CHAPTER 1

INTRODUCTION

1.1 Overview

In the last few years, there has been great progress in the area of mobile computing. The term *ubiquitous* has come into use to describe the notion that users should be able to communicate with other hosts regardless of their location.

Recent advances in technology have provided portable computers with wireless interfaces that allow networked communication even while a user is mobile, whereas today's first-generation notebook computers and personal digital assistants (PDAs) are self-contained; networked mobile computers are part of a greater computing infrastructure. Mobile computing - the use of a portable computer capable of wireless networking - will very likely revolutionize the way we use computers.

Wireless networking greatly enhances the utility of a portable computing device. It allows mobile users' versatile communication with other people and expedient notification of important events, yet with much more flexibility than with cellular phones or pagers. It also permits continuous access to the services and resources of fixed networks. The combination of networking and mobility will engender new applications and services, such as collaborative software to support impromptu meetings, electronic bulletin boards whose contents adapt to the current viewers, lighting and heating that adjust to the needs of those present, and navigation software to guide users in unfamiliar places and on tours (Weiser, 1991).

The most important metrics in the design of battery operated, wireless devices is energy efficiency. Operating using a battery necessarily implies that energy is a limited resource, and yet improvements in battery technology have been slow in arriving. Meanwhile, users continue to want to extract more functionality from mobile communication devices. In support of these conflicting trends, low power design techniques have been an important focus of recent research. More detail of this issue is discussed in the next chapter.

However, this project focuses on an adaptive error control technique that continually change it decision to select the most effective error control scheme for a particular channel condition. Through simulation and experimentation, we show that the proposed approach does indeed improve the efficiency substantively.

1.2 Motivation

Although the subject of low power consumption of integrated circuits (ICs) is drawing considerable attention, this interest is only of recent date. There are several motivations for energy efficient design of wireless devices. Perhaps the most visible driving source is the success and growth of the portable consumer electronic market. Today's desktop computers are not intended to be carried, so their design is liberal in their use of space, weight, energy consumption, noise, cabling, and heat dissipation. In contrast, the designer of a hand-held mobile computer should strive for the properties of a wristwatch: light, small, durable and long battery life.

Minimizing energy consumption can improve portability by reducing battery weight and lengthening the life of a charge. However, the functionality of a mobile computer is limited by the required energy consumption for communication and computation. Unfortunately, the rate at which battery performance improves (in terms of available energy per unit size or weight) is fairly slow, despite the great interest generated by the booming wireless business. Aside from major breakthroughs it is doubtful that significant reduction of battery size and weight can be expected in the near future (Sheng, 1992). It has been generally expected that battery technology alone will not solve the low power problem. It, therefore, makes sense to look for alternative strategies for energy savings and energy management. The emergence of various applications and the need to support them in a wireless setting may open new possibilities for energy-saving strategies.

Remarkably, high performance computing systems also drives the low power needs. The power dissipation of high performance microprocessors is now already several dozen Watts, comparable to that of a hand-held soldering iron (Yeap, 1996). The cost associated with packaging and cooling such devices is becoming prohibitive. In addition to cost, there is the issue of reliability. High power systems tend to increase the silicon temperature, and high temperature tends to exacerbate several silicon failure mechanisms. Every 10°C increase in operating temperature roughly doubles a component's failure rate (Landman, 1994).

Another major demand for low-power systems comes from environmental concerns. Computers are the fastest-growing electricity loads in the commercial sector (Yeap, 1996). Since electricity generation is a major source of pollution, inefficient energy usage in computing equipment indirectly contributes to environmental pollution. Finally, a fraction of the consumed energy is radiated into space, possibly affecting other electronic equipment (Electro-Magnetic Compatibility, or EMC) (Berkel, 1994). The way out is *energy efficiency:* doing more work with the same amount of energy. Traditionally, energy efficiency has been focussed on low-power techniques for VLSI design. However, the key to energy efficiency in future mobile multimedia devices will be at the higher levels: energy-efficient system architectures, energy-efficient communication protocols, energy-cognisant operating system and applications, and a well designed partitioning of functions between wireless device and services on the network.

A major challenge in achieving this will be that many attributes of the system environment may vary drastically by several orders of magnitude over the short and long term. Key to these issues will be *adaptability*. Research has shown that continually adapting the system and protocols may significantly improve the energy efficiency while maintaining a satisfactory level of performance (Sheng, 1992). Adapting to the variability is a shared responsibility of many layers in the system design of the mobile device, including the applications.

1.3 Project Objectives:

Portable computers like PDAs and laptops that use wireless communication to interact with the environment must rely on their limited battery energy for their operations. Power consumption is becoming the limiting factor in the amount of functionality that can 'placed' in these devices (Havinga, 1997). The design of wireless communication protocols must be done very carefully. Since high error rates are inevitable to the wireless environment, low power error control is an important issue for mobile computing issues. Another important factor in adaptive error control of a wireless channel is the overhead of performing that control. Frequent changes in the control parameters of algorithm may be required to maintain a required channel quality.

The four main objective of this project are listed below:

1. To develop and compare the performance of adaptive error control algorithm to non-adaptive error control algorithm.
2. To drive the selection and adaptation of the most efficient error control scheme as a function of quality of service, and channel state and determines which one has the best performance.
3. To study specifically the wireless link interface function (error control) that has a direct effect on different mobility speed such as car or pedestrian speed.
4. To determine which error control strategies should be used in a wireless environment with stringent QoS, and which parameters they should apply to obtain the most efficient solution for a variety of error conditions in a wireless environment.

1.4 Significance of the Research

The study for low power error control is important in mobile computing because of the battery power limitation. As well known, battery is the largest source of weight in a portable computer or any wireless devices. Minimizing energy consumption can improve portability by reducing battery weight and lengthening the life of a charge. Moreover, the functionality of a mobile computer is limited by the required energy consumption for communication and computation. Because of this problem, users need to recharge frequently, carry spare batteries, or use their computers less. So, the study for optimizing battery energy consumption in portable devices may help roaming users to solve their problem from the portability perspective.

1.5 Scope of the Research

The data link layer, which is the focus of this project, offers perhaps the most potential for gain. This layer's task is to structure each frame, i.e. the atomic unit which passes through the medium, in a way that is most energy efficient given the existing channel conditions. Wireless links are known to experience widely varying channel conditions as compared to their wired counterparts. Effects such as path loss and multipath fading, compounded by device mobility, result in a channel that may experience varying bit error rates over orders of magnitude with bursty bit error characteristics. At the same time, the Quality of Service (QoS) guarantees of the higher layer protocols should still be supported. Toward this end, one may alter the error control strategy and the frame size on a frame-by-frame basis to keep up with changing conditions while simultaneously minimizing energy consumption.

In some cases, it may be impossible to maintain the QoS guarantees originally promised to the application as the channel degrades. While mobility introduces the problems of channel allocation, handoff, and so on as a user moves through cells, a far more difficult problem is that of wireless connectivity where a user may move into a radio shadow, and simply lose physical layer connectivity, or at the very least, have it degraded so far that QoS contracts become irrelevant. We consider a case where the user is always on the move, and that while fades experienced from radio shadows appear with some statistical probability, they also disappear regularly such that overall, a link is maintained with some average error rate. In any case, the techniques developed here will remain energy efficient if the worst case conditions, even when QoS guarantees must be sacrificed.

There are a large variety of error control strategies, each with its own advantages and disadvantages in terms of latency, throughput, and ultimately energy efficiency. Broadly, the available schemes fall into the categories of Automatic Repeat reQuest (ARQ), Forward Error Correction (FEC), and hybrids of the two. These schemes is discussed more detail in the next chapter. Within each category, there are numerous options to choose from, for example, in terms of the protocol used and scaling of protection.

Another possibility, the one we focus on in this study, is to allow the error control strategy to vary as the channel conditions vary. Since wireless links are known to experience widely varying channel conditions, it seems likely that any one of these schemes is not likely to be optimal in terms of energy efficiency all the time. As a further degree of freedom, we may also alter the packet size, the unit to which error coding is applied. This final option provides the ability to decide with what granularity packets are sent, thereby allowing us to choose how many need be retransmitted in the case that ARQ is required, or more fundamentally, how many are lost in the case of uncorrectable error. Because of the exponential relationship between bit error rate and packet error rate, this intuitively seems likely to be a source of further gains.

1.6 Dissertation Outline

The dissertation is structured as follows. Previous studies on low power consumption and the extent to which they are relevant to this study are discussed in Chapter 2. Chapter 3, describes the error control strategies and their algorithm used in the simulation. Details of simulation environment and approach taken in designing experiment are discussed in Chapter 4. Meanwhile, Chapter 5 presents the analysis of simulation results and their discussion. Finally, Chapter 6 concludes the dissertation.