Intelligent Traveler Assistant (ITA) Simulation Platform Design

James G. Haran
University of Illinois at Chicago
Department of Computer Science
851 South Morgan Street
Chicago, IL 60607-7053
jharan@cs.uic.edu

Kouros Mohammadian, Ph.D.
University of Illinois at Chicago
Department of Civil and Materials Engineering
842 West Taylor Street
Chicago, IL 60607-7023
kouros@uic.edu

Peter Nelson, Ph.D.
University of Illinois at Chicago
Department of Computer Science
851 South Morgan Street
Chicago, IL 60607-7053
nelson@uic.edu

ABSTRACT
This paper describes the design of an intelligent traveler assistant (ITA) simulation environment capable of multi-modal traffic simulation in an ad hoc wireless network enabled environment. This hybrid platform integrates the traffic micro simulator VISSIM, the wireless network simulators SWANS, and a set of software ITA interfaces and services designed to model various applications.

Categories and Subject Descriptors
I.6.5 [**Computing Methodologies**]: Simulation and Modeling – *Model Development, Modeling Methodologies*

General Terms
Measurement, Design, Experimentation

Keywords
VANET, MANET, inter-vehicle communication, wireless ad hoc networks, traffic simulation, micro simulation, intelligent traveler assistant (ITA), multi-modal simulation, JIST, SWANS, STRAW, ns-2, Java.

1. INTRODUCTION
The intelligent traveler assistant (ITA) environment is best understood as the integration of a dynamic multi-modal transportation network, wireless communication, handheld and vehicular computing devices, and software services and applications that provide real-time access to transportation resources and facilitate the efficient coordination of activities. Real implementation of the ITA requires significant investment in transportation infrastructure, improvement to current wireless hardware devices, development of collaborative software systems, and integration of thousands of disparate transportations sensors. Given the prohibitive cost and logistics of implementing such an environment, the focus of this research is to provide a simulation platform for the rapid prototyping and analysis of the ITA using proven methods for simulation from the fields of wireless networking, transportation science and traffic modeling, and computer science.

This paper describes the design of a hybrid simulation environment based on the network simulator SWANS, commercial transportation micro simulator VISSIM [17], and various software components designed for the study of vehicle-to-vehicle (V2V), vehicle-to-person (V2P), and vehicle-to-infrastructure (V2I) analyses. The desire is to use this platform in ITA research to understand the transportation, economic, environmental, and societal impact of emerging transportation technologies, specifically the ITA.

2. BACKGROUND
Previous work on VANET simulation has focused on the development of integrated network and transportation simulation environment either through modification of and existing network of transportation simulator [7, 6, 2, 3, 4] or through hybridization of separate simulators into a common simulation platform [1, 5, 8].

Perhaps the most recent effort to augment a network simulator to perform transportation tasks is the STRAW project which builds upon the existing SWANS framework to provide a constrained movement environment such that transportation networks can be adequately modeled. Although analysis [9] supports the maturity of the SWANS network simulator, the accuracy of the transportation model is left unproven [6, 7]. Furthermore, the difficulty of configuring transportation-specific parameters within STRAW leaves its value as a tool for the transportation scientist in question. The major advantage of the STRAW/SWANS project is the availability of complete source code for all components of the simulator and the continued development of new models and components to enhance the product.

TraNS [3] builds upon the Network Simulator 2 (ns-2) [16] framework to provide transportation modeling in a VANET environment. NCTUNS [2], like STRAW, attempts to build both a realistic transportation environment within a wireless communication platform. Although these models provide a more realistic transportation network that STRAW, but they fail to provide an adequate platform for the verification of ITA models.

Recent hybrid studies have focused on the integration of the commercial transportation micro simulator VISSIM [17] with the network simulator ns-2. These studies benefit from proven

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network and traffic models and provide a realistic platform for the modeling of VANET applications.

2.1 Traffic Micro-Simulation

A traffic simulation model is a computer program that uses mathematical models to conduct experiments with traffic events on a transportation system over extended periods of time [11] using either a discrete or continuous system. The state of the system in a discrete system is adjusted at discrete points while the state of the system in a continuous simulation varies constantly over time. Continuous simulation systems can characterize the traffic flow system more effectively, whereas discrete models typically allow better stepwise configuration and adjustment. As with any simulation platform, high frequency discrete simulation is a sufficient approximation to continuous activity.

Traffic simulation models can be roughly classified into three categories of macroscopic, mesoscopic, and microscopic, depending on the representation of the traffic flow in the model.

Macroscopic simulation models take into account more of the system wide representation of the traffic flow and characteristics rather than individual vehicles. These models can be either deterministic or stochastic. Fundamental traffic speed flow relationships are utilized in these models to describe aggregate traffic condition at any given time. TRANSYT, FREQ, and META are examples of such models. These models have limited applications in responding to changes in traffic condition.

Mesoscopic models analyze platoons of vehicles and their characteristics as a single unit to study traffic flow. These models are capable of analyzing minor changes in the traffic condition over a short period of time. Examples of these models include DYNASMART, VISTA, SIMNET, and SATURN [13, 14, 15].

Microscopic models simulate the individual interaction of the vehicles and thus are more suitable for the simulation studies of traffic system. Developed generally based on traffic behavior theory, these models simulate the time-space trajectory of individual vehicles in the network. Microscopic models tend to be more flexible in which different classes of vehicles can be associated with different characteristics like speed, acceleration and driving characteristics. Moreover, the driver behavior, as in relaxed or more aggressive driver behavior, can also be simulated in this simulation platform.

It has been shown that microscopic models can generate more accurate results (e.g., in terms of travel time, speed, delay, or queue length) compared to mesoscopic or macroscopic simulation models [12]. Unfortunately, these models are typically more difficult to calibrate since the underlying car-following and lane-changing theories used in these models may not well represent real life driving behavior. Therefore, model calibration is an important task in this approach. Common microscopic models include CORSIM [22], which is based on the older FRESIM and NETSIM models, AIMSUN2 [18], PARAMICS [21], TRANSIMS [19], MITSIM [20], and VISSIM [12].

The popularity of micro-simulation models is due in part to the availability of rich application programming interfaces, discrete time step control, and powerful visualization engines (Figure 1). Many of these tools also provide users with the capability to record videos of running simulations for future playback. The most powerful feature of microscopic traffic simulations, however, is their ability to efficiently model multi-modal transportation systems.

2.2 Multi-Modal Simulation

Multi-modal simulation involves the simulations of multiple types of transportation and their interaction. Typical multi-modal traffic studies evaluate the effectiveness of transportation features when considering pedestrian, vehicle, and mass transit activity. Standard modes of transit available for study in micro simulation tools include individual vehicles, buses, trains, trams, pedestrians, wheelchairs, bicycles, and airplanes. The systems used in this project, VISSIM, also allows a rich API which enables users to specify their own vehicle types and set vehicle parameters based on predefines features such as maximum speed, acceleration, number of passengers, or automobile color.

Figure 1: The VISSIM Micro-simulation Application

2.3 Wireless Network Simulation

Like traffic simulation, a number of environments exist for modeling the behavior of wireless ad hoc networks. The most common of these models is the open source ns-2 [16], but various other simulators such as SWANS, Qualnet, and Opnet provide different capabilities with different usage considerations. Each environment allows users to model standard network protocols such as IEEE 802.11, IEEE 802.16, or Bluetooth with various tradeoffs of configuration, scalability, and speed.

The majority of existing micro simulation models consider the random node movements in a fixed field area. This model is adequate for modeling worst-case movement scenarios in ad hoc wireless networks but has proven inadequate for the analysis of the constrained and somewhat predictive nature of transportation studies. Attempts to build upon these network simulators to model inter-vehicle communication often fail to adequately model the interaction of vehicles with one another. Car following and lane changing behavior is typically absent because the core design is the evaluation of wireless networks under linear movement constraints. These models also typically do not provide the sensor and actuator control features that is available in most traffic simulations to allow transportation scientists to reconfigure live simulations. Finally, multi-modal simulation on these platforms is typically not possible. These restrictions leave the value of IVC research uncertain or difficult to understand.

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Although most recent research [1, 5, 8] focuses on the coordination of VISSIM and ns-2, this project will also attempt to integrate VISSIM with the SWANS wireless ad hoc network simulator. Studies on SWANS [9] show it provides results comparable to ns-2 and may scale more efficiently.

3. Architecture

The architecture of the ITA simulator consists of the VISSIM application, SWANS simulator, and a coordinator application which maintain a single simulation time step between the two environments (Figure 2). In addition, a framework will be built for the collection of data output from the combined environment such that various models may be quantitatively evaluated. This model will follow the approaches of [1, 5, 8], but with a goal of modeling the coordination of multiple modes of transit rather than vehicular traffic only.

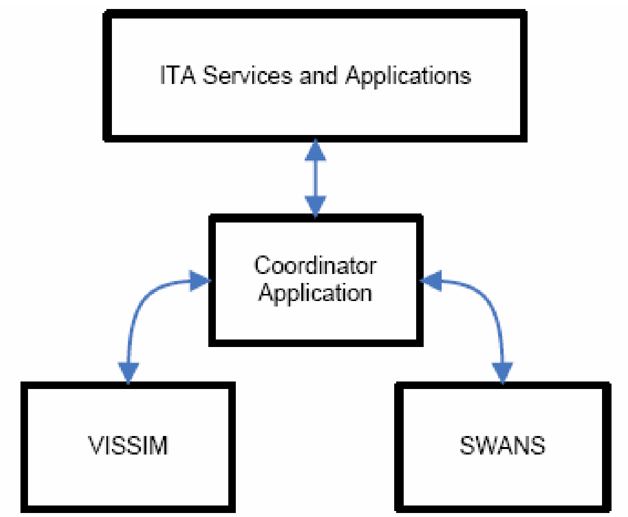

Figure 2: Conceptual Simulator Architecture

VISSIM follows Microsoft Windows architecture and provides three methods for external control, a COM interface, an integrated scripting engine, and a set of external DLLs that allow developers to replace or modify various features of driver behavior.

SWANS provides and open source Java framework with a light resource footprint and good scalability. In addition to SWANS, ns-2 will also be studied as a possible alternate network simulator building upon the projects of [1, 5, 8], but the desire is to have a single platform system to avoid the overhead of network utilization.

These applications will be coupled with a special purpose application to maintain the time steps between the two environments and provide state sharing such that the traffic model is updated with the results or network / ITA interaction and the network simulator maintains the most recent position and vector state of the traffic entities.

4. Summary

This paper discussed the initial design of an ITA simulation environment based upon proven simulation tools for ad hoc wireless communication and transportation studies. The goal of this work and the ongoing project is to build a framework for the testing of coordinated traffic activities across multiple models of transportation for tasks such as ride sharing, multi-mode origin to destination mapping, and traffic prediction among others.

5. REFERENCES

[1] Lochert, C., Bartheis, A., Cervantes, A., Mauve, M., Caliskan, M. 2005. Multiple Simulator Interlinking Environment for IVC, Proceedings of the 2nd ACM Workshop on Vehicular Ad Hoc Networks, September 02, 2005, Cologne, Germany.

[2] Wang, S.Y., Chou, C.L., Chiu, Y.H., Tzeng, Y.S., Hsu, M.S., Cheng, Y.W., Liu, W.L., Ho, T.W. 2007. NCTUNS 4.0: An Integrated Simulation Platform for Vehicular Traffic, Communication, and Network Researches, Vehicular Technology Conference, 2007. VTC-2007 Fall. 2007 IEEE 66th Volume, Sept. 30 2007-Oct. 3 2007 Page(s):2081 – 2085.

[3] Piorkowski, M., Raya, M., Lezama Lugo, A., Papadimitratos, P., Grossglauser, M., Hubaux, J.P. 2007. TraNS: Realistic Joint Traffic and Network Simulator for VANETs, The 13th ACM Annual International Conference on Mobile Computing and Networking MobiCom'07, Montreal, Canada, September 2007.

[4] Leung, K., Dao, T.S., Clark, C., Huissoon, J. 2006. Development of a Microscopic Traffic Simulator for Inter-Vehicle Communication Application Research, Proceedings of the International IEEE Conference on Intelligent Transportation Systems, Toronto, Ontario, Canada, September 2006.

[5] Killat, M., Schmidt-Eisenlohr, F. Hartenstein, H., Rössel, C., Vortisch, P., Assenmacher, S., Busch, F. 2007. Enabling Efficient and Accurate Large-Scale Simulations of VANETs for Vehicular Traffic Management. Vehicular Ad Hoc Networks 2007: 29-38.

[6] Gorgorin, G., Gradinescu, V., Diaconescu, R., Cristea V., Iftode, L. 2006. An Integrated Vehicular and Network Simulator for Vehicular Ad-Hoc Networks. Proceedings of the 20th European Simulation and Modeling Conference, October 2006.

[7] Choffnes, D.R., Bustamante, F.E. 2005. An Integrated Mobility and Traffic Model for Vehicular Wireless Networks, In Proc. of the 2nd ACM International Workshop on Vehicular Ad Hoc Networks (VANET), September 2005.

[8] Schroth, C., Dötzer, F., Kosch, T., Ostermaier, B., Strassberger, M. 2005. Simulating the traffic effects of vehicle-to-vehicle messaging systems. Proceedings of the 5th International Conference on ITS Telecommunications, 2005. The 5th International Conference on ITS Telecommunications. Brest, France.

[9] Schoch, E., Kargl, F. 2007. Simulation of MANETs: A Qualitative Comparison between JiST/SWANS and ns-2, MobiEval. System Evaluation for Mobile Platforms 2007 (in conj. with MobiSys), San Juan, PR, June 2007.

[10] Chon, H.D., Agrawal, D., El Abbadi, A., 2002. Data Management for Moving Objects, IEEE Data Eng. Bull. 25(2): 41-47, 2002.

Digital Object Identifier: 10.4108/ICST.MOBIQUITOUS2008.3987
http://dx.doi.org/10.4108/ICST.MOBIQUITOUS2008.3987

[11] Highway Capacity Manual (HCM) 2000, Transportation Research Board, 2000.

[12] Smartest Project. http://www.its.leeds.ac.uk/projects/smartest/

[13] Haran, J., Fan, P., Nelson, P., and Dillenburg J., An intelligent vehicle approach to mobile vehicular ad hoc networks - clustering optimization in dynamic traffic networks. Proceeding of ICINCO: 224-231, 2005.

[14] Fan, P., Haran, J., Nelson, P., and Dillenburg J., Traffic Model for Clustering algorithms in VANETs, IEEE CCNC, Las Vegas, Nevada, USA, 2006.

[15] Fan, P., Haran, J., Nelson, P., and Dillenburg J., Cluster-Based Framework in Vehicular Ad-Hoc Networks. Proceeding of ADHOC-NOW: 32-42, 2005.

[16] Network Simulator 2: http://www.isi.edu/nsnam/ns/

[17] VISSIM: http://www.vissim.com

[18] Barcelo, J. The Parallelization of AIMSUN2 Microscopic Traffic Simulator for ITS Applications. Presented at the 3rd World Conference on Intelligent Transportation Systems. Orlando, FL. 1996.

[19] Barrett, C.L., R.J. Beckman, K.P. Berkbigler, K.R. Bisset, B.W. Bush, S. Eubank, K.M. Henson, J.M. Hurford, D.A. Kubicek, M.V. Marathe, P.R. Romero, J.P. Smith, L. L. Smith, P.L. Speckman, P.E. Stretz, G.L. Thayer, E. Van Eeckhout, and M.D. Williams. TRANSIMS Volume Two – Networks and Vehicles. Los Alamos Unclassified Report 00-1724, Aug. 2004.

[20] Ben-Akiva, M., M. Cortes, A. Davol, H. Koutsopoulos, T. Toledo, MITSIMLab: Enhancements and Applications for Urban Networks, 9th World Conference on Transportation Research (WCTR), Seoul, Korea, July 2001.

[21] Quadstone Ltd. Paramics V5.0 Release Notes. Quadstone, Ltd., Scotland. 2004.

[22] CORSIM Federal Highway Administration (FHWA), TSIS Help Files. Version 6.0. Software Help System, 2006.

[23] Giannotti, F., Nanni, M., Pinelli,, F., Pedreschi, D. 2007. Trajectory Pattern Mining. KDD 2007: 330-339.

Digital Object Identifier: 10.4108/ICST.MOBIQUITOUS2008.3987
http://dx.doi.org/10.4108/ICST.MOBIQUITOUS2008.3987