Performance Analysis of a Parallel PCS Network Simulator

Azzedine Boukerche\textsuperscript{1}, Sajal K. Das\textsuperscript{2}, Alessandro Fabbri\textsuperscript{1}, and Oktay Yildiz\textsuperscript{1}

\textsuperscript{1} Department of Computer Science, University of North Texas
Denton, TX 76203-1366, USA
\{boukerche, fabbri, yildiz\}@cs.unt.edu

\textsuperscript{2} Center for Research in Wireless Computing (CReW)
Department of Computer Science & Engineering, University of Texas at Arlington
Arlington, TX 76019-0015, USA
das@cse.uta.edu

Abstract. This paper presents an analytical performance study of a parallel simulation testbed for PCS networks, called Simulator of Wireless Mobile Networks (SWiMNet), and reports experimental results obtained using a realistic model executed on a cluster of workstations. SWiMNet achieves linear speedup, thereby significantly reducing the execution time of a PCS network simulation. Performance results demonstrate that our simulation model is consistent with the analytical study.

1 Introduction

Rapid development in portable computing platforms and wireless communication technology has led to significant interest in mobile computing and wireless networking. One such technology is called personal communication system (PCS). Mathematical analysis has brought some insight into the design of PCS networks, but analytical methods are often not general or sufficiently detailed. Therefore, it is through simulation that telecommunication system engineers can obtain crucial performance characteristics.

With increasing use of PCS simulation to design large and complex systems, PCS systems have brought several challenges to wireless simulation and parallel discrete event simulation (PDES) communities in general [4]. These challenges require not only extension and advances in current parallel simulation methodologies, but also innovative techniques to deal with the rapidly expanding features of PCS systems. Several results have been reported in the literature on parallel simulation of PCS networks [2,7,8,9,10,12]. To the best of our knowledge, these approaches do not consider realistic PCS models, the performances of which strongly depend on both mobile host (MH) profiles and PCS coverage area characteristics. We believe real PCS models must be considered to make meaningful recommendations to system designers.

Recently, we designed and implemented a parallel simulator for large scale PCS networks, called SWiMNet (Simulator of Wireless Mobile Networks, [1]). It exploits event precomputation made possible by model independence among realistic PCS model components. Process coordination is based on a hybrid of...
both conservative [3] and optimistic [5] PDES schemes. In this paper, we present an analytical performance study of SWiMNet to predict the achievable speed-up.

The paper is organized as follows. Section 2 describes the basics of PCS networks. Section 3 summarizes our methodology to simulate PCS networks. An analytical study of the model is presented in Section 4. Section 5 presents experimental results, while Section 6 concludes the paper.

2 PCS Network Basics

A personal communication system (PCS) is a network that provides low-power and high-quality wireless communication to mobile hosts (MHs) [6,11]. The coverage area is partitioned into cells, each serviced by an antenna or base station (BS). Cell sizes and shapes depend on signal strengths and obstacles to signal propagation. Radio channels are allocated by a BS for calls to/from MHs within its own cell. Channels can be assigned to cells according to a fixed channel assignment (FCA) scheme or a dynamic channel assignment (DCA) scheme [6,11], or a combination thereof. In FCA, each BS is statically assigned a set of channels, while in DCA, channels are dynamically assigned to cells. In this paper, we consider simulation of FCA schemes.

When a call attempt is made to/from an MH in a cell where there are no channels available, the call is blocked. If an MH moves from one cell to another while a call is in progress, the MH must be connected to the destination BS (a hand-off). The original BS releases the channel used by the MH, while the destination cell tries to allocate a channel for the call to continue. If an ongoing call cannot be handed-off due to lack of available channels, the call is dropped.

An important performance criteria for a PCS network is call blocking probability, defined as the ratio of blocked calls to attempted calls. The blocking probability should be kept small, typically around 1% [2].

3 SWiMNet

In [1], we proposed the Simulator of Wireless Mobile Networks which exploits event precomputation due to the following assumption: mobility and call arrival are independent of the state of the PCS network, and they are independent of each other. As shown in Fig. 1, processes composing SWiMNet are grouped into two stages: a precomputation stage (Stage 1), and a simulation stage (Stage 2). Processes in Stage 1 precompute all possible events for all MHs assuming all channel requests are satisfied. Possible events are: (1) call_arrival, (2) call_termination, (3) move_in, and (4) move_out. Events relative to different MHs can be precomputed independently, therefore Stage 1 processes do not communicate. Precomputed events are sent to Stage 2, where their occurrence is checked according to the state of the PCS network simulation. Stage 2 processes cancel events relative to calls which turn out to be blocked or dropped due to channel unavailability. Since events for the same call can span various cells, Stage 2 processes need to notify other processes of blocked calls.

Process coordination in SWiMNet is based on a hybrid approach, using both conservative and optimistic techniques. A conservative scheme is used for communication from Stage 1 to Stage 2 such that Stage 1 processes send precomputed