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A Mathematical Model for Cell Zooming Mechanism of Base Station using Classification Approach

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Abstract: In this paper, an efficient approach for cell zooming mechanism of Base Station is proposed using classification method. The proposed cell zooming methodology has the following stages: capacity computation of base station, determination of payload of each cell and processing of BS to be switched ON/OFF using Neural Network classification approach. The performance of the proposed cell zooming methodology using classification approach is analyzed in terms of call handling rate, latency and throughput. The proposed cell zooming mechanism using feed forward back propagation neural networks achieves 94.2% of CHR, 14.4 ns of latency and 18,187 bits/esc of throughput.

Keywords: Cell zooming, base station, payload, cell, classification

1 Introduction

Mobile communication and networks are fast growing techniques from past decades. There are huge amount of mobile users who access the mobile networks in cell in peak hours. The cell regions are split into urban area, sub urban area and rural area. The numbers of mobile users are high in case of urban area and there are low numbers of mobile users in case of rural areas [7]. At present, there is a huge requirement for mobile networks for transferring or receiving the user call or mobile data which are connected with notebooks and various tablet units. Hence, the network operators should make effective considerations for each mobile user for preventing call drops at either user side or network server side [8]. To improve the efficiency of mobile networks, each cell division is equipped with mobile Base Station (BS).

The number of mobile base stations in a cell increases the energy consumption and also leads to environmental issues. As per the report of Information and Communication Technology (ICT), each BS in a cell produces 2% of CO_2 with respect to overall CO_2 emission [9]. The energy consumption of the whole world is affected by launching a number of BSs in a cell. At the same time, each BS in the network is designed taking in consideration the following conditions: the number of day-night usage of mobile users and the number of mobile users moving from one cell to another cell in the same network. Hence, some of the BS in a cell are switched OFF with respect to the number of mobile users in cell. To overcome such limitations of BS in a wireless networks, an efficient BS switching methodology is required for each individual BS. This is possible by implementing cell zooming mechanism on each individual BS in cellular mobile networks [10]. There are two types of cell zooming methods: centralized and distributed cell zooming. The centralized cell zooming mechanism is based on the number of mobile users within a cell region. In this centralized cell zooming mechanism, the mobile BSs are switched on when there are low number of mobile users for that particular BS and the mobile BSs are switched OFF when there are high number of mobile users for that particular BS. The distributed cell zooming mechanism is functioning based on the bandwidth of information users. This paper is sectioned as follows: section 2 details the conventional methods of cell zooming mechanisms, Section 3 proposes an efficient centralized cell zooming mechanism using classification approach. Section 4 discusses the simulation results of the proposed method and section 5 concluding this paper by indicating the performance analysis parameters.

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2 Literature survey

Hao Jiang et al. (2018) used data driven approach for improving cell zooming methodology on very large area network cells. Heuristic switch-off strategy was used by this data driven technique. The authors achieved 90.6% of CHR, 26.8 ns of latency and 16,293 bits/sec of throughput. Hani'ah Mahmudah et al. (2016) proposed dynamic centralized methodology for cell zooming mechanism. The authors tested their proposed method on low to high and high to low traffic patterns in various cell regions for analyzing the performance of the proposed dynamic centralized approach. The authors achieved 87.7% of CHR, 29.7 ns of latency and 14,298 bits/sec of throughput. Payal Santosh Gundawar et al. (2015) used vertical cell zooming methodology in order to improve the performance of the wireless mobile networks. The authors compared the performance of the proposed vertical cell zooming methodology to horizontal cell zooming methodology. The authors achieved 82.9% of CHR, 31.5 ns of latency and 12,398 bits/sec of throughput by implementing vertical cell zooming methodology on individual BS in cell.

Oh et al. (2013) used dynamic base station switching methodology for individual BS in cellular networks. The authors proposed energy efficient BS switching methodology for improving the performance of the cell zooming mechanism. Zheng et al. (2016) used data driven optimization methodology on individual BS in order to support different framework models for cell zooming mechanism. The authors improved Quality of Service by implementing data-driven approaches on individual BS in the cell. Niu et al. (2010) developed cost efficient cell zooming methodology for improving the performance of the green cellular networks. The authors implemented various types of cell zooming methods on each individual BS in cell for analyzing the performance. The authors tested their proposed cell zooming methodology with respect to number of mobile users.

3 Proposed Methodology

3.1 Capacity computation of base station

In order to apply cell zooming mechanism in a particular BS, the capacity of each cell is computed for improving the efficiency of cell zooming mechanism as shown in Fig. 1. The capacity of the base station in each cell is computed as:

$$C_b = \frac{1}{A_b}\int_{A_b} r.P(P_{rx}(r) \geq P_{min})\, dr.d\varphi$$

Whereas, A_b is the area of the base station having the radius about 100 m, 'r' is the distance between the receiver (mobile station or unit) and the base station, P is the probability of power which is received from mobile unit with respect to minimum power consumption.

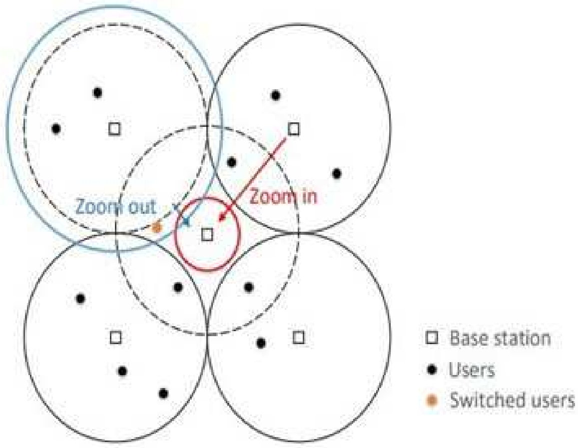

Fig. 1: Illustrations of cell zooming process

The power consumption for each base station for obtaining maximum coverage area within a cell is determined as:

$$P_{b}=\sqrt{\frac{(M \times g)^3}{2P.A}}$$

Whereas, P is the density of air at the top of the base station, g is the gravitational force (9.8 N/Kg), A is the area coverage, which is computed as 2π*r and M is the mass of the base station with all payloads.

The power consumption of base station can be determined as:

$$P_{Cons} = P_{TX} + P_b$$

The user capacity of each cell for 'N' number of base station is stated as:

$$C_{cell} = C_b \cdot P(N)$$

Whereas, $P(N)$ is the probability of the mass function of base station unit and it is given in the following equation as:

$$P(N) = \frac{3.5^{3.5}\sqrt{\ }(n+3.5)\left(\frac{\lambda_u}{\lambda_b}\right)^n}{\sqrt{(3.5)n!}\left(\frac{\lambda_u}{\lambda_b}+3.5\right)^{n+3.5}}; \qquad n = 1,2,\dots N$$

Whereas, λ_u is the density function of user and λ_b is the density function of base station.

These density functions of user and bases station are given as:

$$\lambda_u = \sqrt{S} \times \left[\frac{\pi}{2} - \arctan\left(\frac{1}{\sqrt{S}}\right)\right]$$

$$\lambda_b = \pi\lambda_u^2(1-(1+3.5\lambda_u)^{-3.5})$$

The number of surrounding users is represented by 'S'.

3.2 Determination of payload of each cell

The loads (number of users) in each cell of mobile networks can be categorized into offered payload and carried payload. The total number of mobile users entering into cell is defined by offered payload and the average number of present mobile users in a cell is defined by carried payload. If the carried load is greater than the offered load, the payload in cell is high. If the carried load is less than the offered load, the payload in cell is low. The cell having low payload is allowed to be merged with other cells and the present low load cell is allowed to be switched off using the following algorithm:

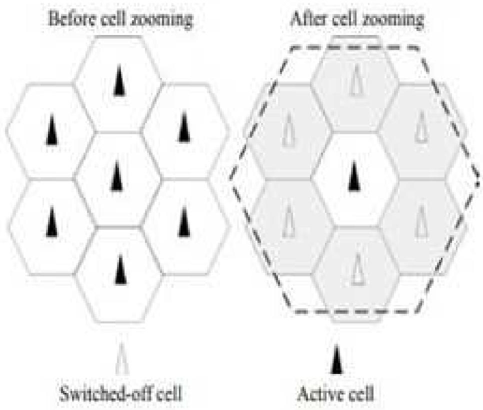

Fig. 2: Switch OFF BS before and after cell zooming

Fig. 2 shows the switch OFF BS before and after cell zooming. There is only one BS that is while others are switched off and they are linked with active BS.

3.3 Process of BS to be switched ON

During cell zooming of particular BS with its surrounding BS in network environment, the BSs which are located around the central BS, is switched off and their calls are forwarded towards the central BS. Based on the capacity of the surrounding individual BS, these BSs are switched ON or switched OFF with respect to its central BS. The surrounding BS which is to be switched ON is identified using classification approach. In this paper, Feed Forward Back Propagation Neural Network (FFBPNN) is used for this process. The FFBPNN classifier can be operated in two modes which are training and classification. During training mode of FFBPNN classifier, the capacity of the base station, user capacity of each cell, density functions of user and bases station, offered payload and carried payload of each BS in a cell are determined from each individual BS and they are trained. During classification mode of FFBPNN classifier, the capacity of the base station, user capacity of each cell, density functions of user and bases station, offered payload and carried payload of the BS to be checked for switched ON process are determined and they are classified with respect to trained patterns which are obtained from training mode of this classifier. The classified pattern is low which indicates the BS for testing to be switched OFF and the classified pattern is high which indicates the BS for testing to switch ON. Fig. 3(a) shows the training mode of NN classifier and Fig. 3(b) shows the classification mode of NN classifier.

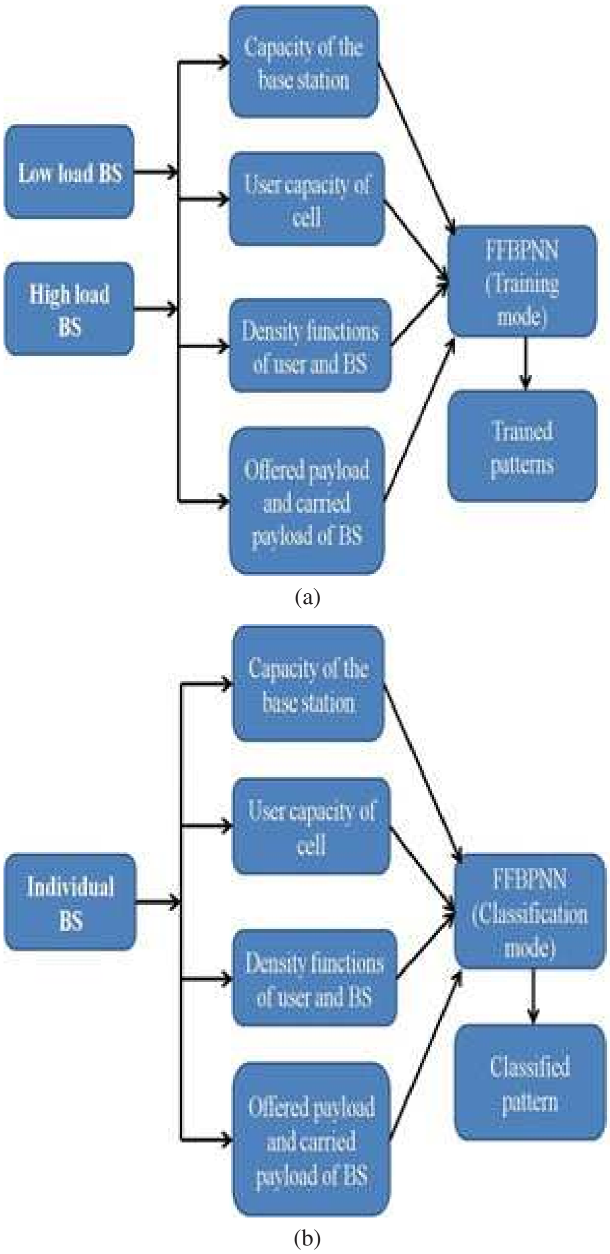

Fig. 3: (a) Training mode of NN classifier (b) Classification mode of NN classifier

Methodology to switch-off BS

The individual BS in a cell can be either switched OFF/ON using the following algorithm. The algorithm determines the sleeping factor of each individual BS using its capacity and number of current voice calls with its corresponding bandwidth. The sleeping factor is compared with threshold. In this paper, the threshold value is chosen as 0.7 after several iterations. The BS in the cell is switched OFF if the computed sleeping factor is less than the threshold. The BS in the cell is switched ON if the computed sleeping factor is greater than the threshold. The proposed BS switching methodology is explained in the following steps:

Inputs: BS parameters;
Output: BS switches OFF/ON;

Start
Compute total number of voice calls for each individual BS in cell;
Determine cell load factor (L) using total number of current voice calls on individual BS;
Find energy consumption of BS using its payload;
Find sleeping factor of BS using the following equation;

$$S = L \times P$$

The following constraint is checked for BS switch OFF/ON as stated below;
S<threshold;
If (constraint = = TRUE)
Switch OFF BS;
If (constraint = = FALSE)
Switch ON BS;
End;

4 Results and Discussion

In this paper, two base stations in different areas are used for simulation cases urban and sub urban environmental cases. The number of users in urban environmental area is higher than the number of users in suburban area. The Rayleigh distribution model is considered as channel condition in both environmental cases. Each environmental case have 1000*1000 m^2 sizes as an area in this simulation. Each receiving mobile unit is separated by 5m from the other and their height is considered as 2m which is above the ground level. The isotropic antennas are placed in all base stations and receiving mobile units. The height of BS in this simulation environment is considered as 150 m above sea level. For simulation purpose, a signal with 2 GHz and 15 MHz bandwidth is used and it is transmitted from base station to all mobile units. Table 1 shows the cell area in urban and suburban environmental cases with number of building per base station and its corresponding building area.

Table 1: Cell area in urban and suburban environmental cases

Scenario	Number of buildings /BS	Building Area (m^2)	Cell Area (m^2)
Suburban	750	10.3	93.5
Urban	500	31.1	72.7

The performance of the proposed cell zooming methodology using classification approach is analyzed in terms of call handling rate, latency and throughput. These performance evaluating parameters are explained as following.

Call Handling Rate (CHR)

It is defined as the ratio between the total number of calls handled by central BS before cell zooming mechanism applied and the total number of calls handled by central BS after cell zooming mechanism applied. It is measured in percentage and it is varied between 1 and 100. The large value of CHR indicates that the ability of cell zooming mechanism is high and efficient. The low value of CHR indicates that the ability of cell zooming mechanism is low and inefficient. It is given in the following equation:

$$CHR = \frac{\text{Total number of calls handled by central BS before cell zooming mechanism applied}}{\text{Total number of calls handled by central BS after cell zooming mechanism applied}}$$

The performance of the proposed cell zooming mechanism is analyzed in terms of CHR with respect to the number of BSs connected to central BS and it is depicted in Table 2. The CHR for 10 numbers of surrounding BS is 98.5% and the CHR for 35 numbers of surrounding BS is 90.1%. The average CHR of the proposed cell zooming methodology is about 94.2%.

Table 2: Performance analysis of proposed method in terms of CHR

Number of surrounding BS	CHR (%)
10	98.5
15	96.1
20	95.6
25	93.2
30	91.8
35	90.1
Average	**94.2**

Latency

It is defined as the time taken by central BS to switch ON or switch OFF the surrounding BSs and it is measured in

Nano seconds. This parameter is important to prevent the call drop in central BS and its surrounding BSs. The large value of latency indicates that the ability of cell zooming mechanism is complex and inefficient. The low value of latency indicates that the ability of cell zooming mechanism is high and efficient. The number of surrounding BSs increases the latency rate. The performance of the proposed cell zooming mechanism in terms of latency with respect to number of surrounding BSs is depicted in Table 3. The latency for 10 numbers of surrounding BS is 7.8 ns and the latency for 35 numbers of surrounding BS is 20.6 ns the average latency of the proposed cell zooming methodology is about 14.4 ns.

Table 3: Performance analysis of proposed method in terms of latency

Number of surrounding BS	Latency (ns)
10	7.8
15	10.3
20	12.8
25	16.4
30	18.7
35	20.6
Average	**14.4**

Throughput

It is defined as the rate at which the packets can be transmitted or received from central BS in a particular cell division in wireless mobile networks. It is measured in bits/sec. The large value of throughput indicates that the ability of cell zooming mechanism is efficient. The low value of throughput indicates that the ability of cell zooming mechanism is inefficient. The number of surrounding BSs which is connected with central BS decreases throughput. The performance of the proposed cell zooming mechanism in terms of throughput with respect to number of surrounding BSs is depicted in Table 4. The throughput for 10 numbers of surrounding BS is 24,182 b/s and the throughput for 35 numbers of surrounding BS is 12,846 b/s. The average throughput of the proposed cell zooming methodology is about 18,187 b/s.

The proposed cell zooming mechanism using feed forward back propagation neural networks achieves 94.2% of CHR, 14.4 ns of latency and 18,187 bits/sec of throughput. Hao Jiang et al. (2018) achieved 90.6% of CHR, 26.8 ns of latency and 16,293 bits/sec of throughput. Hani'ah Mahmudah et al. (2016) achieved 87.7% of CHR, 29.7 ns of latency and 14,298 bits/sec of throughput. Payal Santosh Gundawar et al. (2015) achieved 82.9% of CHR, 31.5 ns of latency and 12,398 bits/sec of throughput. Table 5 shows the performance comparisons of the proposed method with respect to conventional methods. The proposed methodology for cell zooming mechanism used classification approach for improving the performance in terms of CHR, latency and throughput.

Table 4: Performance analysis of proposed method in terms of throughput

Number of surrounding BS	Throughput (bits/sec)
10	24,182
15	21,459
20	18,856
25	16,846
30	14,936
35	12,846
Average	**18,187**

Table 5: Performance comparisons of proposed method with respect to conventional methods

Methodology	CHR (%)	Latency (ns)	Throughput (bits/sec)
Proposed work (in this paper)	94.2	14.4	18,187
Hao Jiang et al. (2018)	90.6	26.8	16,293
Hani'ah Mahmudah et al. (2016)	87.7	29.7	14,298
Payal Santosh Gundawar et al. (2015)	82.9	31.5	12,398

Conclusions

This paper proposes a classifier-based cell zooming mechanism for switching ON/OFF individual BSs which is connected to the central BS in a cell. Based on the capacity of the surrounding individual BSs, these BSs are switched ON or switched OFF with respect to its central BS. The surrounding BS which is to be switched ON is identified using classification approach. The performance of the proposed cell zooming mechanism is analyzed in terms of CHR, latency and throughput. The proposed cell zooming mechanism using feed forward back propagation neural networks achieves 94.2% of CHR, 14.4 ns of latency and 18,187 bits/sec of throughput.

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