Evaluating a Signal Control System Using a Real-time Traffic Simulator Connected to a Traffic Signal Controller

Kazama, T. [1], N. Honda [2] and T. Watanabe[2]

[1] Kyosan Electric Mfg Co. Ltd.,Yokohama City, Japan
[2] The University of Electro-Communications, Chouhu City, Japan
Email: t-kazama@kyosan.co.jp

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EXTENDED ABSTRACT

A platform has been developed for evaluating a signal control system using a real-time traffic simulator with an actual traffic signal controller.

In this simulation platform, signal controllers that operate in the traffic simulator show signal aspects instructed actual traffic signal controller. Because the interface of a practical signal controller transmits contact-point conditions, the interface cannot exchange information directly with a traffic simulator program operated on a personal computer. So, a LAN/parallel converter was used to convert contact-point conditions from the signal controller into a LAN packet that is connected to the traffic simulator.

In this simulation platform, Because no traffic signal control algorithm needs to be incorporated into the simulator, a number of signal control algorithms jointly operated can be evaluated easily. Using the simulation platform, a signal controller can have optimum signal control parameters for evaluating traffic status at any time by outputting to the traffic evaluation system whether or not there are cars at a point selected in the traffic simulator. A significant merit of the simulation platform is that it can evaluate various local traffic conditions without requiring installation of a traffic signal controller in the field.

At present in Japan, the so-called "Profile signal control system" is being considered to be put into practice. The profile signal control system which realizes an optimum signal control based on the prediction of the vehicles arrival in the future can become a solution.

The profile signal control system was evaluated by using the simulation platform. Vehicle arrival data were given to the model intersection in the traffic simulator thereby delay times were compared between profile signal control system and conventional signal control system to operate signal controllers.

As a result, the profile signal control system renders less total delay times than the conventional signal control system. Also, at each time period, the profile signal control system gives less total delay times than the pattern signal system, so the authors could confirm that the profile signal control system is effective for reducing delay times.

The novel simulation platform was constructed by connecting practical signal controllers to the traffic simulator, and applied to evaluate signal control systems in practice. Consequently, the simulation platform the authors have now developed plays an important role in evaluating profile signal control systems.

1. INTRODUCTION

When a signal control system is evaluated in a road traffic control system, the normal practice is to install the signal controller in the field for system evaluation. However, in a field environment, it is impossible to reproduce practical traffic conditions or assumed conditions (incidental demand variations, oversaturated status, very rarely emerging traffic conditions, etc.).

A traffic control system can also be evaluated using a traffic simulator as a substitute field evaluation. However, pattern signal traffic simulators are closed systems. Therefore, a traffic simulator needs to incorporate an algorithm for a signal controller operated in the respective signal control system.

To solve these problems, the authors constituted a simulation platform wherein a practical traffic signal controller is connected directly to a traffic simulator, and the signal control system can be evaluated and examined.

This paper outlines the simulation platform and examples of evaluations for signal control systems using the simulation platform.

2. SIMULATION PLATFORM

2.1. Outline of simulation platform

The simulation platform shown in Fig. 1 was configured to evaluate signal control systems by connecting practical signal controllers to a traffic simulator. Because the interface of a practical signal controller transmits contact-point conditions, the interface cannot exchange information directly with a traffic simulator program operated on a personal computer. So, a LAN/parallel converter was used to convert contact-point conditions from the signal controller into a LAN packet that is connected to the traffic simulator. On this simulation platform, traffic signals in the traffic simulator are controlled according to signal aspects outputted from the signal controller, and the platform can output car presence information (car-sensing information) at any point in the traffic simulator to the signal controller.

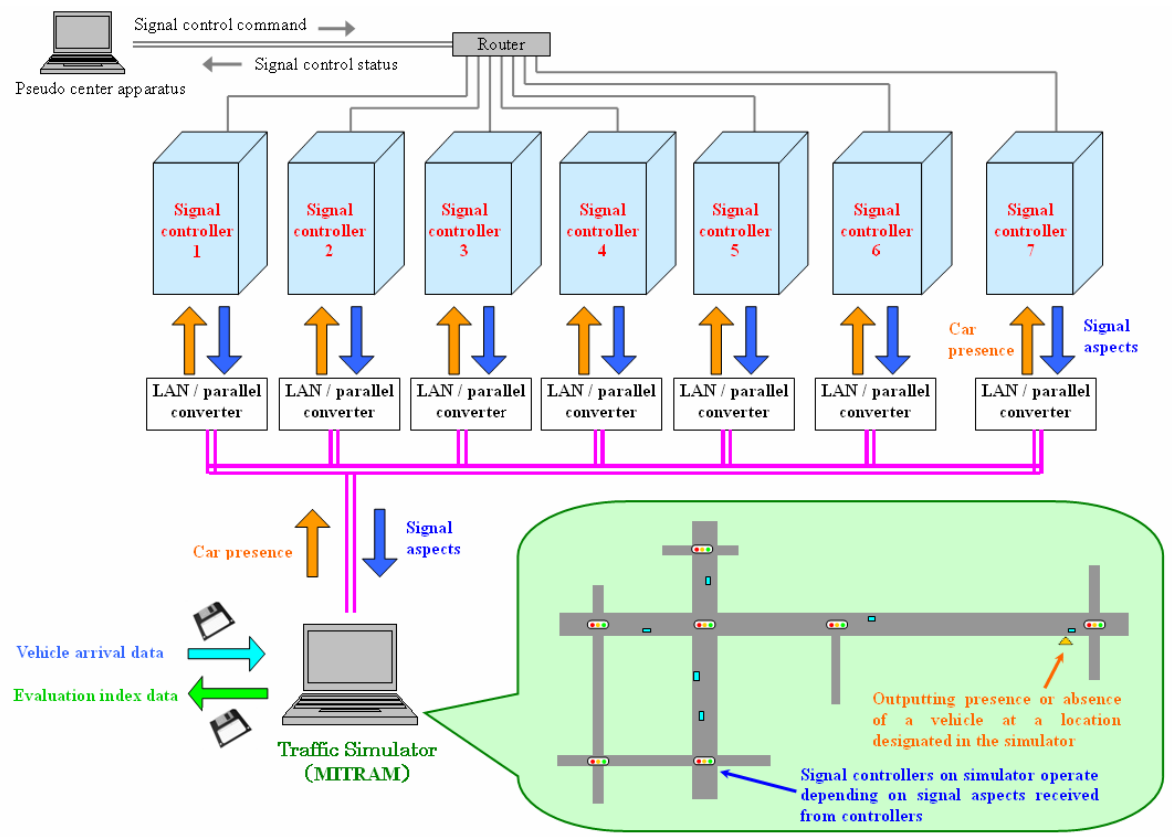

Figure 1. Simulation platform.

2.2. Traffic simulator

The simulation platform configured at present is based on a traffic simulator (MITRAM) developed under the leadership of The University of Electro-Communications, and is a micro-simulator that can express the behavior of vehicles using fuzzy calculations. Each vehicle in the simulator moves individually depending on space headways and signal light colors, and can individually judge whether to turn right, left, or change lanes.

Figure 2. Example of traffic simulator screen.

Vehicle arrival data can be set freely in the traffic simulator. It is also possible to acquire evaluation index data such as delay time after a simulation has been carried out, for each approach road.

Before the simulation platform was constructed, the traffic simulator had been used for various evaluations and examinations with actual roads, and it has been confirmed that the sectional traffic volumes shown in the simulator agree substantially with practical data.

The details of the traffic simulator have already been presented in other papers etc., so no further description is given in this text.

2.3. Advantages of simulation platform

Using the present simulation platform, identical controllers to commercial ones can be connected to and operated with the traffic simulator by means of a simple wiring work.

Traffic signals processed in the traffic simulator of this simulation platform are not limited only to any particular signal control system, but a signal controller with any type of signal control system can be connected. The authors succeeded in making a compact platform that can be operated from a personal computer, by separating the signal control algorithm from the traffic simulator, and limiting traffic simulator functions to those needed mainly for reproducing road traffic phenomena.

Another merit of this simulation platform is that by connecting an actual signal controller to the traffic simulator, traffic conditions similar to real ones can be reproduced or a trial examination can be implemented by giving assumed conditions (sporadic demand fluctuation or oversaturated status).

3. EXAMPLE OF SIGNAL CONTROL SYSTEMS EVALUATION

3.1. New signal control system

At present in Japan, the so-called profile signal control system with the following features is being considered to be put into practice.

(a) Time-series variations of traffic volume, called traffic flow profile, and the number of seconds for which a signal phase is displayed are exchanged between intersections at intervals of several seconds.

(b) Exit traffic profile is predicted using a planned number of seconds for displaying the signal phase at the subject intersection. (The arrival time of a vehicle can be estimated)

(c) Using a traffic profile, delay times (signal waiting times) are simulated by varying the number of seconds for signal display, while searching for the number of signal display seconds that gives the minimum delay time at the subject intersection. (Signal equipment is controlled in detail according to intersection status)

In the profile signal control system, optimum signal control parameters are determined spontaneously at each intersection, therefore, it can be expected that traffic signals can be controlled most appropriately depending on traffic status, without requiring the traffic control center to control signals centrally.

The following example represents the evaluated effects of the profile signal control system, using the simulation platform configured at present.

3.2. Intersections under evaluation

The model intersection for evaluation, shown in Fig. 3 was set out in the traffic simulator for evaluating signal control systems.

At the model intersection, various factors assumed in the field are incorporated (distance between intersections: near/far, number of lanes: 1 lane/2 lanes, intersection forms: cross road/T road, signal phase: right turn with arrow mark light/right turn without arrow mark light/time difference phase, etc.). Fig. 4 shows a signal phase at each intersection.

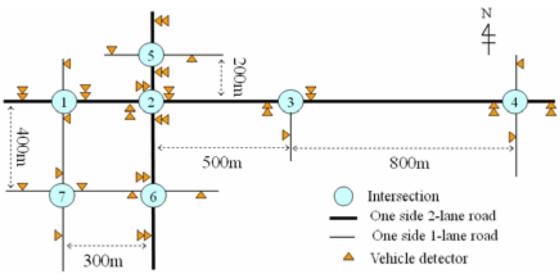

Figure 3. Model intersection for evaluation.

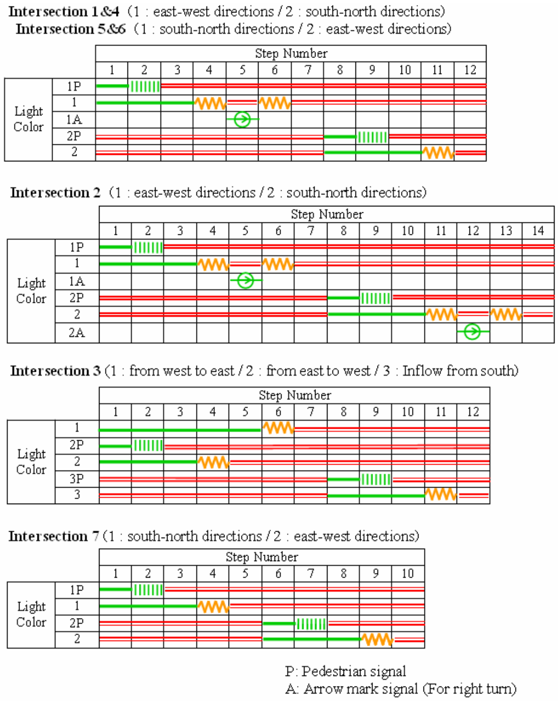

Figure 4. Signal phase at each intersection.

3.3. Evaluation method

Vehicle arrival data were given to the model intersection in the traffic simulator, and the approach traffic flows shown in Fig. 5 and Table 1 were created, thereby delay times were compared between profile signal control system and conventional signal control system to operate signal controllers.

This evaluation example aimed at examining the effects of delay times minimized with the profile signal control system. Therefore, the conventional signal control system selected for comparison was a pattern selection system, the cycle length of which was applied also to the profile signal control system.

The vehicle arrival data simulated the traffic status that can occur in practice, namely, steep increase of vehicles in a morning rush hours and gentle increase of cars toward evening rush hours. Vehicle-increasing directions were set towards the west in the morning and the east in the evening.

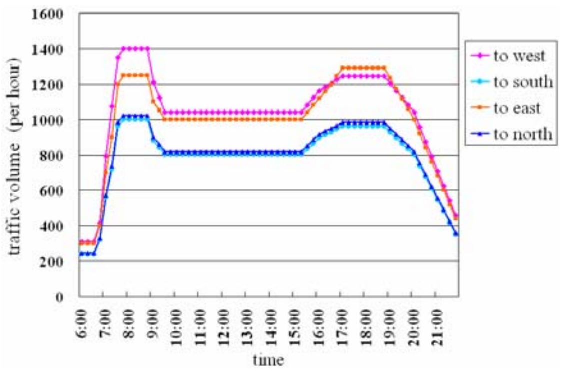

Figure 5. Inflow traffic volume into intersection 2.

Table 1. Inflow traffic volumes for other intersections.

Time period	Intersection 1				Intersection 3		
	To east	To west	To south	To north	To east	To west	To north
Morning	1250	1368	312	312	1248	1380	375
Daytime	1000	996	252	252	1008	1008	300
Evening	1300	1236	300	300	1272	1212	360

Time period	Intersection 4				Intersection 5			
	To east	To west	To south	To north	To east	To west	To south	To north
Morning	1212	1260	500	500	500	500	1000	1032
Daytime	972	900	400	400	400	400	800	816
Evening	1224	1080	480	480	480	480	960	996

Time period	Intersection 6				Intersection 7			
	To east	To west	To south	To north	To east	To west	To south	To north
Morning	312	188	1020	900	313	312	324	313
Daytime	252	150	804	720	250	250	250	250
evening	300	180	972	864	300	300	312	300

Traffic Volume (per hour)
Morning = 7:30 to 9:00 , Daytime = 9:30 to 15:30 Evening = 17:00 to 19:00

3.4. Records

One of the features of the profile signal control system is that the number of signal display seconds can be finely determined in real-time at each intersection using a traffic flow profile. Fig. 6 shows signal control implementation records with a pattern signal control system, and Fig. 7 shows the same using the profile signal control system.

With the profile signal control, splits obviously vary finely at individual intersections.

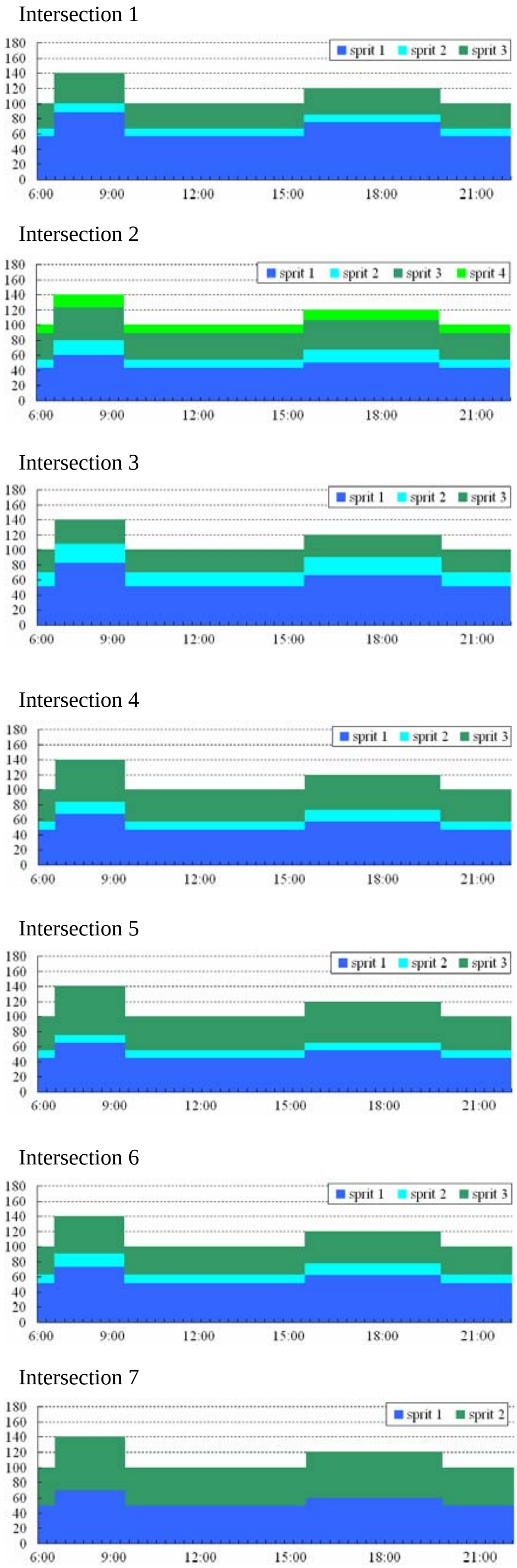

Figure 6. Signal control records with pattern signal control system.

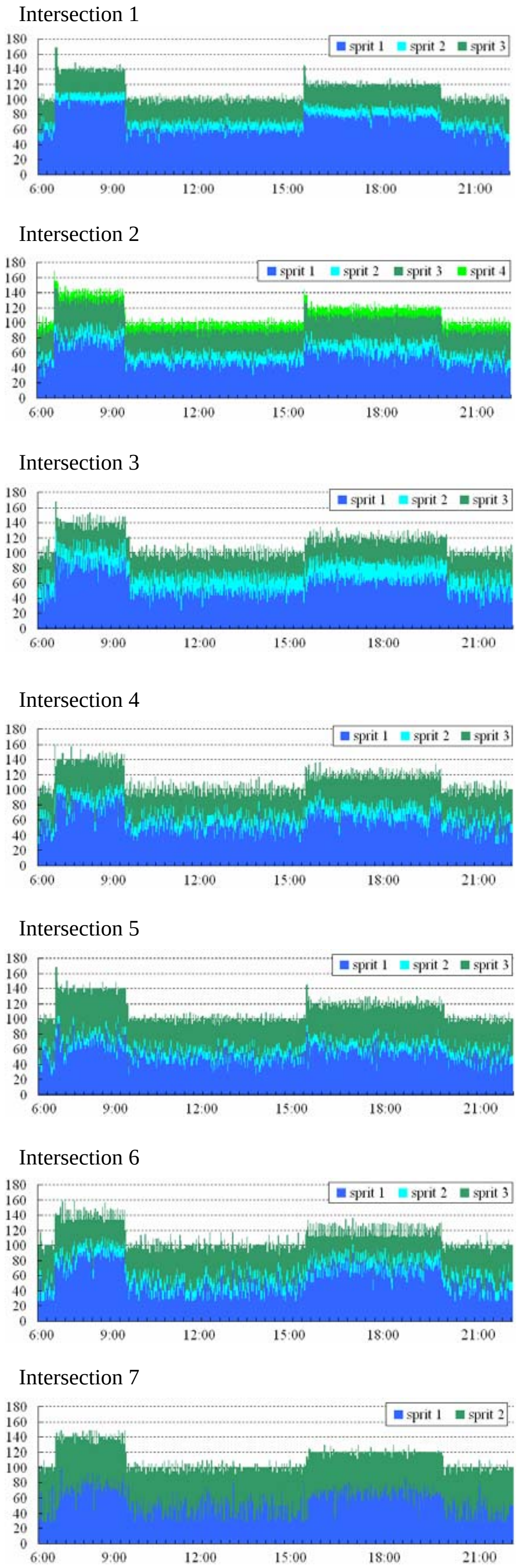

Figure 7. Signal control records with profile signal control system.

3.5. Evaluation results

Fig. 8 shows time-series variations of total delay time for all intersections when signals were controlled by the profile signal control system and the pattern signal control system. Table 2 lists summations of total delay times for each control system.

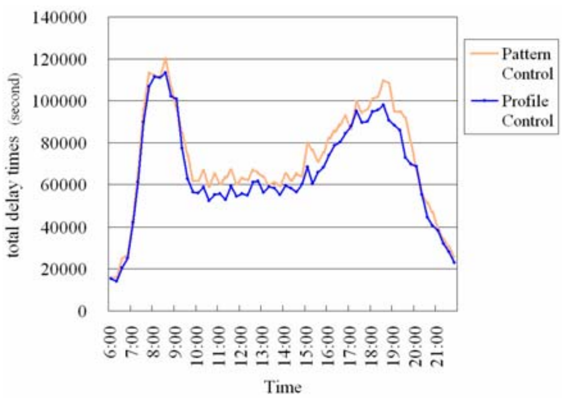

Figure 8. Time-series variations of total delay times for all intersections.

Table 2. Total delay times for each control system.

Time period	Total delay times (second)	
	Pattern control	Profile control
Morning rush *(7:00 to 9:00)*	1,002,524	961,788
Evening rush *(15:30 to 20:00)*	1,654,486	1,509,725
Light traffic *(Excluding the above-mentioned)*	1,935,487	1,747,754
Total	**4,592,497**	**4,219,267**

The profile signal control system renders less total delay times than the pattern signal control system. Also, at each time period, the profile signal control system gives less total delay times than the pattern signal system, so the authors could confirm that the profile signal control system is effective for reducing delay times.

Fig. 9 shows delay times at each intersection. At intersection 2, the profile signal control system significantly reduces delay times from the pattern signal control system.

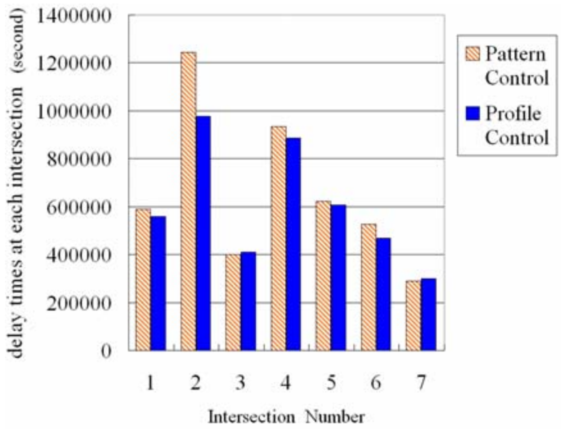

Figure 9. Delay times at each intersection for each control system

4. CONCLUSINOS

The novel simulation platform was constructed by connecting practical signal controllers to the traffic simulator, and applied to evaluate signal control systems in practice. In particular, the algorithm of the profile signal control system represented above is so complicated that each intersection can determine signal control parameters spontaneously discretely by exchanging information between intersections, so it was difficult to incorporate the profile signal control algorithm directly into the traffic simulator. Consequently, the simulation platform the authors have now developed plays an important role in evaluating profile signal control systems.

We plan to utilize this simulation platform to evaluate and compare various signal control systems, and investigate the effects of signal control systems under a wide range of traffic conditions, not limited only to the profile signal control system.

5. REFERENCES

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