Chapter 45
Networked Wireless Sensors, Active RFID, and Handheld Devices for Modern Car Park Management:
WSN, RFID, and Mob Devs for Car Park Management

Djamel Djenouri
CERIST Research Center, Algeria

ElMouatezbillah Karbab
CERIST Research Center, Algeria

Sahar Boulkaboul
CERIST Research Center, Algeria

Antoine Bagula
University of Western Cape, South Africa

ABSTRACT

Networked wireless sensors, actuators, RFID, and mobile computing technologies are explored in this paper on the quest for modern car park management systems with sophisticated services over the emerging internet of things (IoT), where things such as ubiquitous handheld computers, smart ubiquitous sensors, RFID readers and tags are expected to be interconnected to virtually form networks that enable a variety of services. After an overview of the literature, the authors propose a scalable and lowcost car parking framework (CPF) based on the integration of aforementioned technologies. A preliminary prototype implementation has been performed, as well as experimentation of some modules of the proposed CPF. The results demonstrate proof of concept, and particularly reveal that the proposed approach for WSN deployment considerably reduces the cost and energy consumption compared to existing solutions.

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INTRODUCTION

Automatic car park management using modern technologies becomes an inevitable option to rationalize traffic management in modern cities. With the constant increase of vehicles in agglomerations worldwide, finding a car park with available spots becomes a worry for the citizens in modern societies. This increase is the main cause of high fuel consumption, increased traffic congestion, and the dramatic impacts on the environment, drivers' health and wellbeing. New technologies such as mobile computing and emerging handheld devices (Hu et al., 2010) (smart phones, smart watches, etc.), sensor/actuator (Borges et al., 2014), and Radio Frequency Identification (RFID) (Delen et al., 2011), (Bagula et al., 2013a) may play a pivotal role to modernize and improve car park management, and to provide modernized services via a new first mile of the Internet in the emerging the ''Internet of Things (IoT)''. These devices can be endowed with an IP address and outfitted to the objects of the smart parking and/or its infrastructure to form smart objects. The latter may be interconnected into an IoT platform with sensor devices used for empty park spot localization, while the RFID devices are used for parking spot authorization, car localization, and theft prevention. The users will use their mobile handhold devices to access the services over local networks and internet. However, integration of these technologies yields a heterogenous environment with many challenges in terms of deployment, communication and protocol engineering. Some of these challenges have been addressed in this paper to propose a Car Parking Framework (CPF), which is builds around a modular approach to enable a variety of services such as driver guidance, automatic payment, parking lot retrieval, security and vandalism detection. Its partial implementation as a lab prototype is also described in this paper, where some modules have been tested and evaluated by real experiments.

Smart parking solutions that are closely related to the one proposed in this paper have been presented in Tang (2006), Yan Zhong and Li Min (2006), and P. K. et al (2010). These solutions use a single wireless mote per parking lot, which is outfitted with a sensor for vehicle detection. The sensor can be a magnetic sensor, an ultrasonic sensor, an optical sensor, etc. When a car is in sensing field of some sensor (a parking spot), the sensor status will change and a signal will be transmitted to the connecting mote. The latter processes the incoming signal to decide about possible detection. Using a mote in every spot has drawbacks. First, the cost will be high (both in terms of financial cost for deployment, and energy consumption when in operation). Second, it increases the collision domain and creates more interference. An interesting study about indoor communications in B. J. R. et al.(2006) shows the dramatic impact of mobile metallic objects over the mote on wireless communication channels, which is a typical situation that takes place when detecting a vehicle that parks over the sensor mote. It is thus useful to separate the communication module from the sensing area. To overcome the drawbacks of using a single mote per parking spot, we propose the clustering of a bunch of sensors and the use of hybrid wire/wireless communications. Every sensor board is connected to a microcontroller unit (MCU), then the bunch of sensors is connected in serial mode to a single mote using serial wired communication. The mote is considered as a master of the communication, and the sensors are considered as slaves. Wireless communication is used to connect the mote to the rest of the network. This pattern considerably reduces the cost and the interference, as it will be illustrated in the upcoming sections.

The rest of the paper is organized as follows: The next section presents the state of the art on car park management with integration of WSN and RFID. Section III introduces the proposed framework, and Section IV its implementation. Section V presents the interfaces we developed for mobile users. Section VI is the proof of concepts of the proposed solution with some prototype experimentations and some preliminary performance evaluation. Finally, Section VII concludes the paper.