Power Saving in Ultra Small Cells Used in Internet of Things

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Abstract- **In this paper, we derive a technique for reducing the power consumption in ultra small cells network used in internet of things. This technique allows establishing a baseline of active base station fractions in order to be able to determination wireless network architecture. The base stations are more responsible for the energy consumption in ultra small cell networks. We also demonstrate that sleep modes can lead to significant modification in power saving algorithm in ultra small cells. The sleep modes work as enabler for ultra small cells deployments. Results and discussion shows that more power saving is achieved with the help of Optimized heuristic algorithm and is compared with power consumption using algorithm for various bit rate, different base station density, different boundary areas and different user density.**

***Index Terms* – Ultra small cells, Base station, Sleep modes, Heuristic algorithm, Internet of things.**

I. INTRODUCTION

This paper focuses on maximization in energy conservation by increasing number of sleeping base station i.e to make the network more energy efficient and optimized through reduction in the power consumption of base station. We know that the base stations are the main consumer of the power consumption and 90% power of wireless access network is consumed by the active base stations. Today almost each and everyone poses one or more cell phones and thus the trend is projecting towards wireless devices In light of ICT being estimated to be responsible for about 2-5% of world wide carbon emission[1].This is an important challenge and power efficiency is important design parameter for present & future wireless networks .In mobile communication the mobile user bit rate demand is ever increasing and in the time of 1990-1995 or nineteenth century the mobile access networks is used only for transferring text voice communication, however data communications are rapidly increasing and presently responsible for the maximum part of traffic on mobile access network[3].

The method and technique to reduce the power consumption in ultra small cells is optimization of the base stations in order to make them more energy efficient also new network technologies long term evaluation are emerging which will allow higher bit rates.

The introduction of sleep modes is very important and commonly used in optimizing a system for power efficiency. Sleep mode is the essential part if we want to deploy wireless network with high coverage for large bit rates. Sleep mode in wireless networks are already used in various situations. For example providing coverage while certain nodes can sleep is well known problem in sensor networks.

The another important technology which is used in mobile access network is called cell zooming where during low use period base stations are turned off and only lower bit rates are fully covered this technique allows a limited fraction of base station to be turned off and reduce the level of service for the users the approach does not account for user behavior[1].The term (IOT) is known as the internet of things The Internet of things links smart objects to the Internet. It can enable an exchange of data never available before, and bring users information in a more secure way. Cisco estimates the Internet of things will consist of 50 billion devices connected to the Internet by 2020. Gain deeper insight with analytics using our internet of things System to enhance productivity, create new business models, and generate new revenue streams.

According to the Telecom Regulatory Authority of India (TRAI) [4] the Indian telecom sector continued to register a remarkable growth in the year 2012-13. Over the past two decades the Indian telecom sector has seen a tremendous growth. The number of mobile phone subscriptions increased from 13 million in 2003 to 867.80 million by March 2013 while the wire line base recorded a decline from 41.48 million in 2003 to 30.21 million by March 2013. In the past mobile access networks were mainly used for voice and text communication but the increasing popularity of wireless access networks led to an increased traffic on wireless networks deployment. The increasing demand for higher data rates and better quality of service due to the constant growth in the number of active wireless terminals corresponds to higher number of base stations Currently, the no. of base stations in India as on November 2012 are approximately 736654 so more than 50% cell-site operating expenditure is spent to power up base stations .

Thus, in this paper we focused on wireless networks and more specially reducing the power consumption in ultra small cells using the optimization of the base stations with heuristic algorithm. The performance of proposed algorithm is demonstrated for different scenarios to calculate the active base station fraction.

II.TECHNICAL DESCRIPTION ABOUT SLEEP MODE USING HURISTIC ALGORITHM

In terms of introducing sleep modes in base stations, some solutions are already suggested. Some authors make the distinction between micro-sleep where base stations are only shortly suspended and deep-sleep where users need to connect to different base stations in order to maintain connectivity [5]. An important parameter when determining the bit rate at which we want to evaluate the range is the receiver signal-to-noise ratio (SNR) which represents the SNR at the receiver for a certain Bit Error Rate (BER) and depends on the modulation scheme and coding rate use. Higher the coding rate scheme and higher the modulation scheme, higher the bit rate, but also higher the receiver signal to noise ratio (SNR) and thus lower the range becomes.

According to CISCO Visual Networking Index (VNI) Global Mobile Forecast reports, 2013 -2018 [3], projecting future mobile data traffic over cellular networks (2G, 3G or 4G) and Wi-Fi offload traffic shows that by 2018, global mobile data traffic will reach 15.9 Exabyte per month or 190 Exabyte annually, increasing nearly 11-fold from 2013 to 2018. 190 Exabyte is equivalent to four trillion video clips or 42 trillion image. By 2018, there will be 4.9 billion mobile users from 4.1 billion in 2013. In 2013, nearly 58% of the world's population (7.2 billion people) were mobile users. By 2018, more than 64% of the world population (7.6 billion people) will be mobile users. Thus, the number of users are rapidly increasing and currently responsible for the larger part of the data traffic on mobile access networks. With this user bit rate demand is increasing day by day.

In this context, an optimized heuristic algorithm has been designed to find the best possible combination of base stations to be put to sleep mode in order to minimize power consumption. Deploying a mobile network for a certain bit rate depends on the range of the base station i.e. it varies depending on what bit rate is required. To determine the range of a base station, first the maximum allowable path loss which a transmitted signal can be subjected while still being detectable at the receiver needs to be calculated [1] [6][3]. Based on maximum allowable path-loss , the range can be determined by using a propagation model which describes the relation between path loss and range. In this study, focus is on ultra small cells base stations.

Another important parameter that influences the bit rate and the range is the channel bandwidth. Lower the channel bandwidth, lower the bit rate, but higher the range. The relation between bit rate and Base station range is given in Table 2.1, together with the corresponding Modulation and Coding Scheme (MCS) for LTE small cells at a channel bandwidth of 5 MHZ. This relation between bit rate and range is also shown in Fig.2.1.

Table 2.1 Bit rate versus range for a ultra small cell

MCS	BIT RATE(mbps)	RANGE
1/3 *QPSK*	2.7	187.4
1/2 QPSK	4.1	129.4
2/3 QPSK	5.6	69.8
1/2 16-QAM	8.6	52.4
1/2 64 QAM	13.6	25

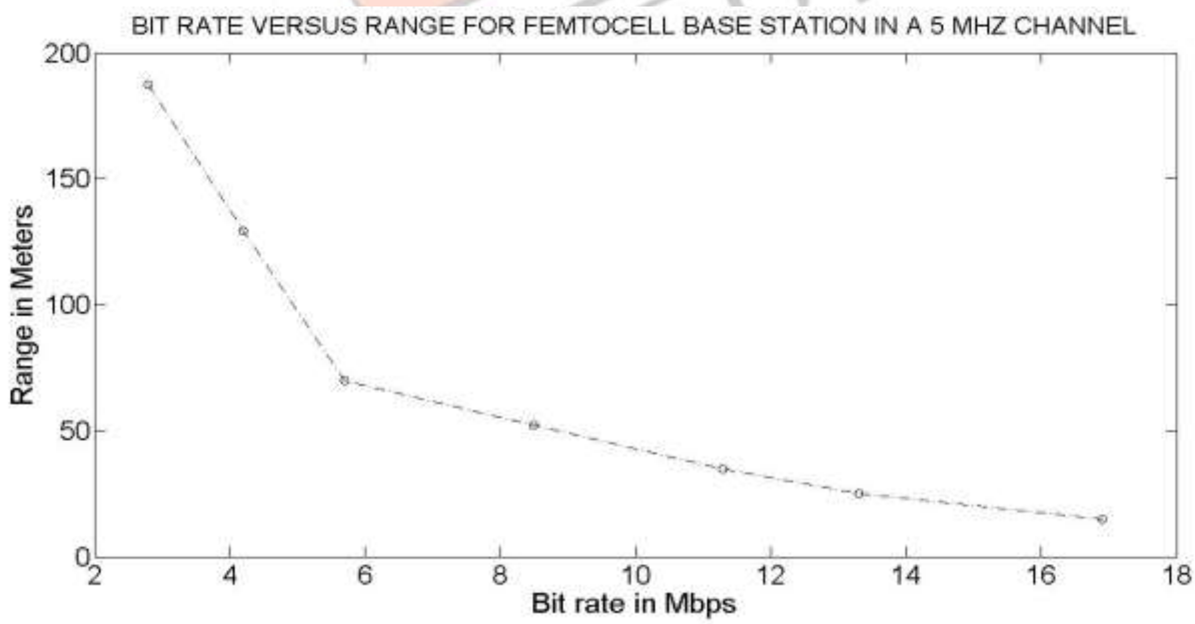

Fig.2.1 Bit rate versus range for ultra small cell

Assume the number of users as ''m'' and the number of base stations as ''n''. The coordinates of users and base stations are taken as random because the predetermination of the location of users and the location of small cells base stations is not possible as these base stations are user deployed. As different user require different bit rates, so to distribute users according to different bit rates an exponential probability distribution ϕ for different bit rates is taken. This distribution shows the probability of bit rate required by the user as shown in Fig.2.2. In this the preference for lower and higher bit rates is determined by α. When α< 0 then there are larger chances of higher bit rates, at α >0 there are larger chances of low bit rates and at α=0 there is a uniform distribution of bit rates. Higher bit rates correspond to video traffic and lower bit rates correspond to voice traffic.

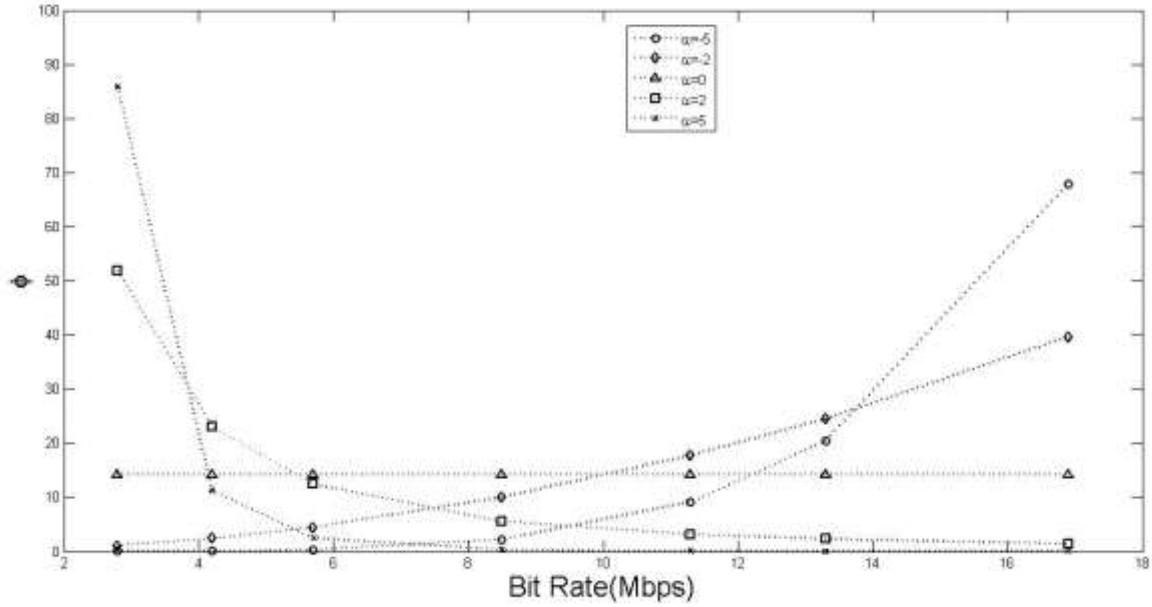

Fig.2.2 Probability distribution of bit rates in function of alpha

$$W_{ij} = \begin{cases} \mathbf{1}, & \text{if } |Bj - Ui| \leq Ri; \\ \mathbf{0}, & \text{if } |Bj - Ui| \geq Ri; \end{cases}$$

This matrix represents the possibilities to provide a user with a suitable connection. In case a row of the matrix R contains only zeroes, this implies that no user is in range of base station. Since nothing can be done to serve those users its better to keep them out of the equation. Based on the matrix W, we can now construct two vectors

$$H^u: H_i^u = \sum_{j=1}^{n} Wij$$

$$H^b: Hj^b = \sum_{i=1}^{m} Wij$$

Where H_u is a ''m'' dimensional vector whose every indices shows that a users is connected to how many number of base stations. H b is a ''n'' dimensional vector whose every indices

$$\phi(BR) \propto 1/BR^{\alpha}$$

The probability distribution is normalized:-

$$\sum_{BR} \phi(BR) = 1$$

The vector U contains the coordinates of the users. The vector R contains the required range of the users. It is calculated based on the bit rate requirement of the user which is then mapped on the corresponding base station range. The matrix B contains the coordinates of the base stations. We now construct m × n matrix W.

shows that a base station can serve how many number of user according to the bit rate requirement of the user. Strategy to put base stations in sleep mode using optimized heuristic algorithm is as follows

(1)choose a user which is connected to minimum no. of base stations.
(2)From these base stations select a base station to which large no of users can connect.
(3)Switch on this base station.
(4)determine the users which can connect to this base station according to their bit rate requirement by taking a assumption that base station can support any no. of users.
(5)Remove the connections of these users from other base stations after the users get connection to the selected base station which is switched on.

Mobile user and base station distribution is random so every time algorithm will give separate result, so to approximate this, the average over 5 repetition of the process are taken. In this work assumption is taken that a base station can connect any number of users, this assumption is taken by keeping in mind the capacity that the futuristic base stations will offer that can support a large number of users. As the technology is enhancing and new techniques are coming in to picture such as massive MIMO, VAMOS, asynchronous transmissions, large bandwidth and high frequency transmissions etc that are increasing the capacity of base stations in terms of bit rate and the capacity in terms of increasing the number of users a base station can support. In the algorithm given below a m dimensional all zero vector S is taken where n is the number of base stations in which we change a zero to one each time to switch on a base station. Each time in loop only a single base station is turned on.

POWER SAVING HEURISTIC ALGORITHM:-

H^u:H_i^u=$\sum_{j=1}^{n} Wij$
H^b:H_j^b=$\sum_{i=1}^{m} Wij$
[Val, Ind]=Min (H^u);
While Val= =0
H^u(Ind) =10000;
[Val, Ind]=Min(H^u);
end
H^b=H^b.*W (Ind,:);
[Val, Index]=Max(H^u);

S(Index)=1;

N=find(P(:,Index));
P(N,:)=0;
until$\sum_{i,j} W(i,j) = 0$

In heuristic algorithm minimum value H^u index is selected not to switch on a base station for a one user in final and maximum value H^b index is selected to serve maximum number of users by switching on a base station. In each results only one base station gets switched on, users removed which can get service from the switched on base station and the connection of these users from other base stations also removed. Active base station fraction is evaluate by dividing the active number of base stations after heuristic with the total number of BS. Minimum values for active base station fraction implies more base stations are switched off and thus power saving is achieved.

(III) RESULTS AND DISCUSSION

Simulation is done for ultra small cells at bandwidth 5 MHz and frequency 2.6 GHz. Every time simulation gives different result for active number of base stations. This is taken care during the simulation for comparison between optimized heuristic algorithm and new modified heuristic algorithm [1] by taking same user density distribution and base station density distribution. The users are randomly distributed with a user density Du of 500 users per 1.1km^2 for α = 3 shown in Fig.3.1 and in a ultra small cell network operating for a channel bandwidth of 5 MHZ. it rate and low bit rate users respectively, solid blue and hollow blue circles shows active base stations and switch off base stations respectively α = 3 shows users will have the preference for lower bit rates whereas shows that users will have preference for higher bit rates. In the access network there are 1951 base stations, covering an area of approximately 1.1km^2. Of these base stations, some need to be active in order to provide all users with a connection. This leads to an active base station fraction of 2.3578 and 2.1527 for α=3 using new modified algorithm. so we are successful for decreasing the active base station fraction with the help of modified algorithm.

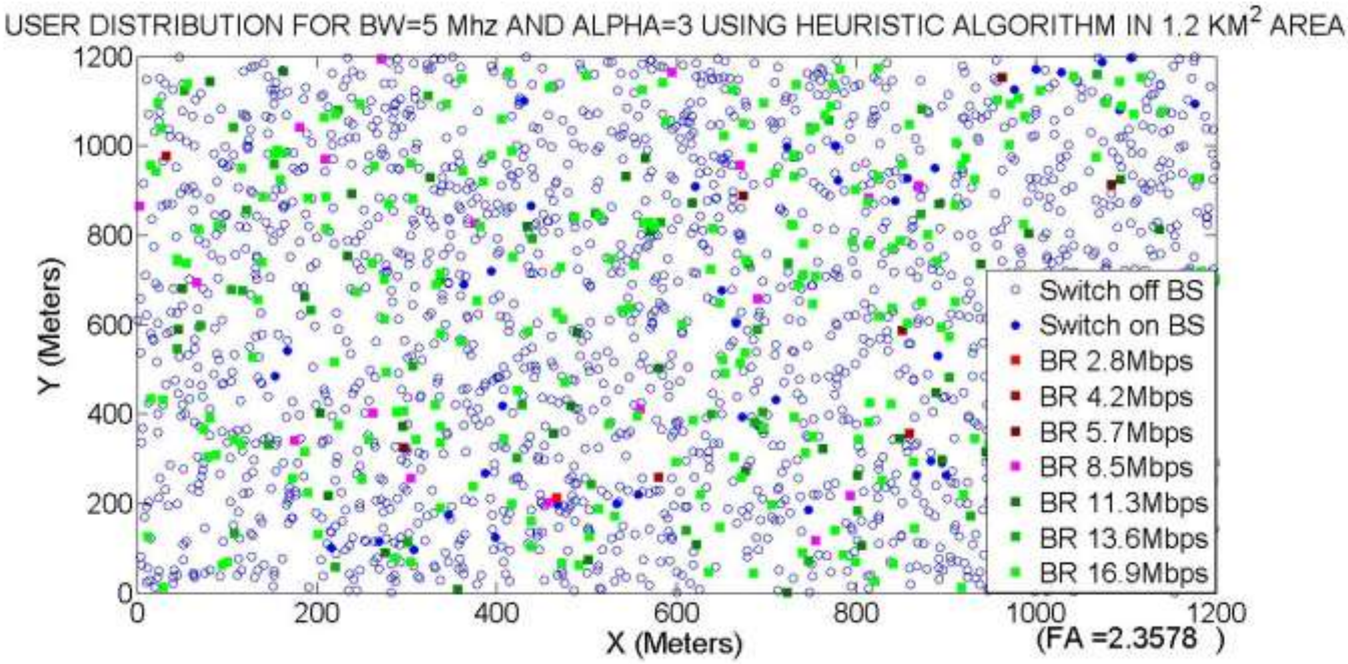

Fig3.1 Distribution of users for α=3

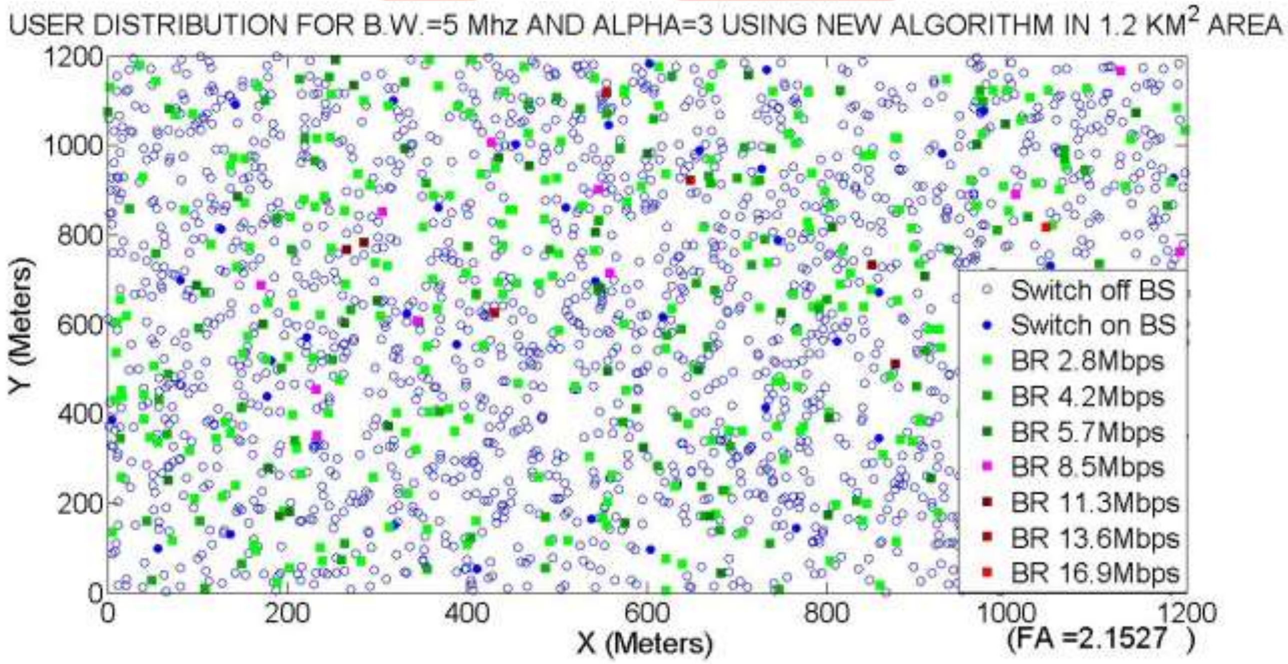

Fig.3.2 Variation in F_A Using new Modified algorithm

1.INFLUENCE OF ALPHA ON THE ACTIVE BASE STATION FRACTION

Users operating at low bit rates can connect to base stations at longer distances. Therefore, lower active base station fractions will be possible. In order to evaluate this, we simulated user distributions of 500 users per 1.1 km^2 with 1951 base stations with varying α and a channel bandwidth of 5 MHZ. We performed 5 simulations of which we display the average result .

The standard deviation, represented by error bars. The result is shown in Fig.3.3 for heuristic algorithm [2] and optimized heuristic algorithm.

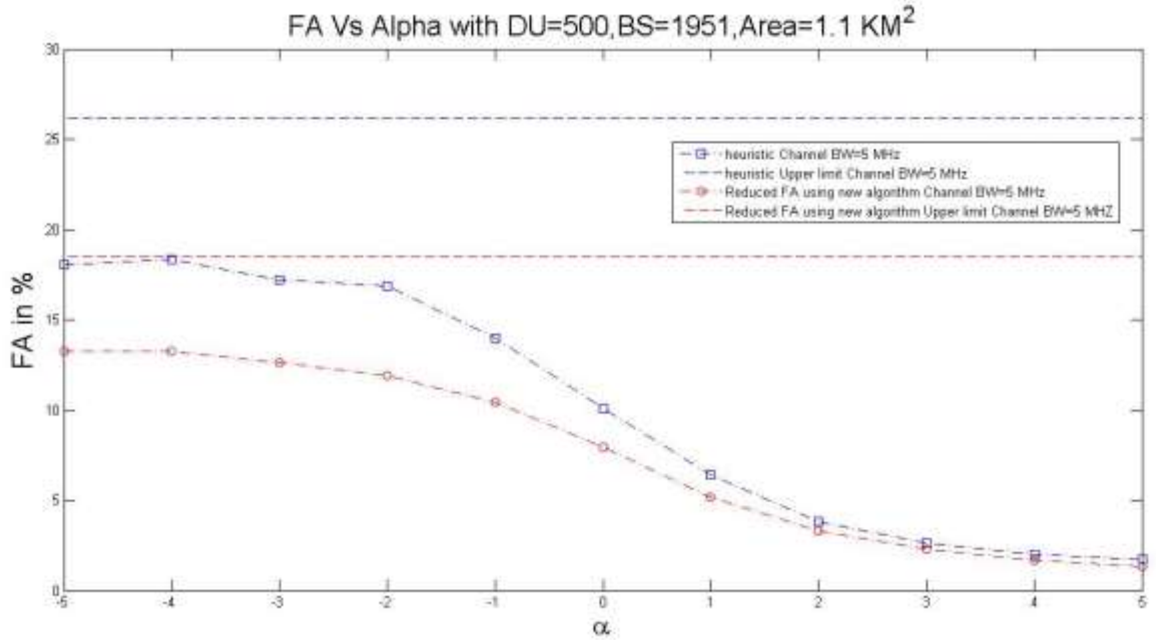

Fig. 3.3 Influence of alpha on active base station fraction

2.VARIATION OF ACTIVE BASE STATION FRACTION WITH USER DENSITY

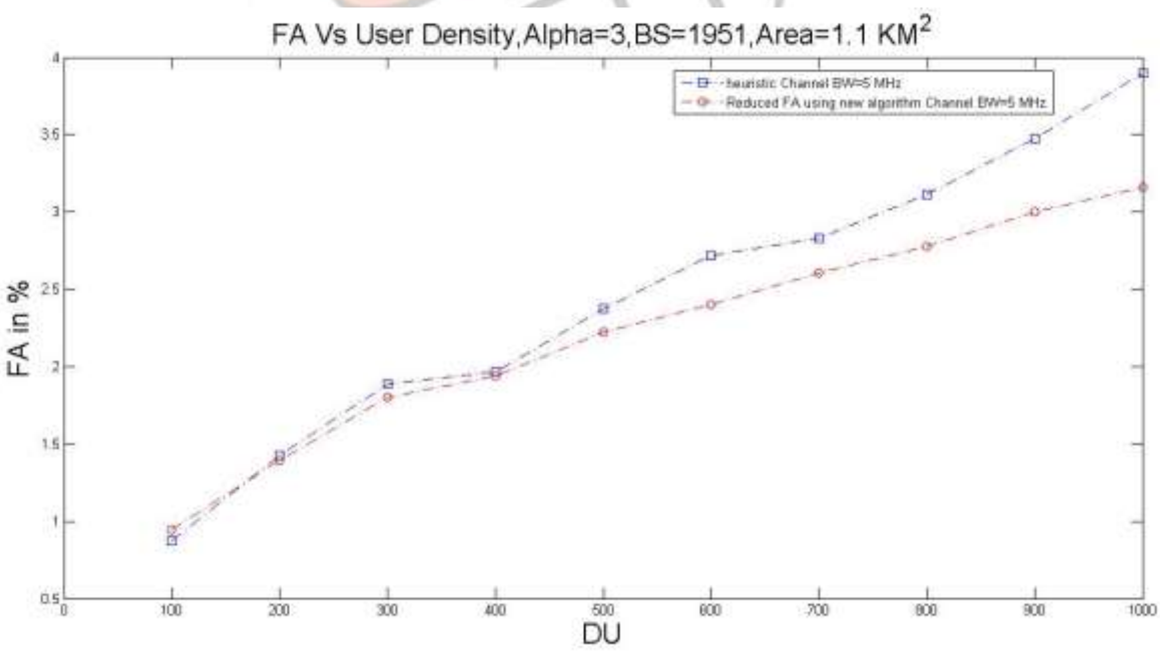

Fig.3.4. Variation of active base station fraction with user density

The influence of the user density on the active base station fraction is as shown in Figure 3.4 for heuristic algorithm [1] and optimized heuristic algorithm. The result obtained is for 5 simulations per case for varying user densities and channel bandwidth is 5 MHz when using ultra small cells with $\alpha = 3$. With increasing user density, the simulations result in a slower increase of active base stations.

(IV) CONCLUSION

Thus, in this paper we focused on wireless networks and more specially reducing the power consumption in ultra small cells using the optimization of the base stations with heuristic algorithm. In particular, an optimized heuristic algorithm has been proposed for decreasing the active base station fraction by removing the redundant connections from base stations. The results achieved are far much better than heuristic algorithm [1]. In the current wireless access networks, the bit rate that is to be available to the users is the determining factor in the power consumption of the network. The higher the available bit rate in the entire area covered by the network, the more base stations (BS) need to deploy and the higher the power consumption of the network becomes. Furthermore, a higher bit rate corresponds with a lower power efficiency of the base station (BS). This consumes a lot of power which will degrade the quality of the environment and also increases the level of pollution as a large amount of pollution is generated from the communication network operation. The pollution from the carbon emission increases the risk of many breathing problems like asthma etc. With the introduction of sleep modes power consumed and carbon emissions can be reduced to large extent. Thus, sleep modes are a very promising solution for power reduction especially for the ultra small cells.

(V) FUTURE TRENDS

Nowadays, wireless access networks consume high amount of power and are thus large contributors to carbon-dioxide emissions and in increasing pollution. In the near future, more and more devices will be equipped with wireless interfaces, which will results in the activation of new services, base stations with small coverage will also increase to fulfill the increasing needs of users for high bit rates so existing networks need expansion. Thus, the future wireless access networks need advanced power saving algorithms. So, low power consuming circuits and powerful algorithms should be designed to save power and to reduce harmful emissions in to the environment which will degrade environment quality.

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