Chapter 2
Ubiquitous IoT in the Automotive Domain:
Decentralized Adaptation

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ABSTRACT

Ubiquitous IoT systems open new ground in the automotive domain. With the advent of autonomous vehicles, there will be several actors that adapt to changes in traffic, and decentralized adaptation will be a new type of issue that needs to be studied. This chapter investigates the effects of adaptive route planning when real-time online traffic information is exploited. Simulation results show that if the agents selfishly optimize their actions, then in some situations the ubiquitous IoT system may fluctuate and the agents may be worse off with real-time data than without real-time data. The proposed solution to this problem is to use anticipatory techniques, where the future state of the environment is predicted from the intentions of the agents. This chapter concludes with this conjecture: if simultaneous decision making is prevented, then intention-propagation-based prediction can limit the fluctuation and help the ubiquitous IoT system converge to the Nash equilibrium.

INTRODUCTION

Ubiquity and interconnection are important in information systems, and they are behind many concepts like pervasive computing, ubiquitous computing, ambient intelligence and the internet of things (IoT). IoT is a concept of everyday objects having built-in sensors to gather data across a network and then helping the IoT system and the users to take actions based on that data. Such systems are developed in the hope that we can derive economic benefit from analyzing and utilizing the generated data streams in several application areas. IoT systems open new ground in the automotive domain by introducing entirely new services to the traditional concept of a car. The connected, smart car provides a way to stay in touch with the world during drive time. There is a possibility for new kind of infotainment services and connected car applications to provide better services for drivers and the automotive industry as well, as Table 1

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Table 1. There are several application scenarios in the automotive domain to exploit IoT capabilities

IoT Sensor Capabilities	IoT Innovative Services
• Vehicle sensors • Real-time car operation tracking • Vehicle location tracking • Fuel consumption tracking • Speed measurement • Real-time vehicle monitoring • Fault detection, testing • Alerts • Seatbelt sensor • Acceleration • Driver attention monitoring	• Vehicle scheduling • Speed control • Vehicle usage analytics • Smart car leasing • Usage-based insurance • Fleet management • Traffic management • Remote diagnostics • Automated maintenance scheduling • Maintenance history analytics • Acceleration control • Anti-sleepiness warning • In-lane positioning • Navigation • Location-based services • Driver-assist applications • News and entertainment • Integration with smart home • Car-on-demand • Car security services • Over-the-air updates

shows a few of them. The novel applications include fleet management based on data collection via embedded software, data management in the cloud, and data analytics. The predictive maintenance can be based on the monitoring of the state of the vehicle, and the analytics can be based on cloud-enabled platforms to provide new services to car manufacturers, maintenance and service companies, insurance companies, and entertainment providers.

Automotive manufacturers and suppliers can utilize these IoT services to diagnose vehicle malfunctions on the road. This direct and immediate information can be used to avoid costly recalls by understanding product quality and rapidly assessing safety issues in order to optimize production. Telecommunication companies can develop new connected applications and services, which may be consumed either in vehicles or remotely through smartphone apps. Better driving experience can be delivered by exploiting information about the location, movement, and status of vehicles by analyzing map context and driver behavior. Non-traditional automotive industry participants may provide many of these novel services.

The novel services mentioned in Table 1 are mainly centralized services, in the sense that there is a single organization that collects data from the IoT sensors, analyses it, and then takes actions. Because there is only one actor that senses the environment and takes actions, this is centralized adaptation. This model suits well the traditional automotive industry.

Ubiquitous IoT helps the development of self-driving cars as well. Autonomous vehicles can detect their environment, using different sensors like radar, LIDAR, GPS, computer vision and shared smart phone data. The planning unit of the autonomous vehicle merges and interprets the sensor information to determine the necessary control actions to navigate the car and avoid obstacles. Autonomous vehicle technology is expected to provide several benefits like those shown in Table 2. In order to achieve these benefits, the autonomous vehicles have to act collectively. Because there are several actors that sense the environment and take actions, this is decentralized adaptation.

With the advent of autonomous vehicles, decentralized adaptation will be a new type of issue and it needs to be investigated. Humans and software agents are working together in such decentralized