

# A Traffic Simulator for Advanced Transport Telematics (ATT) Strategies

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## Abstract

**ATT systems are now widely deployed. The traffic simulation models need to represent ATT elements and the driver's reactions to them. We present a model for traffic simulation of systems with ATT elements and the simulator developed using this model.**

## Introduction

The fast growth of the urban road traffic is a very important global problem. The problems of congestion and road capacity cause delays penalizing the users. The urban traffic is also a source of environmental problems such as noise and pollution. The resolution of these problems requires the installation of strategies of traffic control and management.

Nowadays, simulation are used as a tool for evaluation of the strategies more than in the past. Mainly, because simulation eliminates the need for lengthy and expensive experiments. Moreover, new technologies require prediction, which can be achieved by simulation.

During last years new technologies made the real traffic systems more complex, such as the ATT (Advanced Transport Telematics), guidance by radio, etc. Thus, the simulation of the traffic (and transportation) plays an essential role, since the centers of control which are being implemented need information to divert the traffic or to evaluate the various strategies in order to avoid the congestion.

We developed a traffic simulator, within the Hipertrans project <sup>1</sup>, having among the objectives to study the effect of ATT on traffic control policies. This simulator, built upon the simulation framework PROSIT [4], communicates in real time with UTCs (Unit Traffic Control systems), allowing it to update its data.

The drivers in the simulator have an aggressiveness degree that characterizes them and determines their responses to a message from an ATT device. The simulated drivers should decide between three actions: change their itinerary to the new one advised by the ATT device; follow their present route; change to another path. Since the drivers' decisions can create a new congestion problem, it is necessary to evaluate the possible results of a recommendation given by telematics devices.

Using our simulator, the traffic manager can estimate the results for many traffic control scenarios in order to implement the best one. Furthermore, the simulator has a graphic interface that facilitates and accelerates the creation and simulation of many scenarios. The simulator runs sequentially under Unix or MS-Windows/NT and we are now developing a parallel version for simulating a city-sized network in real-time.

This paper is organized as follows. In the next section () we give some background information on ATT. We continue in section () with an analysis of the requirements to simulate this ATT strategies. In the section () we explain the model used for the simulator and we outline several implementation issues. We end with the conclusions and future directions.

<sup>1</sup>EEC project N.:RO-97-SC-105, <http://www-sop.inria.fr/sloop/hipertrans/>

## The ATT Strategies

Advanced Transport Telematics (ATT) can be explained as the use of information technology and communications to manage the road traffic. ATT is mainly useful to inform drivers about the conditions of the road network traffic and for controlling the dynamics of road signals. These capabilities of information and control allow the traffic manager to avoid undesirable situations.

In Europe, the EEC sponsored many projects aiming at developing a good understanding of the ATT systems and techniques. To that end, they defined seven areas of interest: demand management, traffic and travel information, integral urban traffic management, integral inter urban traffic management, driver assistance and cooperative driving, freight and fleet management, and public transport management. In each of these areas pilot projects were performed with the aim of testing, validating and evaluating ATT systems. Not only technical performance was tested, also administrative, political, social and other questions were analyzed [1].

One of the directions that is now being developed is the use of modeling and simulation tools to deal directly with road capacity and specific traffic management problems. The Smartest project [2] reviews the existing simulators and investigates how they can best be enhanced. The Hipertrans simulator has been developed so as to fulfill the requirements of a general multi-modal traffic simulator for traffic control and ATT strategies.

## Simulation of ATT Strategies

We think that the use of simulation can improve the application of ATT on real traffic networks because simulation allows the traffic manager to explore, evaluate and compare several ATT strategies and consequently to implement the best one. But the simulation of ATT strategies requires to deal with two main problems: how to model and simulate the ATT and how to couple the simulator with the ATT devices.

For modeling and simulating the mechanisms of ATT we can consider mainly two approaches:

(i) the mesoscopic approach, which groups the vehicles with a behavioral coherence compared to the signals given by ATT, or (ii) the microscopic approach, where the behavior of each individual is modeled.

This approach distinguishes between drivers according to the information to which they have access and to the behavioral characteristics of each driver [6]. In order to model and simulate precisely the interactions between the vehicles and UTC devices we decided to use a microsimulation paradigm. We simulate the vehicles and the elements of the ATT system: sensors, traffic lights and UTC devices and the interactions between them. The problem with the microscopic approach is that the amount of data to process is bigger than in other approaches. To deal with this problem we decided that the more expensive elements - in code execution time - be those that are, normally, inferior in number in a traffic network system, i.e. the road elements (links and nodes), whereas the vehicles and ATT elements are not so expensive.

For coupling the simulator with the ATT devices it is necessary to have an interface for communicating between them. Generally, the UTC devices work in a periodic way, i.e. they take the parameters and operate with these parameters for a previously precised time and then they communicate for updating the parameters if necessary and the loop continues. The simulator needs to synchronize with the real UTC devices for updating the information about the simulated UTC devices. Consequently, we decided to implement a time step approach for this traffic simulator. This decision allows us to handle communication between the simulator and the real UTC devices more easily.

## The Road Traffic Simulation Framework

We used the object oriented paradigm for the programming of this framework and we chose C++ language to develop it.

We present in the figure 1 the architecture designed for our road traffic simulation framework. "... A framework is the design of a set of objects that collaborate to carry out a set of responsibilities"[3]. This architecture has the advantage that the underlying model can be easily replaced.

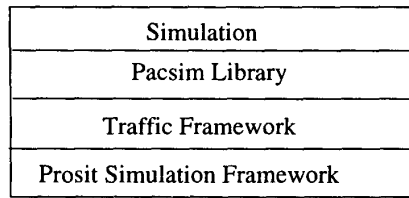


Figure 1: General architecture of the framework

### The Simulation framework PROSIT

PROSIT is itself a framework for discrete event simulation co-developed by INRIA and Simulog. PROSIT provides a library of classes and a programming architecture based on the concept of active objects which evolve in time. All the active objects are synchronized on the simulation time using a simulation clock with the current simulation date. The time progress and the temporal coherence are automatically managed by the PROSIT system. Each active object is able to communicate with the others by service requests. All the details about this framework are given in [4].

### Traffic Framework

Using the classes of the PROSIT framework we developed a new framework specialized in road traffic. The abstraction level is the one used by the traffic modelers and most of the PROSIT mechanisms are hidden. This framework provides the basic classes for the creation of the network (links and nodes) and a general vehicle class with the characteristics owned by all types of vehicles, such as speed, size, weight, etc. This framework also has the basic elements of the ATT network with their main characteristics. For example, there are the class **Traffic\_Light** and the class **Phase** that allow the traffic manager to implement different light control strategies. General sensors and UTC devices are also modeled and their principal characteristics and functionalities are provided, such as examine the number of vehicles passing through the sensor in one detection interval.

### Pacsim library

The *Pacsim* library [7],[5] uses the classes from the traffic framework to implement a specific approach of the traffic modeling. This layer can be substituted, partially changed or increased to test new concepts in a easy way. The *Pacsim* library provides all the classes needed to implement different types of driver's behaviors as well as the models for the main driving task: car following, gap acceptance, and lane changing. This library has an interface for the coupling with real UTCs and has a particular model for the network perception that can be different for each driver. We have used a modular approach allowing each component to be easily redefined and extended (see Fig 2).

The route assignment model produces the route for a vehicle based on a shorter path algorithm. The traffic generation module reads the specification file with the number of vehicles to simulate at each period, creates them and sends them to the origin node of their routes. The vehicles behavior manager implements the driving process algorithms and takes into account the aggressiveness degree of drivers. The statistics module collects and computes all the statistics needed as output of the simulation. The simulated road network module executes the simulation process: activating the objects at each step and advancing the simulation time. The UTC module models the ATT devices and the traffic lights. The interface with the real UTC elements is implemented in it.

### The simulation

A simulation is an instantiation of the classes on the Pacsim library layer with the parameters corresponding to a specific experiment. In our simulator a graphical interface facilitates the creation of the traffic network and the entry of parameters for the simulation scenario. The simulation can provide as

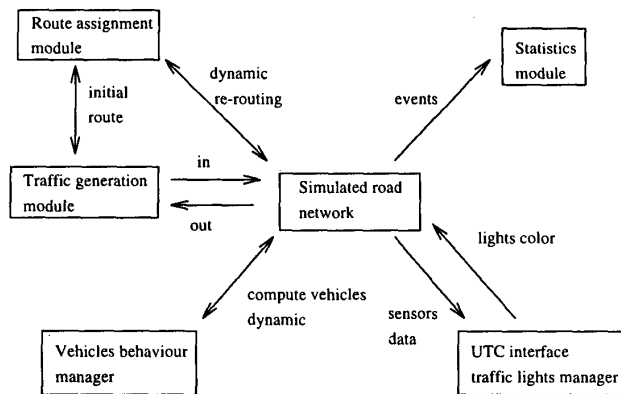


Figure 2: Pacsim library components

output statistics of each node and link, as well as global network statistics. The results of the simulation and the links occupation ratios can be visualized interactively.

The architecture presented can adapt to new techniques at a low development cost. It takes advantage of object oriented and framework approaches, i.e. reduces coding, debugging and testing, and provides a open architecture and reduces maintenance.

### Conclusions and Future Works

Simulation is a powerful tool for traffic managers that allows them to study and evaluate many traffic control strategies in order to implement the best one. ATT systems complicate the study of these strategies, so new simulation models that provide the capability to simulate ATT systems are needed.

We sketch in this article a microscopic traffic simulation model that provides the necessary characteristics for model ATT systems. The simulator developed using this model can be connected with real UTC devices. We used an open approach that allows us to add new concepts or elements easily.

A parallel version of this simulator is now being tested, it will allow to simulate a medium size town faster than real time.

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