Possibility of Applying Green Communications in Palestinian Cellular Networks

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***Abstract*— Due to the large deployment of wireless networks, energy efficient networks have attracted the attention of researches in recent years. The main challenging aspect is the development of policies and protocols for enabling energy saving. Green Communication is a key idea in this direction. It mainly focuses on network design that enables activation of resources on demand. This paper studies the possibility of applying the green communication idea in Palestinian cellular networks. Detailed simulation experiments have been conducted using real traces from Palestinian cellular operators. We present simulation results that demonstrate the amount of energy saving when green communication is applied. Further, we demonstrate the effect of green communication on Quality of Service experienced by cellular users.**

***Keywords*—Green Communication, Cellular, Networks, energy consumption, Optimization.**

1. Introduction

Recently, the number of cellular subscribers has reached 4 billion [1]. 120,000 new base stations (BS) are being deployed every year to serve 400 million new mobile subscribers around the world [2].

The huge number of BSs, coupled with the large number of cellular mobiles consume tremendous amount of energy. This situation has triggered the attention of network designers and researchers to seek for energy efficient networks to reduce energy costs. Towards this goal, a new innovative research field has been created under the name of ***"Green Communications"***.

Green Communication includes policies and protocols that enable a reduction of the energy consumed by the network entities. Most efforts in this direction are devoted to design of optimal energy saving approaches at BSs.

It is known that cellular operators are primarily focusing on technological developments that meet consumers' capacity and Quality of Service (QoS) requirements as well as increased broadband data rates in order to support real time applications. However, the increasing awareness of environment and economic together with the high cost of energy have posed challenges on improving power efficiency in communication systems. In [3], it has been pointed out that information and communication technologies consume about 2% to 10% of the world power consumption, where cellular networks consume the most. BSs together with their supporting equipments consume 80% of energy consumed by a cellular network [4]. Each BS consumes 35MWh per year [2]. Therefore, a special focus is being given to reduction of energy consumed by these units. This can be achieved by switching off some BSs or some cells (sectors) within a BS during low traffic periods.

In this work, we investigate the possibility of applying the green communication concept within Palestinian cellular networks. Our study is based on real traces regarding traffic and network topologies obtained from operators in the country. The rest of this paper is organized as follows: Section 2 discusses the related work. In section 3, details of green communication and insights on the paper work are provided. Experimental setup is discussed in section 4. Simulation results are provided in section 5, before we conclude the paper in section 6.

2. Related Work

Reduction of energy consumption in wireless networks has significantly attracted the attention of several research groups in recent years. A focus is given to energy efficient strategies for wireless sensor network (WSN), Wireless Local Area Networks (WLAN) and cellular networks, including 2G, 3G and 4G.

In [1], Marsan et. al evaluate the amount of energy that can be saved by using two networks under high traffic conditions. They switched off one network during low traffic periods, assuring at the same time QoS obtained when both networks are active. The authors demonstrate a 25%-35% energy saving. This efficiency is attributed to the fact that network operators plan their networks based on peak times.

The authors of [3] focus on the dynamic planning of UMTS networks. They consider switching off some UMTS cells and Node B's in urban areas during low traffic periods, while still guaranteeing QoS constraints in terms of blocking probability. The authors conclude that in some scenarios, it is possible to reduce power consumption of the network by 50%.

The authors of [5] provide simple analytical models that study the energy-aware management of cellular access networks. They try to characterize the amount of energy that can be saved by reducing the number of active cells during low traffic periods. The paper assumes that traffic is uniform across cells and neighbouring cells fill the coverage of switched off cells. The paper encourages the cellular network operators to consider devised approaches for dynamic management of network resources, so as to obtain very large energy savings. Several extensions are also suggested including the consideration of cell breathing, antenna tilting and power control.

The papers of [6] and [7] address power saving in WLANs. They provide strategies for reducing power consumption within WLANs without affecting clients' performance.

In [6], the authors are concerned about high density WLANs, wherein the possibility of applying green communication may be affordable, by switching off some Access Points (APs) during low traffic periods.

Reference [7] develops improved analytical model used for simple on-demand polices in dense WLANs. The authors concentrate on saving the energy of underutilized APs. Such APs are candidates to be switched off. Their users are handed off to other ones.

These encouraging results have triggered us to study the potential benefits of applying the green communication concept within Palestinian cellular networks, where two operators are currently active and a licence for a third one is under consideration.

3. Applying Green Communication in Palestinian Networks

In this work, we study the possibility of applying the green communication in Palestinian cellular networks. We consider two cellular network operators, which we refer hereafter as Operator 1 and Operator 2. Each BS operates 3 cells (sectors). We concentrate on three cases. In the first, we try to switch off some cells within one operator network, while in the second we switch off all cells within a network owned by one operator and roam potential active users to the second network. In the third case, collaboration among BSs of both operators is assumed and we switch off some cells in both networks and roam potential active users to the best cells regardless of their operator. The selection strategy of cells to be switched off is based on traffic conditions and possibility of roaming users to other cells assuring acceptable level of Signal to Noise Ratio (SNR). In each case, we compute the percentage of energy saving as well as the number of users that experience an SNR below a target threshold due to roaming.

The power saved in one day is calculated as follows:

$$P_{res} = (P_{con} * T * C_{off}) \rightarrow (1)$$

Where:

P_{res}: is the amount of power saved in KW.

P_{con}: Power consumed from a cell per hour in KW.

T: Time of cells turned off in hours.

C_{off}: # of cells turned off.

The motivation of the work stems from our observation of the traffic profiles obtained from both operators. They are shown in figures 1 and 2.

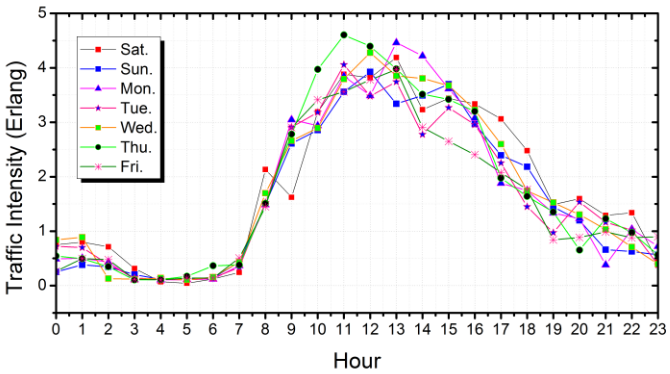

Fig. 1 Traffic Profile of Operator 1

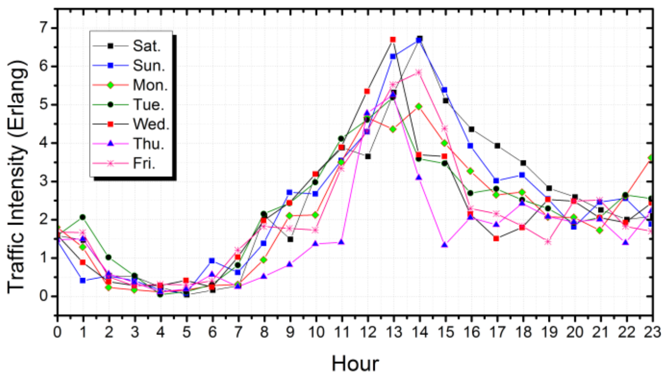

Fig. 1 Traffic Profile of Operator 2

The figures show that each traffic profile has a peak from 12:00PM to 2:00PM, wherein this period, applying green communication idea may not be possible due to the high network load. However, the low traffic period observed between 12:00AM to 08:00AM is encouraging for applying green communication.

The traffic profiles are used in our experimental work. The average daily traffic intensity (Au) is about (λ*H) 0.025 Erlang/User, where λ (the number of request per hour) =2 calls\hour, and H (the average call duration) = 45 seconds. The accepted Grade of Service (GoS) (blocking rate) is 2%.

4. Experimental Setup

Based on the BSs locations we got from two operators in Palestine, we constructed the network in OPNET as shown in figure 3. These BSs cover the Palestine Polytechnic University area. Through sectoring, each BS supports 3 cells. Distances between BSs are shown in the figure. The tarffic intensity profiles are used to emulate the network load. They are mapped to VoIP packets in OPNET. From the intensity profiles, we extracted a number of users during each hour. Users are randomly distributed across the coverage area of the BSs. Users are stationary. Transmitted power is used accroding to specifications from both operators (20Watt and 28Watt). The Hatta model for suburban areas is used for path loss. We focus on the low traffic period between 12:00am and 7:00am

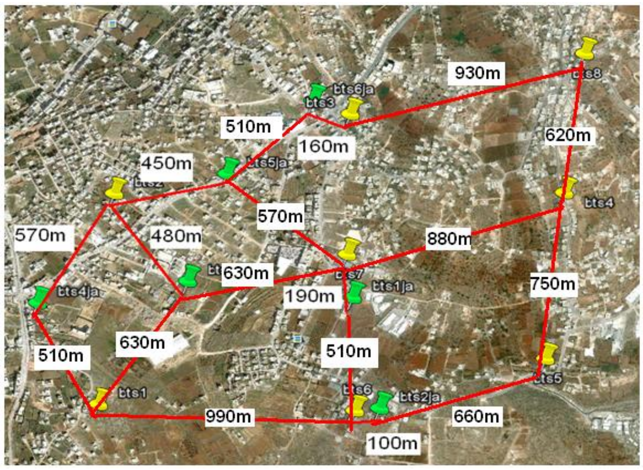

Fig. 3 BSs Distribution of both Operators

5. Simulation Results

5.1 Power Saving

Using equation 1, we computed the percentage of power that can be saved when green communication is applied during the low traffic period. Results are shown in Table 1.

TABLE I
PERCENTAGE OF POWER SAVED

Case	Percentage of Saved Power
One Network	**17.8%**
Two Networks (one Off – Roaming to one)	**33%**
Two Networks (Roaming to all)	**16.93%**

The results show that applying green communication by the two operators independently, each one can save about 17.8% of power. However, if the coverage area is serviced by only one of the two operators and the other switches off all his BSs, 33% of power can be saved. Finally, if some cells from both operators' networks are switched off during low traffic period, 16.93% of power can be saved. Note that, in each of the three cases the SNR experienced by users will be affected due cells switching off and consequently the handoff among cells. The effect of green communication on the SNR experienced by cellular users is discussed in the next subsection.

5.2 SNR Analysis

With green communication, some cells will be switched off and their serviced users will handoff to other cells, which sometimes belong to different BSs. This is expected to influence the SNR user's experience. We addressed this issue for two cases. In the first case, one operator network is completely switched off and users handoff to cells of the second operator. The results are shown in figure 4.

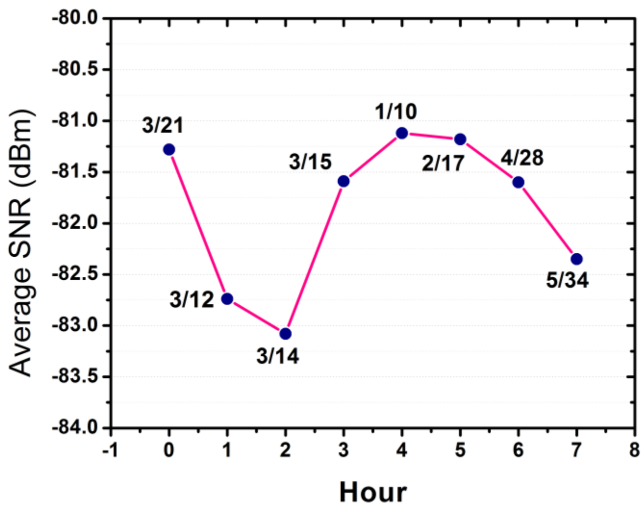

Fig. 4 Average SNR for the Case of One Network

The figure plots average SNR for all users during low traffic period. On the figure, we also show the fraction of users which experience SNR below -80dBm (a known value for acceptable QoS). The results show that, despite a 33% of power can be saved in this case (from section 5.1), some users may experience SNR below -83dBm when they handoff to the second operator network.

In the second case, some cells from both operators' networks are switched off. Figure 5 shows the average SNR experienced by all users with green communication. On the figure, we also show the fraction of users that experience SNR below -70 dBm. Interestingly, we have found that non of the users experience SNR below -80dBm. This is attributed to the fact that the consideration of cells of both networks, users have more potential closer cells to roam to. Noting the 16.93% power saving for this case, the results of figure 5 reveal the trade-off between power saving and QoS users will experience with green communication.

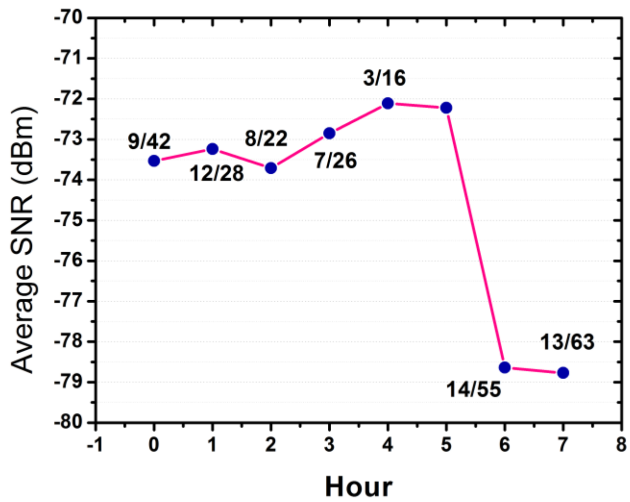

Fig. 5 Average SNR for the Case of Two Networks

6. Conclusion

In this paper, we investigate the possibility of applying green communication idea in Palestinian cellular networks. We considered the networks of two operators. The results show that a good amount of power can be saved with green communication. The results also show that in order to maintain a good SNR for all users, collaboration between operator's networks is necessary in order to handoff users to close cells when their original ones are required to switch off. Our next step is to work on development of policies and protocols to realize the green communication idea.

Acknowledgment

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