

Chapter IX

A Case Study on the QoS, Energy Consumption and Mobility of WLANs and WMANs

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ABSTRACT

The present chapter contains a thorough investigation of Quality of Service, Energy Conservation and mobility in 802.11 and 802.16 standards. Interest on these two technologies arises from the fact that they are designed to cooperate offering wireless access capabilities in Next Generation Networks (NGNs). Under NGN Wireless architectures, key challenges must be taken into account: (a) Broadband technologies are based on QoS Enabled Telecommunication Services; (b) Mobile devices are battery limited. In fact, how to prolong the life time of a mobile device and minimize power usage is a very important design issue; (c) Wireless operation means that the user is expected to roam freely, which must also be taken into account. The dependability of NGN operation is obviously depended on these three features.

INTRODUCTION

Two very important features of the Wireless Next Generation Networks (Wireless NGNs) are the energy consumption and the mobility of terminals. Energy consumption constrains the infinite bandwidth-roaming space of a wireless terminal and therefore it requires a careful power saving strategy every time that a communication endpoint needs to reside to battery life. On the other hand, the term mobility has been used to describe many different aspects of a wireless network like the movement of the wireless nodes (cellular networks mostly), the ability to transfer network layer settings (like mobile IP) and the handover theory. This chapter is dedicated to study of power saving mechanisms, Quality of Service (QoS) and handover mechanisms in modern wireless networks in view of the forthcoming Wireless NGNs. These mechanisms are necessary to combat the problems that arise from mobile wireless communication and make this capability efficient, transparent and above all possible.

Introduction to Power Management

The transfer of information is associated with energy consumption even from the principles of Physics. The amount of energy per bit required in a specific communication depends casually on the modulation scheme, on the interference and Noise levels and several other transmission issues and techniques. Taking the above into account the following symbols are introduced: a terminal requires on average a P_T power level to communicate sending information via the wireless transmitter and P_R to receive information from it. Moreover, when the transmitter is idle (in other words in a state waiting for an information arrival), it also utilizes P_I power on the average. Even when the transceiver is set off, the wireless terminal will still consume energy which is signified by the average P_S level. It is straight-forward that for an average transceiver it holds $P_T > P_R > P_I > P_S$. If the terminal occupies the energy state k for a time duration T_k in every hypothetical transmission circle, the average power consumption per transmission cycle will be the following sum $\sum T_k P_k$. A power saving mechanism is an effort to minimize this sum using either a transmission technique or a network algorithm. The generalization of power saving strategies of a specific Network is usually referred to as the Power Management feature of a Wireless Network.

There are three different categories of Power Saving schemes:

- **Physical Layer (Layer-1) Power Saving Schemes.**

On the Physical Layer, the effort is focused on improving the transmission techniques so as to lower bit-error rate (BER) using a fixed Signal-to-Noise ratio (SNR) or equivalently conserve power by transmitting the same amount of information with lower power levels. In this context, the aim is to minimize P_T and sometimes P_R levels while maintaining the same performance. This can be achieved with novel modulation, coding and multiple access techniques, by using multiple channels and different kind of antennas, or even transmission concepts as the use of relay nodes or optimal power control and power allocation, (Tourki, 2007; Han 2002).

- **Medium Access Control Layer (Layer-2) Power Saving Schemes.**

On the Medium Access Control (MAC) Layer, power levels are assumed fixed, as the underlying Physical Layer dictates. The aim here is to minimize T_T and T_R and maximize T_I and T_S while the efficiency of communications is maintained and the packet transfer is not delayed. These MAC Layer approaches oftenly correspond to a centralized scenario where the central base station schedules the transmissions accordingly and more rarely to distributed scenarios where the effects of turning off the transceiver are much more destructive for the network performance, (Salkitzis, 1998; Xiao, 2005).

- **Network Layer (Layer-3) Power Saving Schemes.**

Network Layer perspective is much more distributed in its essence. The network is considered as a graph and weights are assigned per graph edge indicating the link cost in terms of power consumption. In this case, the flow of information is monitored and the optimal route is discovered for maintaining low energy consumption. Another possibility is to categorize nodes in different clusters and devise clustering algorithms that for a given amount of information transactions the consumed energy per node is minimized or evenly shared in a fair way. This case of Power Saving Schemes applies more to the case of Mobile Ad hoc Networks (MANETs) and Wireless Sensor Networks (WSNs), (Kawadia, 2003; Bandyopadhyay, 2003).

Power Management at the MAC Layer has been already introduced in GSM networks (2G), (Redl, 1995). When the GSM mobile station (MS) is not in the process of an ongoing connection with the base station, it switches off the transceiver for a fixed period of 1/8sec in order to save energy. Had it not been for this basic Power Saving Scheme, the mobile battery would be consumed ten times faster when the phone is not active! In this case, the power saving mechanism is simplified by the nature of the GSM networks and the fact that it is used only in non-activity regions and for fixed intervals. In modern Wireless Networks, these mechanisms are utilized in more complex situations where centralized control is not so evident and the terminal saves power even when an ongoing connection is active. In any case, it is then obvious that an optimal Power Saving Mechanism is required

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