Applying Mobile and Internet of Things Technologies in Managing Parking Spaces for People with Disabilities

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Abstract
Parking in public areas is one of the major problems faced in modern urban environments. This is more so the case for citizens with disabilities who have a limited number of spaces allocated for their exclusive use which are often not enough to meet demand and are sometimes illegitimately occupied. A smart city system that combines mobile and machine-to-machine communications has been designed aiming to alleviate the above issue. The system uses sensors to acquire disabled parking spot availability information which is disseminated to registered users in real time. Utilising such information, users can drive directly towards spots currently available or even reserve one of them. Upon arrival, legitimate users are able to verify themselves through a simple text message, a special device or a smart phone application. User verification enables more efficient monitoring of these precious parking spots.

Author Keywords
Smart cities; mobile parking assistant; parking space monitoring and reservation; people with disabilities

ACM Classification Keywords
C.3 [Special-purpose and application-based systems]: Microprocessor/microcomputer applications

Introduction

As urban areas experience an increase in population, it is inevitable that demand for various services and city facilities rises. One such facility is public parking spaces which are often found in city centers as well as shopping and business areas. During peak times, it has been observed that a large number of drivers are circling around trying to find an empty spot something which in addition to the time wasted leads to congested streets. Among the various parking locations we find a limited number of spots that are allocated for people with disabilities; to assist their intended users, such spots usually offer convenient access to nearby places of interest. For this reason, in many instances these spots are occupied by opportunistic offenders thus people in real need of them are deprived of their use. Unfortunately, the physical observation and verification of entitlement is costly and in many cases, ineffective.

Utilising technological innovations, smart city infrastructures are being developed in order to alleviate some of the issues faced by citizens. In this context, the proposed system facilitates the dissemination of real-time availability information for parking spaces allocated for people with disabilities. By obtaining such information, drivers can head to available spots without circling around in traffic wasting time and causing further congestion. Moreover, they can even reserve a spot before they arrive in order to guarantee its availability. Upon arrival to a spot, a number of mechanisms are available so that user authentication is performed; this immediate entitlement verification, allows for more efficient monitoring of these special spots on behalf of the managing entities.

Through this work, we demonstrate how pervasive technologies can be applied and have a serious impact on society and quality of life. This becomes more important considering that the proposed system has been specifically designed and developed to assist people with disabilities.

Ubiquitous computing - Internet of Things

The continuous enrichment of the services offered over mobile communication infrastructures, along with the rapidly increasing capabilities of end-user mobile devices, enable providers to deploy richer and more advanced applications. The purpose of such applications is twofold: to increase service provider revenues and increase customer satisfaction. Researchers are experimenting with advanced applications for urban interactions [1, 2] in an attempt to develop functional and scalable services.

A key component of smart urban infrastructures is a collection of devices that have sensing and wireless communication capabilities. Spread around buildings, streets and open areas, such devices gather data and use Machine-to-Machine (M2M) communication to transmit it towards a central location so that it is collectively processed.

Parking in public areas

As mentioned earlier, parking in public areas is one of the major problems faced in modern urban environments. Various systems have been deployed by the industry to assist in parking management whereas researchers have been examining more advanced topics such as parking availability monitoring for roadside parking spots [3] and parking reservation policies [4, 5, 6]. Individual parking spots are monitored using either ultrasonic (in covered car parks) or magnetic sensors (in open air car parks). The

processed availability data forms the basis of Parking Guidance and Information (PGI) systems. Moreover, a number of mobile applications have appeared that help drivers find the locations of parking lots in specific areas and in some cases, their current availability.

System architecture

When designing our system architecture and component interactions (Fig. 1) we considered the specific issues associated with parking spaces allocated for people with disabilities.

Relying on M2M communications, we expect sensors to provide the central monitoring system with occupancy data for the various parking spots scattered around the city. This information is necessary as it will be used to update the relevant databases that will provide availability information to parking administration authorities and the end-users.

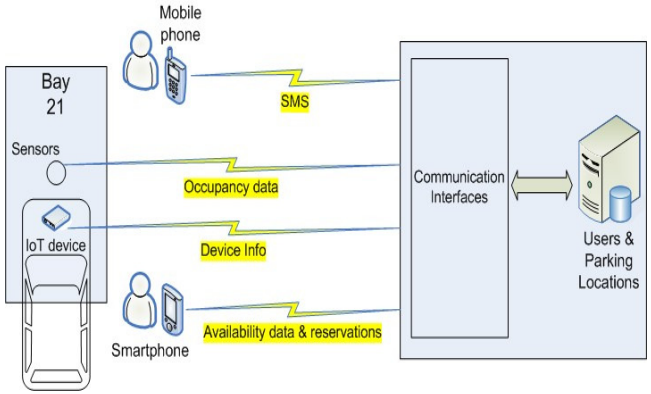

Figure 1. System component interactions

We purposefully enable interactions with the system through a multitude of ways in order to cater for a broader user range and address privacy concerns. As such, we observe a standard mobile phone, a smart phone and a dedicated device. Access to the full functionality of the system will be feasible through a smart phone. The provision of seamless connectivity to the Internet via the smart phone enables users to obtain real-time information on the availability of parking spots and interact with the system in real-time (e.g. to carry out a reservation, verify the location they have parked at etc).

System implementation

In implementing the system we used off-the-shelf components for the sensors and communications and developed our own map-based application for the Android platform.

Each parking spot is monitored using a magnetic sensor which transmits a signal to a nearby gateway. This transmission is based upon Zigbee communication and the gateway uses its GPRS or Ethernet connection to forward the data to the server (i.e. the database). Also, an LED is used to indicate the status of the spot. More specifically, a red colour signals that the spot is currently reserved and only the driver who made the reservation is allowed to park there. A blinking red LED indicates that the car currently parked at the spot is unauthorized whereas a green coloured LED indicates an available spot. Finally, a correctly verified vehicle is indicated if the LED is off and blinks occasionally in green colour.

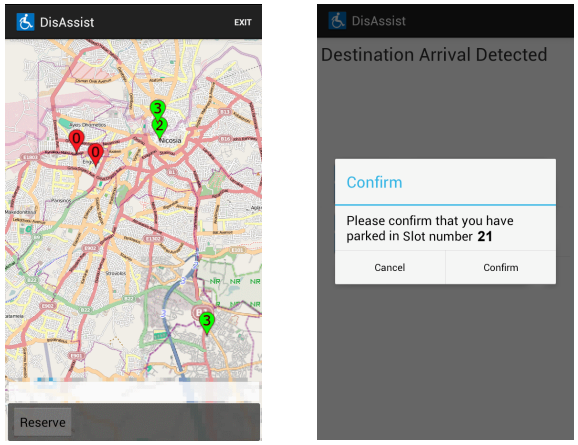

Figure 2. Smart phone application

Through the smartphone application, users can see on a map the locations where spots are currently available and carry out a reservation for a currently vacant spot. Upon arrival at a parking spot, a user can choose from a number of verification methods: a) a simple text message through a pre-registered phone that contains the spot number b) an exact (GPS-based) location confirmation via the smartphone application and c) a special device that will communicate directly with the rest of the infrastructure and convey the user's details. It is important to note, that user verification must take place irrespective of whether or not a reservation was carried out for the spot.

Different policies can be applied in situations where a reservation can not be easily enforced. At the present stage, our reservation mechanism only operates for short-term reservations for slots that have been identified to be empty at the time of the reservation. Hence we allow for a short time period between the reservation and the arrival at the parking slot; the reservation is automatically cancelled after this time.

Conclusion and future work plans

The proposed system is an example of how mobile communications and Internet of Things technologies can be applied and have a positive impact on society and quality of life. In future work, we will devise different policies to encourage users to adhere to the rules of the system increasing its reliability and functionality especially in terms of user verification and reservation enforcement.

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