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Load Balancing Among The Base Stations For Green Cellular Networks

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***Abstract* - In the recent days, the evolution of mobile devices such as smart phones and tablets is now driving data traffic demand. Network providers have responded by expanding their network coverage to minimize data traffic, resulting in a rise in the number of Base Stations (BSs) around the world. This has negative consequences for the environment because it increases emissions by a significant percentage. As a result, a feasible BS switch ON/OFF algorithm to turn off under-utilized BSs during off-peak hours is required to reduce energy usage. BSs often offer signal to their own users. When a BS is turned off, its neighboring BS automatically extends its coverage to accommodate service. If the traffic load exceeds the expected loads, the excess loads should be balanced by surrounding BSs. The proposed BS switch ON/OFF algorithm outperforms the competition, according to the results.**

Keywords: Heterogeneous network, Base station switching, energy consumption, Quality of Service (QoS).

1. INTRODUCTION

Global information has huge reputation in the Information and Communication Technology (ICT) fields. Every five years, the pace of data transmission has increased by a factor of ten, while the corresponding energy usage has increased by 20% per year [1]. More than 2% of global energy consumption is now attributed to the ICT industry, which is expected to expand much more in the future. According to researchers, mobile network energy usage accounts for between 0.2 and 0.4 percent of worldwide emissions [2,4]. The ever-expanding mobile networks have dramatically raised energy expenditures and greenhouse gas emissions. As a result, the concept of green cellular networks was born. The primary goal of these mobile networks is to reduce energy consumption while also ensuring that the service continues to function properly. The goal of this article is to reduce energy usage at the BS. In mobile networks, BSs consume a significant portion of input energy, accounting for 60-80 percent of overall energy consumption [3,5]. Applying improvements in power amplifiers, devising power saving protocols, establishing cooperative BS power management, leveraging renewable energy resources, and making some minor architectural adjustments are all examples of ways to reduce energy consumption at network BSs.

2. RELATED WORK

A. Bousia et al. [6] proposed a switch ON/OFF algorithm that does not turn off BSs depending on their traffic load, but rather on the typical distance between their network users. The BS also determines the distance between all of its users and those of its surrounding BSs. The estimated distance data is then divided among all of the BSs, and the BSs are turned off at the most extreme normal distance. The proposed approach makes no attempt to address the issue of affiliation. Current network users inside the cell serviced by the corresponding BS should be redirected to neighbouring BSs if the associated BS is turned off to provide a reasonable QoS. It is not essential to transfer the users of a BS to the closest BS. The BSs that handle the lightest traffic may be the ones that deliver the best QoS. Despite this, the researchers were able to show that their suggested method preserved 29% of energy during execution. This is a significant energy savings, but the topic of Quality of Service was not fully explored. To fully exploit the measure of energy savings from BS's traffic aware functionalities, an adequate association technique is required.

K. Son and B. Krishnamachari [7] proposed a distributed switching OFF technique that is designed to share signal quality and network load parameters among BSs and UEs. Every BS decides whether to turn off or stay on based on this dispersed data, and there is no centralized controller. The BS that has chosen to turn off must first issue a request to switch off (RTSO) and will only be able to turn off after receiving a clear to switch off (CTSO) signal from nearby base stations. This is done to prevent overlapping neighboring base stations from turning off at the same time, causing traffic congestion for their neighbors. Because the process of turning on and off is not centralized, there is a good chance that the cellular system will have coverage gaps. Similarly, if the RTSO and CTSO are exchanged at the same time, the proposed technique may fail, resulting in a degraded QoS.

A large number of BS sleeping techniques have been suggested. A. Conte et al. [8] proposed a method for reducing the BS's transmitting power over time. This method was dubbed cell shrinkage or cell dynamic switch OFF by the researchers. This method anticipates or mitigates the effects of ongoing calls/sessions. During the process of coverage shrinkage, if any user equipment experiences unsatisfactory QoS degradation with no way to relocate to surrounding base stations, it may cause the BS that is shrinking to become aware of the situation and stop doing so. This process also results in significant energy savings. Its main problem occurs when a UE is turned on in a zone where a BS is in rest mode. The BS is turned off, and it is unable to recognize this UE, which has no way of signaling its problem because it is located in an area with no coverage. These researchers' algorithm is incapable of dealing with coverage gaps. Sudden changes in transmission power levels may have an impact on QoS. A UE that receives a solid signal from a nearby BS is unable to discern between the signals of other BSs, and if this base station switches off too quickly, the UE will lose its connection. The provided approach does not have a solution for dealing with such quick disconnection.

S. Zhou et al [9] states the result that includes BS sleep regulation and the use of traditional BSs that are connected to the power grid powered by solar and wind. Without enough gathered power in the battery, renewable energy using BSs is forced into sleep mode. The grid-controlled BS, on the other hand, goes into sleep mode when traffic is minimal. To arrange the two sleep modes so that energy outages do not occur, the framework requires a truly complicated process. Energy blackouts could occur if energy saved by renewable energy BSs is insufficient to confirm UEs that have been handed over to grid-powered BSs, which would have gone into sleep mode. The proposed structure saves control energy, but it comes at a high cost in terms of CAPEX (capital expenditures).

Z. Niu [10] presented a Traffic-Aware Network Arrangement and Green Operation (TANGO) framework with the goal of increasing energy efficiency while ensuring coverage. In their proposed work, the researcher did not consider the arbitrariness of cell traffic. The given cell zooming method does not address the issue of coverage gaps, which is commonly associated with cell zooming. The proposed system does not include a wake-up mechanism for these BSs that would have been built to go into sleep mode.

3. SYSTEM MODEL

Consider a heterogeneous network with three base stations (BS1, BS2, and BS3). The suggested system's architecture is depicted in Figure 1. In a heterogeneous network, several types of base stations (coverage and size) are typically employed. To balance the network load, these three base stations are linked to each other. The number of communication channels is indicated by the letter C. These channels are orthogonal and are randomly assigned to each user.

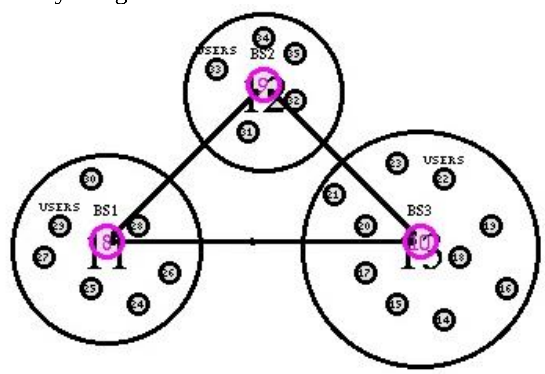

Figure 1: Architecture of the proposed system

Traffic arrival rate of a mobileuser placed $'l'$ at the time of $'t'$ followsPoisson distribution which is given below,

$$\gamma(l,t) = \frac{\lambda(l,t)}{\mu(l,t)} \qquad (1)$$

where, $\lambda(l,t)$ is the mean arrival rate.

4. Proposed Technique

In this research, we suggest a heterogeneous network deployment in which different energy base stations (BSs) are placed to efficiently service the entire network. These base stations have varying capacities/thresholds, i.e., base stations serving high-density regions such as train stations and shopping malls should have very high capacities, but BSs serving low-density residential areas should not. An examination of daily traffic variance should be done in order to define the threshold values. Our suggested technique's major goal is to reduce energy consumption by reducing the number of BSs in the network at any one time. However, it is also vital to maintain the quality of service (QoS).

The proposed BS switch ON/OFF approach was operated in the following steps. The traffic load history of all base stations is initially gathered. The BSs are then arranged in increasing or descending order according to their traffic volumes. The minimum and maximum thresholds for each BS are determined by its daily traffic history.

Algorithm:

1. Calculate the total number of BSs.
2. Link the BSs together.
3. For each BS, set the Minimum and Maximum Threshold Values.
4. Checking each BS's Threshold value on a regular basis.
5. If each BS's threshold value is less than the minimum, it sends signals to its linked neighbor BSs.
6. Obtaining Acknowledgement from the closest BS.
7. Send the Message (i.e., BS1 is in sleep mode) to its adjacent BSs in a connection to put it to sleep.
8. To supply the service, neighboring BSs extended their coverage.
9. Send the wakeup alarm message to sleep mode BS if the threshold value is greater than Maximum.
10. Obtaining Acknowledgement from the BS in Sleep Mode.
11. BS switches from sleep to active mode in order to serve its own consumers.
12. If the sleep mode BS threshold value is equal to or greater than the minimum threshold value.
13. Bring the Sleep Mode BS back to life.
14. When there is no neighboring BS during a BS's maximum threshold, stop the algorithm.

If a BS's traffic load falls below a certain threshold, it must be turned off, and its mobile users must be routed to other BSs, which may accommodate them by delivering signals, so extending its coverage. The minimum and maximum thresholds of different BSs in a heterogeneous network are not the same.

The maximum threshold condition must be considered. If a BS's maximum threshold is reached or exceeded, the extra traffic load is directed to a neighboring BS via a handover process. It's worth noting that the nearby BS was chosen in such a way that it can handle additional traffic demands. Consider the following scenario: a BS's traffic load reaches its maximum level, and the only other BS in its proximity is in sleep mode. The sleep mode BS is awoken at that point, and the additional traffic is passed to it. Where there is no neighboring BS to accommodate or accept higher traffic load, the switch off algorithm is discontinued. Here, a controller is required to broadcast switch-on and switch-off intentions to BSs

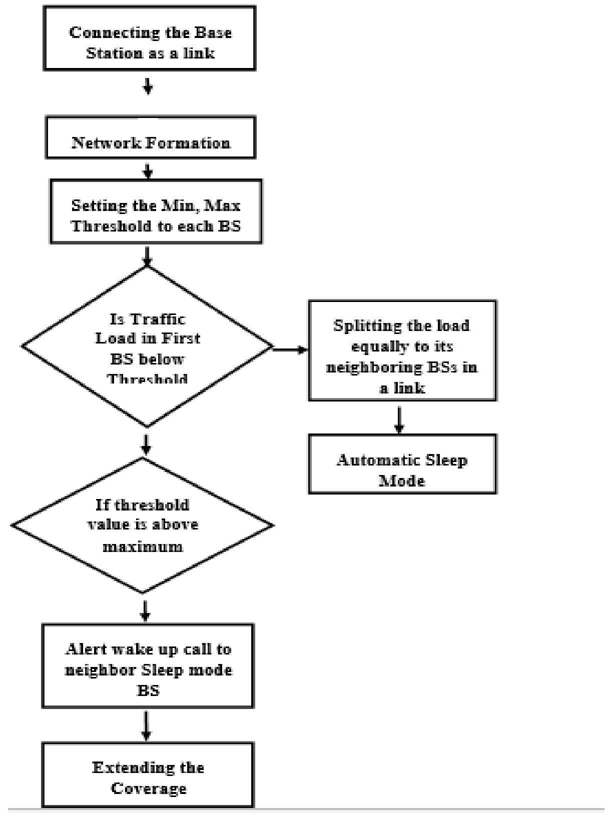

Figure 2: Flow diagram of the proposed system

4. Experimental Results

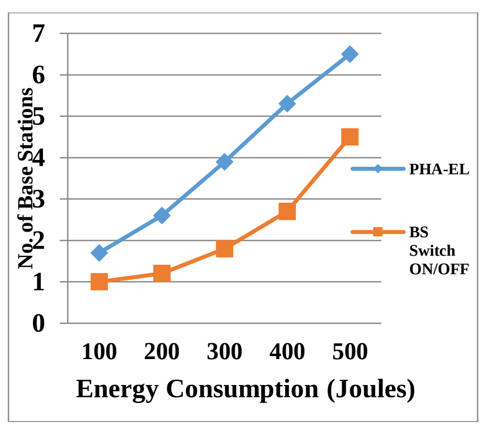

Figure 3: Energy Consumption vs. No. of Base Stations

Figure 3 present PHA-EL and proposed BS Switch ON/OFF algorithms are compared in terms of energy consumption and number of base stations. The graph clearly demonstrates that the suggested BS Switch ON/OFF algorithm improves performance by reducing energy usage and the number of BS utilized.

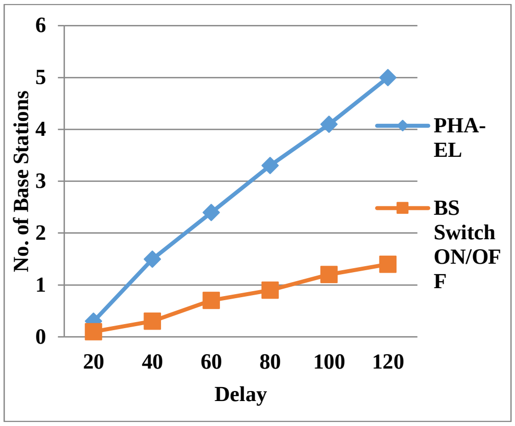

Figure 4: Delay vs. No. of Base Station

Figure 4 present PHA-EL and proposed BS Switch ON/OFF algorithms are evaluated in terms of delay and number of base stations. When compared to the conventional PHA-EL algorithm, the network delay and the number of BS are reduced in this graph, resulting in greater performance.

5. CONCLUSION

We developed a Base Station Switch ON/OFF method for energy conservation in heterogeneous networks in this paper. The minimum and maximum criteria are determined by the BSs' traffic loads. Because BSs represent for a large portion of total energy usage, the method can result in significant energy savings. Only if the threshold requirement is met are the mobile users served by the BS transferred to the neighboring BS. When the BS is turned back on, it will control all mobile users within its range. In a cellular network, this technique can save a lot of energy.

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