TOWARDS COLLABORATIVE NETWORK COMMUNICATION USING SIMULATION-BASED TRAFFIC MODEL

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KEYWORDS

collaborative communication, traffic simulation, traffic analysis and ETC system

ABSTRACT

The authors have been working on a simulation-based solution for traffic issues around ETC toll plaza of expressways in Japan. Timely and detailed discussions are required to propose a better solution. However, it is not always possible to hold timely meetings because of time/distance reasons for participating members. This research proposes an approach of collaborative communication based on IP video conference system with video streaming function, which is designed to support remote audio/video communication along with simulation-based video streaming which can be shared among participating members. This paper describes the simulation model for traffic analysis around ETC toll plaza, shows the basic mechanism of IP video conference with video streaming function, and discusses the validity of our approach using some experimental results.

INTRODUCTION

The authors have been studying ETC toll plaza issue from various respects using simulation-based traffic model approach, some of which have been reported so far. To study the issue of traffic jams and to find solutions, participating members of the project needs to get together and have discussions in a timely manner. However, the members may be physically distributed and it may not be always easy to get together in one place in a timely manner. So basically what we use in this project is a network-based collaboration approach using IP-based video conference system.

IP-based communication tool, such as video/voice conference systems, is becoming popular these days. These systems can be used quite effectively in our projects. However, it is not always easy to share the most updated information, or to interactively update the information during meetings over the network. File sharing over the network could work quite effectively in restricted conditions. However, file sharing is not always available for security purposes. Under these circumstances, in addition to conventional network-based communication function with audio/video communication, we are developing VOD-based simulation function, in which we can timely review simulation results during our discussion.

This paper first addresses the issue of traffic jam around ETC toll plaza, a solution to which is the goal of our research. Then the paper presents the overview of our approach using simulation-based model. Describing the basic module of our collaboration system which is called CELAVIS, the paper shows the overall systems using video-on-demand simulation, and discusses the feasibility of our approach.

SIMULATION MODEL FOR ANALYSIS OVER TRAFFIC JAMS AT ETC TOLL PLAZA

Model of toll plaza

The model in this study covers traffic jam vehicles ranging from the starting point of traffic jams, all the way to toll plaza which is the bottle-neck of the traffic, and exit of the toll plaza. This section describes the definition of simulation model to represent the traffic jam, and some of the critical parameters used in the model. Analyzing the process of traffic based on the process oriented approach, basic 6 processes starting from the vehicle generation to toll gate exit are defined as follows.

(1) Generation of vehicle entities: Vehicle entities are generated at the starting point in the simulation either as ETC or non-ETC vehicles, of which attributes such as passenger vehicle or large commercial vehicles are assigned here to be used in the simulation process.

(2) Lane selection: One of the lanes is selected from several candidate lanes. Selection ratio is assigned to each vehicle based on predefined probabilities, vehicle types, traffic condition, etc.

(3) Vehicle travel time: The travel time for each vehicle is calculated according to the travel distance

from the starting point to the end of traffic jams, which is up to the traffic condition.

(4) Selection of toll gates: Availability of gates to each vehicle is first made clear. For example, ETC-only gate is only available to ETC vehicles, which means non-ETC vehicle cannot take ETC-only gate. Then, one of the gates will be selected.

(5) Toll payment: Any vehicles arriving at the booth occupy the gate, which means other vehicles need to wait in a queue. Job queue is used to represent the line of vehicles.

(6) Gate exit: After toll payment, vehicles are regarded to leave instantly without any traffic jams because the model covers until the gate exit.

Input parameters for the model

Generation of vehicle entities

Interval of generation for vehicle entities is determined based on the assumption of the number of arriving vehicles per unit time, which is arbitrarily assigned beforehand.

$$t_i = \frac{T}{N} \tag{1}$$

ti : interval of vehicle entity generation [sec]
T : arbitrary time [sec]
N : estimated number of arriving vehicles

Interval time

The interval time is determined based on exponential distribution curve to randomly generate initial vehicles at the starting point. Each vehicle type is assigned based on some initial parameters, or stochastically assigned.

Vehicle travel time

Vehicles travel from the initial point to toll gate under the restriction of traffics. The travel time for this movement is defined as Scheme 2.

$$T_d = \frac{[L-(L_s+L_t)]}{V_c} + \frac{L_s}{V_s} \tag{2}$$

Td : travel time using travel distance [sec]
L : distance from starting point to toll gate [m]
Ls : distance from traffic-end to toll gate [m]
Lt : traffic jam length [m]
Vc : ave. travel speed [m/sec]
Vs : ave. speed during deceleration [m/sec]

While all of the parameters with one exception of traffic jam length are determined in Scheme 2, the remaining parameter of traffic jam length is determined by the calculation of travel time in simulation. When a vehicle reaches to the end of traffic jams, the expected travel time to the toll gate is calculated.

Service time

Service time at toll booth is determined for ETC/non-ETC vehicles respectively. The time is either set to a fixed value or derived from distribution curve.

Simulation results

As for simulation environment to implement the model presented in the sections 2.1 and 2.2, this study adopts process simulation software called Arena 6.0 by Rockwell Software Co. Verification of simulation model was carried out based on some real traffic jams data, and significant results were obtained.

Table 1: Gates conditions of simulation

Case	The gate type to be used
Case-1	General gate*3 ETC gate*1
Case-2	General gate*3 Combined use gate*1

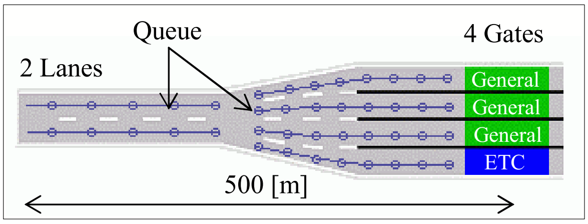

Figure 1: Example of ETC tollgate model

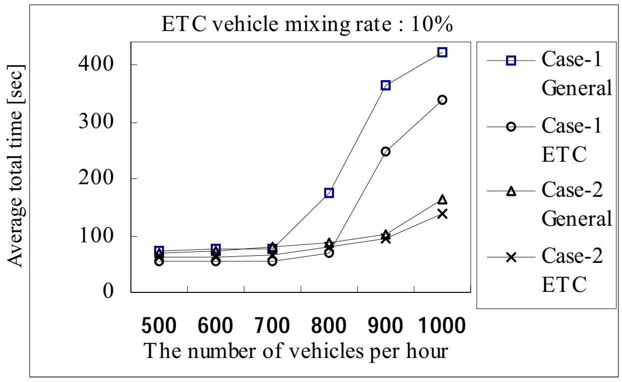

Figure 2: Comparison of average total time for the number of vehicles

Proceedings 19th European Conference on Modelling and Simulation
Yuri Merkuryev, Richard Zobel, Eugène Kerckhoffs © ECMS, 2005
ISBN 1-84233-112-4 (Set) / ISBN 1-84233-113-2 (CD)

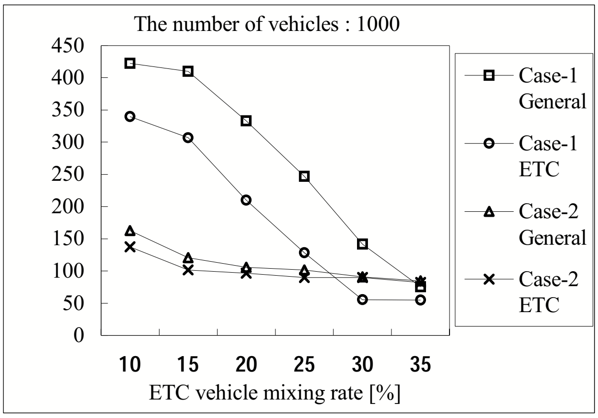

Figure 3: Comparison of average total time for ETC vehicle mixing rate

This paper shows some comparative results using several conditions based on a simple simulation model as show in Figure 1. Service time [sec] of ETC/non-ETC vehicles at the gate is determined by a triangular distribution of (14,16,18) and (3,4,5), respectively, for 1 hour simulation each.

Figure 2 shows the change curve of average travel time according to the increase of traffic volume. It shows that the travel time of Case-1 using ETC-only gate by far exceeds that of Case-1 which adopts a combination gate to comply with the traffic condition. What does this means is that introduction of ETC gate indirectly decreases the availability for non-ETC vehicles, resulting the traffic jams which affect even ETC vehicles.

Figure 3 shows the affect of ETC penetration ratio to traffic jams. If the penetration ratio reaches to 35%, travel time of Case-1 with combination gate would become shorter than that of Case-2, which indicates that 35% is a target ratio to enjoy the benefit of ETC system. This result can give a good reference in designing toll plaza.

IP-BASED VIDEO CONFERENCE SYSTEM (CELAVIS)

IP-based video conference system called CELAVIS (Collaborative Engineering LAboratory VIdeo conference System) plays a central role in the communication system presented in this paper. CELAVIS is a custom-made IP-based video communication system which has been developed in CE lab (Collaborative Engineering Laboratory) at the University of Tokushima. Using CELAVIS server based on Flash Communication Server MX (FCS) of Macromedia Co., custom-made client software which we have developed enables audio/video communication based on RTMP (Real Time Messaging Protocol) protocol developed by Macromedia. Client PC requires Flash Player (Plug-in) to use CELAVIS system but no other specific requirements are needed. This section covers the overview of CELAVIS.

One of the advantages of CELAVIS architecture is that custom-made configuration or modification can be applied to the system based on the need of users. For our research purposes, commercial system is not a good choice for this reason. As for some implemented features of CELAVIS, user/client authentication, bidirectional distribution of video images, two-way audio conversation, text chat, etc.

User/client authentication makes it possible to keep CELAVIS secure and available only to our research community. Accessible client machines are controlled by CELAVIS server to make it secure as well. Two-way audio and/or video function provides basic communication tool but it also enables conference communication for multiple sites.

Users can enjoy the service either by locally installed software or by web access. Figure 4-a shows the client program access, whereas Figure 4-b shows the web browser access. In either access, CELAVIS users can communicate using on-demand video streaming function as well as audio/video functions using typical Laptop/PC.

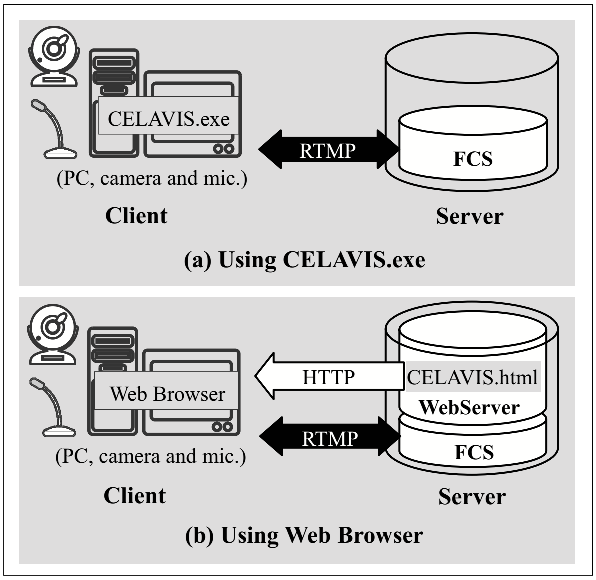

Figure 4: Client connection methods

Figure 5 shows an example for the former access. Upon authentication, the client machine loads audio/video data from microphone and CCD camera, and perform an internal process to communicate with the CELAVIS server. Active user information is managed by the server, and displayed to the user interface. Selecting an active user from the list, communication line will be established. For audio/video conference, each user makes connection to the corresponding users, which will establish conference connection for multi-users.

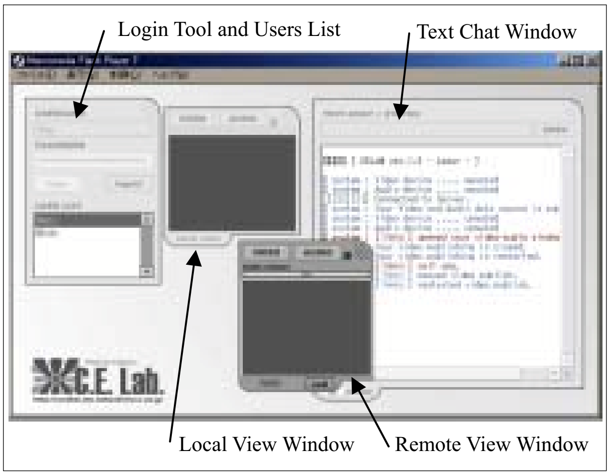

Figure 5: User interface of CELAVIS

Login tool and user list shown on the upper-left of Figure 5 show an active user list. Local and remote view windows, and text chat windows are show as well.

SIMULATION WITH VIDEO STREAMING

For technical video meeting, sharing of on-demand simulation results as well as audio/video communication can play a critical role, which is the basic idea of this research. On-demand video streaming function was implemented using FCS server. Currently, streaming function is implemented as a separate function to CELAVIS. However, integration to CELAVIS can be available. This section covers how the video streaming function has been implemented.

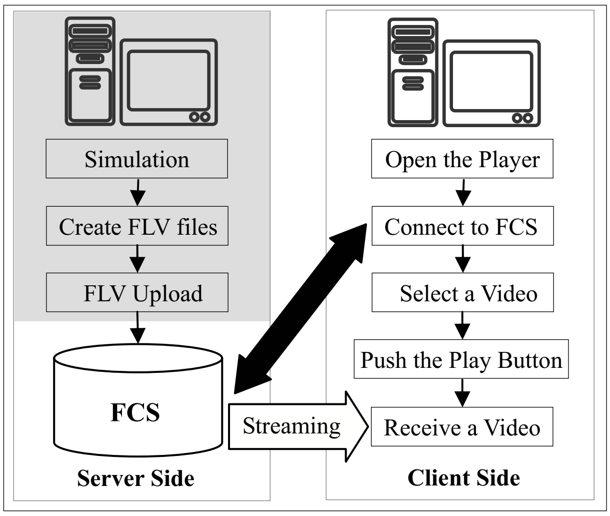

Figure 6: Workflow of server side and client side for video streaming

Figure 6 shows an overview of how to set up the video streaming function in this study. Video streaming data has been prerecorded from simulation processes and converted to FLV format so that it could be uploaded to FCS server. CELAVIS user launches client software or activates it from web site to play the streaming video. Function of player software includes basic functions, including monitor window, video selection, play/rewind/forward/stop buttons, etc.

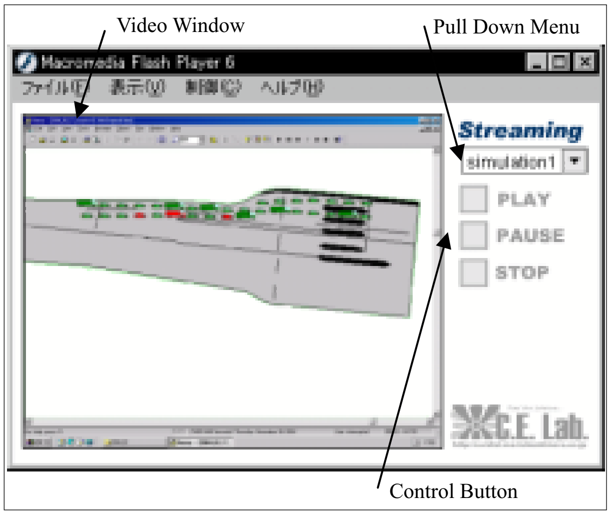

Figure 7: User interface of video streaming tool

When the player is launched, RTMP connection to FSC server is automatically established. During video conference, participants can share simulation results in the form of video streaming on-demand basis, selecting one of the videos using pull-down menu.

Figure 7 shows an example of user interface of video streaming tool which will be integrated into CELAVIS. Video window in Figure 7 shows simulation result based on traffic jams occurred around toll plaza with ETC gate. The system allows users to manipulate basic operations to review the video streaming during video conference. Parameter change in simulation requires rerunning of simulation, which means that interactive parameter change is not allowed here. However, preparation of simulation results beforehand based on several parameters makes it possible to review the results during the video conference.

As for the resolution of video streaming, low resolutions, or 72-144dpi video images were used in this study. This resolution is quite low, however, sharing of video image information did work quite well for video conference to discuss traffic issues, which is not image quality-oriented. If the topic of discussion were more image quality-oriented, for example, image processing, color reproduction, image quality, much higher resolution may be required.

RESULTS AND DISCUSSION

This paper described the overview of process simulation model to study traffic jams occurred in ETC toll plaza. To verify the model, data collection at a real traffic jam site was performed and used in this study. Much detail regarding the simulation model has been reported.

The paper then presented the integrated test environment including CELAVIS video conference and video streaming function where simulation results can be shared for video conference participants who may be distributed globally. As for the conversation using audio/video communication, the results were quite favorable in most of the cases of video conferences held so far, in terms of quality-wise of video image and audio sound. In the meantime, image quality was not good enough to share detailed images of reference materials on video screen, such as detailed view of physical object. However, low resolution of video streaming images not only worked fine in our study, but also allows us to A few seconds of time delay was observed during conference depending upon the time of the day because of network traffics.

Video streaming was timely and effective to accelerate the sharing feeling of overview information for most of the participants. Detailed information can be more effectively shared by some alternative way such as file sharing. However, timely and effective means of information sharing, the objective of video streaming worked fine. Further study should be conducted regarding the process of video streaming preparation and their management on the web.

CONCLUDING REMARKS

The paper described the approach of collaborative communication environment using IP-based video conference system with video streaming function. The case study in this research includes the simulation-based approach to problem solving for traffic jam issues occurring expressway toll plaza with ETC gate.

On one hand, face-to-face communication might be more natural for us than network-based communication. On the other hand, the latter provides us more extension of communication environment than the former does. The video conference results using video streaming communication showed good results, which moved this research one step forward to the collaborative communication over the network.

ACKNOWLEDGEMENT

The authors would like to acknowledge the support and cooperation of Shikoku Branch Office of Japan Highway Public Corporation, which was provided to this research.

REFERENCES

Fernandes, R.J. and S. Bampi. 1998. “A software environment to integrate urban traffic simulation tasks”, Proceedings of the 10 th European Simulation Symposium, October 26-28, Nottingham, United Kingdom, pp.371-377.

Gale, C. and M.J.Oliveron and G.Silvan. 2002. “Simulation tool for managing a non-automated distribution warehouse”, Proceedings of the 14 th European Simulation Symposium, October 23-26, Dresden, Germany, pp.266-270.

Horiguchi, R. and M. Kuwahara. 2000. “A theoretical analysis for the capacity of toll plaza partially with ETC tollgates.” Journal of Japan Society of Civil Engineers, No.653/IV-48, pp.29-38. (in Japanese)

Ito, T. and T. Hiramoto. 2004. “Analysis of traffic jams using process simulation model.” Vol.3, No.3, pp.371-372 (2004) (in Japanese)

Ito, T. 2004. “An approach of whiteboard-based interface for collaborative environment.” European Concurrent Engineering Conference, Hasselt, Blegium, April 19-21, pp.71-75.

Johanson, B., A. Fox and T Winograd. 2002 “The Interactive Workspaces Project: Experiences with Ubiquitous Computing Rooms.” IEEE Pervasive Computing Magazine 1(2), April-June, 71-78.

Kiyan, K., et al. 2003. “Construction of regional cooperation activities support system combined television conference and streaming distribution.” Journal for academic computing and networking, No.7, pp-33-42. (in Japanese)

Krajzewicz, D., G. Hertkorn and P. Wagner. 2002. “An example of microscopic car models validation using the open source traffic simulation SUMO”, Proceedings of the 14 th European Simulation Symposium, October 23-26, Dresden, Germany, pp.318-322.

Milne, A. and T. Winograd. 2003. “The iLoft Project: A Technologically Advanced Collaborative Design Workspace as Research Instrument.” Proc. Int’l Conf. on Engineering Design ICDE2003, Stockholm, August, pp-no.1657.

Ponnekanti, S.R., B. Johanson, E. Kiciman and A. Fox. 2003. “Portability, Extensibility and Robustness in iROS.” Proc. IEEE International Conference on Pervasive Computing and Communications (Percom2003), Dallas-Fort Worth, TX. March.