Energy Optimization Mechanism for Mobile Terminals using Vertical Handoff between Heterogeneous Networks

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Abstract: *Several techniques for optimizing the power consumption of MTs have been considered in literature. Some of these techniques could be used separately or in tandem. Considering the importance of efficient energy management for MTs, the research in this area could be taken a step further. The technique considered in this is allows a multimode terminal to take advantage of two integrated networks to efficiently manage its energy consumption. Two integrated networks considered are WLAN and LTE. Previously we use CDMA2000 network in place of LTE. This develops an algorithm that allows the MT to always get connected to the most cost-effective network. The results obtained showed that the MTs power is more efficiently managed when the MT is using the integrated networks than when it is using each of the networks independently.*

Keywords: WLAN, CDMA2000, NIC, VHO, MT, energy optimization, multimode device, service time, user's preference indicator, LTE.

1. Introduction

The 3G cellular networks are designed to offer high speed access for mobile data users. However, the demand for bandwidth in the 3G cell is not uniform throughout the cell. Rather, it is clustered in hotspot areas such as airports, hotels, shopping malls, apartment buildings, Internet cafes etc. In general, higher bandwidths are Only available close to the cell site while only lower bandwidths are available further from the cell site. Fading and obstructions further affect the availability of bandwidth at any point within the cell. IEEE 802.11 Wireless LAN (WLAN) is a short-radius radio technology that is gaining a tremendous momentum in the marketplace. The cellular operator can take advantage of this low cost, high speed technology to cover the hot spots and gaps in coverage within its cellular network. We propose a novel architecture to allow seamless mobility between the North American 3G cellular standard (cdma2000) and 802.11 WLAN networks.

The release of the IEEE 802.11 WLAN standards in 1997 gave rise to a number of other related standards which form the 802.11 family of standards. These standards were made to facilitate the interoperability of WLANs, and allow for the introduction of several new services. One of these services introduced is the public wireless access data networks more commonly known as "hot-spots". The great success and massive recent deployment of WLAN technology indicates that these networks will play an important role in the development of the 4G networks. To achieve the dream of universal mobile telecommunications as specified by the international telecommunications union (ITU), it is necessary to integrate WLAN and CDMA2000 cellular networks. The Internet certainly, will be used to support this integration because it has become the main thrust of network integration between complementary heterogeneous networks. CDMA 2000 radio technology provides circuit switched (CS) service for voice and the packet-switched (PS) service for data transport. Here the proposed mechanism is Vertical handoff (VHO). In this paper we use two different network technologies are used. So Vertical handoff is occurred between these stations. In this paper we place LTE(Long Term Evolution) instead of CDMA network.

LTE(4G Long Term Evolution) standard of wireless communication of high speed of data rates of mobile terminals.LTE carries both CDMA and GSM Network such as Verizon wireless. LTE provides uplink peak rates 75MBPS and downlink peak rates of 300MBPS.It carries Bandwidth from 1.4MHZ to 20MHZ. It supports both TDD(Time Division Duplex) and FDD(Frequency Division Duplex). LTE has the ability to manage fast moving mobiles and support multicast and broadcast streams. It supports handover for both voice and data to cell towers such as GSM, UMTS, and CDMA2000. It supports only packet switching over IP networks and circuit switching for voice cells in GSM, UMTS, and CDMA2000 Networks.

One issue which is fundamental to mobile wireless devices is power conservation. It has been shown that different network interfaces attached to the MTs consume power at different rates. The power consumption rate is dependent on the network to which the MT is connected, and also on the state of the MT, which may be transmitting, receiving or idle state. Based on this, the power consumption of a multimode MT could be optimized via the use of integrated networks. This could be done by configuring the MT to automatically select the most cost effective network, not only in terms of bandwidth consumption, as has always been considered in literature, but also in terms of power consumption and user's preference. This paper considers an algorithm that enables MTs with WLAN and CDMA2000 interfaces to automatically select the most cost-effective network which optimizes the MT's power consumption without degrading the network performance.
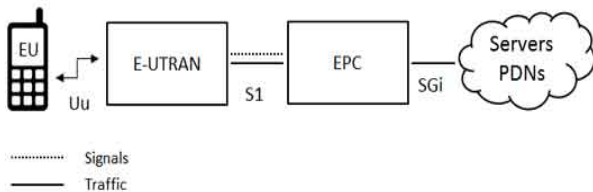
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Figure 1: LTE Network Architecture

The user equipment comprised of the important modules. Mobile Termination (MT): This handles all the communication functions. Terminal Equipment (TE): This terminates the data streams. Universal Integrated Circuit Card (UICC). The E-UTRAN handles the radio communications between the mobile and the evolved packet core. EPC contain HSS (Home Subscriber Server) contains information about all network operator subscribers. It also contain P-GW (Packet Gate Way) communicates without side world and S-GW (Serving Gateway) acts as router.

2. Description of the Optimization Method

Energy optimization model that makes use of vertical handoff to support the optimization of MT's power consumption without network degradation. This is an algorithm that makes the MT to select the best network (LTE or WLAN) in terms of power consumption rate of their network interface card (NIC) respectively at a time without reduction in QoS. Before the MT enters a given state, the decision model computes the energy consumption for each NIC with respect to that state. The decision on what interface to be selected is based on the outcome of the computation. The interface with lower power consumption rate is activated while the other is deactivated. NICs generally can be in any one three conditions (Uploading or transmitting, downloading or receiving and idle or redundant mode) when activated. Table 1 shows the power consumption requirements of two NICs (CDMA1x wireless modem and Orinoco IEEE802.11b wireless LAN modem).

MT's state: Power consumption of	Uploading or transmitting	Downloading or receiving	Idle or redundant
CDMA1x wireless modem	2.800 (W)	0.495 (W)	0.082 (W)
Orinoco IEEE802.11b wireless LAN modem	1.300 (W)	0.900 (W)	0.740 (W)

$$E_W = \begin{cases} 1.3 \times t \times u & MT \quad on \quad upload \quad state \\ 0.9 \times t \times u & MT \quad on \quad download \quad state \\ 0.74 \times t \times u & MT \quad on \quad idle \quad state \end{cases}$$

$$E_C = \begin{cases} 2.8 \times t \times u & MT \quad on \quad upload \quad state \\ 0.495 \times t \times u & MT \quad on \quad download \quad state \\ 0.082 \times t \times u & MT \quad on \quad idle \quad state \end{cases}$$
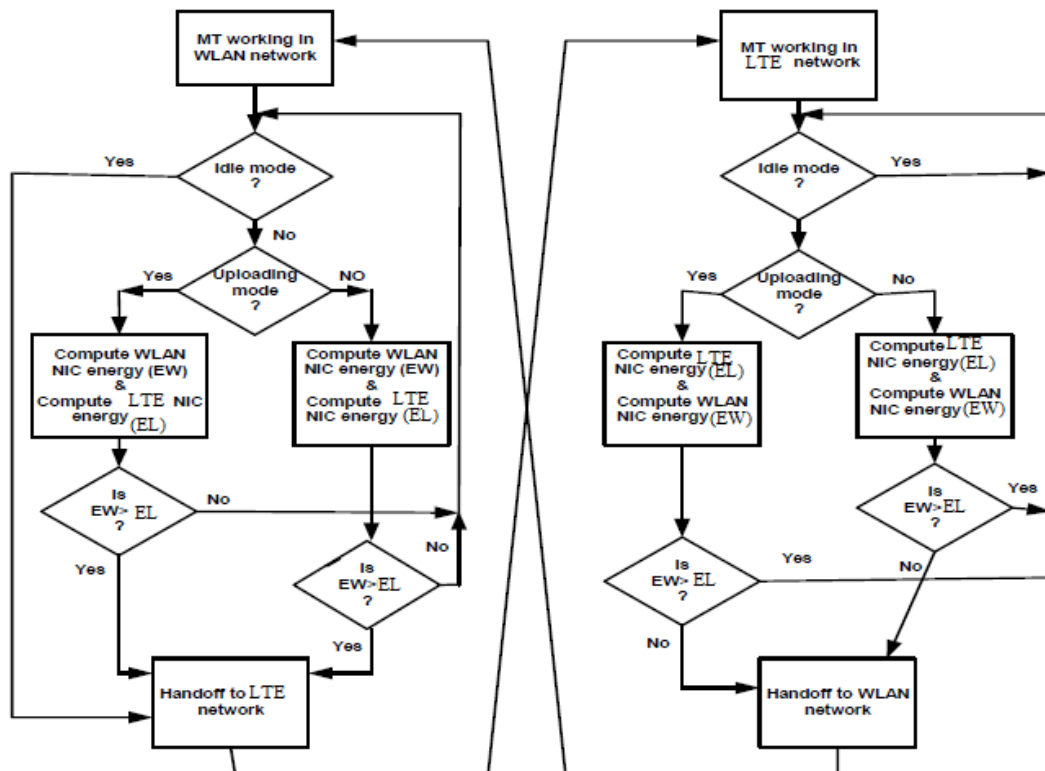

Figure 2: Power Flow chart for the optimization algorithm

3. Performance Evaluation

This section presents the effect of the power optimization algorithm on MT power consumption. Several data downloads from the Internet were made using the three different states (Idle, Download and Upload) a MT could be in a time. In each case, we estimated the time required to perform the requested service was estimated. This is denoted as service time (t) in seconds. Let idle state, Download state and Upload state be denoted by ID, DL and UP respectively. In addition, User Preference (u), which may allow the user to remain in the preferred network regardless of the network's performance is turned off by setting u = 1 for both networks in this evaluation. This is done demonstrate the energy saving effect of the algorithm. Parameter values used for evaluation are shown in Tables 1 and 2.

Table 2: Parameters for performance evaluation

NIC state	ID	DL	UP	ID	UP	DL	ID	DL	UP	ID	UP	DL
t (s)	30	120	60	20	100	130	60	40	125	40	30	60
U	1	1	1	1	1	1	1	1	1	1	1	1

Power consumption rates for WLAN network, CDMA2000 network, and the proposed VHO mechanism are presented in Figures 3, 4 and 5 respectively. In each case, we plotted energy consumption against service time was plotted to show power management trend of the MT in each network.

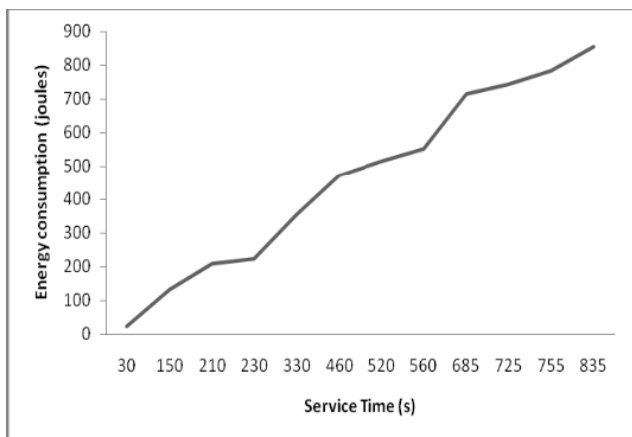**Figure 3**: Power consumption rate of MT when on WLAN alone

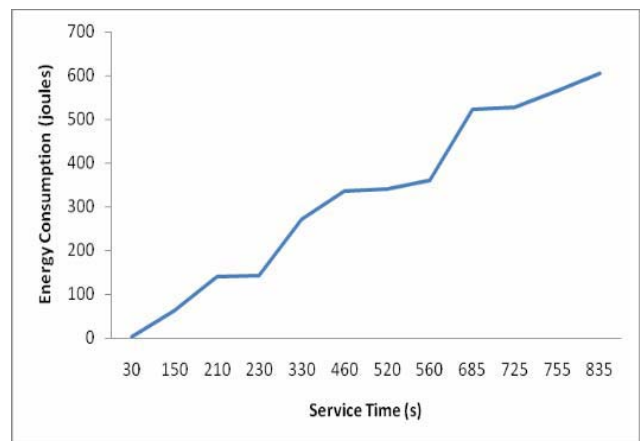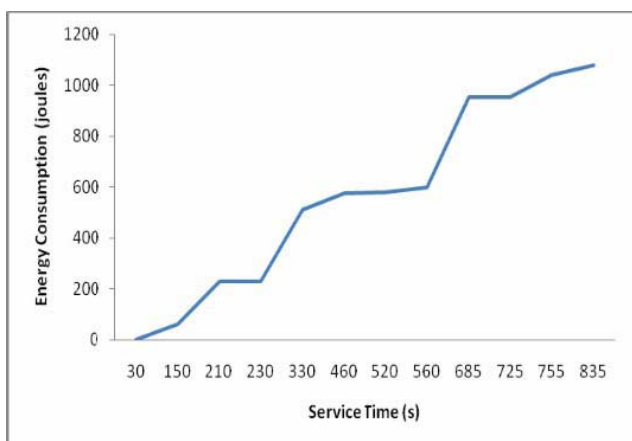**Figure 4:** Power consumption rate of MT when on CDMA2000 alone

Figure 5: Power consumption rate of MT of Integrating Networks

From Figure 4, it could be observed that over 800 joules of energy was consumed by the MT for a period of 835 seconds while in Figure 5, it could also be seen that over 1000 joules of energy was consumed by the MT for the same period of 835 seconds. But in Figure 6, it could be seen clearly that a little above 600 joules of energy was consumed for the same 835 seconds. This shows a significant improvement over the first two cases. This means that MT's power can be better conserved when used in an integrated network involving WLAN and CDMA2000 network. The plot of the three scenarios on the same axis for effective comparisons is hereby presented in Figure 6.
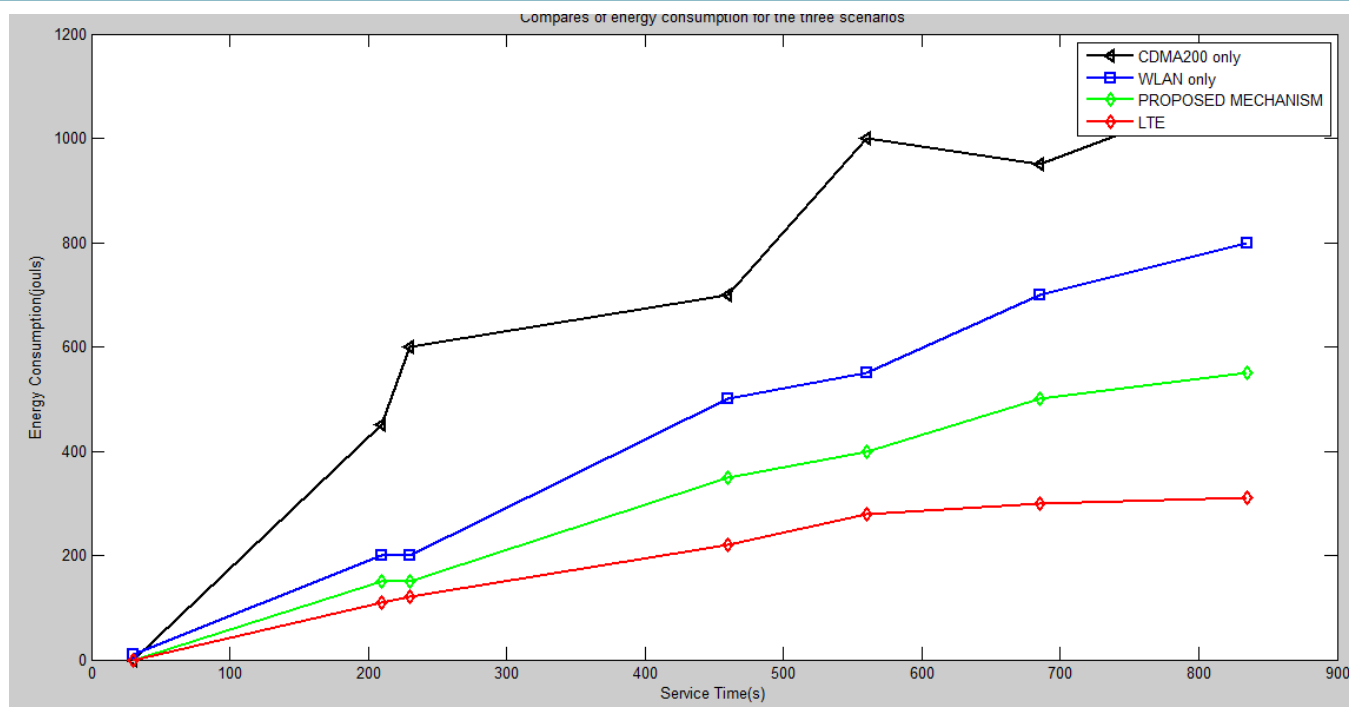
Figure 6: Compares of energy consumption for the three scenarios

4. Conclusion and Future Works

This paper proposed an energy optimization mechanism for MT using VHO between WLAN and LTE network. The power consumption rates of the two popular NICs, one for each network, were used to carry out this work. The result shows that our proposed mechanism performs considerably well. The benefits of the two complementary heterogeneous networks have also been discussed. By using LTE network Instead of CDMA2000 network Spectrum Efficiency, network security are improved, handoff latency are reduced. There are, however other issues that not is addressed in this paper such as network QoS. It could be considered as future works in this area.

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