A Novel Technique for Achieving Energy Efficiency in Heterogeneous Cellular Network

Mamta Arora
Research Scholar
ECE Department
Chandigarh University,
Gharuan

Bobbinpreet Kaur
Research Scholar
ECE Department
Chandigarh University,
Gharuan

ABSTRACT
This paper addresses the issue of achieving energy efficiency in heterogeneous cellular networks (HetNets). The use of sleep control strategy and distance based energy requirement enables us to achieve optimized energy efficiency. The proposed system connects to the problem of heterogeneity and finds solution to the balance in terms of communication distance based energy requirement, the network connects the micro users and the macro users to the same station on the basis of the distance from the concerning station, then an election is started for the nearest station to the user node ignoring the rely networking, the user can be assigned a network with micro users on it, in this case the priority is given to the macro user and the micros are adjusted, this adjustment is marked with reduced density of the micro by switching them off for a concerned period while the macro is in effective fading limit of the micro station.

Keywords
Heterogeneous cellular networks

1. INTRODUCTION
Wireless communication is the fastest growing part of the communication industry. Growth in cellular system has increased exponentially and there are approximately two billion users worldwide. Cell phones have become the part of daily life in almost all the countries and also an important business tool. Heterogeneous network is one which consist of more than one type of network. One will be the traditional high power network i.e. Macro base station and other are low power networks like micro cells, femto cells and picocells. With the introduction of LPN in the traditional network the power consumption will reduce, as the LPN will serve the users that are close to the BS and there will be no path loss and hence power consumed will be less. Unique Optimization of the energy efficiency is considered not just to positively add to the ecological appraisal, but also picks up the significance from administrator's perspective too, since energy price for running an adaptable mobile radio framework have an extending offer of the operational utilization. From this perspective, the utilization of small, low powerbase stations is seen as a promising system to intensify a framework's throughput and to improve the energy efficiency [1]. The utilization and production of ICT contributes a growing percentage to worldwide greenhouse gas discharges representing more than 2% as of now in 2007. Within the communication sector a pattern towards enhancing the vitality efficiency of key innovations can be observed. Though mobile radio systems are just a minor maker of greenhouse gas discharges today noteworthy difficulties can be envisioned later on. Over the previous years, mobile telecom systems have demonstrated exponentially expanding vitality utilization figures, doubling every four year. In addition, setting up western norms in communication services on an overall scale would expend around 40% of today's worldwide electrical power era abilities [2]. To meet the devastating data demands by smart phones, tablets and other media hungry devices, cell systems are presently experiencing a noteworthy change from a completely arranged organization to more sporadic, heterogeneous arrangements of macro, micro, pico- and femto-base stations (BSs) [3]. In heterogeneous specially appointed systems, hubs have diverse transmission reaches, channel limit and users have distinctive QoS requirements. This builds the danger of conflicting managing tables. Additionally, performing affirmation control and asset booking for distinctive QoS necessities needs to be tested.

A.Macrocells
It is raised that, just about 60% rate of a cell framework is used for the working of macrocell base stations (BSs). Therefore research work orienting the greenness of macrocell base stations has recently gained momentum in following three aspects: component arranging of BSs, cell zooming and power saving of power amplifiers. BSs are encountering "over-provisioning" issues, so by tuning the BSs, on or off, in perspective of the dynamic traffic load, energy can be fantastically saved from the point of view of whole mobile frameworks. Approx. 50% of the operation use of a normal convenient framework system, is for the consumed essentialness, so convincing green strategies are imperative to lessening the imperativeness usage of the entire flexible structure.

B.Microcells
The term micro is used to describe any cell that is smaller in size than macro. Its coverage distance is about 2km. The cells that cover less than 2km are pico or femto cells. Micro-cells consume less power than macro. They help in increasing the capacity and coverage of cellular network.

2. NEED OF ENERGY EFFICIENT ENVIRONMENT
It has been reported that mobile operators are already among the top energy consumers (for example, Telecom Italia is the second largest energy consumer in Italy), and energy consumption of mobile networks is growing much faster than ICT on the whole. Moreover, as the mass deployment of 3G systems in developing countries (like China and India) and later 4G systems worldwide occurs, mobile communications will consume significantly more energy if no effective actions are taken.

A large electricity bill results from the huge energy consumption of a wireless base station (BS). More than 50% of the total energy is consumed by the radio access part, where 50-80% is used for the power amplifier (PA). It is also pointed out that the energy bill accounts for approximately 18% of the Operation Expenditure (OpEx) in the mature European market and at least 32% in India. Therefore, from the operators' perspective, energy efficiency (EE) not only has great ecological benefits and represents social responsibility in fighting climate change, but also has significant economic benefits. Thus, it is urgent to shift from pursuing optimal capacity and spectral efficiency to efficient energy usage when designing wireless networks.

From the users' perspective, energy-efficient wireless communication is also imperative. According to the 2010 wireless smartphone customer satisfaction study from J. D. Power and Associates, the iPhone received top marks in every category except for battery life. The latest report in China also reflects the same problem. Based on the data in, up to 60% of the users complained that battery endurance was the greatest hurdle when using 3G services. Without a breakthrough in battery technology, the battery life of the terminal sets will be the biggest limitation for energy-hungry applications (e.g., video games, mobile P2P, interactive video, video monitors, streaming multimedia, mobile TV, 3D services, and video sharing).

With the explosive growth of high-data-rate applications in wireless networks, EE in wireless communications has recently drawn increasing attention from the research community. Several international research projects dedicated to energy-efficient wireless communications are being carried out. Table I outlines the main solutions to dealing with EE from Green Radio, EARTH ,OPERA-Net and eWIN.

Low-power circuit design, high-efficiency PA and digital signal processing (DSP) technologies, advanced cooling systems, adequate EE metric and energy consumption models, cell-size deployment, various relay and cooperative communications, adaptive traffic pattern and load variation algorithms, and energy-efficient network re-source management, as well as MIMO and OFDM techniques, are the highlights of energy-efficient wireless communications. Several international research projects dedicated to energy-efficient wireless communications are being carried out.

3. CHALLENGES AND FUTURE DIRECTIONS FOR DYNAMIC ENERGY EFFICIENT OPERATION OF CELLULAR NETWORK

Energy savings can be achieved if "redundant" base stations could be switched off during periods of low activity. However, this analysis has glossed over many important details pertaining to how such dynamic base station operation can be implemented in practice. A number of questions arise: What are the mechanisms by which coverage can be maintained when subsets of the base stations are switched off? What changes may be needed to make the mobile units more "cognitive" in order to enable more agile base station management across multiple spectrum bands? What is the temporal granularity at which base station operation decisions should be made? At what locality level of the cellular network hierarchical architecture should these decisions be implemented? Is there really an incentive for different operators to cooperate in base station operation? If so, how can such cooperation be realized? We now explore these issues in greater detail, in the process identifying avenues for future research and development in this area. In particular, we focus on coverage extension, then address other technical issues and consider the location estimation problem that arises in some cellular deployments.

1. *Maintaining coverage using power control*

The primary constraint of green cellular operation is to preserve coverage and service quality when certain cellular base stations are turned off in the case of low load. Techniques for preserving coverage and maintaining quality of service have much similarity. To be concise, we focus the following discussion on maintaining coverage.

Power control will play an important role in balancing coverage and interference. In the case of low traffic load, the main challenge is to increase coverage, while interference management is less critical. Therefore, one can potentially increase transmission power when some base stations are turned off to increase the coverage area of the remaining base stations. Although a simple idea, it needs to be carefully evaluated for both uplink and downlink transmissions.

2. *Cognitive multi-frequency operation*

Multi-frequency-band operation can potentially be explored in green operation. Lower frequency bands have better penetration capability and can provide better coverage under the same transmission power constraint. An example of such a band is the vacant 700 MHz TV band in the United States, auctioned in February 2009 and acquired mainly by large cellular operators. Such a lower frequency band could potentially be used by larger cells, overlapping with smaller cells on a higher frequency band. It is worth noting that frequency selection requires more advanced physical layer technology, which is available in current commercial mobile devices to some degree, with more advanced features being developed as part of the cognitive radio paradigm.

3. *Multi-hop relay for coverage extension*

Various techniques have been considered in cellular networks to improve network coverageand/or increase network throughput. Some of these techniques can be applied in the case of green cellular operation with a focus on covering the cells with shut-down base stations. The basic idea is simply to allow other devices to relay the traffic of a cellular user that receives weak or no signal directly from its nearby cellular base stations. This will clearly be useful to ensure that the dynamic shutting down of base stations, while saving energy, does not leave coverage holes. However, finding such relays can be a challenge.

4. *Coordinated multipoint transmission and reception*

Another novel approach that can play a role in extending coverage is the use of coordinated multipoint transmission and reception (CoMP) being developed in the context of Long Term Evolution (LTE)-Advanced cellular networks. The basic idea in CoMP, a macro-diversity scheme, is to coordinate transmission and reception at neighboring cells. On the uplink, coordinated receptions at multiple base stations can effectively reduce the received power requirement at each individual base station. The increased power on the downlink and lowered power requirement at the uplink together provide coverage with accept-able service quality for mobile users in nearby cells whose base stations have been shut down during low activity periods.

5. *Handling heterogeneous cell sizes*

In our simplified estimate of energy savings, we considered uniform cell sizes. In third-/fourth-generation (3G/4G) systems, because of the required high data rate, cellular towers will be more dense and have varying coverage, with more heterogeneous cells, such as microcells, picocells, and femtocells. In particular, heterogeneous cellular architecture should be considered in the deployment stage so that umbrella macro-cells can provide overall coverage with lower data rate, and smaller microcells/picocells can provide better data rates for congested areas. This can potentially be exploited for energy efficiency, since in the case of light load we can turn off (most of) the smaller cells. On the other hand, considering energy efficiency introduces additional complexity in network planning and deployment, and thus needs to be further studied.

6. *Granularity of control*

The issue in dynamic base station switching is the temporal granularity of the control. While most of the early work in this area has primarily focused on switching off base stations once a day, it remains to be seen whether finer-grained operation (e.g., on an hourly or even more frequent basis) can improve energy efficiency, particularly in settings where traffic patterns are not predictable from day to day. However, this may require more active online monitoring of traffic and increase the complexity of coordination with other cells to ensure coverage. Another related question is the spatial granularity of coordination. Base stations can be switched off and on in a distributed manner at either a base station controller or mobile switching center level. This granularity can affect different trade-offs between timeliness, complexity of coordination, and efficiency of the base station switching policy.

7. *Maintaining emergency location service*

There are other practical considerations related to the green operation of cellular infrastructure. One such issue in the United States is E911 (Enhanced 911). E911 is a North American telecommunications-based system that automatically associates the physical address with a caller's phone number, which enables the call to be routed to the most appropriate public safety answering point for that address. In cellular networks, this requires location determination of a cellular caller. In E911 Phase II, it is required that 95 percent of a network operator's in-service phones be E911 compliant, with a granularity of 300 m. Therefore, if cellular towers are used to triangulate caller locations, the 1-coverage requirement needs to be extended to 3-coverage (i.e., each caller can reach three cellular towers).

4. PROPOSED SYSTEM MODEL

The proposed system measures the energy variation due to the change in micro density, the system works softly for the macro users, who are not turned off and are made to access their demanded space in the network, however at higher densities, it may occur that the heterogeneity may go over saturated in terms of user density and network may not show higher utilization for available bandwidth due to sluggish switching taking place with high users densities to be reallocated under fading scheme and a new multiple antenna fading test which requires the exact shadowing estimation for the user. network, the system applied in current network reduces distortions among the hetero circle and gives a higher throughput with balanced bandwidth usage, giving reserve space for more adjustments in the network congestion.

(A) User Distribution area

The hetero network is simulated with an area of 100x100 network spread and the user number and heterogeneity count is dependent on the user based inputs. The base inputs are 100 users in 100x100 network area, with 50% heterogeneity among the users with half concentration as micro networks and other half as macro network.

(B)Base station

The base station is divided into two parts the main station and the second is the micro station, the micros are designed for low power communication and are considered as advanced users, however these users are high bandwidth demanding which results in higher traffic data rates, thus the imbalance is created. The main station is the head provider for all the micro and macro users.

(C) Micro Users

The third design parameter is the micro distribution in the network, as the network for micro coverage is close, the micro users are located in a confined region, also no restriction is imposed for the macro users in micro region, although interference is concern for all users.

(D)Macro Users

The macro user or mobile users with high energy consumption are the priority for the hetero balance and are connected based on the distance configuration form the base stations, if the users are located near the main station the macro connects to the base station. The case where the micro is located in the region of the macro, the switching is essential as the micro micro user bandwidth can be utilized with that of the high energy consuming macro user prioritized with momentary offloading. The proposed system works with first integrating the two network in one frame.

- The first step is to decide the number of users for simulation by taking the user defined node number as input.
- Every user is firstly assigned as macro user and the general energy consumption is parameter and transmission energy is assigned to the user, the energy and selection of the micro and macro user is based on the region division, where the users are deployed, there are 5 region in the network where the users are interpreted as macro and the other areas are considered as the macro cell area where only the macro users are considered.
- The simulation is carried out by initializing the users as nodes with a threshold set to the average energy required for sending the data to the nearest base station, after detecting the user type, micro or macro, assignment of the station is done for the user and energy consumption, switching and energy to area ratio is calculated.
- The network simulation is for a particular number of simulation runs which ensure the robust test for the system network.
- The density of users is measured with fading in three form the random fading, weibull fading, and nakagami fading scheme with interference based on the user density, the user density increases and adjusts.

A.Macrocell Pathloss

The calculation of macrocellpathloss parameter is based on the Hata urban area user propagation model:

$$PL[db] = (44.9 - 6.55 \log\log_{10} h_{bs}) \log_{10}\left(\frac{d}{1000}\right) + 45.5 + (35.46 - 1.1\, h_{ms}) \log_{10}(f_c) - 13.82 \log_{10}(h_{bs}) + 0.7 h_{ms} + C \quad (1)$$

where h_{bs} is base station antenna height in meters, h_{ms} the macro station antenna height in meters, f_c isthe required carrier modulation frequency needed in MHz, dis the distance between the base station and micro station in meters, and C is a constant factor (C = 0dB for urban macro concentration and C = 3dB for urban macrocell).

B.Microcell Pathloss

The microcell pathloss model with the following parameters: BS antenna height adjustable depending upon the network user density, building height based fading, building to building distance more than 20meters, micro station antenna's height with average length 1- 1.5 meters and selection of metropolitan center. With the given parameters, the equation will transform to:

$$PL(db) = -55.9 + 38 * \log_{10}(d) + (24.5 + 1.5 * f_c/925) * \log_{10}(f_c) \quad (2)$$

The resulting pathloss at given user frequency in Mhz, where d distance is in meters. The distance d is at lowest level. A bulk log normal shadowing applying to all sub-paths has a standard deviation of 10dB.

C. Propagation and Effects of channeling

Besides the low available bandwidth and the high density of users who access wireless systems, the largest issue in systems is of noise and fading. This is derived from the decreasing power when a signal is received as the transmitter and receiver distance increases. The power which is at receiver can be deduced from following

$$P_R = P_T \frac{A_T A_R c^2}{(4\pi f d)^2} \quad (3)$$

Where P_R and P_T are received and transmitted power, respectively, A_R and A_T are amp.of the receiver and transmitter system antenna, c is the speed of light $(3\times10^8\ m/s)$, f is the given frequency, and d is distance space of the transmitter and receiver. This given us the reduction in power.

5. SIMULATION RESULTS FOR VARIOUS SCENARIOS

A Results for the following system settings:

Network settings for 100x100 network for 200 users with division probability of user spread is 50%, simulation is run for 40 iterations.

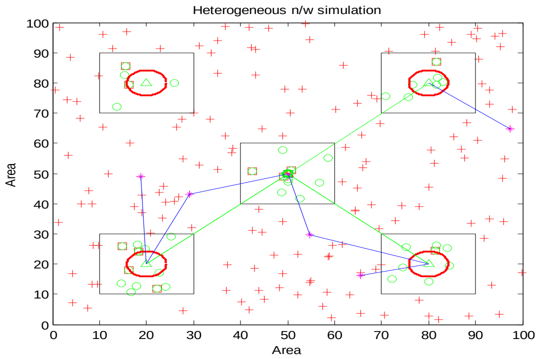

Fig 1: The network simulated area for heterogeneous network

Figure 1 shows the cut out from the network simulation run mode, where the red crosses are the macro users and green circular point are the assigned micro users there are four micro units located at each corner of the main macro station, the micro stations also inhabit the macro users who are present in close range to the station when compared for the threshold from the main station, this is controlled by distance based strategy which reduces fading by estimating the right path , if micro is chosen the switching of micro users takes place when needed.

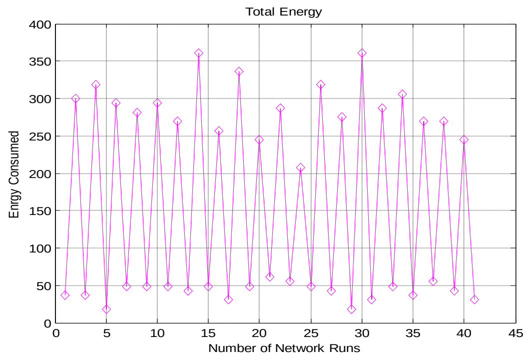

Fig 2: Energy consumed for all iterations under micro switching

Figure 2 presents the graphical analysis showing the energy consumption by the users, the continous shift of the energy readings is due to the user changes, theenergy spikes as macro users increase and the micro low power decrease. When the micro goes to sleep mode the energy consumption drops down.

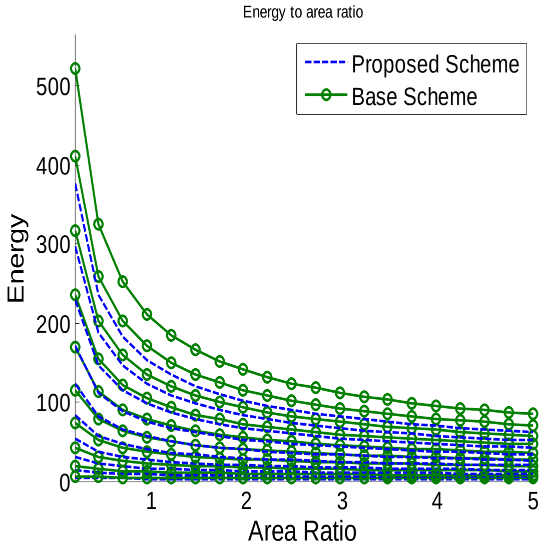

Fig 3: Energy to area ratio of the network for multiple fading

The utilization of the multiple antenna strategy is used when the number of users increase the total fading is considered to be high as a result the antenna selection is made according to the demand and also with respect to serve the kind of user near or far, the user dependent antenna selection is based on urban network design with high shadowing limit, this is compared to the low or no fading as considered in systems with only one antenna adjustment, this when compared with proposed policy of power requirement, gives better estimation of energy consumption for the given area density.

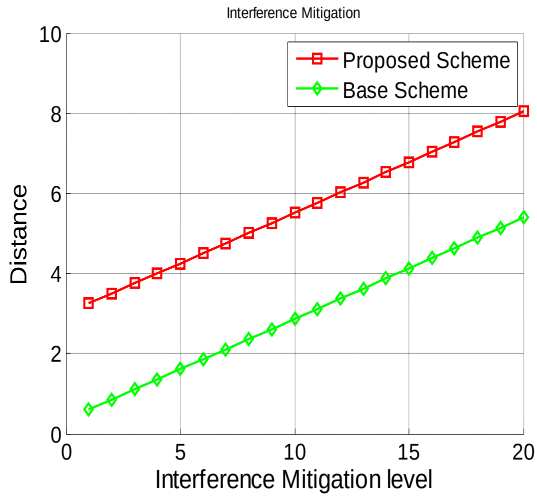

Fig.4. Reduction in interference by base system approach and proposed system

Figure 4 shows the reduction in interference due to the proposed and base strategy in the network, as it can be seen the interference compensation given by the base strategy when analyzed for a low area gives good results, whereas the proposed system strategy gives better results for much greater distance.

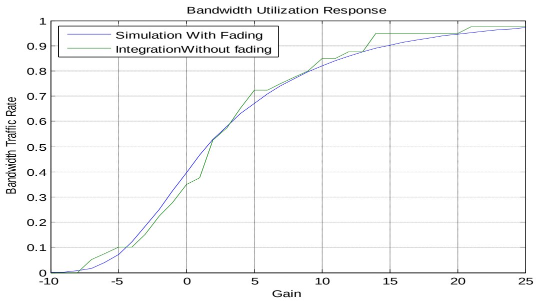

Fig 5: Bandwidth utilization with and without fading consideration

The bandwidth utilization graph shows the distribution of user who access the spectrum and communicate by access the networks for both micro and macro networks, this access is unguided in terms of non-fading channel and when the system is applied for the fading based scheme its response becomes linear and access the spectrum bandwidth according to the calculated user demands.

6. CONCLUSION AND FUTURE SCOPE

The hetero cellular concept is derived from the instance when two same domain networks exist in different phase of communication in the same circle, giving high diversity to the users to switch between the mode of network access, to comply for the same we have designed a strategy which highlight:

- The use of balance between two networks on the basis of optimized network access for available bandwidth, as the limited bandwidth only allows given number of users to communicate, the system needs to adapt in strategy in order to exceed the performance from past proposition, the new system reacts to HCN system in dynamic way as the intensity of the user heterogeneity increases.
- The fading scheme is developed for higher interference measurements, which was not shown in previous approach.

As user density was estimated for balancing and controlling the micro working cell, the new method used distance strategy to assign the macro micro users their desired space and then prioritized the macro by giving it needed space in network adjusting the micro. The results from the simulation give the estimation of proposed strategy for HCN system control and design for optimal performance.

In future the given system can be applied to other hetero networks which may have even more fine network cells and a low range to service, the network congestion is the main issue in the communication, the proposed system model may be modified with energy harvest network in cellular domain, these networks have an energy source which can be added as backup to the base station planning and can yield more delay to allow planning for proper assignment of users to their needed access in the system.

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