PARAMICS—Parallel Microscopic Simulation of Road Traffic

GORDON D.B. CAMERON
SOFTWARE, Inc., 3510, boul. St-Laurent,
bureau 400, Montreal, Quebec, Canada H2X 2V2
gordon.cameron@softimage.com

GORDON I.D. DUNCAN
Quadstone, Ltd, 16, Chester Street, Edinburgh, EH3 7Ra, Scotland
gordon@quadstone.co.uk

(An earlier version of this paper was presented at Supercomputing '94. Received June 1995; final version accepted December 1995.)

Abstract. This paper describes work done on the original PARAMICS project, which was developed for the Edinburgh Parallel Computing Centre to examine parallel microscopic road traffic simulation. The simulator, constructed originally for a Thinking Machines Connection Machine (CM-200), uses a data-parallel approach to simulate approximately 200,000 vehicles on 20,000 miles of roadway. More recent work has focused on the use of a message-passing paradigm, with a 256-node CRAY T3D as the target machine. The message-passing version of PARAMICS, PARAMICS-MP, is inherently scalable and can model many smaller networks on a broad range of platforms.

Keywords. Parallel, traffic simulation, SIMD, MIMD, high performance, vehicle dynamics, Connection Machine, MPI, CHIMP, microscopic simulation.

1. Introduction

PARAMICS is an ongoing development examining parallel microscopic road traffic simulation using supercomputing techniques at the Edinburgh Parallel Computing Centre (EPCC). The simulator was constructed originally for a Thinking Machines Connection Machine (CM-200), using a data-parallel approach, and could simulate approximately 200,000 vehicle "slots" on 20,000 miles of road lanes. Later work used the message-passing paradigm and was targeted at a 256-node CRAY T3D. This solution could model 120,000 vehicles at three times the real-time rates on 32 nodes of the T3D. An inherently scalable design, based upon the message-passing standard MPI [2], the Message Passing (MP) version, named PARAMICS-MP, can also model many smaller networks on other platforms, such as single and clustered workstations.

This paper describes work done on the original PARAMICS [5], and more recent developments using PARAMICS-MP.

2. Background

While traffic simulation programs have been in existence for many years, many have used simplified models of traffic flow in order to produce results within practical time scales. A typical assumption is to represent traffic flow on a particular road as a single quantity,
analogous to fluid flowing in a pipe. Unfortunately, such macroscopic models do not properly represent real traffic behavior in congested situations and do not reproduce the inherently fluctuating nature of real world situations.

In traffic engineering circles, microscopic traffic modeling (a process whereby each and every vehicle in the road network under scrutiny is modeled in some detail) is known to be a very powerful tool, but computationally very expensive. Traffic flow is extremely complex, since it is dependent on several nonlinear functions. It has been argued that congestion formation is a phenomenon associated with the chaotic, nonlinear nature of road traffic and as such is best modeled at the microscopic level [7].

Of course, microscopic simulators can also gather statistics on flows through roads, and these figures can be compared with results from the macroscopic simulations.

In early 1992 EPCC and SIAS Ltd, a local road traffic consultancy based in Edinburgh, saw the potential of parallel computing to offer a solution and aimed to exploit it. The goals of the original PARAMICS project were

- to demonstrate that a microscopic modeling approach can be applied to large geographic areas and can accurately predict congestion through the use of high-performance computing.
- to provide a research tool for the investigation of the relationship between congestion and demand.
- to undertake a demonstration application through the solution of an existing problem in the central belt of Scotland.
- to enable an evaluation of traffic control strategies, driver information systems, and driver behavior studies.

Given the direction in road traffic policy at the time, the project was seen as being particularly timely [4]. Network data for the Scottish Trunk and Key Principal Road Network, a network that carries around 150,000 vehicles in peak times, was obtained from the Scottish Office. This network was of a size large enough to demonstrate the efficacy of microscopic simulation—it is doubtful whether there would be a need for a single model to simulate a larger volume of traffic than this.

Later work extended the flexibility of the simulator by converting it to a message-passing solution, but using the same road network for the basis of the model. Both approaches will be described below.

3. Data Available for the Simulation

This section first discusses the data available to PARAMICS, supplied and created by SIAS, The Scottish Office, and EPCC. The same “real world” data were used in the original PARAMICS and much of the work in PARAMICS-MP.

3.1. Network Data

The network data available consist of a graph description (nodes and links) for the entire major Scottish trunk road network (the so-called TKPRNR data). Each node-to-node con-