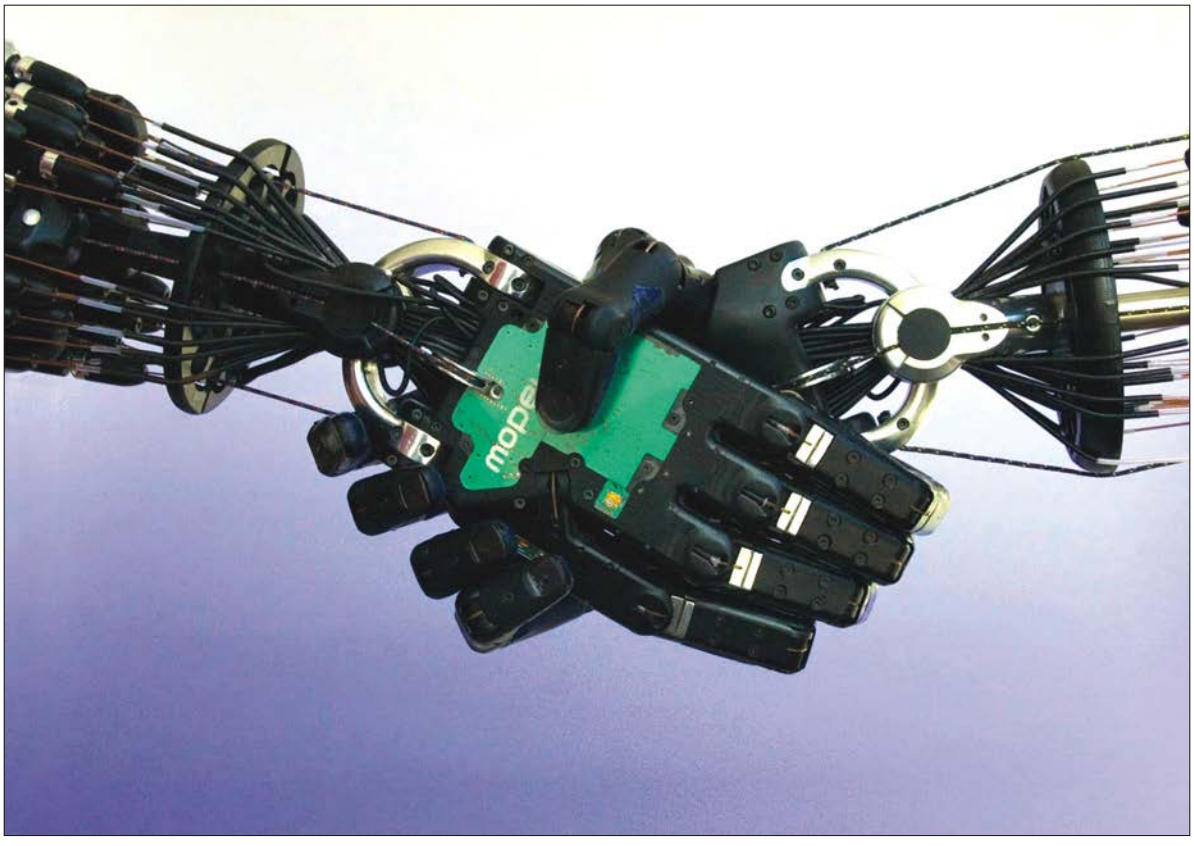

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Competent Smart Car Parking: An OSGi Approach

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ABSTRACT

In cosmopolitan expanses, parking of vehicles has become a major problem as it is becoming unproductive. It is also one of the key causes of city traffic congestion. A mechanism is needed to monitor the parking area. Other associated issues such as lighting of large parking lots and tracking availability of parking spots need to be addressed. The proposed study discussed these issues and gave a solution by employing Open Source Gate Initiative (OSGi), a middleware that helps in efficient communication. The parking system discussed here integrates various communication standards such as the SMS features of a standardized mobile, ZigBee enabled proximity sensors and a system meant for storage and processing of the data. The proposed architecture eliminates the hassles of searching empty parking spots and thus can save a lot of time on a daily basis for the general public who own and use a vehicle for commuting. The merits of this study compared with the existing models are emphasized here. This study also highlighted the advantages of using a standardized middleware such as OSGi for the communication between sensors and a system meant for the storage and processing of the obtained data.

Key words: OSGi, Knopflerfish, middleware, smart parking, sensors, ZigBee

INTRODUCTION

The developments in fields of communication, embedded systems and sensors have made it possible to create a smart environment (Xu *et al*., 2012; Alam *et al*., 2011; Augusto *et al*., 2010; Marques, 2010; Chan *et al*., 2008; Liao and Tu, 2007; Abowd and Mynatt, 2005) in homes, offices, automobiles and even in military equipment such as tanks and aircrafts. For instance, in developed countries the elderly are now able to live a relatively simpler life by themselves with less needed intervention from caretakers. The environment of an office is being made more secure by implementing Wireless sensors networks (Sakthidharan and Chitra, 2012; Diallo *et al*., 2012; Yick *et al*., 2008) with advanced security systems. Various car manufacturers such as BMW and Volkswagen are now using such smart technologies to make their vehicles efficient and increase their comfort factor. The benefits of this study are now being observed in numerous other environments such as hospitals, schools and even in hotels. One such environment where the inclusion of sensors and embedded devices can improve the overall efficiency while making the system intuitive is a smart parking lot (Placzek, 2012; Geng and Cassandras, 2011; Idris *et al*., 2009; Kumar *et al*., 2007; Lee *et al*., 2010).

In today's fast moving world where time is of the essence, it becomes a daunting task for many who have a vehicle to find a parking spot in large parking lots. The number of cars on the roads

is increasing at a steady rate. With this, constraints come in when a person wishes to park his vehicle in a prime area where the number of parking spots are limited and if available, it becomes difficult to search for them as they are distributed over a vast area. Initially, the number of parking areas was increased with each structure having a parking area for it in the basement. But as the structures became bigger and started scaling more floors, the available basement was not able to accommodate the number of cars that were being bought by the workers/visitors in these buildings. Then, separate parking areas were developed. These structures were specifically meant for parking (Wang *et al*., 2011) only.

When work was previously done to solve such issues of finding an appropriate parking spot, electronic parking systems were introduced. These systems were not capable of finding or keeping track of the available spots or guide the user towards the parking spot allocated to him. A user must be able to efficiently book a parking spot and locate it in the least amount of time spent. To solve these issues, improve the existing standards while making the overall system smarter and efficient, this paper has been proposed. The smart parking system that has been developed would discover the parking zones which would be notified to the user who wishes to park his car. This proposed system is capable of reducing the time spent in search of a parking spot by any person and thus gives him time for other relevant and important activities.

To create a customer friendly parking (Wang *et al*., 2011) experience, complicated electronic parking meters have to be removed. Parking sensor which will be able to reply to user query based on the available parking slots are being proposed here that will cater to these requirements. The wireless sensors will also send the information regarding where the user has to park. The comfort level and user experience has also been enhanced by providing additional information such as the route which the user has to take for getting out of the premises. Light coming from the sun in daytime and during night, from the installed lighting would be monitored through simple light detectors so that excess lighting is not used and thus the overall wastage of electricity reduced perilously.

The proposed study aimed to cater a large number of prospective users. The statistics show that the usage of cellular phones and SMS are more popular as compared to the internet. Hence for this scenario, it has been proposed that users can reserve their places using the SMS without having to go online. With this, the person can also book his parking space even if he is on his way and does not have internet connection. They will receive the parking slot area once their reservation is confirmed. They will also receive the deadline telling till when they can park. If the user does not respond in the stipulated time, the spot will be deemed available and can be given to another person.

SCENARIO DESCRIPTION

The basis of the entire procedure is quite straight forward. The process is initiated by the SMS which the user will send to a server established centrally for the parking area. The server can be a computer connected with a wireless modem capable of sending and receiving SMS through the GPRS network. This server will receive the SMS and then obtain the data from the sensors regarding the availability of parking spot. The spots that have been booked and occupied would also be retrieved.

Open Source Gate Initiative (OSGi) (Alcarria *et al*., 2012; Martin *et al*., 2009; OSGi Alliance, 2003) has been used here and plays its role for the data transfer. When there are

various devices to be connected which are of different make and seamless data transfer is needed, a middleware is needed. OSGi, based on Java is prominently used as a middleware today. Adding a service platform such as OSGi to a networked device will give it the capability to manage life cycle of the software components present in the device from anywhere in the network.

Open source specification Knopflerfish, which is Java based has been used for this purpose. It has features such as activation and pausing of the active bundles which can also be done while the bundle is being updated. The bundles in this case are the services of the parking area. A database was made which has all the information regarding the available parking spots. This makes the entire system efficient as the database ensures that a large number of queries can be simultaneously sent to the database and their responses can also be obtained in a short duration. With the use of a database, any loss of quality of service in terms of delay or any other factors, such as inefficiency or lack of scalability are minimized. The user details are stored in the database. When a query for a parking spot is made, the reply will be sent to the respective user who has requested the parking slot. Certain other services have also been provided which will provide specific information to the users on positioning, traffic management, mapping, location, provisioning, HMI device access, security and COMM CALM API. The services that were developed are:

- In case of failure of any node or sensor, the information would be sent to the main server
- Parking reservation helps to reserve the parking spot for the requested user
- The server can handle a large number of requests coming from users and arranges them in the FCFS (First Come First Served) order. The service can deal the requests from many users at the same time
- Enhanced driver awareness has been used to indicate the driver with the park slot, exit ways and lane to be followed such that the user can get in or out without any difficulty

Introducing centralized real-time support inside OSGi: Smart car parking system developed employs centralized real-time support inside OSGi. The real-time specification for Java (RTSJ) has been developed by the JSR-1 and JSR-282 expert groups. JSR-1 initially proposed specification which is now under the control of JSR-282. RTSJ proposes several improvements in areas for real-time Java. The goal in each area is to improve the predictability feature of VM (virtual machine) in specific aspect. The seven areas refer to scheduling of threads, handling unpredictable events, Managing Memory, new synchronization rules, control transfer, termination of threads and accessible physical memory. The main category that allows a programmer to define periodic, random and aperiodic real time activities is through the mechanism of thread scheduling and dispatching. The scheduler class may carry out admission control depending upon the CPU utilisation (for instance, if the amount of CPU used is full, it does not allow the execution of new applications). In essence, the feasibility of this algorithm is RTSJ implementation dependent and may do nothing more than always return true (feasible), provided there are no aperiodic threads in the feasibility set.

TECHNOLOGIES USED

Open source gate initiative (OSGi): OSGi service platform makes use of Java environment for the development of smart car parking system. The portable feature of Java enables the services to be provided in different platforms (Cross-Platform). Java provides the applicability with divergent

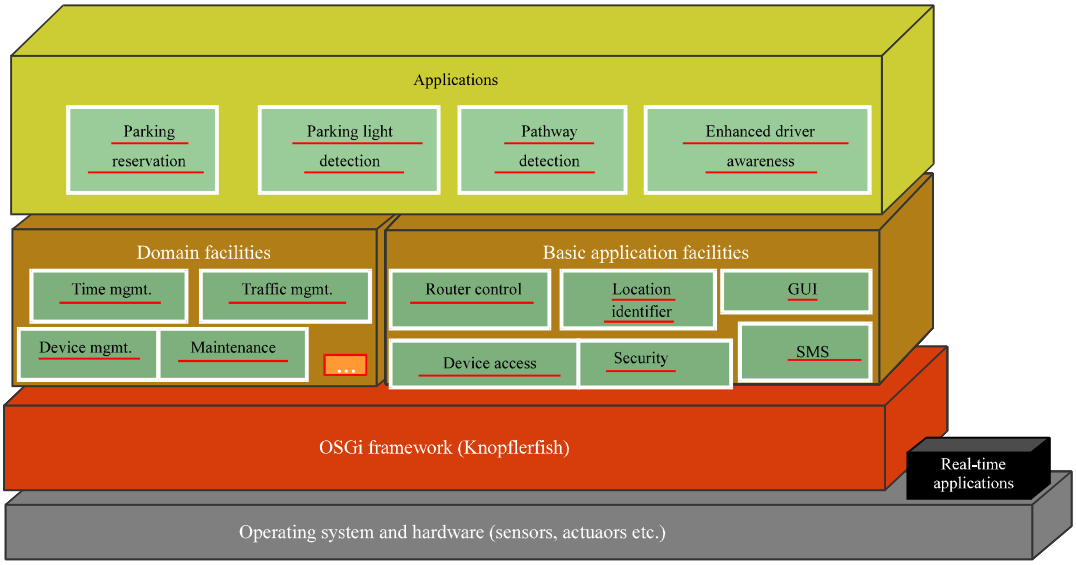

Fig. 1: Architecture of smart car parking

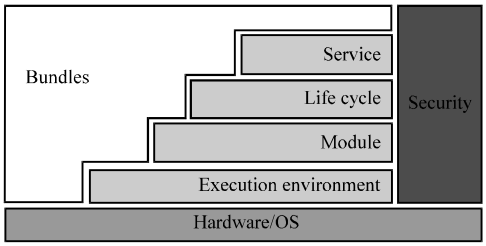

Fig. 2: OSGi layers

product and platform support. The OSGi technology provides the basis of creating components that are reusable and collaborative. Applications are made up of several components which can be deployed independently.

Specific protocols are used to remotely control them. If the built-in management system is provided with standardized OSGi protocol bundle, it can work with any developer's device irrespective of the underlying protocol. The framework helps us in combining the data from a number of sources. Then the data which has been gathered is used as per requirement. The separate bundles are able to collaborate in a single Java Runtime Environment. Figure 1 is used to diagrammatically describe the architecture of the proposed smart car parking system.

The functionality offered by the OSGi framework (Fig. 2) is divided into the following layers:

- **Security layer:** This layer extends Java's security with a packaging format and runtime interaction models
- **Module layer:** It defines a modularization model for Java with strict rules on how to hide and export packages

- **Life-cycle layer:** Life-cycle management defines how bundles are started/stopped, installed, uninstalled and updated. Life cycle management requires the module layer to be operative, whereas the security layer is not strictly required
- **Service layer:** The service layer provides a bundle model which decouples bundle specification from bundle implementation

ECLIPSE

Eclipse, an open source IDE has been used for the development of the Java application. Projects that are implemented under this IDE can be deployed to be used in an OSGi framework. Deployed bundles can be started and stopped at any time according to the needs of the user. The IDE allows multiple tasking environments allowing multiple projects to be opened in a simultaneous manner so that user can work with the projects in a relative way.

KNOPFLERFISH

The open source platform based Knopflerfish framework has been chosen for the deployment of individual tasks referred to as bundles. During the deployment, Bundles can be manually updated to reflect the changes in the working environment.

MySQL

MySQL was used to create and manage the database. The database system handles large number of tuples and queries with no complications such that the data can be retrieved or stored with less complexity.

ZIGBEE

The sensors would use ZigBee (Sayeeraman and Ramesh, 2012; Zigbee Alliance, 2008; Zhang *et al*., 2007) as the mode for communication. It is IEEE 802.15.4 compliant technology. It has capabilities to transmit over ranges of up to 75 m. ZigBee uses a basic master slave configuration that works efficiently in star networks of devices that may be used infrequently and transmit data in small packets. Since this parking area would have a very large number of nodes and present in a very large area, ZigBee was used. Also, it is capable of connecting 254 devices thus giving us the advantage of increasing the area of parking area and still uses this network without any major changes.

IMPLEMENTATION

The parking sensor uses the WSN (Wireless Sensor Networking) i.e., Sending and Receiving messages from the WSN gateway (Guo and Zhang, 2011; Liu *et al*., 2011) and WSN nodes using an Application Programming Interface(API).The sending and receiving of messages has been shown in Fig. 3. Debugging of messages can be easily performed through this interface. Errors occurring during run time are stored in the Debug message area and the required correction messages are sent from WSN node to the WSN gateway. Message debugging cannot take place in the host system. User messages are explicitly reserved for the users. Host uses WSN gateway as a tunnel to send or receive user messages. To receive user messages from a Host API running on a WSN RT gateway, use local host of the WSN RT gateway.

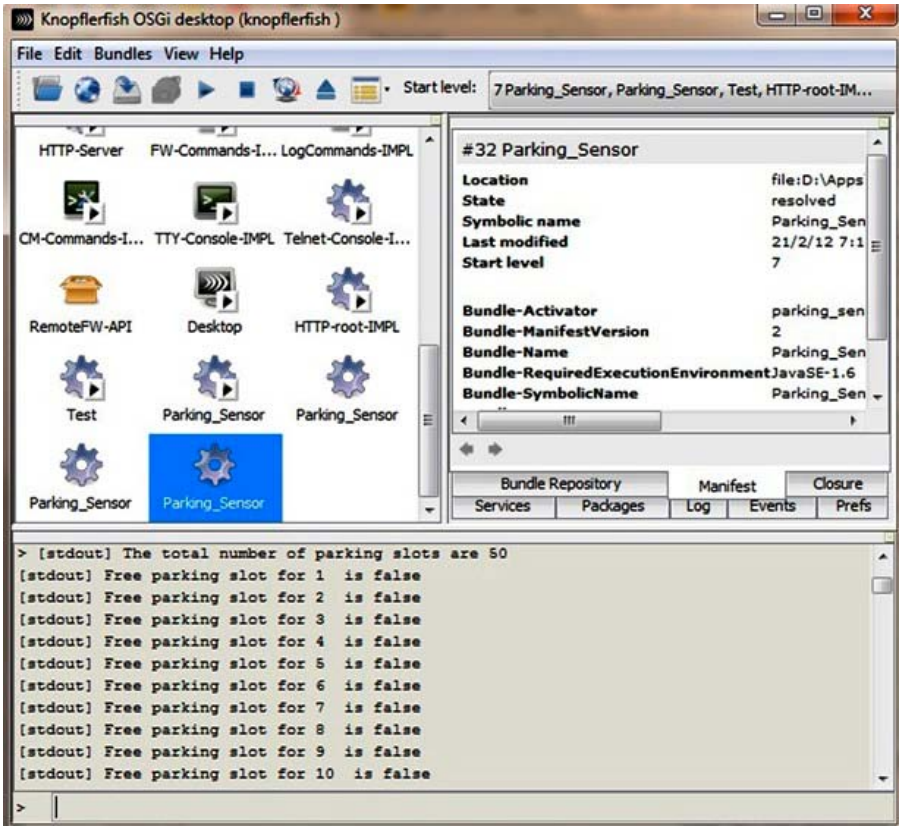

Fig. 3: Parking sensor's retrieval of information

RESERVATION SYSTEM

The flow chart of the reservation system is as shown in the following Fig. 4. The flow chart shown here shows the step by step occurrence of activities that occur in this scenario. The following activities take place:

- User sends the reservation SMS to the parking sensor
- If user sends the SMS properly then it proceeds further otherwise it again goes to start
- Parking sensor sends the confirmation SMS to the requested user
- If user arrives within the time limit, user may access the parking slot otherwise it cannot

SMART CAR PARKING PROCESS

Here, the experimental results have been provided. The user's interaction with sensor is stored in the database. The parking sensor accesses the information regarding the parking slots and whether any slots are free or not. After retrieving the current status from the database, if there is no free parking slot the parking sensor sends a message stating there is no free parking slots available for the requested user. If some car leaves the parking, sensor senses it and according to it changes the content in the database. If any request from the user comes now, it gives the current free parking slots and also the slot in which the requested user has to park. If the number of users requested for the parking slot is more than that of available free slots than the sensor processes them according to the First Come First Served (FCFS) basis and provide them the slots. The allocation of parking spots has been shown in Fig. 5.

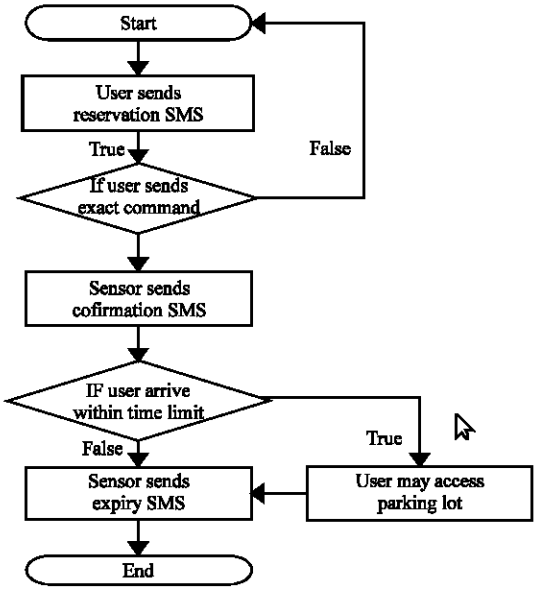

Fig. 4: Flowchart showing the process of booking or parking spot

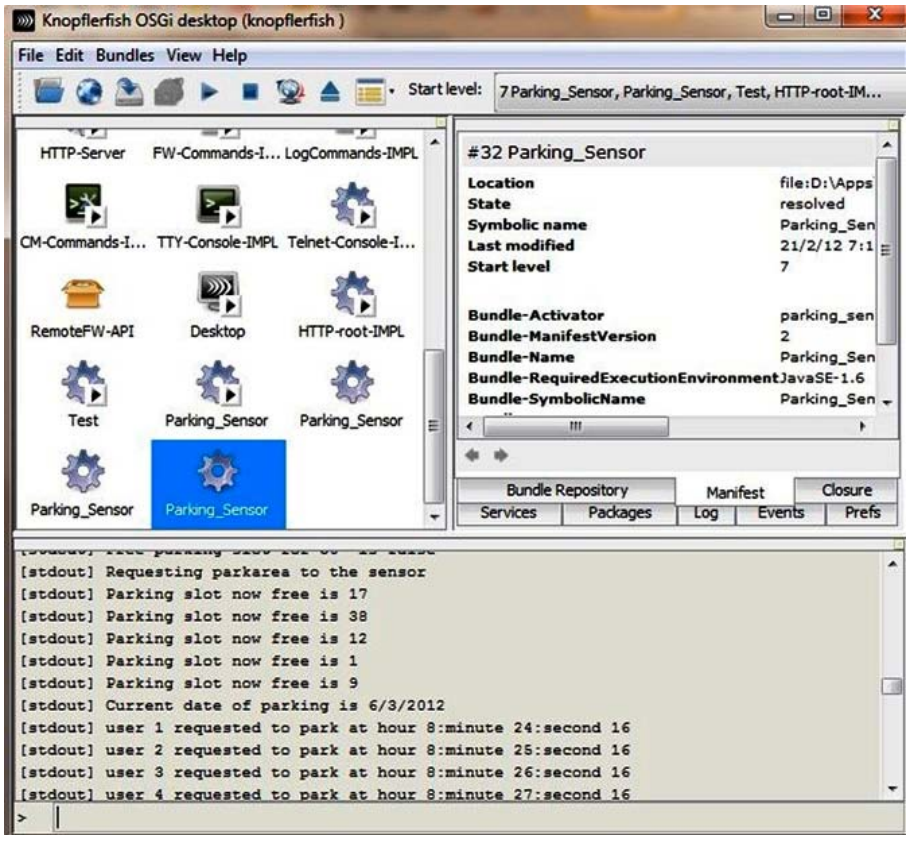

Fig. 5: Allocation of parking spots based on FCFS

Here, the date and time in which user requested is also stored and retrieved when needed. And there is a parking light for each parking slot which will be used based on the time. If day means

the parking light will be automatically turned off and if it is night, it will be automatically turn on in presence of a car. Then, the parking sensor gives the time limit to the user till which it can be parked at that slot. And the sensor here also directs the way to take the exit from the parking slot provided by it. So, here whatever difficulties have been faced by the user during parking has been solved. And finally proposed project has been successfully carried out by the above mentioned processes with the help of the technologies given here.

CONCLUSION AND FUTURE WORK

Smart parking is needed in to tackle the problems of finding a parking spot in large parking lots. The proposed architecture deals with these issues and also a few other problems have been addressed. The prototype shows the capability of the proposed system to reserve parking through SMS as well as gaining entry to the parking area and also gives the way to reach the exit. Wastage of electricity for excess lighting in a parking lot has also been tackled. Upon implementation this system is capable of saving a lot of time for those who commute on a daily basis. The number of parking lots could be increased depending on the area. Such a system can be scaled to a great extent to make a centralised monitoring system for many parking lots. A lot of parking lots in a city can together be connected so that a person may be directed to a different parking lot in case this parking lot has reached its limit.

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