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Energy Saving in Cellular Radio Access Networks

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Abstract:

The explosive popularity of smart phones and tablets has ignited a surging traffic load demand for radio access and has been incurring massive energy consumption. Currently, over 80% of the power consumption takes place in the radio access networks especially the base stations (BSs). The reason behind this is largely due to that the present BS deployment is on the basis of peak traffic loads and generally stays active irrespective of the heavily dynamic traffic load variations. Recently, there has been a substantial body of works towards traffic load-aware BS adaptation and the authors have validated the possibility of improving energy efficiency from different perspectives. And some of other research work proposed how to dynamically adjust the working status of BS, depending on the predicted traffic loads. Our ultimate aim is to reduce the energy consumption with traffic load variations in radio access networks. In this paper, we extend the research over BS switching operations, which should match up with traffic load variations. Instead of depending on the dynamic traffic loads which are still quite challenging to precisely forecast, we firstly formulate the traffic variations process. And we design BS switching operation scheme to minimize the energy consumption of RANs. We selected the domain as Cellular Radio Access Networks.

Keywords: Cellular network, RAN, power, BS.

I.INTRODUCTION:

A base station is comprised of an antenna (or several antennas), a mast or other supporting equipment to hold the antenna and equipment to transmit, receive and process the radio signals. A base station can vary in size from a small box attached to a light pole providing mobile phone coverage in a street to a tower providing a combination of wireless services over a large geographical area.

Base stations need to be located close to where people are using their mobile or wireless devices, because the devices themselves only have limited range within which they can communicate. Therefore each base station is designed to serve a particular area known as a 'cell' within the network.

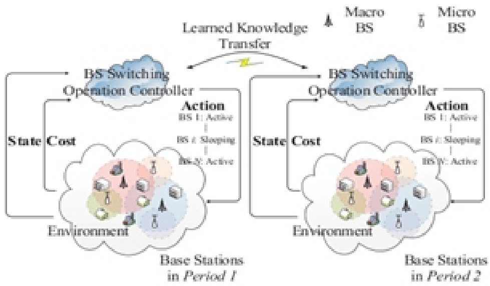

Fig.1 Network design with BS

When positioned correctly, they allow the available radio frequencies to be reused in other cells without interference and which then increases the overall number of calls that the network can handle at any one time. Base stations have two limiting factors – one is the capacity of calls that they can handle, and the other is the geographical area that they can cover. In areas with fewer users, base stations can be quite far apart, but in areas where there are many users, the base stations need to be located much closer to each other. This is because each base station can only manage up to about 100 calls at the same time. Where there are not so many simultaneous users, the capacity is not an issue, so the base stations are placed to maximize their geographical coverage.

In areas where there are many users, more base stations will be needed to handle the call traffic, and as such, are located much closer to each other to increase overall capacity.Where base stations are located closer to each other, their output power must be lower to avoid interference with other base stations in the area.

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Our work proposes a reinforcement learning framework for energy saving in RANs. An RAN usually consists of multiple BSs while the traffic loads of BSs are usually fluctuating, thus often BSs under-utilization. We propose the BS switching operation is conducted based on one learned strategy and the energy saving in the whole system tends to be optimized in the long run.By this proposed system, the system might come into the same state in two different tasks, whereas the traffic loads in the source task (e.g., Period 1) might be usually higher than that in the target one (e.g., Period 2). Hence, instead of staying on the chosen action.

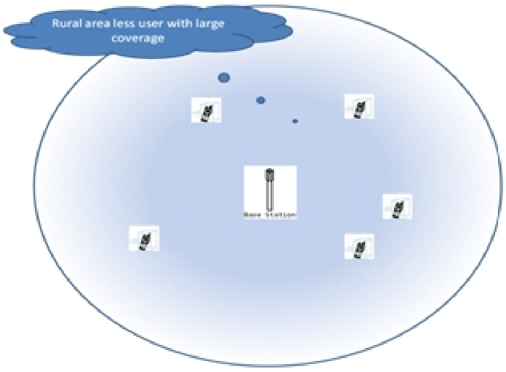

Fig.2 BS at rural area with high coverage

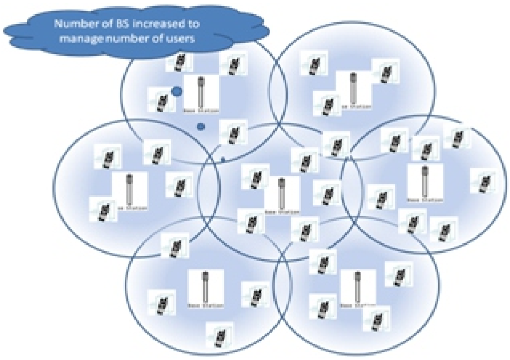

Fig.3 Base station at rural area & urban area

A in source task, the controller in target task can make a more aggressive choice to turn more BSs into sleeping mode, thus saving more energy consumption.

II.RELATED WORK:

Currently, over 80% of the power consumption takes place in the radio access networks (RANs), especially the base stations (BSs) [5]. The reason behind this is largely due to that the present BS deployment is on the basis of peak traffic loads and generally stays active irrespective of the heavily dynamic traffic load variations [6], [7].

Recently, there has been a substantial body of works towards traffic load-aware BS adaptation [8] and the authors have validated the possibility of improving energy efficiency from different perspectives. Luca Chiaraviglio et al. [9] showed the possibility of energy saving by simulations. [10] And [11] proposed how to dynamically adjust the working status of BS, depending on the predicted traffic loads. However, to reliably predict the traffic loads is still quite challenging, which makes these works suffering in practical applications. On the other hand, [12] and [13] presented dynamic BS switching algorithms with the traffic loads a prior and preliminarily proved the effectiveness of energy saving.

The explosive popularity of smart phones and tablets has ignited a surging traffic load demand for radio access and has been incurring massive energy consumption and huge greenhouse gas emission [1], [2]. Specifically speaking, the information and communication technology (ICT) industry accounts for 2% to 10% of the world's overall power consumption [3] and has emerged as one of the major contributors to the world-wide CO2 emission. Besides that, there also exist economical pressures for cellular network operators to reduce.

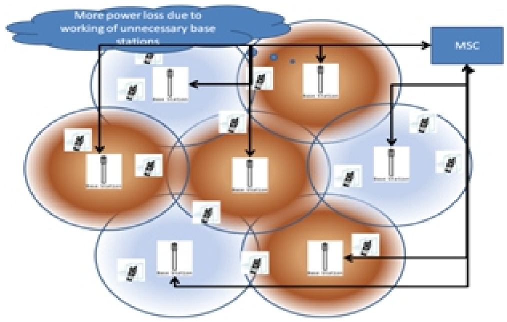

Fig.4 Power saving problem due to base station working.

However, to reliably predict the traffic loads is still quite challenging, which makes these works suffering in practical applications. Besides, it is also found that turning on/off some of the BSs will immediately affect the associated BS of a mobile terminal.

Moreover, subsequent choices of user associations in turn lead to the traffic load differences of BSs. Hence, any two consecutive BS switching operations are correlated with each other and current BS switching operation will also further influence the overall energy consumption in the long run.

III.PROPOSED TECHNIQUE:

We planned to do the project by the small modules, they are given below.
» Traffic Prediction
» User Localization
» Cell Zooming

3.1 Traffic Prediction:

In this first module, we will analyze the traffic usage per day manner. By predicting the traffic, we can get the detail when the base station has to be in sleep and awake. And MSC can know, which base station has the more user and less users.

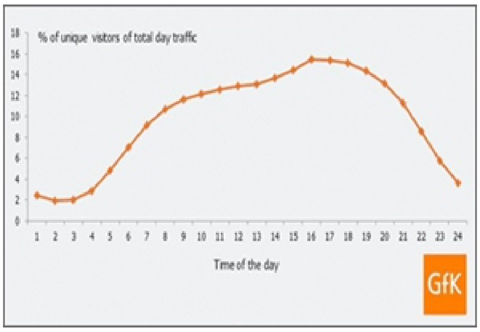

Fig.5 Traffic prediction per day

3.2 User Localization:

By this second module, the MSC can know the information, the user location and distance from second base station. By this knowledge, MSC can desire the base station switching

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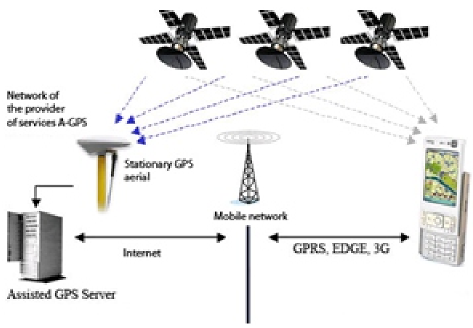

Fig.6 example for GPS positioning

3.3 Cell zooming:

Cell zooming is a technique to avoid the coverage hole. By knowing the user location information the neighbor base station will increase the coverage. And other base station can go to sleep. By this method we can improve the power saving and we can maintain the QoS.

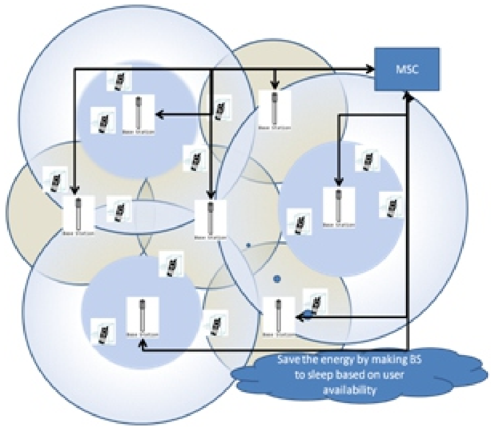

Fig.7 BS switching

IV.SIMULATION RESULTS:

We have tested our proposed work with ns2.

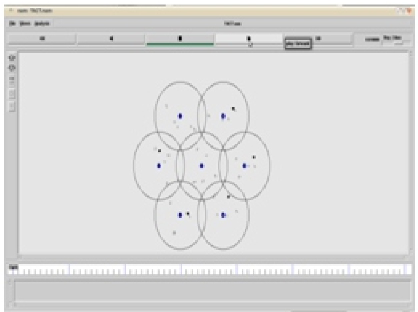

Fig.8 all the base stations working in less traffic.

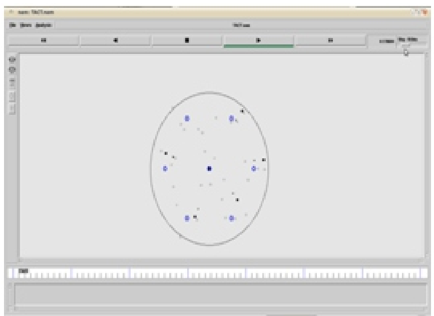

Fig.9 base station switched to one with low traffic.

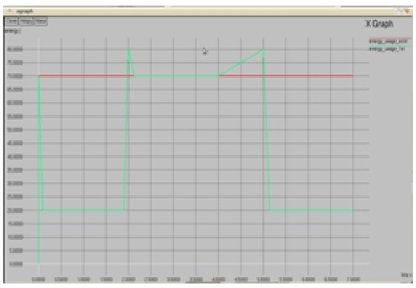

Fig.10 power saved compare than old method

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V.CONCLUSION:

In this paper, we have developed a learning framework for BS energy saving. We specifically formulated the BS switching operations under varying traffic loads as a Markov decision process. Besides, we adopt the actor-critic method, a reinforcement learning algorithm, to give the BS switching solution to decrease the overall energy consumption. Afterwards, to fully exploit the temporal relevancy in traffic loads, we propose a transfer actor-critic algorithm to improve the strategies by taking advantage of learned knowledge from historical periods.

Our proposed algorithm provably converges given certain restrictions that arise during the learning process, and the extensive simulation results manifest the effectiveness and robustness of our energy saving schemes under various practical configurations. The work performed has some limitations. The technique developed is theoretical in nature and has to be implemented on ground. Although the technique is shown to perform well at a particular speed and it has to be tested to verify performance. The speed limit in this case can be adjusted according to what the error constraints are.

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