Impact of Pervasive Computing on Service Design in Hospitality

Ebru Gökalp and P. Erhan Eren
Department of Information Systems, Middle East Technical University
Email address: egokalp@metu.edu.tr

Abstract—The economies of developed countries have significantly transformed from manufacturing based to service based, where the hospitality industry plays an important role. Within this context, new service design and service innovation are vital for maintaining competitive advantage. Recently, pervasive computing has emerged as a key enabler in various industries in support of service innovation by facilitating the design of new services. This study aims to investigate the benefits provided by pervasive computing in the hospitality domain for improved customer satisfaction, profitability, and operational efficiencies. First, an overview of pervasive technologies is presented. When reviewing existing applications in the hospitality domain, it is observed that most of the pervasive applications currently found in the hospitality market are primarily focused on the RFID technology, and managed by disconnected systems. Our aim is to propose an integrated pervasive computing framework supporting innovative services incorporating pervasive technologies for the hotel industry, and not being limited to RFID applications. Via the analysis of the framework, changes in business processes are exposed, and improvements obtained through the collected data on the framework integrated with the enterprise systems are discussed.

Index Terms—hospitality, pervasive computing, service design, service innovation

I. INTRODUCTION

Based on the nominal GDP (Gross Domestic Product) sector composition of 2010 [1], it is observed that in the developed countries like UK, USA, EU, and Japan, service sector has the highest contribution to the economies, by around 80%. Most developed countries’ economies are dominated by the service sector as a result of its continuous expansion [2]. These economies are significantly transformed from manufacturing-based into service-based [3]. Progress in the tourism and hospitality sector is a key issue in this transformation. Many similar and easily substitutable services in the hospitality market result in higher customer expectation and increased competition. One of the main differentiation strategies is offering more innovative alternatives by integrating novel functionalities into the service. Service innovation is defined as introducing radical changes and developing new designs, procedures, methods and service concepts [4]. There are many examples proving how service innovation provides differentiation in the market and keeping up pace with the rapid changes in information and communication technology in the hospitality domain.

As one dimension of information and communication technology, pervasive computing aims to create human-centered environments saturated with computing and communication, and to increase the quality of life. The vision introduced by Mark Weiser in 1990s [3] is becoming a reality as a result of recent developments in technology, and pervasive computing is being utilized in various industries for introducing new services within the context of service innovation.

The purpose of this study is to introduce an integrated pervasive computing framework enabling innovative services for the hospitality sector. It provides data collection, analysis, and sharing capabilities to be used as part of the three main enterprise systems: Customer Relationship Management (CRM), Enterprise resource planning (ERP), and Supply Chain Management (SCM), which in turn results in increases in employee efficiency, profit, and customer satisfaction.

In Section 2, we provide an overview of pervasive computing. Section 3 highlights existing pervasive computing applications in the hospitality industry. We propose a pervasive computing framework and associated innovative services for the hotel industry in Section 4. The benefits provided by this framework are discussed in Section 5, and the conclusion is given in Section 6.

II. PERVERSIVE COMPUTING

Mark Weiser [3] coined the term “Ubiquitous Computing” in order to describe fundamentally the same position with the term “pervasive computing” as making many computing instruments, devices, resources and technologies available throughout the physical environment and making them structured, thoughtful and invisible to users. The idea of weaving computers seamlessly into the physical environments provides embedded computation everywhere while these technologies are vanishing into the background. As a result, people do not have to focus on the computer itself and carry out their work with the assistance of such a computing infrastructure. Weiser envisions a world full of connected computers in the form of tabs, pads and
boards, cheap wireless networks and information accessible everywhere for serving much functionality in and out of the room.

When he wrote the article, this was a vision too far ahead of its implementation time. In the later decades, significant improvements regarding hardware, sensors, wireless communications, and global networking developments have had major impact on materializing Weiser’s vision toward technical and economic viability. Such developments include fiber optics for data transmission providing nearly limitless bandwidth, human voice controlled systems used for new generation user interfaces, and discoveries on image processing. Similarly, improvements regarding wireless networking and cloud computing technologies facilitate flexible collaboration of connected devices.

Regarding the impact of pervasive computing technologies in the hospitality domain, the available examples are mostly in the form of Radio Frequency Identification (RFID) based deployments; hence integration with other pervasive computing technologies is missing. Oztaysi et al. [5] studies such innovative RFID technologies in hospitality, but is limited in scope regarding other important components of pervasive computing. In the current study, we intend to extend that work by incorporating those complementary technologies and services designed around them with the goal of providing service innovation through a more integrated pervasive computing framework for the hotel industry. The descriptions of these components together with the services they enable are provided in the next section.

III. THE PROPOSED PERSVIVE COMPUTING FRAMEWORK

Our main objective in designing the proposed framework is to address automation issues related to pervasive computing systems within a multimodal and multimedia environment. We intend to automate services and application selection according to user and hardware profiles, and optimally configure them automatically, when possible.

The customer uses mobile devices such as smartphones, tablets, or kiosks in the hotel, whereas the hotel-staff use hand-held devices given by the hotel for accessing the system. Components of the introduced framework (Fig. 1) are users (hotel customers and staff), device access manager, privacy manager, task manager, performance manager, information manager, services manager, application manager, server, profile manager and databases for tasks, services, and profiles.

A. Access Device Manager

The Access Device Manager (ADM) resides on devices that the users utilize to access the pervasive system. Access Device stands for devices such as smart phones, personal digital assistants (PDA), kiosks, and desktop computers. It manages a set of software agents: Notification Agent, Session Agent and Service Agent. The Notification Agent manages announcements sent to and received by the current user of the device. The Session Agent manages the user activities during the session. The Service Agent manages components needed to provide services to the current user’s device. The utilized components are stored in a local cache, and provided on demand to the Session agent.

B. Security and Privacy Manager

The Security and Privacy Manager (SPM) uses pre-defined security policies based on user profiles for preventing non-authorized access.

C. Task Manager

This module is responsible for all tasks carried out by the hotel-staff. Based on the information collected from other manager modules, the Task Discovery Agent creates the tasks and assigns them to the corresponding hotel-staff based on their profiles.

D. Services Manager

This module is in charge of services available through the pervasive system. Service components are stored in a database, which the Services Manager will access when looking for a specific service. Upon demand, the Application Manager sends posts to Service Agents located on computing devices such as smart phones, tablets or kiosks, as well as to the Service Handler in the Services Manager module. The Services Manager communicates with the Information Manager, set-top box, and entertainment units in order to provide the service. Services are stored in the database communicating with the enterprise applications in the hotel such as ERP, CRM and SCM.
The module manages the user/hotel staff profiles database. It communicates with the Security and Privacy Manager in order to respond to requests on user profile information. It communicates with the service agent for providing users’ preferences needed to adapt the services. Profile databases are communicating with the enterprise applications of the hotel such as CRM.

**F. Information Manager**

This module handles data received from various sensors and contains algorithms which transcribe the data received from sensors and send this information to the Services Manager.

**G. Application Manager**

This module manages applications installed on the computing devices with networking capabilities, e.g. smart phone, PDA, kiosks, desktop computer. The Notification Agent manages inputs sent to and received by the current user of the device. It communicates with the Service Manager if the input requires a service and with the server if updating data stored in the databases is necessary.

**H. Services Supported by the Framework**

We investigate possible applications of this pervasive computing framework in the hospitality industry. Candidate services provided by the proposed framework include self-check-in, concierge, identity recognition, in-room resource access, in-room ambience adjustment, in-room service access, personalization, contactless payment, information access, tracking children via RFID-enabled wristbands, smart waitresses, smart mini-bar, and employee performance management. Before starting to use these services, it is assumed that the user is authenticated, and the necessary profile information is loaded for adapting the services.

**Self-Check-in** is the process where a customer selects his room on his own through the application installed on his own mobile device or a kiosk in the hotel, which provides functionalities such as self-check-in and customized service interactions by offering different language options for foreign travelers. Similarly, by using the mobile application, concierge services are provided in the form of a hotel guide including descriptions of different facilities in the hotel such as spa, pool, fitness room as well as touristic places nearby. Multimedia content is used in order to obtain more comprehensive visualization. Customer requests to use the service through the web browser software installed on his mobile device. The notification agent in the application manager receives the request. For the check-in service, it establishes a connection to the server for updating room availability, and assigning the most appropriate room to the customer for the defined time period. Then, the customer is informed through the web browser.

**Identity recognition** is the system which identifies the customers and controls their access permissions, such as in the form of keyless room entrance. Each customer can enter his/her own room without using any key. Similar to the use of a smart card, a mobile device with integrated NFC module or infrared/wireless connectivity can be used as the key for a hotel room. The necessary information is loaded onto the mobile device of the customer securely after authorization. In the case of not owning a smart-phone, a smart card can be used for this purpose. The information manager communicates with the application manager through the service manager after receiving inputs from smart mobile devices or RFID readers. A confirmation is sent from the server in the application manager to the smart phone. Thus, upon arriving at the hotel, customers can go directly to their rooms and gain entry using their smart-phones or smart-cards.

**In-room resource access** is the system that intelligently adjusts comfortable temperature settings based on the outside temperature and personal preferences, as well as turning thermostat down at desired intervals, and the air conditioner off when no one is in the room. The information manager sends information gathered from various sensors located in the room to the service manager, and intelligent software modules in the service manager component provides adjustments of heating, cooling and lighting systems so that they respond appropriately according to the number of occupants in a room at any given time. The application manager provides remote monitoring and control of the room through the customer’s mobile device. After receipt of the input from the mobile device browser by the notification agent, communication with the service manager occurs for transforming the request to a service.

**In-room ambience adjustment** is provided by smart walls which are inherently large displays. They can be turned into a video player or customizable wallpapers. Remote control is provided by the application manager. Mechanism works similar to the remote control function of in-room resource access.

Instead of calling the reception desk, **service access** by automatic voice recognition is used in the hotel for getting information regarding services such as breakfast/lunch time and menus, entertainment activities in the hotel. The information manager provides recognition of the voice commands through the customer mobile device and sends them to the task manager for translating them into corresponding tasks for the hotel-staff and to the services manager for informing the customer through the application manager. Customer is informed by the web browser installed on his mobile device.

**Personalization** is provided based on the past history of hotel guests regarding TV, climate, mini-bar usage, and consumed services stored in the profile database. After authentication, this information is loaded onto the server managed by the application manager which translates them to related services/tasks, and forwards them to the services and task managers. To illustrate; a created task can be replenishing the mini-bar in the room with preferred drinks of the customer during his stay. A
created service is adjustment of room temperature to
preferred levels. As a result, when same guests enter the
room next-time, the room environment settings are
automatically adjusted, and the mini-bar orders drinks
according to their preferences.

For the smart waitress service, hotel-staff working in
the restaurant uses the software installed on his hand-held
device for recommending menu items to the customers. A
recommendation engine in the application manager uses
customers’ past preferences for lunch and dinner
selections as well as their demographic information. All
of this information is loaded on the server of the
application manager, after authentication. All orders that
are entered into the handheld devices by waiting staff are
transmitted wirelessly to the printers in the kitchen and
bar. They are also transmitted to the administrative
terminal to log the order on the database. This
communication is provided through the wireless access
point, which acts as the bridging point between the
printers, hand-held device and administrative server.

Contactless payment system is an automation service
for in-hotel expenditures of the guests. Every expense is
paid via smart phones or similar devices by using NFC
technology. Also, in addition to smart phones, smart
cards with predefined expense limits can be used by
children so that their parents can control their expenses.
Information manager receives the input data of user/card
id from phones, smart cards, and amount of charge
entered by the hotel-staff and transmits to the service
manager which is responsible for updating balance in the
card and phones corresponding to the user profile
according to the charge.

Information access includes augmented reality
applications which are used for viewing the hotel
environment with virtual computer-generated overlay
information in the form of sound and graphics on a
mobile device. Notification agent in the application
manager takes input from the camera of the phone, and
intelligent software in the application manager overlays
computer generated pictures in real-time, then sends
processed information to the user in real-time, such as
displaying the work hour information, and spa services
when the user points the camera in the direction of the
hotel spa.

Tracking children is performed by using RFID-enabled
wristbands. The information manager takes the
information regarding the exact location of the children in
the hotel from RFID readers located in different places in
the hotel and sends the data to the application manager
to be seen on the parents’ mobile phone or kiosks. Thus, the
parents can trace their children through this service.

Smart mini-bars provide fast replenishment in the bar,
automatic locking after check-out, and automatic billing.
The information manager sends received inputs from
sensors in the bar (e.g. data from the RFID reader in the
mini-bar which reads RFID tags placed on the bottles) to
the services manager for transforming the input into
useful information about in-room consumption,
corresponding charges and restocking needs, and to the
task manager for transforming related information into a
task for the hotel-staff, such as ordering of the consumed
drinks. Related information stored in service and task
databases is used for the SCM system.

Employee performance management is used to create
measurable parameters for managing employees’
performance. The information manager captures service
time and waiting time in the queues through real-time
information retrieved from deployed sensors and the
software installed in the hand-held devices used by the
hotel-staff and transforms them into related information
for the performance manager through the task manager.
To illustrate, this system can be used in the restaurant of
the hotel. A waitress uses her hand-held device for
entering ordering and service times. Sensors are used to
measure the number of people and waiting time of a guest
in the line. The information manager sends the
information to the performance manager over the task
manager in order to transform it into performance
information to be used within the human resource module
of the ERP system in the hotel.

IV. BENEFITS OF THE PROPOSED FRAMEWORK

These systems provide increased customer satisfaction,
customer loyalty, and employee efficiency, as well as
decreased costs for inventory, labor, and energy
consumption. As a result, the business revenue increases,
and competitive advantage and brand differentiation are
achieved.

Customer satisfaction is the key issue in the hospitality
industry, and is increased by reducing waiting times in
the queues with the deployment of the employee
performance management service, by helping find
information about locations in the hotel by using the
augmented reality applications as part of the information
access service, and by providing all preferred drinks in
the smart mini-bar. In addition, personalization is
achieved by capturing user preferences for the room
environment (e.g. light, temperature), TV, and mini-bar
usage results so that when the same guests enter the room
next-time, the room environment is adjusted
automatically, and the mini-bar is filled with drinks they
prefer. Menu options are recommended based on the
guests’ past preferences, as well. These collected
preferences are used in the hotel CRM system for
customer segmentation in order to offer highly demanded
packets, and inform customers about packets they prefer.
These data are used for service innovation as well, which
results in brand differentiation, competitive advantage,
and loyalty.

The in-room resource access service reduces energy
expenses of the building. The employee performance
management and the smart-waitress service increase
efficiency of the employees, and decrease labor cost. The
self check-in service eliminates the process carried out by
the receptionist. Thus, workload on the employees and
labor costs are reduced. The smart mini-bars send
messages for restocking to the hand-held devices of the
employees, so that they don’t have to physically enter
every room. This reduces labor cost, as well. Smart mini-
bars reduce inventory levels of the drinks based on actual
consumption, and trigger automatic ordering. Thus, inventory cost of the drinks is reduced.

V. CONCLUSION

Developers bring many innovative products in the domain of pervasive computing after its introduction in the 1990s. Pervasive technologies are still in the early-adoption stage in their product life cycle, and have not reached their maturity levels, yet. However, many enterprises have noticed the importance of these technologies because of their benefits. Therefore, the idea of using pervasive computing technologies in an integrated system in the hospitality domain brings many innovations as explained in this study. The proposed pervasive computing framework for the hotels provides reduced labor and inventory costs, as well as increased revenues, customer satisfaction, and operational efficiency.

Data collected within this framework are used as part of the three main enterprise systems; one of them is CRM, collected data is transformed into meaningful information in CRM in order to provide brand differentiation, competitive advantage and loyalty. For instance; customers’ profile information is used for appropriate customer segmentation, and offering different campaigns based on this information helps increase the number of customers, and the revenue of the hotel. Using data captured in the personalization service provides customer satisfaction and loyalty.

Data such as real-time consumption, replenishment time, real-time stock levels are collectable through the integrated framework. The SCM system transforms these data into meaningful information in order to help reduce inventory costs.

The last enterprise system using the data gathered through the integrated framework is ERP, where captured data such as service time and waiting time in the queues are used for improving operational efficiency and hotel-staff performance in the ERP system.

Providing secure wireless connectivity between mobile devices and application manager is one obstacle of the proposed framework. Additionally, privacy and ethics related issues are another obstacle. These should be taken into consideration as part of the implementation of these systems.

For future studies, cost-benefit analysis of the proposed framework should be performed in order to assess the feasibility of deploying these technologies.

REFERENCES


Ebru Gökalp is a PhD student at the Informatics Institute, Middle East Technical University, Ankara, Turkey. She received her bachelor's degrees at Cukurova University, Textile Engineering Department in 2005, and Industrial Engineering Department in 2006. She received her master's degree in 2010 at Middle East Technical University, Industrial Engineering Department. She works as a research assistant in the Informatics Institute at Middle East Technical University, Ankara since 2010.

Dr. P. Erhan Eren is an assistant professor at the Informatics Institute, Middle East Technical University, Ankara, Turkey. He received his B.S. degree at Bilkent University, Department of Electrical and Electronics Engineering; He attended the University of Rochester where he received his M.S. and Ph.D. degrees. He was with the Motorola Research Labs in Schaumburg, IL for seven years, where he worked as a Senior Staff Research Engineer. His research interests include pervasive computing, mobile business, cloud computing, and multimedia communications.