TMC Simulator for Operator Training Using Micro-Simulation

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ABSTRACT

Fast incident response and management are main tasks of Traffic Management Center (TMC) operators. Using the latest microscopic simulation modeling techniques and a comprehensive simulation management scheme, a next-generation TMC operator training simulator was developed and made operational at the California Advanced Transportation Management Systems Testbed. The development of the simulator was a cooperative effort between the California Polytechnic State University San Luis Obispo, University of California Irvine, and the California Department of Transportation Department of Traffic Operations (Caltrans Traffics Ops). The simulator is designed to duplicate the standardized TMC software systems and data feeds found in California TMCs in an off-line environment, where TMC operators can be trained to enhance their skills using various incident scenarios. The simulator provides an interactive environment where actions students take to manage an incident affect the simulated traffic in the system and students see the results of their activity. Four training classes have been successfully performed since the completion of the new TMC simulator.

1. INTRODUCTION

Traffic Management Centers (TMCs) are facilities which allow an agency to perform traffic surveillance, detect accidents and traffic related problems, and then formulate and implement appropriate responses. This typically involves coordinating with other agencies or divisions within an agency. A TMC is usually staffed by engineers and maintenance personnel, highway patrol personnel, dispatchers, and dedicated TMC operators. Different diverse sets of technologies are currently applied in TMCs. A basic TMC has limited equipment, such as telephones, computers, fax machines, and log books or files for the management of traffic operation. An advanced TMC may additionally have a Computer Aided Dispatch (CAD) system and a central traffic monitoring system that connects with various field elements such as in-pavement and video/radar-based vehicle detection systems, Closed Circuit TeleVision (CCTV) systems, ramp metering systems, permanently mounted changeable message signs (CMSs), and highway advisory radio (HAR).

The primary objective of a typical TMC is to detect and verify incidents and then take appropriate actions to avoid and relieve traffic congestion (1). Upon becoming aware of an incident, TMC operators pinpoint its location, determine its severity, and assess resulting congestion through available resources, such as CCTV cameras, vehicle detection systems, the CAD system, maintenance personnel in the field, and other allied local traffic and transportation agencies. TMC operators then implement an appropriate traffic management response to the incident. This response will typically utilize continuous real-time monitoring of traffic conditions, dispatching appropriate personnel to the field (e.g. maintenance personnel and/or a traffic management team), determining alternative routes, informing motorists via CMS and/or HAR, and disseminating appropriate information to other agencies and the media.

For major metropolitan areas such as Los Angeles, the freeway system has become increasingly subject to non-recurring congestion. Unlike the recurrent traffic congestion, the non-recurrent congestion derived from incidents is unpredictable and may cause serious delay and exacerbate recurring congestion. . One effective method of reducing non-recurring congestion is to hasten the speed of incident detection and response (2). TMC Operators' experiences and skills are important in attaining this goal.

TMC operators are traditionally trained through on-the-job training. Most of this type of training focuses on the familiarity with the existing facilities in TMC. Recently, TMC operator training software was identified as a potential project by the TMC Pooled-Fund Study when it was initiated by Federal Highway Administration (FHWA) and other State Departments of Transportation (DOT) members in June 2000 (3). A project called "Developing TMC Operator Training Program Guidelines" will start in spring 2008 and will provide recommendations for the development of a comprehensive training program.

Recently, the I-95 Corridor Coalition, which is an alliance of transportation agencies, toll authorities, and related organizations along the I-95 freeway of the east coast of the US, developed a TMC simulation program for operator training by considering different technological settings of different TMCs. The computer program has three scenarios under which individual operators can be trained to gain experiences in managing incidents or events with a multi-state impact (4).

Compared to other states in the US, the California Department of Transportation (Caltrans) has been the most proactive in the training of its TMC operators. This training approach is due to the existence of serious traffic congestion problems in California's major metropolitan areas. Caltrans has a state TMC operator training program and its goal is to enhance TMC operators' skills and enrich their traffic management experience via a simulated and off-line environment that is similar to that found in advanced-TMCs. The first-generation TMC simulator was implemented at California Polytechnic State University San Luis Obispo in 1992 (5,6). This TMC simulator was periodically updated and served as a training platform for Caltrans TMC operators and CHP officers from 1994 through 2004. This simulator did allow instructors to modify traffic flow in response to student actions, but was limited in that it was not script-based and thus not easily reconfigurable, it did not have interactive video display, and operated using a primitive traffic simulation scheme. The Cal Poly TMC simulator was removed from service in 2004 as a second generation TMC simulator was planned for development and installation in the Caltrans Advanced Transportation Management Systems Testbed in Orange County CA at the University of California Irvine.

This paper presents the second-generation TMC simulator that utilizes the cutting-edge microscopic traffic simulation to replace real-world traffic sensor data working in conjunction with a script-based TMC simulation manager to provide a realistic TMC simulation for training purposes.

The rest of this paper is organized as follows. Section 2 introduces the methodology. Section 3 describes how the system was implemented. Section 4 explains the application of the system for training session. Finally, conclusions and remarks regarding future development are given.

2. METHODOLOGY

2.1 Typical Caltrans TMC ITS Framework

A typical Caltrans TMC utilizes a traffic management software platform, which provides an integrated system for accessing all Intelligent Transportation Systems (ITS) within the district or region. The software platform used in California is named the Advanced Transportation Management System (ATMS). The term ATMS in this paper will refer to this California software package, not the standard category of ITS. All live traffic data from vehicle detection stations is fed into ATMS via a data communications server. This real-time traffic data is displayed in various forms on a map-based display on the ATMS to show traffic conditions. ATMS provides all CMS controls, which allow operators to post traffic management messages. The platform may additionally be used to control CCTV systems. These CCTV systems may also be controlled via dedicated video control panels which are tightly integrated with video collection, switching, and display system in the TMC. The California Highway Patrol (CHP) CAD sits alongside the platform and also plays a critical role in traffic management. TMC staff utilizes the CHP CAD to learn of emerging incidents and track their status as this system provides a direct reflection of CHP actions in the field. The CHP CAD also provides a method for the TMC operators to communicate with CHP dispatchers. TMC operators also have an activity logging system which aids in coordination of operators' activities, creates a record of Caltrans responses to incidents, and provides a means for tracking performance measures and response times.

2.2 TMC Simulator Framework

The TMC simulator has been designed to emulate typical functionality found in a Caltrans TMC by replicating the data and information that flows in and out of the TMC via the ATMS, CHP CAD, maintenance radio systems, CCTV systems, CMS controls, and activity logs (7). Additionally, the TMC simulator must allow all training actions to be carried out in a controlled and predictable fashion.

Figure 1 shows the general framework of the TMC simulator. The Simulation Manager provides control for the startup, execution, and termination of all TMC simulations based on content within Extended Markup Language (XML) scripts. Upon initiation of a simulation, the Simulation Manager commands the enhanced Paramics microscopic traffic simulator to begin populating the simulation area with traffic representative of non-incident conditions. The Paramics simulator, which operates in real-time, provides simulated traffic data to the ATMS SIMulator (ATMSSIM) via the field element interface, i.e. Semi-Actuated Traffic Metering System (SATMS) Data Emulator Plugin, so that ATMSSIM clients operating on student and control-room desktops, can show traffic conditions within the network. The Paramics simulator also provides roadway traffic condition information at all CCTV camera locations to the Simulation Manager, allowing the Simulation Manager to maintain a summary of traffic conditions within the network.

The Simulation Manager utilizes the roadway traffic conditions returned to it from the Paramics simulator to control the playback of prerecorded traffic video sources, which are stored on remotely controlled DVD players. Each DVD player represents traffic conditions for a single surveillance camera within the simulation area, and has up to six video clips stored for it. Each of the six video clips is representative of a different traffic conditions, i.e. slow, medium, or fast. The appropriate clip is automatically queued up based on traffic conditions in the area of the selected camera, as received from the Paramics simulator. Students select the video source, i.e. a roadside camera that they would like to have displayed on the video display system via the video switch controls. The correct video footage that is representative of traffic conditions for the selected 'camera' in the simulation network are then displayed.

The simulation manager also provides students participating in the simulation with information regarding simulated CHP activities via the automated playback of CHP audio clips and automated entry of information in the CHP CAD log. The simulation manager also plays audio clips of prerecorded CHP voice radio traffic as the simulation progresses. These clips, which are stored as Windows .wav files, are executed based on lines within the XML simulation script. This audio output is fed to an audio amplifier, which drives loudspeakers on the simulation floor. Students participating in the simulation hear this simulated radio traffic regarding traffic conditions within the simulation network. The simulation manager automatically sends CHP CAD log entries to the CHP CAD Server as the simulation progresses. These CAD entries appear on student CHP CAD consoles as if they had been entered by a CHP officer sitting at a CHP CAD terminal.

Lastly, the Simulation Manager provides TMC trainers with tools which allow them to divert traffic from one roadway to another within the simulation network. Based on observations of student actions on the simulation floor, such as posting CMS messages, the trainers in the control room have the option of using freeway junction diversion controls to effect a traffic diversion within the simulation network. Upon an instructor instituting a diversion, the Simulation Manager sends a message to the Paramics simulator, causing it to perform the diversion of a certain percentage of traffic from one highway to another. This diversion of traffic will then be observable on all ATMSSIM clients, providing immediate feedback regarding students' traffic management actions.

3. IMPLEMENTATION

3.1 ATMSSIM

ATMSSIM is a simulated version of ATMS. It provides the base ATMS functionality including map manipulation, field device control and data integrity and some additional simulation capability. As shown in Figure 2, to the end user the ATMSSIM looks exactly the same as the real ATMS, but with limited field device control function for cameras and CMSs. Each CCTV camera is associated with either a DVD player with various video clips, or a static image. Users can post messages to CMSs, which are seen within the simulation from any ATMSSIM terminal. Although the TMC Simulator typically utilizes simulated detector and ramp metering data, the Paramics interface also allows for the utilization of real-world input.

3.2 Simulation Manager

The Simulation manager is the control center for the TMC Simulator, and has the following functions:

- Starting, pausing, and ending TMC simulations
- Receiving events of incidents from the CAD simulator and playing the corresponding audio files to the audio system
- Receiving traffic diversions from TMC simulator instructors based on actions taken by students
- Sending incident and vehicle diversion information to Paramics, which simulates these activities and affects the traffic network simulation
- Receiving traffic speed data at camera locations from Paramics in order to associate the camera location's traffic condition with appropriate video clip for incident verification purposes

3.2.1 TRAFFIC INCIDENT MODELLING

The TMC simulator must have flexibility to model various traffic incidents, i.e. blocking one or more lanes of freeway. The TMC simulator models these incidents using the following parameters:

- Incident location, including freeway, direction, and milepost number
- Incident type
- Number of lanes affected
- Incident status, e.g., new, changed (indicating a change in the number of affected lanes) or cleared

As the incident occurs, the Simulation Manager obtains the above data from CHP CAD simulator and then sends it to Paramics to model.

3.2.2 CONTROL OF SIMULATED CCTV CAMERA CONTENT

In the real world, TMC operators can check traffic conditions at each CCTV camera location through either the ATMS' GUI or camera selection on a video wall composed of pre-set CCTV video sources. In the TMC simulator, two plasma TV monitors are used to show pre-recorded videos for up to four locations simultaneously. The ATMSSIM can also show a representative snapshot image when a user clicks a camera icon from the GUI.

In order for the Simulator to show accurate representative video of conditions within the simulation, Simulation Manager requires Paramics to report the traveling speeds at specific camera locations. Cameras in the field have pan, zoom, and tilt functions. However, a camera in the Paramics simulation network is assumed to have a fixed zoom level, and its view is defined as a section of freeway (i.e. one link or several links). Since a camera is an area-wide traffic sensor, the speed at a camera location is defined as the average speed of vehicles within the view of the camera. This speed data is dynamically associated with a video clip (if it is displayed in monitor) or snapshot image (if it is viewed via ATMSSIM) of the corresponding traffic condition, which could be free-flow, slow, or stopped traffic.

3.2.3 DIVERSIONS

In the real world, TMC operators may post messages on CMSs in order to divert traffic during traffic incidents and/or traffic congestion. Based on TMC operators' experiences, a diversion message only influences the driving behaviors of a certain group of travelers and only a certain percentage of the group of travelers does divert to the new path. As a result, diversion can be expressed easily with four parameters:

- Initial route (i.e., which route the vehicle is on)
- Original path (i.e., which route travelers has planned to take);
- Diversion path (i.e., new route);
- Percentage of the group of travelers to divert.

In the TMC simulator, trainees need to create an appropriate CMS message to post and determine the optimal location to post it, in order to best effect a desired traffic diversion. The system does not incorporate a behavior model to automatically evaluate the diversion effects of the posted messages due to the existence of many different diversion routes and the difficulty in finding an appropriate behavior model that can safely do the work. Alternatively, the effectiveness of the trainee's posted CMS message is evaluated by one of the simulation instructors and a traffic diversion implemented based on their TMC experience and familiarity with the simulation network and incident. This approach helps to ensure that consistent diversion percentages are based on trainee-posted CMS messages.

The implementation of diversion effects is done through a GUI function provided by the Simulation Manager, as shown in Figure 3. As soon as an instructor finishes implementing the diversion effects, the Simulation Manager sends the diversion information described above to the enhanced Paramics. The diversion plugin will then be activated and implement a traffic diversion within the simulation.

3.2.4 SIMULATION MANAGER AND PARAMICS INTERFACE

The simulation manager communicates with Paramics simulation manager through Internet Protocol (IP) Socket communication and the data exchanged between them uses Extensible Markup Language (XML) format, a simple and flexible data formatting scheme. Currently, the contents of the exchange file include four major types of data:

- Clock synchronization
- Incident data
- Diversion data
- Speed data for camera location

Upon receiving the first three sections of data every 30 sec, Paramics simulation manager responds with speed data for all camera locations and then invokes appropriate plugin modules to emulate given activities including incidents and vehicle diversion.

3.3 Capability-Enhanced Paramics Traffic Simulation

Microscopic traffic simulation is utilized to replace real-world traffic sensor data in the TMC Simulator. This simulation allows for modeling traffic systems at a level that includes detailed specification of roads, individual drivers, and vehicles. Microscopic simulation allows field elements such as loop detectors, CMSs and CCTV cameras, and drivers' responses to incidents and CMS messages to be effectively modeled. This modeling is critical to the TMC incident management environment used in a day-to-day environment.

Notable microscopic traffic simulators include Paramics, VISSIM, AIMSUN, and MITSIM. Microscopic traffic simulation modeling is becoming an effective tool for many applications such as operational improvement and ITS evaluation (2,8,9) because of the advancement in computer technology and traffic flow modeling. The microscopic traffic simulator Paramics is used in the TMC Simulator. Paramics was selected because it is scalable to large networks and has a powerful Application Programming Interface (API), which allows for detailed modeling of traffic elements and situations (10).

3.3.1 PARAMICS SIMULATION MANAGER

The Paramics simulation manager coordinates with the TMC Simulation Manager in order to obtain model-related data, which controls the Paramics simulation process by invoking the appropriate supporting plugins to emulate incidents and vehicle diversions, collect CCTV camera and loop data, and then send traffic data to the TMC Simulation Manager and ATMSSIM.

3.3.2 SUPPLYING SIMULATED TRAFFIC DATA TO THE ATMSSIM

During TMC simulation, roadway network data is continuously reported to the ATMSSIM via the Detector Data Collection Emulator, which consists of the SATMS data collection emulator plugin and the Front End Processor (FEP) emulator. SATMS is the ramp metering and traffic data collection system used by Caltrans, which resides between FEP and field elements such as vehicle detection stations and ramp meters. The FEP is the communications management system which is used to poll data from or send data to all field elements.

The SATMS data collection emulator plugin was developed to mimic the real-world collection and packetizing of loop data based on the SATMS data format and Caltrans loop detector configurations. Figure 4 shows how loop detector data are collected in the field and how the TMC simulator implements data collection from simulation and displays in ATMSSIM. An FEP emulator was also developed to emulate the process of polling simulated detector data from the SATMS data collection emulator and sending it to the ATMSSIM for display via Remote Procedure Call (RPC).

3.3.3 CCTV CAMERA SPEED REPORTING

A CCTV camera plugin was written to report speeds associated with cameras in the simulation network. Upon receiving a request for camera speed data from the Simulation Manager, the CCTV camera plugin looks up the link the camera is located on, obtains the average speed for that link by averaging speeds of all vehicles on the link, and then sends the speed data back to the Simulation Manager.

3.3.4 INCIDENT MODELING

Although Paramics provides powerful incident modeling capabilities, it does not fit the requirements of TMC simulation, which may change the status of an incident as frequently as every 30 second; incidents must be changeable and controllable. A new incident model was developed to emulate these incidents by controlling the speeds of vehicles on affected and neighboring lanes according to incident type and the status of the incident. For example, an incident with two blocked lanes causes speeds of vehicles on the lanes with incident to be zero and speeds of vehicles on other lanes to be affected (in both directions) as well due to drivers' curiosity. The parameters used by the incident model are speed delta, defined as the speed addition from the lane with incident, for each lane under different types of incidents. For example, if there is an incident blocking lane 1 and the speed delta for lane 2 is 10, it means the driving speed on lane 2 is 10 mph. Speed delta parameters of the incident model was calibrated based on data (incident type and queue building up speed) provided by Caltrans.

3.3.5 DIVERSION MODELING

A diversion modeling plugin was developed to allow Paramics to respond to requests from the Simulation Manager to divert traffic from one highway to another at a junction. Upon receiving a diversion request, the diversion plugin finds the diversion path information (decision link and path nodes on diversion path) from the pre-defined diversion lookup table based on diversion data from Simulation Manager, finds a qualified group of vehicles by checking their original paths, selecting vehicles to divert from their original path. Diversion vehicles are selected based on the diversion percentage. These selected vehicles will be controlled by the plugin to follow the diversion path.

3.3.6 PERFORMANCE MEASURES

Both system level and corridor level performance measures are collected from the Paramics simulation process in order to evaluate simulation network's performance, as a way to evaluate students' performance. The system level measures Vehicle Hour Traveled (VHT), Vehicle Miles Traveled (VMT), and average vehicle traveling speed. The corridor level performances include traveling speeds on specified freeway sections and/or along the whole freeway corridors.

3.4 CHP CAD SIMULATOR

The CHP CAD Simulator utilizes a client-server model to implement California Highway Patrol Computer Aided Dispatch functionality within the TMC Simulator. The CHP CAD Simulator was designed to have the same look and feel of the operational CHP CAD. The CHP CAD Simulator implements a subset of actual CHP CAD user commands.

3.4.1 CHP CAD SERVER

The CHP CAD server performs the functions of:

- Initiating incidents within the CAD simulator.
- Receiving incident-data input from any of the CHP CAD clients or from the Simulation Manager.
- Providing all received incident-data to the CHP CAD clients.
- Facilitating message passing between any of the CHP CAD clients.

The CHP CAD server clients and the Simulation Manager are treated equally by the CHP CAD server from the perspective of the entry of incident-data; both provide incident-data to the CHP CAD server using standard CHP CAD data entry keystroke commands.

3.4.2 CHP CAD CLIENTS

CHP CAD clients reside at various student workstations in the TMC Simulator. Each client logs into the server and allows its user to view and update the real-time CHP incident logs including log entries, assigned units, tow vehicles, and witnesses for current incidents. The CAD client will also notify the user of any updates to any incidents currently being viewed.

3.5 Telephone System

The design of the phone system in the next generation TMC Simulator is a key component to creating a realistic experience for the student. The system allows the instructors to call from the control room into the simulator, and emulate a call from any allied agency (police, fire, and other Caltrans districts), members of the media, and the general public. There is no way for the student to anticipate who is calling them or where the call is originating from.

The converse is true for the instructor, as all calls made by the the student are routed to the instructors. The calls are displayed in the instructors' telephone LCD screen, and notify the instructor of which student is calling, and the agency he or she is trying to reach (Anaheim PD, Fire Department, Director of Public Works, OES, etc.). This enables the instructor to respond appropriately when answering the call.

4. APPLICATION

4.1 GEOGRAPHIC SIMULATION AREA

The project area was carefully selected to be neither too small nor too large. On one hand, its size needs to be large enough to appropriately design incident scenarios under which TMC operator students can be trained. Also, a network with reasonable size will challenge the students in incident management activities such as dispatching vehicles and/or personnel to the field and posting appropriate messages for diverting vehicles. On the other hand, the size of the project area cannot be too big due to the limitation of computational power. TMC operator training must be held in a real-time or faster-than-real-time mode; simulation speed must be kept at a speed faster than the real-time throughout the whole simulation process, especially during the most congested time periods of the simulation. If the simulation speed is slower than real time, ATMSSIM will not display traffic data in a timely fashion, which will negatively affect the training.

Figure 5 shows the map for Orange County, California, where District 12 of Caltrans is in charge. The prototype TMC simulator system was currently applied to a part of the Orange County freeway network located in City of Irvine (within the triangle area). It includes sections of three of Orange County's principle freeways, I-5, I-405, and SR-55. The lengths for I-5, I-405 and SR-55 are 18 miles, 12 miles and 10 miles respectively. The area is well covered by loop detectors, has several busy freeways, and also contains a variety of High Occupancy Vehicle (HOV) lane configurations.

4.2 Simulation model

As shown in left side of Figure 6, the study network was coded into Paramics based on aerial photos and geometric data from Caltrans. A previous study has demonstrated that the simulation model is well calibrated and accurately represents traffic conditions on the target network (9).

4.3 Training & Simulation

TMC training requires two rooms. One is a simulation room where students get trained and the other is a control room where instructors control the training process, interact with students, and evaluate student performance.

The instructors select a prepared incident script that controls all simulation activities to begin a training session,. Upon starting of the script, Paramics loads the correct simulation network and begins populating the network with vehicles simulating traffic. A warming-up period is required in order to fill vehicles in the simulation network. When the warming-up is done, instructor can start formal TMC simulation.

During TMC simulation, the Paramics simulation manager is driven by the Simulation Manager. Every 30 sec, the Simulation Manager sends model-related data in the above format to Paramics simulation manager that responds with the average speed for all camera locations, which are used by the Simulation manager to associate videos and images with CCTV cameras. Based on received model-related data, Paramics will then emulate incidents and/or diversions whilst providing ATMSSIM with traffic data by invoking appropriate plugin modules. Also, the clock synchronization between the Simulation Manager (which runs at real time) and Paramics simulation (which runs faster than real time) is important. If Paramics simulates too fast, the Paramics simulation manager can simply make Paramics to wait. If Paramics simulates slower than real-time speed, a queuing model will be enabled from the Simulation Manager side to make sure Paramics will not miss any modeling requests.

During the training, the tasks instructors conduct in the control room also include:

- Instructor controls the CAD Simulator Manager to start, pause and end simulation;
- Instructor can modify the scheduling and severity of the pre-loaded incidents through the CAD simulation manager to suit students' abilities;
- Instructor monitors the actions of students through CCTV cameras and audio system;
- Instructor evaluates the message posted on CMS of ATMSSIM by students and determine the diversion effects;
- Fulfill the role of agents external to the simulated TMC, such as Caltrans service personnel, news media personalities and staff, CHP dispatch, , or motorists.

Students are trained in the simulation room. During the training, they may encounter some operational scenarios designed by instructors. They need to work together to respond to incidents in the way they need to do in the real TMC. The major tasks include:

- Verify incidents via CCTV, ATMSSIM, and CAD client;
- Communicate with CHP, FSP and other related personnel via radios or telephones;
- Alert travelers by posting messages on CMSs or reporting to HAR and the media;
- Divert vehicles by posting diversion messages on CMSs via ATMSSIM.

Figure 6, 7, and 3 are snapshot images taken during the operator training. Figure 6 demonstrates that ATMSSIM displays the equivalent traffic congestion as Paramics. Figure 7 shows students posting diversion messages onto three CMSs via ATMSSIM workstation in the simulation room. When the instructor notices these messages from another ATMSSIM workstation in the control room, the diversion effects of these messages are evaluated by trainers through CAD simulation manager, as shown in Figure 3.

So far, four training classes have been conducted. Both Caltrans and students appear satisfied with system performance and training results, and believe that it will potentially save significant efforts of Caltrans on TMC operator training.

5. CONCLUDING REMARKS AND FUTURE WORK

A TMC simulator has been developed at California Advanced Transportation Management Systems Testbed located at University of California, Irvine. As previously mentioned, this is the next generation TMC Simulator, as envisioned by the California Department of Transportation Office of System Management and Operations. This simulator and the systems that have been integrated together have allowed for an unprecedented leap forward in capability when compared to the methods of the past.

The TMC simulator is effective at its primary task of providing a training environment for California TMC operator training. The TMC simulator also has the potential to serve as a true testing environment for ATMS upgrades and enhancements in California. The TMC simulator mimics the full-functionality of a Caltrans TMC. It has the simulated versions of all software used in a real-world TMC and also establishes a “virtual” connection to the Caltrans field traffic system that includes vehicle detector stations, CMS, and CCTV camera stations through microscopic traffic simulation. Using this comprehensive TMC simulator environment, TMC operators from different districts can be trained together and can effectively exchange experiences and learn skills from each other. Four training classes have been successfully performed since the completion of the new TMC simulator.

Future work includes the development of additional incident scenarios for training purposes, the enhancement of the system to be able to evaluate students’ performance, and the extension of the TMC simulator’s capabilities to handle a larger network once additional computational power becomes available. These efforts will allow training instructors to subject TMC operator candidates to increasingly realistic and complex scenarios. The TMC simulator and future scenarios for it are being planned to include TMC support of homeland security and evacuation management. This will allow TMC operators to be “trained” to respond to homeland security threats. In addition, future TMCs will utilize enhanced traffic control and management capabilities by incorporating ramp metering and signal control functions. As a result, the signal and metering functions will need to be added to the TMC simulator. Since signal control and metering will be even harder for students to grasp, simulator-based TMC operator training be play an even more important role.

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7. REFERENCES

1. Booz Allen Hamilton Inc. and Kimley-Horn and Associates, Inc. Traffic Management Center Business Planning and Plans Handbook, Federal Highway Administration 2005.
2. Chu, L., Liu X., Recker, W. (2004) Using Microscopic Simulation to Evaluate Potential Intelligent Transportation System Strategies under Nonrecurrent Congestion, Transportation Research Record 1886, pp.76-84.
3. TMC Pooled-Fund Study website, http://tmcpfs.ops.fhwa.dot.gov, visited at 11/7/2007.
4. I-95 Corridor Coalition website, http://www.i95coalition.org/traffic-management-simulation.html, visited 11/7/2007.
5. Hockaday, S.L.M., Mastako, K., Chatziioanou, A., Cribb, S., (1993) Simulation Based Training for Transportation Management Center (TMC) Operators, Pacific Rim TransTech Conference, Volume 1: Advanced Technologies, pp.305-310.
6. Hockaday, S.L.M., Kaighn, S., Gerfen, J., Mastako, K. (1995) Evaluation of ATMIS technologies prior to field deployment, Vehicle Navigation and Information Systems Conference, Proceedings. In conjunction with the Pacific Rim TransTech Conference, pp.404 – 407.
7. Sullivan, E., Gerfen, J., (2002), Caltrans Transportation Management Center Next-Generation Simulator, Internal Report to Caltrans Traffic Operations
8. Chu, L., Liu X., Recker, W., Zhang, H.M. Performance Evaluating of Adaptive Ramp Metering Algorithms Using Microscopic Traffic Simulation Model, Journal of Transportation Engineering, 2004, vol.130 (3): 330-338.
9. Breiland, C., Chu, L. and Benouar, H. (2006) Operational Effect of Allowing Single Occupant Hybrid Vehicles into High Occupancy Vehicle Lanes, Transportation Research Record 1959, pp151-158.
10. Gordon D. B. Cameron1 and Gordon I. D. (1996) PARAMICS-Parallel microscopic simulation of road traffic, The Journal of Supercomputing, vol. 10 (1), pp 25-53.

Figures

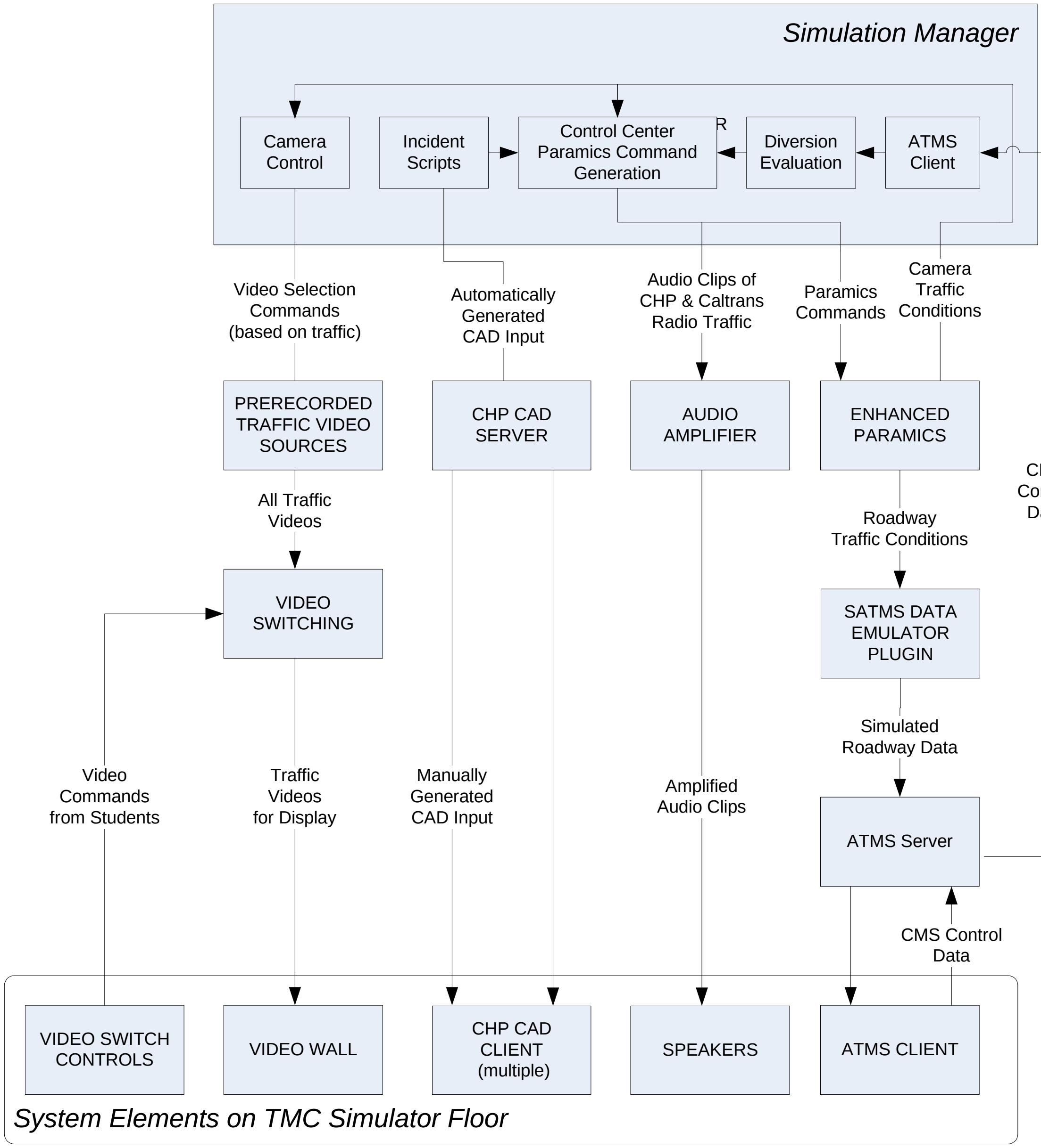

Figure 1 TMC Simulator Framework

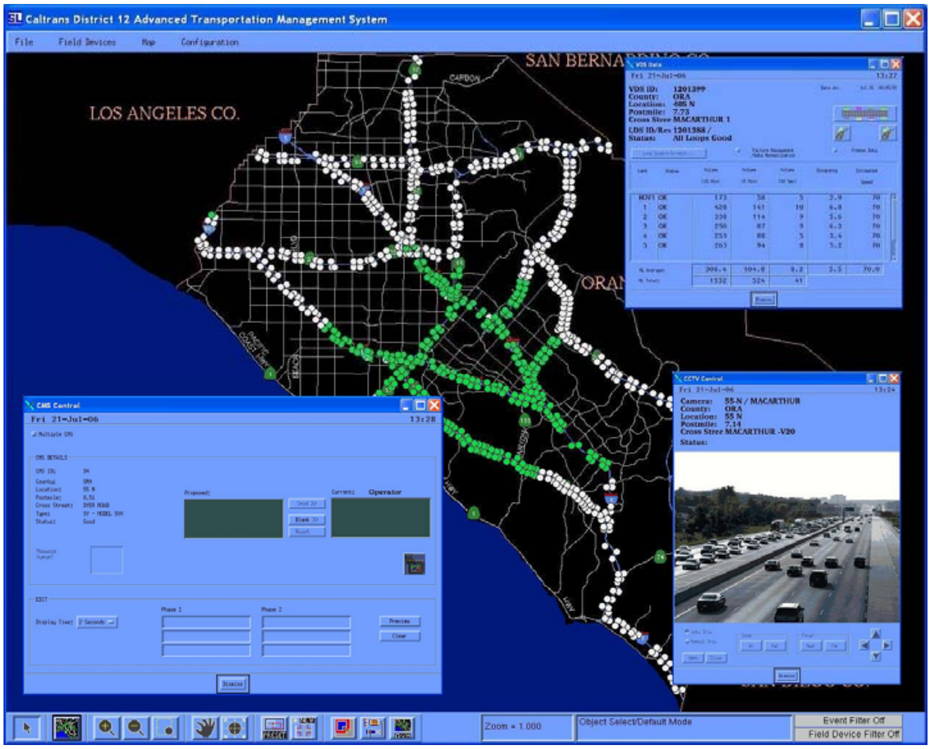

Figure 2 ATMSSIM under simulation mode

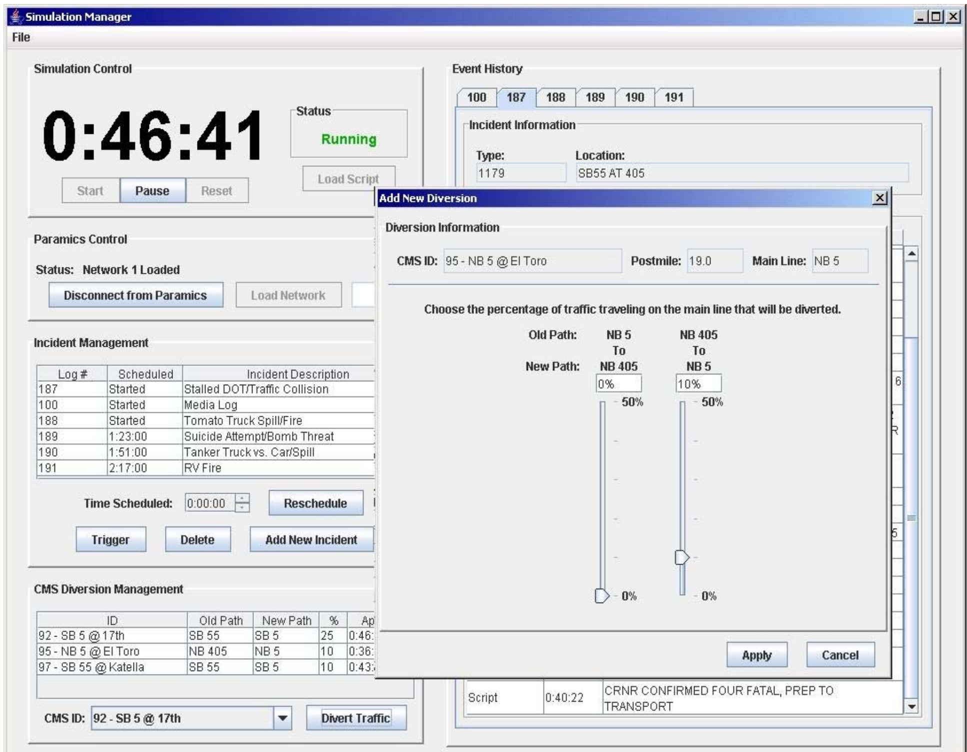

Figure 3 Instructors evaluate diversion effects

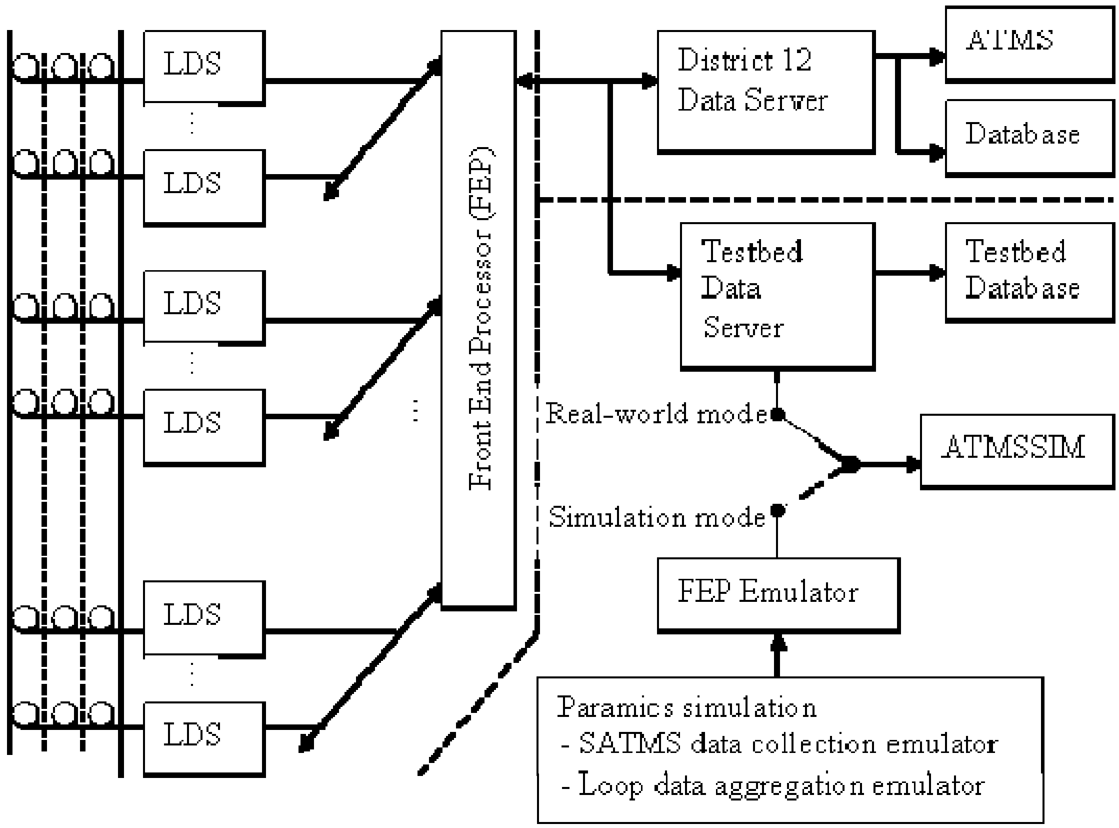

Figure 4 SATMS Emulator routine

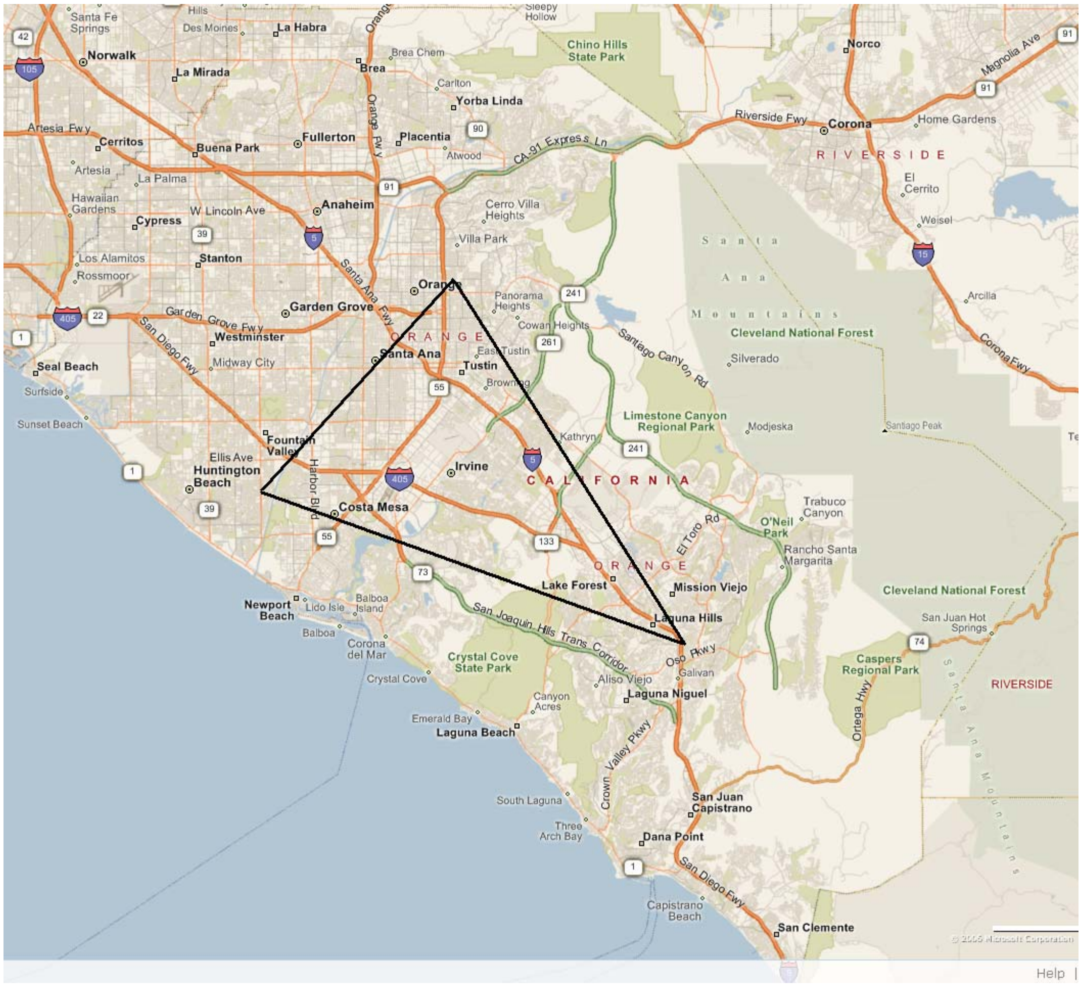

Figure 5 Study Site (Source: Windows Live Local)

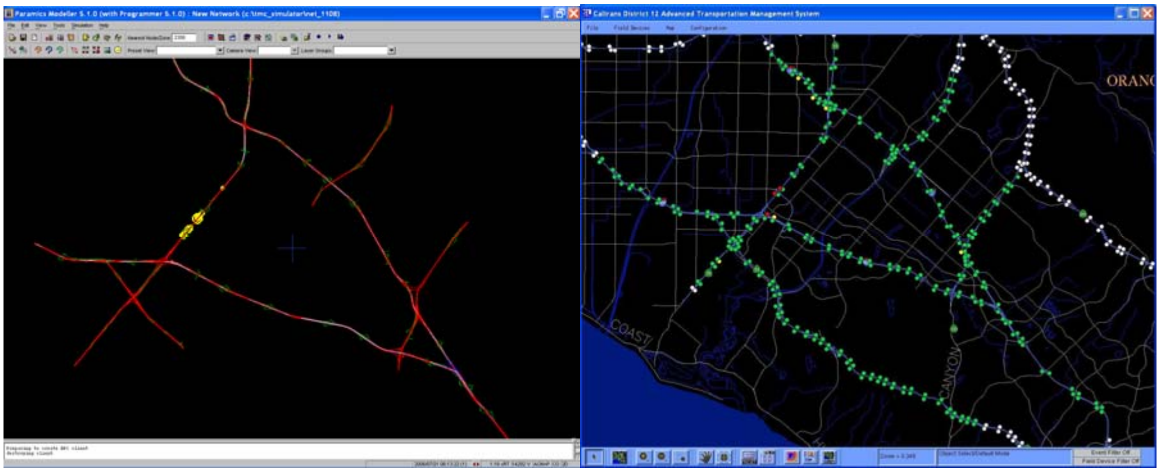

Figure 6 Equivalent traffic condition shown in both Paramics and ATMSSIM

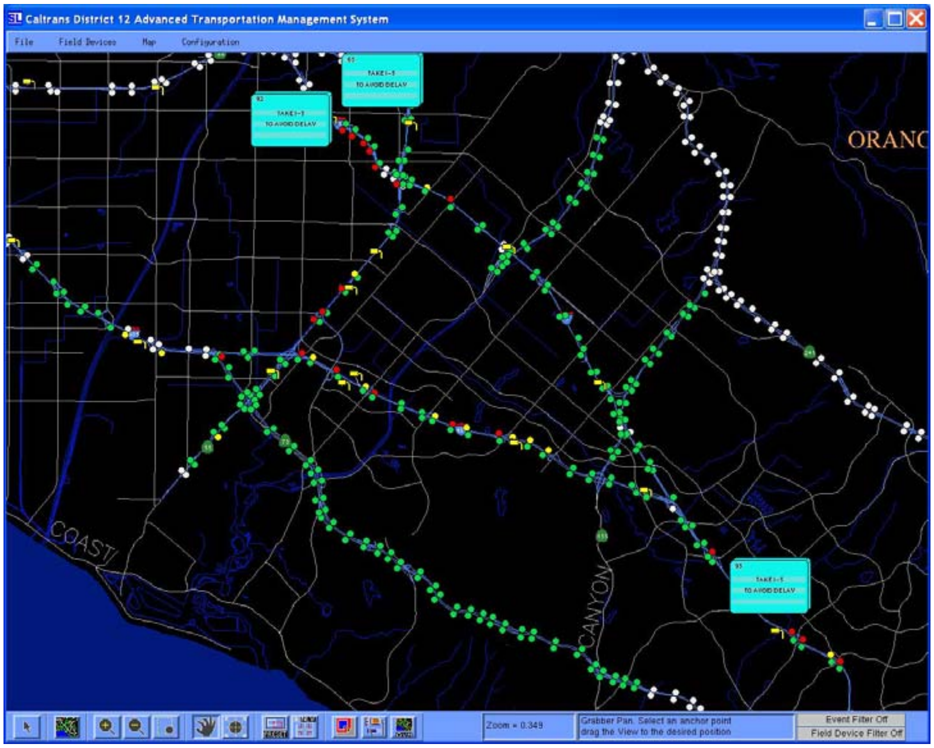

Figure 7 Students post messages on CMSs