The Evaluation of the Road Traffic System Simulator PIMTRACS by PIM

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Abstract The article describes the development, the structure and the evaluation of PIMTRACS(The Road Traffic Control System Simulator by PIM). PIM stands for Parallel Inference Machine. It was developed under the close cooperation of Yaskawa Electric Corporation(Japan) and Flavors Technology Inc.(USA). It has the quite innovative architecture and excellent GUI environment. PIM is a computer system composed of a number of parallel processor units called "cell" and global shared memory. The program assigned to each cell is called "tile" and executed synchronously in a fixed cycle.

The road traffic system is composed of a number of elements or entities such as roads(lanes), traffic signals and vehicles. Each vehicle is regarded as an instance. Each instance is assigned to a tile in PIM and processed in parallel. In the simulation of large scale road traffic system, the number of tiles required in the run is enormous, thus necessarily demands the enough scale of PIM itself. Another problem is that we have to take into consideration how to optimize the assignment of instances to tiles.

The study aims at the effective description of microscopic traffic model of urban district and the analysis and problem solving of traffic congestion based on the actual data. Our model was in terms of 1 intersection for the time being.
We are to expand the traffic network scale ,which will demand us larger scale of PIM. For example as for the model with 10 intersections and 500 vehicles, approximately 1,500 tiles are necessary and with regard to the model of 100 intersections and 5,000 vehicles,13,000 tiles are requested.

1. INTRODUCTION

In our modern social lives, the vehicles assumes an important responsibility in various fields such as commuters/ freight transportation, and the related demand is increasing rapidly. The road traffic network in charge of traffic flow is also growing day by day.
A recent trend seems to be the revision of road facilities and the increase of the number of lanes, in other words, the broadening of road itself.
The problem, especially in Japan is the rapid increase of population in urban area and the insufficient supply of lanes in road construction, which causes the chronic traffic congestion there.
Various studies have been conducted to solve these problems. The computer simulation is a methodology. But the traffic system itself is very complicated and the duplicated characteristics of continuity and discreteness of road traffics have kept refusing the reasonable solution even if the advanced technology of computer simulation has been applied. One of the difficult problems is the existence of many independent entities such as vehicles, pedestrians, roads, signal facilities and the like. The conventional computers were not always appropriate to describe such a model. The modelling by use of priority description was one of the temporary expedient, but it was not complete.

One of the countermeasures we took was the utilization of PIM. PIM is substantially a parallel computer system and suitable for handling parallel events. PIMTRACS is an acronym for the Traffic Simulation System by PIM. It has enabled the reasonable representation of road traffics and simulation execution.
The research study pursuited the effective and useful simulation methodology through "the parallelization of various independent entities" of road traffic system using parallel computer (PIM), and also the expandability of simulation models of large scale road traffic system in PIM.

2. A BRIEFING OF PIM

The scale growth of the road traffic systems and the variety increase of users' needs have promoted the scale expansion of application software of computer systems, and it has also given birth to the reduced productivity and maintenancability.
PIM is an innovative parallel processing machine developed in close cooperation of Yasukawa Electric Corporation(Japan) and Flavors Technology Inc.(USA). It has quite an innovative architecture and GUI(Graphical User Interface) environment. The use of PIM provides quite a new software engineering methodology, and im-

proves largely the productivity and maintenancability of application software.
The main features of PIM are as follows.

- Reduction of response time by way of parallel synchronous processing
- Effective support of system design and maintenance under the integrated development environment
- Free program modification in an online environment
- Easy programming through natural language
- Flexible extension of computer system according to the application system scale

PIM composes the system through the units called 'tile', which simplifies the modularization of system. Thus PIM enables quite a new system configuration and is considered as an ideal computer system equipped with compact and excellent facilities, high reliabilities, productivities and maintenancability.

3. THE OUTLINE OF PIMTRACS

In PIMTRACS a model is composed as shown in Figurl, describing each region and vehicle in parallel.

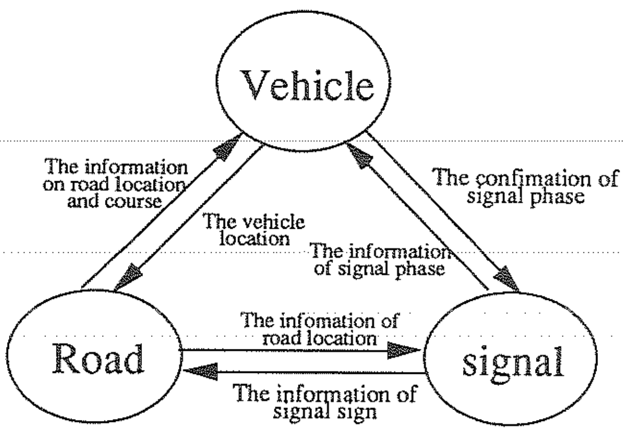

Figure1 A concept of PIMTRACS

Many road traffic simulators have so far been developed, but in most of process-oriented simulators, one among the numerous independent entities was taken up and processed and the other entities were represented as those which gave interruption to the main entity.
Some computers had parallel processing capability, but in general most of them required large scale facilities like workstation or supercomputer and rejected the easy treatment.
Our Macintosh PIM is of personal computer environment, and can use some personal computers if it is equipped with hardware facilities over a certain standard. It can be operated with by far smaller scale installation with parallel processing capability. It is considered to be more effective in simulation of road traffic system.
The road traffic simulation model in PIMTRACS is composed of six modules as shown in Figure2.

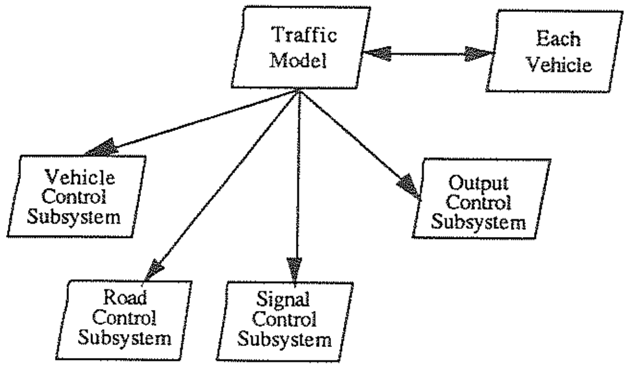

Figure2 PIMTRACS overall comfiguration

4.THE SIMULATION OF ACTUAL MODEL

The validity check should be done through the simulation of actual model.
Thus an intersection and related roads of Kichijoji (The University of Seikei is located near by.) were chosen as an example model. The intersection in Figure3 illustrates the crossing of Itsukaichi street and Seikei street.
Both streets have 1 lane road for one direction, and only the road from left to right (Itsukaichi St.) has a right turn zone of about 30 meters (right turn cars have to wait here for some time until they find any safe moment with no incoming cars.)

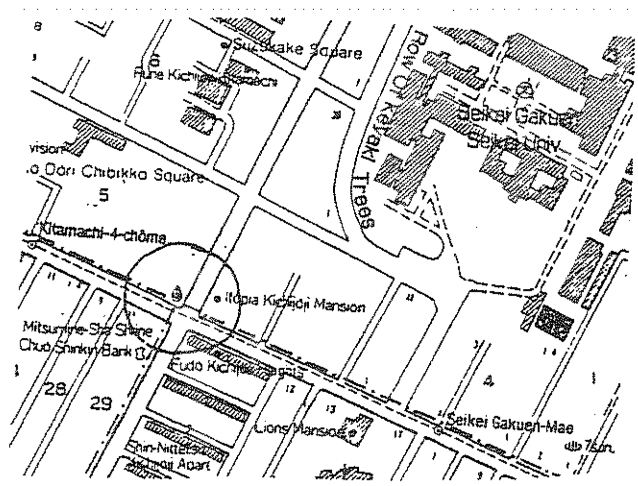

Figure3 A map around Example Model

There is no bus stop and no special zone of no parking or no stopping which are usually found in front of police station or fire station. At this intersection right turns and left turns are not prohibited. The model includes the four wings of 75 meters road sections.
The related data were gathered manually by numbering counters because no video camera or other automatic means could be applicable owing to geographical or locational conditions.

a)Data collection date : Jan. 17, 1997
b)Collection time zone : 50 minutes between 11.20 a.m. and 0.10 p.m.
c)Weather : fine
d)Measured items :
Waiting line statistics owing to each red signal
The percentages of straight proceeding, right-turn, left-turn vehicles.
The inflow traffic volume into the intersection
Signal phase change time record

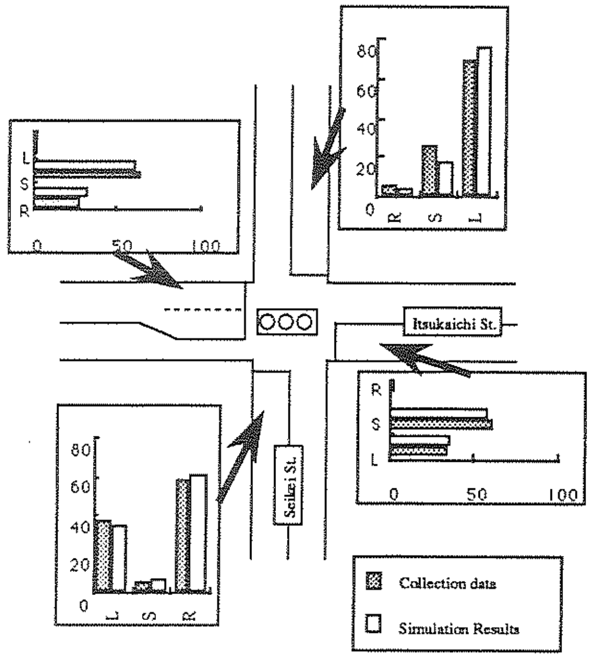

Figure4 Traffic Flow rate in Turnning Directions

A model was built based on the collected and set-up data. The simulation time extended 60 minutes totalling 30 minutes warm up hours and 30 minutes effective simulation hours. The simulation cycle time was chosen to 1 second/cycle.

The simulation statistics extended over the traffic flow volume for straight run, right and left turn vehicles, time occupancies at the locations 65 meters apart from the intersection in terms of inflow traffic in the road sections numbered 51, 52, 21, 31, 41 and queue statistics on the inflow road sections. The simulation results were compared with the actually measured field data. We got the traffic flow proportion at the intersection shown in Figure4, which nearly coincided with the actually collected data.
The waiting queue statistics for the signal red phases was compared between the simulation results and actual measured data, and some difference was found in terms of maximum queue length in the road 41 and the average waiting time in the road 31 between simulation results and actual measured data, but we judged that they are allowable gaps because the average queue length in the road 41 and the maximum queue length in the road 31 are almost the same between the two (Figure5).
Thus we considered that PIMTRACS itself and the simulation model through it can bear the practical use in traffic flow simulation.

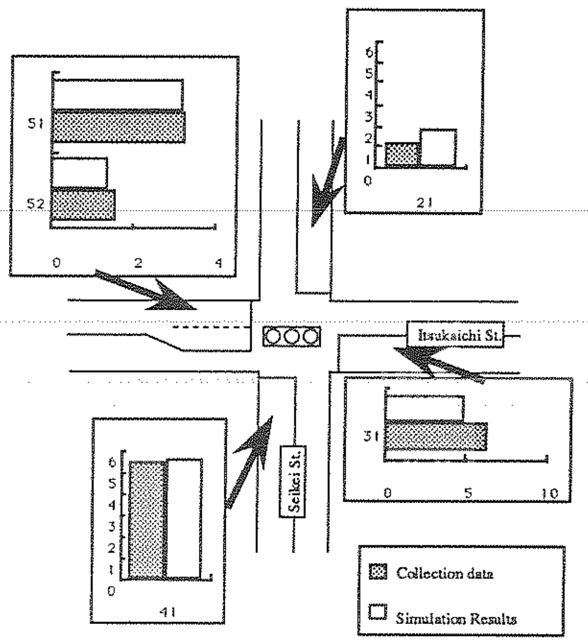

Figure5 Average Queue Length in each Street

5. THE DISCUSSION OF PIM SYSTEM SCALE

The article reports the simulaton of one intersection system, but for the practical evaluation of actual road traffic system, the road network system of larger scale should be chosen. In such a case, the key point is the number of tiles of PIM. Sometimes the system scale of PIM has to be enlarged. The study predicted the number of required tiles when the scale of road traffic network is magnified.
(1)Two tiles needed for describing the run and the output of a vehicle.
(2)The required numbers of tiles in the vehicle control

subsystem and the road cotrol subsystem are different according to each submodule. The Table1 illustrates the needed numbers of tiles for each submodule. The actually consumed number of tiles is the calculated needed tile number divided by the maximum consumed number.

(3)One tile is required for each intersection in the signal control subsystem.

(4)The number of required tiles in the output control subsystem is equal to the number of intersections times the number of lanes.

(5)The number of tiles needed for random number generation, etc. is equal to the number of intersections times 5.

The Figure 6 illustrates the PIM scale indices (the number of required tiles) dependent upon the number of intersections and the number of vehicles.

For example, in case of 10 intersections and 500 vehicles, 1500 tiles are required. The JR Toukai has PIM system with nearly 40,000tiles for its train traffic simulation, so we think the PIM system can be expandable for the road traffic system simulation.

6. CONCLUDING REMARKS

It has turned out that the road traffic network system composed of plural entities such as vehicles, roads, signals, and so on, can be processed in concurrent and parallel mode with parallel computing system PIM.

The results obtained from the simulation of one intersection traffic system showed nearly good conincidence with the actually gathered data. The expanded PIM system will enable the simulation of larger traffic network.

The future problem is the incorporation of pedestrians, the parking vehicle and so on.

7.ACKNOWLEDGEMENTS

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Table1 The number of required tiles of vehicle and road control subsystem (18 tiles par intersection)

	Maximum	Calculated consumed tiles		Actual Consumed
	Consumed number	m intersection	n vehicle	Number of Tiles
Vehicle Generation	7	2m+2	---	[(2m+2)/7]
Vehicle Attribute Control	8	---	n	[n/8]
Running Route	8	18·m	---	[18m/8]
following Vehicle Control	4	---	n	[n/4]
Road Connection Control	8	18·m	---	[18m/8]
Road Length	8	18·m	---	[18m/8]
Right Turn Decision	2	4·m	---	[4m/2]
Initial Vehicle Speed	8	2m+2	---	[(2m+2)/8]
Speed Limit	8	18·m	---	[18m/8]
Standard Speed	8	18·m	---	[18m/8]

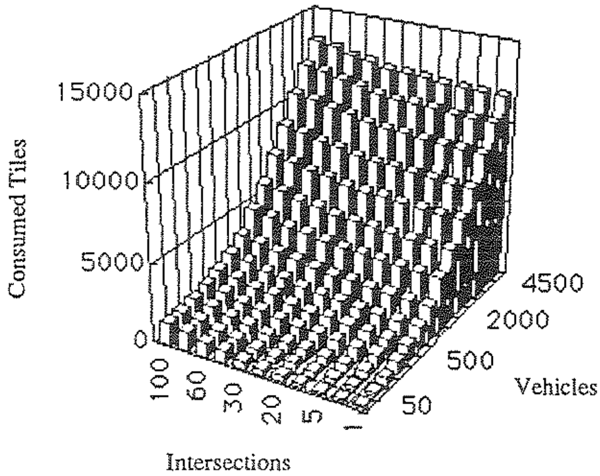

Figure6 The Number of Consumed Tiles for Intersections and Vehicles

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