Chapter 1
Maximizing the Flow Reliability in Cellular IP Network Using PSO

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ABSTRACT

A Cellular IP (CIP) network involves a bulk of data transmission. It is highly reliable and guarantees the safe delivery of the packets required in such systems. Reliable traffic performance leads to efficient and reliable connectivity in Cellular IP network. CIP network, which consists of mobile hosts, base stations, and links, are often vulnerable and prone to failure. During the routing operation in the network, the base station, which works as router for the transmitted packets, may fail to perform. Reliable transmission is desirable, in terms of services of the base stations in the network, reliable routing, and processing the data. In this paper, the authors design a reliability model to increase the reliability of a flow, consisting of packets, passing through routers in a Cellular IP network. Particle Swarm Optimization (PSO) is able to solve a class of complex optimization problems. PSO is used to improve the reliability of the flow in CIP network. The proposed model studies the effects of packet processing rate ($\mu$), packet arrival rate ($\lambda$), and the number of packets per flow on the reliability of the system. A simulation experiment is conducted and results reveal the effectiveness of the model.

INTRODUCTION

Cellular IP is a protocol for mobility management at the micro level and inherits many features of cellular systems. CIP Network is divided into geographical areas called cells and each cell is serviced by a Base Station (BS) located at the centre of the cell. Base station plays the role of router during routing operation in Cellular IP networks. The BS provides a connection end point for the roaming Mobile Hosts (MHs) (Campbell, Gomez, Kim, Valko, Wan, & Turanyi, 2000).

In communication networks, especially in Cellular IP network, router CPU cycle is an important resource. CPU at router takes some amount of time to process a packet of the flow. This time is important for a flow as the routers should not
fail while processing the packet. Any router in CIP network (including base stations as routers) has its processing capability and can process a certain number of packets per second. Router CPU is a scarce resource (Tanenbaum, 2004) and it is desired that the reliability of the flow passing through the CIP network should be maximized.

The growing importance of mobile network has motivated an essential research into how data packets passing through the mobile communication network can be transmitted and processed reliably. This suggests reducing the processing time of the flow of packets while they are being transmitted in presence of failures in form of uncertainties.

Reliability is the ability of a system to perform its functions successfully in routine as well as in hostile or unexpected circumstances. Reliability is the probability that the network, consisting of various components, performs its intended function for a given time period when operated under normal (or stated) environmental conditions. The unreliability of a connection is the probability that the experienced outage probability for the connection is larger than a predefined maximum tolerable value. The connection reliability is related to the traffic parameters (Zhao, Shen, & Mark, 2006). The design of reliable resource management algorithms for CIP networks is an important issue. Reliability studies for mobile computing are still under extensive research (Liao, Ke, & Lai, 2000). The design of a reliable bandwidth management for cellular IP networks is also an important issue deliberated in (Olivena, Kim, & Suda, 1998; Jayaram, Sen, Kakani, & Das, 2000; Tipper, & Dahlberg, 2002; Dahlberg & Jung, 2001). Thus, the reliability issue is to be addressed and studied well in the field of wireless communications.

In a wireless cellular network environment, base stations are prone to failure (Prakash, Shivartri, & Singhal, 1999). A BS may either crash or fail to send, receive or process flows of data packets during routing operation. Due to the failure of a BS, all the connections in the failed cell area get terminated and all the services are interrupted until the failed BS is restored. BS failure significantly degrades the performance and bandwidth utilization of the Cellular IP networks. Specifically, services for high priority ongoing calls such as real-time traffic could be interrupted, which is usually not acceptable.

In recent years the applications of Particle Swarm Optimization (PSO), which is a useful search procedure for optimization problems, have attracted the attention of researchers of various disciplines as a problem solving tool. PSO is a search procedure based on the natural evolution. PSO has successfully been applied for various optimization problems for which no straightforward solution exists (Anbar & Vidyarthi, 2009). This paper discusses the effects of the base station (router) failure in CIP networks, with emphasis on improving the reliability being affected by the wireless environment. A PSO based reliability model for router CPU time management is being proposed here to facilitate CIP network design that meets users’ demand in terms of reliable services.

The rest of the paper is organized as follows. First section contains a review of literature. In the second section, routing operation in Cellular IP networks has been explained. The third section addresses the problem studied in this paper that includes reliability and the PSO. The proposed model has been explained in details along with the algorithm in the fourth section. In the fifth section, the evaluation of the proposed model through experiments is done. Final section contains observations on the conducted experiments and conclusions of the study.

REVIEW OF LITERATURE

A very little work on the reliability based CPU router time management model in CIP Networks have been done. However, some of the models that address the other reliability issues in cellular networks have been briefed here.