Budgeting Power: Packet Duplication and Bit Error Rate Reduction in Wireless Ad-hoc Networks

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ABSTRACT

In this paper we present and evaluate a new technique to lower packet-level error rates of application layer connections in wireless ad-hoc networks. In our scheme, data packets submitted at a connection's source are checksummed and replicated, flowing breadth-first across an overlay network towards the destination. The destination delivers the first error-free copy of each packet, in order, to the application layer, dropping packets that are corrupt or duplicate. Specifically in this paper, we consider overlays consisting of multiple parallel multi-hop paths. We provide an algorithm which determines the optimal parameters of the overlay in terms of the number of paths, their lengths, and specific routes. We demonstrate experimentally that the proposed scheme significantly outperforms traditional routing and power allocation approaches in terms of bit error rate, even when the comparison is made under identical power consumption constraints.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design; C.4 [**Computer Systems Organization**]: Performance of Systems

General Terms

Algorithm, Design, Performance

Keywords

Wireless ad-hoc networks, low bit error rate, energy efficiency, min-hop source routing, power-aware routing.

1. INTRODUCTION

The growing array of distributed computing/communication applications drives the energy requirements of wireless ad-hoc systems ever upwards. Simultaneously, the capacity of batteries which power most wireless devices presents a hard constraint on the operational lifetime of mobile computing systems. Not surprisingly, this tension of supply and demand makes the design of energy efficient wireless ad-hoc networks an important area of current research. Lowering energy consumption indiscriminately, however, often leads to undesirable side effects. Most notably, it can raise the bit error rate (BER) of links—and hence the packet-level error rate (PER) of application connections. Since many applications require a minimal Quality of Service (QoS) to guarantee acceptable responsiveness, such a degradation can yield the network functionally inoperative.

The management of power in multi-hop wireless networks is marked by the tension between: (1) the battery power available on the mobile node, and (2) the communication costs incurred, specifically the power required to transfer the data from one node to another. Reconciling the power gap between consumption and supply involves solving the following issues [16]: (i) improving the power efficiency in the system; and (ii) preventing the system deconstruction due to unfair power usage. In our earlier work [4], we proposed addressing these issues through the principle of *optimal allocation of budgeted power*; we introduced a model in which every connection request is assigned a fixed amount of power to support its instantiation.[1] In this paper, we explore the following salient question:

> Q. If an incoming connection request has been allocated a fixed total power budget to support its instantiation, how should this power budget be utilized to minimize the bit error rate of the connection?

Relatively little research has been conducted on quantifying the tradeoffs between power consumption and BER in ad-hoc networks under a fixed power budget model. This is our focus in this paper. Standard models of *wireless ad-hoc* networks typically consider infrastructure-less networks in which every node assumes the role of both a host and router, and every node is mobile. In this paper, we will not consider mobility-related issues. Although our investigation makes the simplifying assumption of a scenario in which mobility does not greatly impact routing, the conclusions we present are nevertheless significant in the broader

[1] In a more sophisticated version of the model, this budget might be related to a pricing scheme, so that connections could be supported in one of several power classes. Here we will keep the model simple, so as to extract more fundamental conclusions about its behavior.

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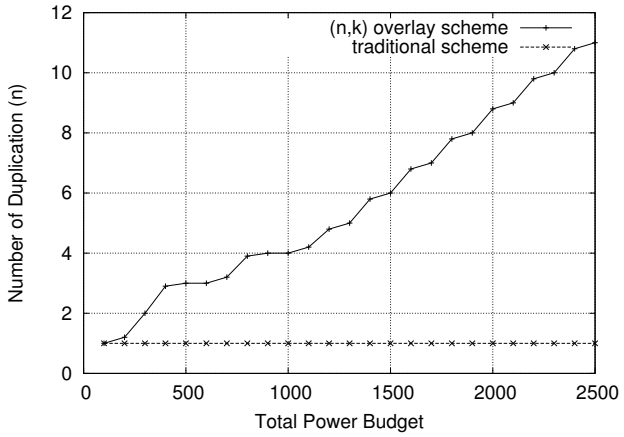

Figure 6: Duplications vs. Power Budget

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