.889 KW and the power consumed by the network using the dynamic switch off method by switching off 7 base stations is 6.890K Watts of power, and this method is able to save 999 Watts of power.

Table-II shows the simulation results for Case-1, Case-2 and Case-3.

TABLE II. SIMULATION RESULTS

S.No.	Parameter	Case-I (Static switch-off BSs > Dynamic switch-off BSs)	Case-II (Static switch-off BSs < Dynamic switch-off BSs)	Case-III (Static switch-off BSs = Dynamic switch-off BSs)
1	Number of base stations (BSs) in network.	49	49	49
2	Number of mobile devices (MDs) in network.	3708	3690	3581
3	Possible switch off base stations (BSs).	12	12	12
2	Static switch off base stations (BSs).	7	5	7
5	Handover mobile devices (MDs) in Static Switch off Method.	213	213	230
6	Dynamic switch off base stations.	6	6	7
7	Handover mobile devices (MDs) in Dynamic Switch off Method.	141	137	173
8	Selected Switch off method	Static Switch-off Method	Dynamic Switch-off Method	Dynamic Switch-off Method
9	Left over mobile devices (MDs) before cell zooming.	1	0	1
10	Handover mobile devices (MDs) with cell zooming	1	0	1

S.No.	Parameter	**Case-I** (Static switch-off BSs > Dynamic switch-off BSs)	**Case-II** (Static switch-off BSs < Dynamic switch-off BSs)	**Case-III** (Static switch-off BSs = Dynamic switch-off BSs)
11	Power consumed in the N/W without switch off BSs.	7.921 KW	7.916KW	7.889KW
12	Power consumed in the N/W with Non Adaptive Switch off BSsMethod.	7.064 KW	7.202KW	6.890KW
13	Power consumed by the N/W with Adaptive Switch off BSs Method.	6.92 KW	7.060KW	6.890KW
14	Power saved by the N/W with Adaptive Switch off BSs Method.	1001W	856W	999W
15	Percentage of power saved by switching of BSs.	12.63%	10.81%	12.66%

Figure 3 shows the power consumed in the network with and without switching off Base Stations.

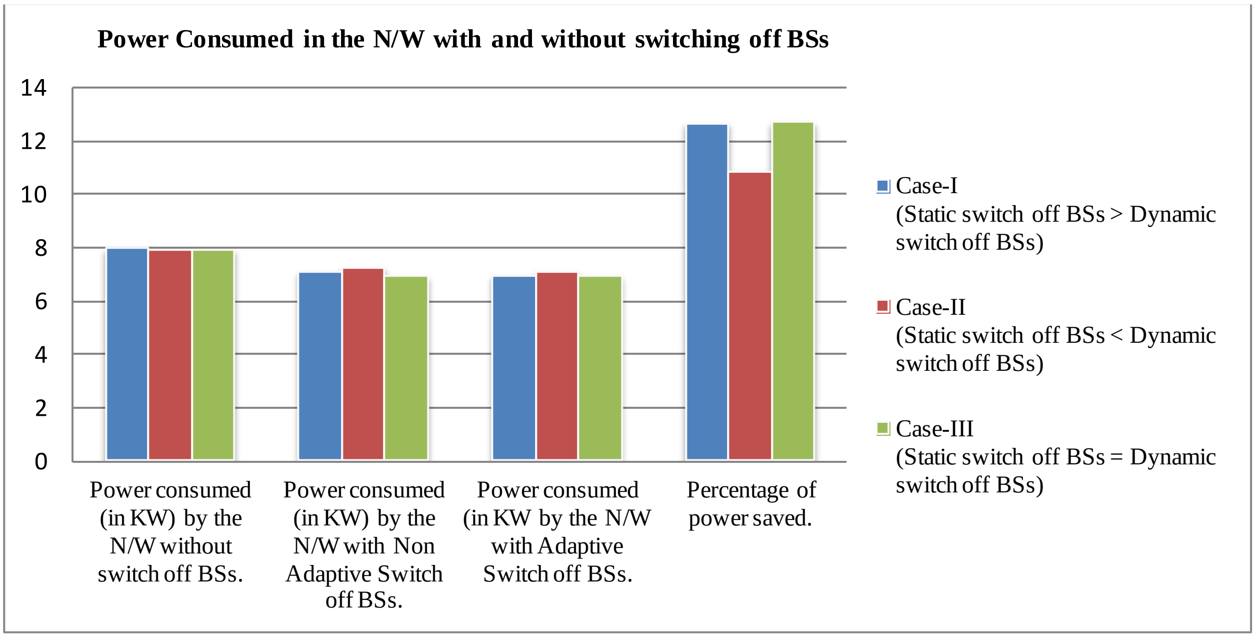

Fig3: Power Consumed in the network with and without switching off Base Stations.

5. Conclusion

In this work, we propose two base station switch-off methods to reduce power consumption in a cluster of BSs by switching off/deactivating a BS with a minimum number of traffic, allocating all the devices in that BS to its neighboring stations. We used the static switch-off method and dynamic switch-off method. The base station switch-off algorithm selects either the static or dynamic switch off method based on the number of BSs able to switch off. We have presented the results for possible cases in the Results and Discussion section. These three cases are

Case-I: Static switch off BSs > Dynamic switch off BSs.

Case-II: Static switch off BSs < Dynamic switch off BSs.

Case-III: Static switch off BSs = Dynamic switch off BSs.

The power consumed in the network for above mentioned three different traffic scenarios, without switching off any base station, is 7.921 KW, 7.916 KW, and 7.889KW, and the power consumed with adaptive switch-off method is 6.92 KW, 7.060 KW, and 6.890 KW, respectively. The power saved in watts and the percentage of power saved for these three cases are 1001W, 856W, and 999W and 12.63%, 10.81%, and 12.66% respectively.

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