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Electric Car Sharing Service Using Mobile Technology

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Abstract
Millions of urban dwellers face difficulties owning a car because of congested and accident-prone infrastructure, sky-high parking fees, and high maintenance cost. The need for car ownership can be reduced by providing an efficient and effective car sharing system. In this paper, we propose an electric car sharing service system using mobile technology, which can be a substitute for fuel consuming cars. Our system will be helpful in saving the resources and the energy consumed in producing and owning cars as well as improving the quality of life in urban areas.

Keywords
Service Innovation, Electric Car Sharing, Eco-friendly, Mobile Technology, Service Driven, Product Driven, Hybrid Solution and Car Sharing System Architecture.

1. Introduction
In 2008, urban dwellers in the world exceeded those of non urban for the first time in human history. Urbanization is accepted as the inevitable mega trend in the 21st century (Hazel & Miller 2007). Thus, the population density in cities is increasing tremendously as people migrate to cities from the country side. Many big city regions in the world are facing the side effects of urbanization, such as heavy traffic jams, air pollution, high price of fuel, and deteriorated quality of life.
Millions of Urban dwellers are facing challenges, such as congestion, scarcity of parking lots, high parking fees, and high maintenance costs (Hazel & Miller 2007). Therefore the demand for cars in urban areas can be reduced by providing efficient and effective public transportation system. However, sometimes public transportation systems, such as buses, subway, and taxies may not be good substitutes for cars to transport handicapped people or shoppers accompanied by children.
Typically, car sharing systems are aimed at substituting car ownership by providing "mobility" for customers. For example, ZIPCAR (Ziegler 2009) offers more than 30 makes and models of self–service cars (Abdel 2010) and Car2go (Motavalli 2010). Though car sharing systems can reduce the demand for cars in urban areas, it is not an alternative for reducing the fuel consumed by cars.
In order to make cities sustainable, we have to solve the problem of increasing car traffic (Special Team Dong-A Ilbo 2009) and car ownership demand in more eco-friendly ways (Hazel & Miller 2007). The current solution to this problem is either service driven or product driven (Verkuijl et al. 2004). In the service driven model, the car sharing system

requires the user to only pay for the fuel expenses and not have to worry about owning a car. Thus, it reduces the demand for car ownership. However, the solution has fuel dependency. In the product driven model, electric or hybrid vehicles are owned by individuals, which alleviates the fuel dependency problem. However, the number of car owners is not reduced and also there are infrastructure problems to support the wider use of these electric vehicles. Hence, there is a great need for not only providing the necessary infrastructure, but also the car sharing mechanism which will reduce the total number of cars on the roads. The public awareness and motivation should also be improved (Charter et al. 2004). Thus, in this research we propose a hybrid solution (Shankar et al. 2009) where we combine the two approaches and suggest a Product-Service System Model where customers can utilize electric cars on demand, without having to own them.

So far there have not been many successful implementations of electric car sharing service. For example, the Autolib (Lefebvre 2009) electric car sharing system was introduced by the Paris Metropolitan government. However, this effort was inefficient and the electronic mobility service concept with a carbon neutral car was not very successful. In this paper, we focus on the mobile technology, and the mobile application service provided by a smart phone system to facilitate the implementation of the concept. We propose an electric car sharing service system using mobile technology. This solution will be a valuable alternative for the fuel consuming car ownership in urban areas.

2. System Description

2.1 Requirements for the System

According to Autolib' in Paris (Lefebvre 2009), there are expectations of Parisians for the Autolib, features such as: guaranteed parking, vehicle availability, clean vehicles, and size of the boot. We start from the customer demands for the electro-mobility service articulated by the Parisians. Service quality can be defined as the gap between perception and expectation of customers towards the service (Parasuraman et al. 1998). In order to reduce the gap between expectation and perception of customers, we have to provide electric-mobility service in terms of the five SERVQUAL factors, namely, tangibility, reliability, responsiveness, assurance, and empathy.

Tangibility of the electric-mobility service involves providing the physical infrastructure for designated pick up and return sites, battery charging and substitution facilities, and repair and maintenance facilities. A mobile application is needed to meet reliability, responsiveness, assurance, and empathy. Users can access the e-mobility server through the mobile application installed on their smart phone, search for the nearest car pick up or return sites, and check the car's status. The car should have its own telemetric system to communicate with the users as well as the control room at all times. These two aspects are the critical requirements for the electric mobility system proposed in this paper.

2.2 Major Functionality of the System

The E-mobility service can be divided into the following two parts (Hara et al. 2000) in terms of system functionality: 1) user side, and 2) administrator side.

2.2.1 User side Functionality

There are four major steps for using the car sharing service with a mobile device (Morency et al. 2007) from the user's point of view. These steps are shown in Figure 1 and briefly explained below.

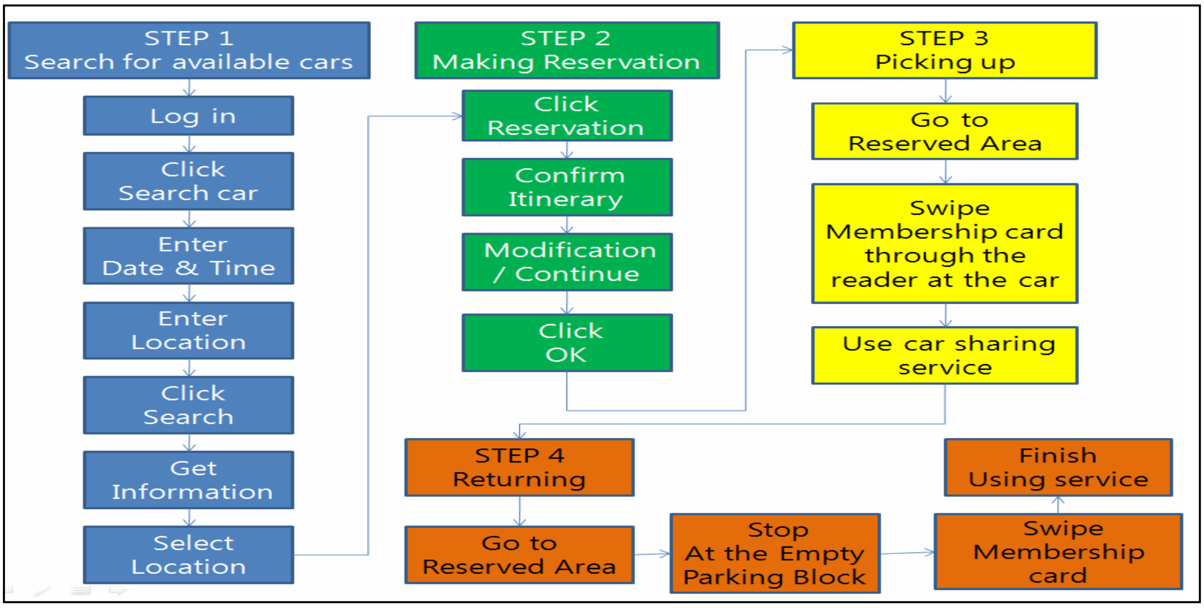

Figure 1: Steps in Using the Car Sharing Service from the User's Perspective

- Step 1. Search for available cars
  After logging in, the user can find available cars by just a few clicks of the mouse on the appropriate menu buttons. To continue with further processing, the user should enter the date, time, and location.

- Step 2. Making Reservation
  In this step, the user can confirm the itinerary for using the car sharing service as well as change their itinerary. However if they do not have to change anything, they can click on the continue button. After that, all reservation steps are completed.

- Step 3. Picking up the Car
  The user can go to the reserved area and swipe the membership card through the card reader installed on the door of the car. Then they can start to use the electric car and the other services provided by the system.

- Step 4. Returning the Car
  After the user is done using the car, he or she can take it to the reserved area and then swipe their card through the card reader to complete the return process. Then, the car sharing process is terminated.

2.2.2 Administrator side Functionality

The administrator should have a convenient mechanism for ensuring that the services are delivered properly and also perform maintenance activities. Payment and data encryption are very important and critical to ensure the privacy of the customers.

- Payment
  Customers of the electric car sharing service should abide by the membership policies. Users can create an account and pay for using the service. However, they can use only the credit card that was entered during the enrollment process. They should pay the basic rate

based on the daily or hourly usage, in addition to the annual fee. When exceeding the time limit and distance, additional fees will be charged based on the excess time and distance.

- Data management
  To protect the privacy of the data in the database system, a data encryption solution must be implemented at the database level. Theft of user information is the most critical issue and the customer data should be protected at all cost.

3. System Architecture

3.1 Necessary Infrastructure

The E-mobility service system consists of four parts:

1) E-mobility service system for booking and returning cars;
2) External Channel Server for linkage of payment;
3) Cars for sharing service; and
4) Mobile User who has membership with the E-mobility service community.

A schematic representation of the system infrastructure is shown in Figure 2.

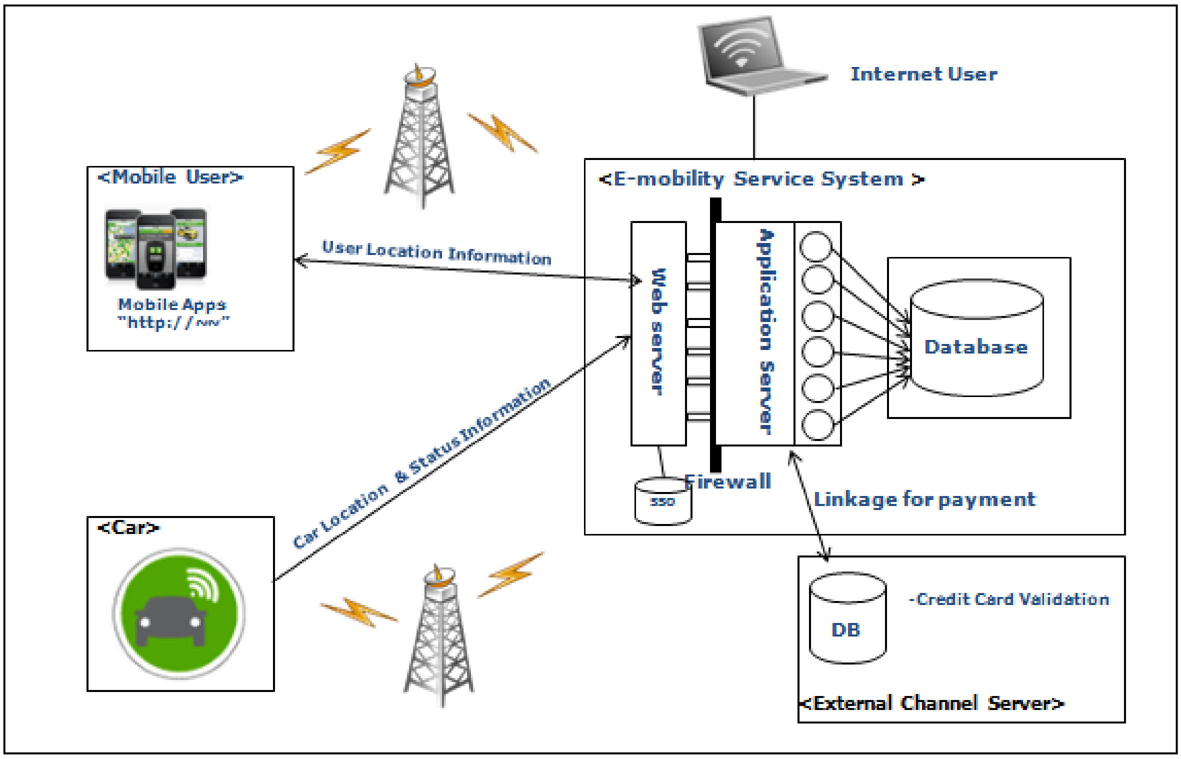

Figure 2: E-mobility Service System Infrastructure

There are several considerations in terms of implementing the E-mobility service system infrastructure, which are outlined below.

- The system should manage the reservation and return of cars, user and car location, membership, car sharing and repair history, facility information, etc. The E-mobility Service System has to gather the car location and mileage information automatically..

- For the secure management of user information, a firewall and data encryption solution must be implemented.
- Before using the car sharing service, a user must register as a member of the e-mobility service community, which is a main difference compared to other existing car sharing services. During registration, mobile phone and credit card information has to be provided to the system (Mannan 2001).
- Car pick-up and return will be processed through self-service. Minimal operation staff will be present in the parking lots. In addition, mechanical services will be provided in the parking lots as and when the cars need them.
- Payment service is provided with the credit card, which can be processed through a third party vendor that deals with credit information & scoring.

3.2 System Architecture

Figure 3 shows the architecture of the E-mobility service system and the main components that will be implemented. The three main components are the user interface manager, the application server, and the database server. The user interface component provides API for different types of hand held devices, computers and smart phones so that the users can interact with any device that they may possess.

The application server contains a web server and a mobile server that takes care of the communication linkages between the users and the system. It also contains a number of modules that facilitate the membership registration, car information, pickup and return as well as payment processing. The database server keeps track of various information related to the e-mobility car sharing service such as member information, reservation, mileage, product information, pick up and return and payment.

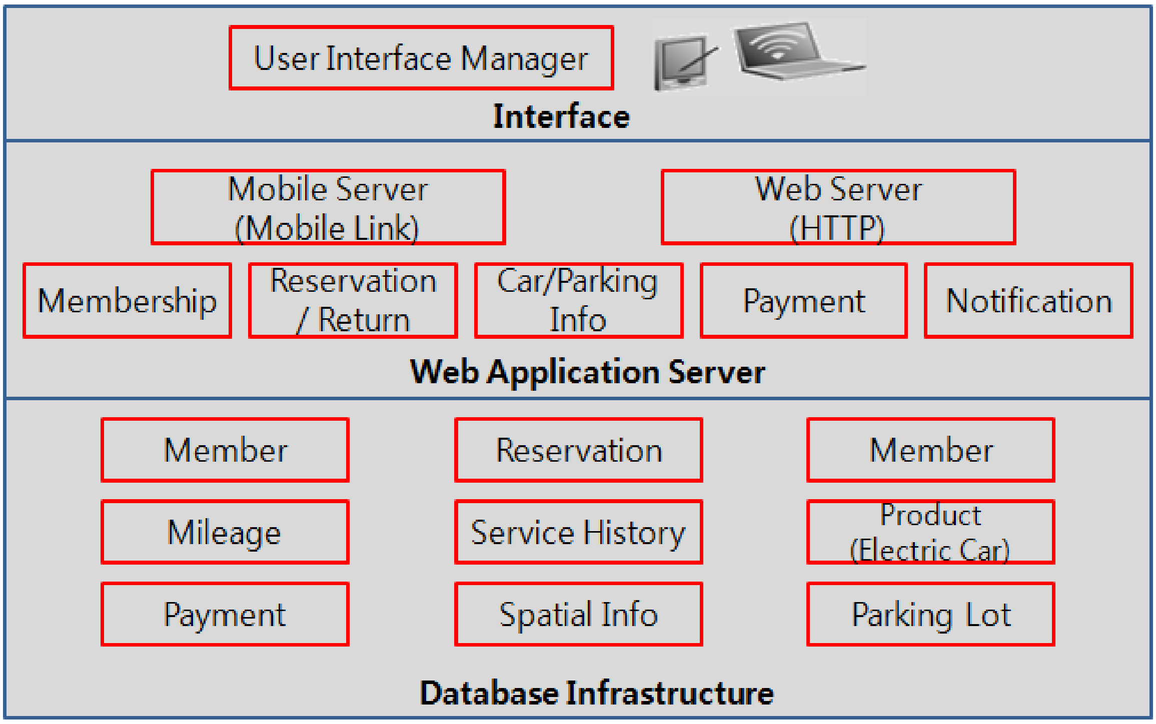

Figure 3: Architecture of the E-mobility Service System

3.2 Database Schema

An appropriate database design is required to efficiently maintain and use all the information related to the e-mobility service. Several normalized database tables are required to ensure data integrity. Among other things, there are several tables that are required to keep track of relevant entities, namely, Customer, Car and Facility, and Utilization.

The schema for the Customer table consists of membership number, user ID, password, driver license number, address, credit card number, valid name on credit card and past record attributes. The Car table includes car number, current location, reservation state, and charge state attributes. The Parking lot table contains attributes such as parking lot number, capacity, and parking lot location. The Reservation table consists of membership number, check in time, check out time and car location. In addition, the Payment table consists of membership number, billing address and valid name on the credit card attributes. These five tables are required for implementing the E-mobility system.

4. Conclusion

In this paper, we have presented the design of an electric car sharing system and the necessary infrastructure. This system would be beneficial for both public and private domains. In the public domain, it can help reduce pollution, noise of cars, road congestion, traffic accidents, lack of parking lots, and carbon emission. According to Étude Autopartage à Paris (Paris 2009), a car in the car sharing system can be equal to five cars that are sold. Moreover, the car sharing service can reduce transportation cost for individuals.

In the private sector, electric car sharing infrastructure including battery changing and charging facilities and service can be huge opportunities for growth (Suk & Jang 2010). For instance, automobile companies can create new markets and business opportunities using the electric cars and the infrastructure. From the customers' perspective, the major benefits are improvement in quality of life and elimination of automobile ownership (May et al. 2007).

Though the electric car sharing system proposed in this paper needs a huge infrastructure, and takes time to build the whole system, we believe that the benefits from the system would greatly outweigh the cost and the effort. This solution will also be eco-friendly, which is the current trend in much of the developed nations.

Acknowledgement

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