Chapter XIV
New Approach to Smooth Traffic Flow with Route Information Sharing

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ABSTRACT

With maturation of ubiquitous computing technology, it has become feasible to design new systems to improve our urban life. In this chapter, the authors introduce a new application for car navigation in a city. Every car navigation system in operation today has the current position of the vehicle, the destination, and the currently chosen route to the destination. If vehicles in a city could share this information, they could use traffic information to improve traffic efficiency for each vehicle and the whole system. Therefore, this chapter proposes a cooperative car navigation system with route information sharing (RIS). In the RIS system, each vehicle transmits route information (current position, destination, and route to the destination) to a route information server, which estimates future traffic congestion using current congestion information and this information and feeds its estimate back to each vehicle. Each vehicle uses the estimation to re-plan their route. This cycle is then repeated. The authors’ purpose in this chapter is to confirm the effectiveness of the proposed cooperative car navigation system with multiagent simulation. To evaluate the effect of the RIS system, we introduce two indexes: individual incentive and social acceptability. In the traffic simulation with three types of road networks, the authors observe that the average travel time of the drivers using the RIS system is substantially shorter than the time of other drivers. Moreover, as the number of the RIS drivers increases, the average travel time of all drivers decreases. As a result of simulation, this chapter confirms that a cooperative car navigation system with the RIS system generally satisfied individual incentive and social acceptability, and had a effect for the improvement of traffic efficiency.
1. INTRODUCTION

With maturation of ubiquitous computing technology, particularly with advances in positioning and telecommunications systems, we are now in a position to design advanced assist systems for many aspects of our lives. However, most of the research we have seen to date has focused on aspects of supporting a single person. We believe a mass user support system (Kurumatani, 2004; Kurumatani, 2003) would have a large impact on society. The new concept would benefit not only society as a whole but would also benefit individuals. In particular, Nakashima (Nakashima, 2003) and Noda (Noda, 2003) have focused on technologies that might enhance urban social life, especially transportation support systems. This chapter reports on our recent multiagent simulation demonstrating the effectiveness of a new kind of car navigation system.

Many researchers have been trying to design better navigation systems, by examining the variety of traffic information available (Bazzan, & Klügl, 2005; Bazzan, Fehler, & Klügl, 2006; Klügl, Bazzan, & Wahle, 2003; Shiose, Onitsuka, & Taura, 2001). However, previous research efforts have revealed that individually optimizing performance with only traffic congestion information is difficult (Mahmassani & Jayakrishnan, 1991; Tanahashi, Kitaoka, Baba, Mori, Terada, & Teramoto, 2002; Yoshii, Akahane, & Kuwahara, 1996). A navigation system recommends the route for the shortest estimated travel time based on the current state of traffic congestion. However, if other drivers, using the same information, simultaneously choose the same route, traffic would become concentrated on the new route.

Active queue management algorithms for TCP (Transmission Control Protocol) traffic, e.g., Random Early Detection (Floyd & Jacobson, 1993) are similar to city traffic management. TCP is one of the core protocols of the Internet protocol suite. Vehicles in road transport system are similar to IP packets in Internet. However, these algorithms are unsuitable for traffic flow in road transportation systems for two reasons. One is a physical constraint: dropping vehicles like packets in TCP traffic is impossible. The other is a social constraint: such algorithms are problematic from the standpoint of fairness because the utilities of the vehicles that are randomly dropped (or stopped) suffer a big loss.

Car navigation systems were originally designed as electronic enhancements of maps automatically indicating the current position of the vehicle and a route to the destination. Japan roads now support the second generation of car navigation systems connected to VICS (Vehicle Information and Communication System) (Vehicle Information and Communication System Center, 1995). This new system can download traffic information and display it on the map. The system uses the information to avoid congested routes when it plans a route. What we suggest in this chapter is yet another generation of car navigation systems. VICS measures traffic volume with sensors located on roadsides, e.g., radar, optical and ultrasonic vehicle detectors and CCTV (Closed Circuit Television) cameras. The gathered information is transmitted using infrared beacon, radio wave beacon, and FM multiplex broadcasting. Each car just receives information from VICS, but does not return any.

If a car could transmit information by using a mobile phone or other short-range communication, we believe that we could design a far better navigation system. Every car navigation system in operation today has the current position of the vehicle, the destination, and the currently chosen route to the destination. If vehicles in a city could share this information, they could use traffic information to improve traffic efficiency for each vehicle and the whole system. Our idea is thus a cooperative car navigation system with route information sharing.

The main purpose of this chapter is to report the results of simulations demonstrating the validity of our idea. In particular, the simulation showed the average travel time is substantially shorter when
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