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Efficient Hand Offs with in Energy Efficient Base Stations of Green Cellular Networks

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***Abstract*—In green cellular networks, the main goal is to reduce the energy consumption. Green cellular networks are a growing concern for cellular operators to increase profitability, and also to reduce the overall environment effects. In cellular networks, base stations (BSs) may consume over 80% of the total energy in the network. One among many ideal ways for reducing energy consumption is to turn BSs off according to the daily traffic conditions. While turning off BS, target area may not be fully covered in the network. The main aim is to minimize the total power consumption of the network by turning off the base station adaptively, at the same time maintaining the network coverage. When few base stations are turned off, radio coverage and service provisioning are taken care of by the switched on base stations, in order to guarantee that service is available over the whole area. When service provisioning are taken care by remaining BSs, there may cause frequent and redundant hand offs. An efficient solution for this problem is to select a single base station to transmit data at given time, for that we proposed an efficient and reliable handoff process between the cells.**

Keywords*— *green cellular networks, hand offs energy efficient-base stations.

1. INTRODUCTION

Green networking is nothing but energy efficient operations of network components and their operations are having less impact to the environment. The traffic in cellular networks increases drastically and the number of base station also increases. Thereby increasing the power consumption. In cellular networks base stations may consume more than 80% of the total power [6]. The fig 1.1 shows the power consumption of base stations. There are currently more than 4 million base stations (BSs) working in cellular networks for serving mobile users. Each consuming an average of 25MWh per year. Information and Communication Technology (ICT) already represents around 2% of total carbon emissions. So the main goal is to reduce the power consumption of base stations.

There are several techniques implemented to reduce the power consumption of base stations. Some of the important techniques are cell zooming [4] and sleep modes [5]. In cell zooming [4] technique, the cells automatically adjusts its coverage area according to the network traffic loads. Whenever the network traffic increases the cell decrease its size in order to provide better services to the nodes within its coverage area. Similarly when the network traffic decreases the cell increase its coverage area in order to provide services to the nodes which are far away from its coverage area. The main advantages of cell zooming techniques are load balancing and energy saving.

Sleep mode [5] techniques is usually implemented in low power cells. In sleep mode technique some of the hardware component of the base station may either turned off or they may operate at low power modes.

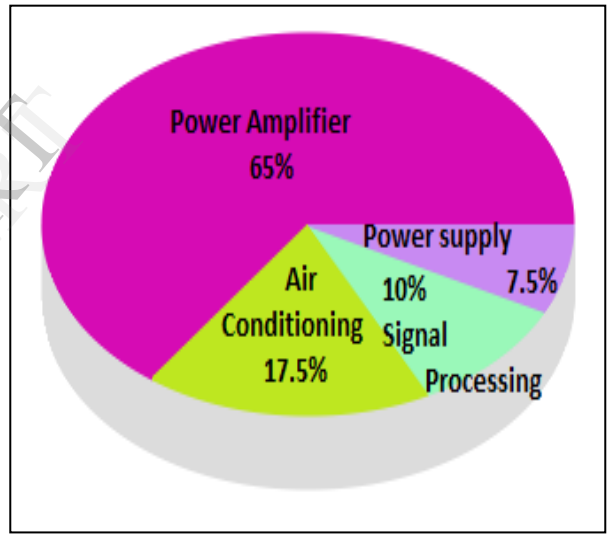

Fig.1.1: power consumption of base stations

Cooperation among base station is the important way for power consumption. In [9], the authors propose a technique based on cooperation between base stations in order to minimize the active number of base stations while maintaining the required quality of service and minimum coverage.

Another efficient way to reduce the power consumption of BSs is to turn BSs off, when there is less traffic. The traffic load of a base stations are able to be predicted according to their behavior. The traffic during night time is very much lower than day time. Similarly during weekends also the traffic load is minimum [7]. During daytime, traffic load is generally higher in office areas compared to residential areas. There will always be some cells under low traffic load, while some others may be under heavy traffic load. So we have to turn off the base stations

automatically when there is less traffic. This will reduce the average total power consumption of the network. Turning off base stations during less traffic load will face several challenges. While one base station is turned off, the service for the nodes under the turned off base station will be provided by the active neighboring base stations. At that time some of the nodes may under the coverage of several base stations. So there exists redundant hand offs between the access points. The problem is that the active neighboring base stations must increase its coverage area in order to provide services to the nodes which are under the coverage of switched off base station. So care must be taken before turning off a base station.

In green cellular networks macro cell deployments are not preferred commonly. Macro cells are mainly designed to provide large coverage. Which are not suitable for providing high data rates. Heterogeneous network deployment [10] is one of the ways of energy conservation in green cellular networks. Heterogeneous Cellular network consists of deployment of smaller cells such as micro, Pico and femto-cells, which are very energy efficient than macro cells. A picocell is a small cellular base station typically covering a small area, such as in-building (offices, shopping malls, train stations, stock exchanges, etc.), or more recently in-aircraft. An average range of a picocell is in the order of few hundred meters. A femtocell is a small, low-power cellular base station, typically designed for use in a home or small business. Femtocells are deployed to serve much smaller areas such as hotels, homes or indoor areas. The range of femtocells is usually about a few meters. Smaller cells because of their smaller size are much more energy efficient in providing broadband coverage. A typical femtocell might consume only less power as compared with macro cell. A jointly macro cell and picocell network can reduce the power consumption of the cellular network by up to 60% as compared to a cellular network with macro-cells only.

2. RELATED WORK

There are several techniques for turning off base stations in green cellular networks. The paper "On Optimal Cell Activation for Coverage Preservation in Green Cellular Networks" proposed by Chen-Yi Chang, Wanjiun Liao had minimize the total power consumption of the network by switching BSs on/off adaptively while maintaining the network coverage. In their work, the authors derived the optimal cell size for minimizing BS power consumption per unit coverage area and propose a polynomial-time algorithm for energy-efficient BS activation. They proposed an optimal cell activation algorithm known as COMIC (Cell Overlap Minimization with Intersection Covered) [1]. This algorithm reduces the average power consumption of the cellular network by turning on and off the base station automatically according to the traffic conditions and at the same time maintaining the network coverage.

In cellular network, each BS can be turned on/off according to the network traffic load. An active BS is a base station which serves users in the network. The traffic load of a base stations are able to be predicted according to their behavior. The traffic during night time is very much lower than day time. Similarly during weekends also the traffic load is minimum. Therefore, the main aim is to optimization of energy saving during off-peak hours. First find the set of active BSs such that the network-wide coverage is maintained. At first all the base stations are in active state in order to maintain the network coverage. During night time or weekends the traffic is very low. At that time by using COMIC algorithm, switch off a base station, and the coverage area of that base station is intersected by neighboring cells in order to provide services to the mobile nodes within the coverage of turned off base station.

In the fig 2.1, six base stations are deployed to provide the coverage for target area. Suppose we switch off any of the base stations in the fig 2.1, target area is not fully covered.

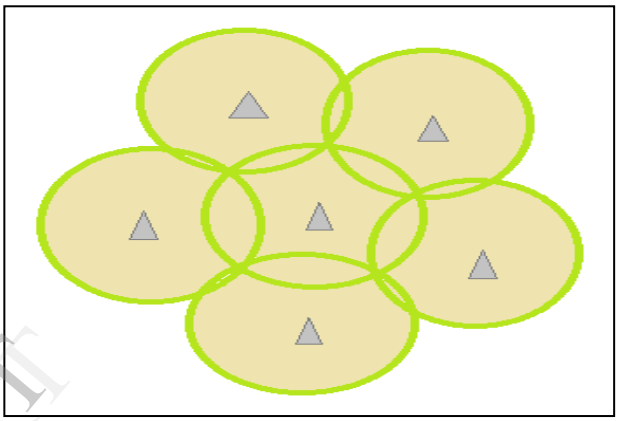

Fig 2.1: Normal cells with base station.

The COMIC algorithm [1], overcomes the coverage hole problem. In this algorithm the cells will intersect each other, and we can switch off the base station which runs on less traffic. The fig 2.2 shows the illustration of COMIC algorithm, according to this figure we can switch off the centre base station when traffic load is minimum and all the remaining base stations will active at that time. At that time the active neighboring base stations will provide services to the target area. The main goal of this algorithm is to activate a specific set of BSs which can reduce the network power consumption. In the fig 2.2 the centre red circle indicates the switched off base station's coverage area. When the centre base station is switched off the remaining base stations will provide services to the mobile nodes that are within the coverage area of switched off base station area.

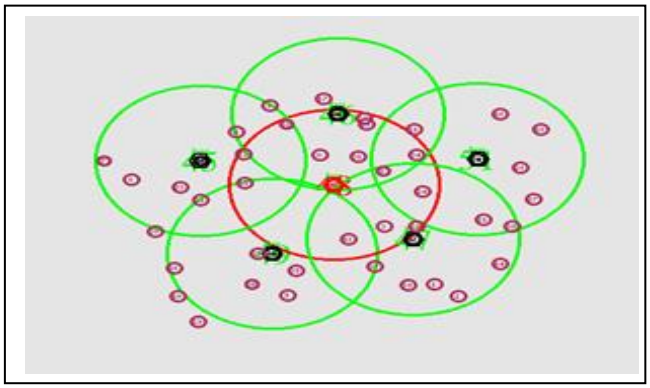

Fig 2.2: Illustration of COMIC algorithm

3. IDENTIFIED PROBLEMS

One of the major problems occurs in COMIC algorithm is that the mobile nodes within the coverage of turned off base stations will provided by service by the active remaining neighboring base stations. For a mobile node within the coverage area of switched off base station will encounter several better quality links from neighboring active base stations. So there occurs redundant and consecutive hand offs between the neighboring base stations. Hand off is a process by which a mobile node disconnects from an access point ,whenever there is a low quality links and connects to other access point having good quality link. Ping pong effect also occurs between two base stations. Ping pong is nothing but when a mobile node moves back and forth between the overlapped areas of two adjacent cells.

4. PROPOSED TECHNIQUE

In order to overcome the problem of redundant hand offs and ping pong hand offs, we propose an efficient and effective hand off process. Hand off is nothing but transferring of a mobile node from one base station to another. Handoff refers to a process of transferring an ongoing call or data session from one channel connected to the core network to another. One of the important reason for a hand off to be conducted is to avoid call termination. When the capacity for connecting new calls of a given cell is used up and also some interference is occurred in the channels, hand off to be conducted.

There are two types of hand off process, hard hand offs and soft hand offs. In hard hand off process the mobile node uses only one channel for communication. That means the mobile node has to break its connection from its current base station and connect to another base station. In other words hard hand off is a break before make connection. That means before hand off process occurs, the mobile node has to break its connection from current base station and make a new connection with the other base station. The fig.4.1 shows the hard hand off process.

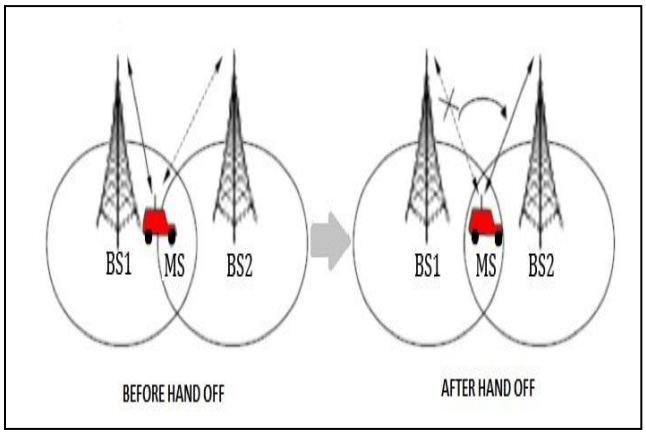

Fig 4.1: Hard hand off between a mobile station (MS) and two base stations (BS1 and BS 2)

The soft hand off is process in which the mobile node uses multiple channels with base stations for communication. In soft hand off process the mobile station first makes a connection from another base station, after connecting to that base station, it breaks the connection from the first base station. That means the soft hand off process is a make before break connection. The fig 4.2 shows the soft hand off process for a MS between two base stations

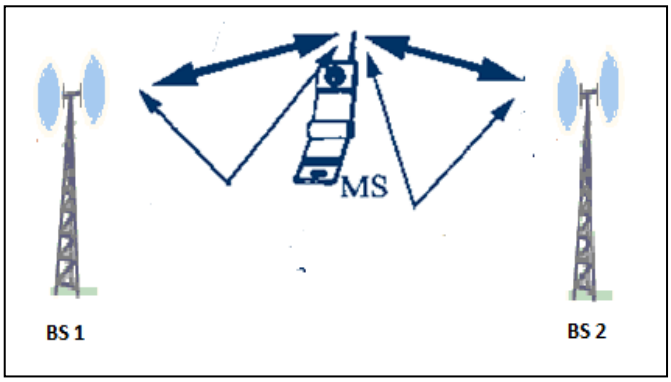

Fig 4.2: Soft hand off between mobile station and base stations

Here we consider hard hand off process. To avoid the redundant hand offs we propose an efficient hand off process, in which the mobile node, for a given time select one base station for communication. There are several hand off process which avoids the redundant hand offs and ping pong effects. We identified the smart-HOP [2], [3] and hand off management [9] proposed by Prof. W.-G. Teng describes a hand off process, which avoids the redundant hand off and ping pong effects. We propose an efficient hand off technique based on these hand off process and that should be used with COMIC algorithm [1]. So that the redundant hand offs between different base stations and ping pong effect can be avoided. First we have to identify the hand off margin (HO margin) and threshold levels. The HO margin and threshold selected according to the transitional region. The fig 4.3 shows the mobile station takes the +hand off decision when moving from BS1 to BS2.

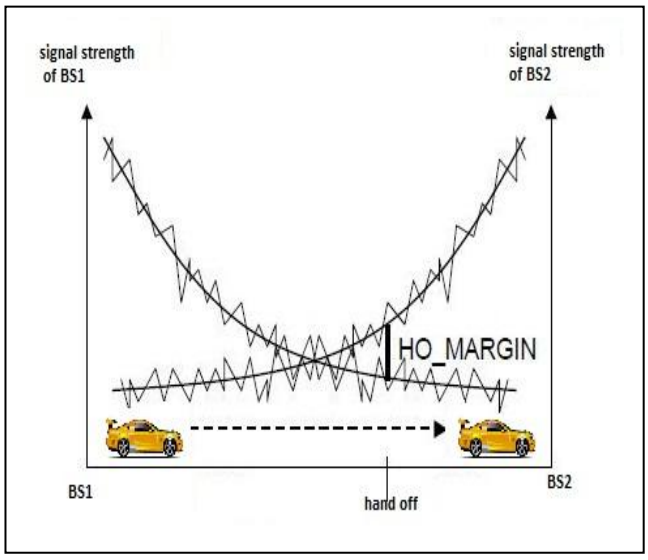

Fig 4.3: Hand off decision and HO margin

The fig 4.3 shows the hand off process. The mobile station MS moves from the coverage area of BS1 to the coverage area of BS2. While moving the relative signal strength goes down to a lower threshold value. At that time the mobile station broadcast probe message, when any base station replies to that probe message (here the base station BS2 replies for that message). At that time onwards the mobile station stops communication with the BS1 and if the received signal strength from the BS2 reaches greater than the threshold value (TH-high), the hand off takes place. Then mobile station starts communication with BS2.

The hand off decision time is an important factor. It is based on HO margin and threshold levels. There are two threshold values, TH-low and TH-high. Hand off process begins when a link quality of current base station goes down that is, less than TH-low. At that time the mobile node starts finding a good quality link, which is above TH-high with other base stations. The threshold values are set by using the received signal strength (RSS) and signal to interference and noise. When the link quality reaches below a certain threshold value, TH-low, the mobile node broadcast messages to nearby base stations. If any base station replies to that message having a good link quality, then the mobile node is connected to those base stations. If more than one base station replies to that message having above TH-high, the mobile node identify the best link based on received signal strength and signal to interference and noise and connected to that base station.

Our proposed efficient hand off consists of the following steps.

- At first the mobile node is communicating with a base station having strongest signal, which is greater than the threshold value (TH-high).

  RSScur > TH-high

- While moving the mobile node identifies several good quality links better than the current one. But to avoid redundant hand offs, the hand off process doesn't takes place at that time.

  RSSnew > RSScur

- When the link quality goes down to the threshold value (TH-low). The mobile node start searching for a base station with better quality link, i.e. high threshold (TH-high) as well as HO margin.

  RSScur < TH-low

  RSSnew > TH-high

  RSSnew > HO margin

  The mobile node starts searching for a new base station only if the link quality goes down below a threshold value (TH-low). Otherwise there is a chance for ping pong effect between two base stations.

- If the mobile node finds a better quality link based on high threshold an HO margin. Then the mobile node is connected to that base station. If the mobile node doesn't find any base station. It continues its search for a new base station.

- After hand off the mobile node begins to communicate with the new base station.

Hand off decisions can be taken based on the following parameters,

- Received signal strength (RSS)

  RSSnew > RSScur

- Received signal strength (RSS) with threshold

  RSScur < TH-low

  &

  RSSnew > TH-high

- Received signal strength (RSS) with hand off margin

  RSSnew > HO margin

- Received signal strength (RSS) with hand off margin and threshold

  RSScur < TH-low

  &

  RSSnew > RSScur + HO margin

The hand off decision taken based on only RSS has many limitations. This method selects the strongest received BS at all times. The decision is based on a mean measurement of the received signal. This method is observed to provoke too many unnecessary handoffs, even when the signal of the current BS is still at an acceptable level. The effect of threshold depends

The hand off decision based on RSS and with threshold allows a MS to hand off only if the current signal is sufficiently weak (less than threshold) and the new signal from other BS is larger than the threshold.

The hand off decision based on RSS with HO margin allows a mobile node to hand off to a new base station only if the new BS is sufficiently stronger (by a HO margin in Figure 4.4) than the current one. In this case, the handoff would occur at point x4. This technique prevents the ping-pong effect, the repeated handoff between two BSs caused by rapid fluctuations in the received signal strengths from both BSs.

The hand off decision based on RSS with threshold and HO margin allows a mobile node to hand off to a new base station only if the current signal level drops below a threshold and the target BS is stronger than the current one by a given HO margin. This scheme prevents the redundant hand offs as well as ping pong effect. We suggest hand off decision should be taken according to RSS with threshold and HO margin.

In order to avoid redundant hand offs the mobile node communicates only with single base station at a given time. When communicating with a base station it identifies several better links from other base stations. So there occurs redundant hand offs. To avoid that, when a mobile node is

connected to a base station, it maintains communication with that base station itself, even after it identifies several better links. Hand off occurs only whenever the link quality goes down to a threshold value, (RSScur < TH-low) and the RSS of new base station greater than the HO margin (RSSnew > RSScur + HO margin)

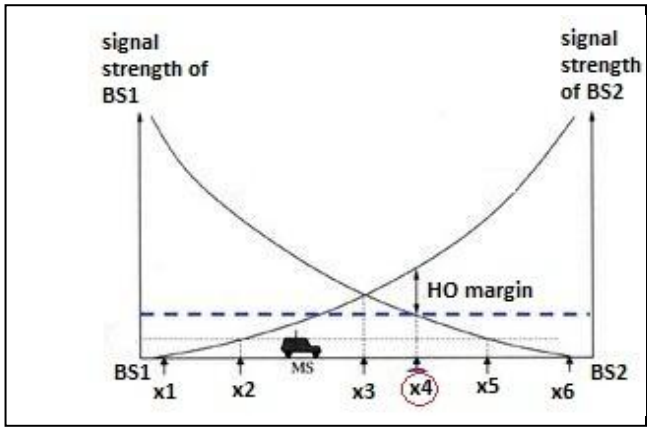

Fig 4.4: Avoids ping pong effect. Proper hand off process takes place at x4.

In the fig 4.4, the mobile station moves from BS1 to BS2. At the point x1 onwards it gets signal from BS2. From the point x2 onwards the mobile station MS start looking for a new base station. To avoid ping pong effect the MS continues to maintain connection with BS1, until x4. Here the actual hand off takes place at the point x4, to avoid ping pong effect.

5. EXPERIMENTAL ANALYSIS

For validation, we have implemented COMIC [1] in the ns2 simulator first, and then we implement our efficient hand off process. In our simulation we considered 6 base stations. At first we decide when to turn off the base station (during less traffic period). Traffic load of a base station is predictable according to their behaviour. During night hours the traffic is very much lower in compared with the day time. Our simulation results show that the average power consumption is very much reduced. Usually a base station consumes average of 75KWh per day. For almost half of the day the base stations are having only less traffic. At that time we can turn off that base station. According to our findings almost for 8 hrs the base station had run with less traffic as shown in fig 5.1, at that time we can switch off the base station. During that time the neighboring cells provide traffic for the mobile nodes.

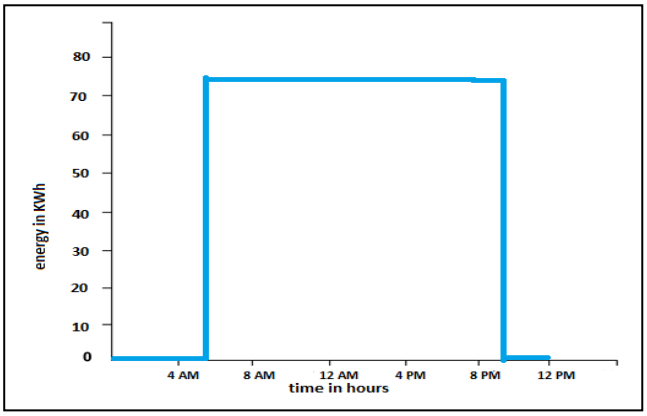

Fig 5.1: Energy consumption of single base station during a day

Our simulation for hand off process in ns2 encounters several limitations. Reference [2] conducted experiments in a realistic environment. They used 6 base stations for providing coverage for mobile nodes. In their experiments they observed that selecting lower threshold level (TH-low) and wider HO margin avoids ping pong effect.

6. CONCLUSIONS

In cellular networks power consumption of base station is a challenging issue. In this short paper we tried to improve the efficiency of energy efficient base station operation in green cellular networks for energy conservation. We proposed an efficient hand off process by combining hand off mechanisms proposed in smart-HOP [2], [3] and hand off management [8]. We identified a major problem in COMIC algorithm [1], as their occur redundant hand offs between cells and also ping pong effect. We solved this problem by proposed an efficient hand off technique. We found in our simulations, that the COMIC algorithm will reduce the total power consumption by turning off the base stations automatically according to the traffic profile. This paper describes about the limitations of COMIC algorithm and can be solved by using an efficient hand off technique.

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