TOWARD PERVASIVE COMPUTING IN RESTAURANT

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Abstract: In this paper, an example of pervasive computing in restaurant, a wireless web-based ordering system is presented. By using mobile devices such as Personal Digital Assistants (PDA) and WebPad, customers can get many benefits when making orders in restaurants. With this system, customers get faster and better services, restaurant staff cooperate more efficiently with less working mistakes, and enterprise owners thus receive more business profits. This system has multi-tiered web-based system architecture with good integration and scalability features, and is client device operating system fully independent. Details of design and implementation of this system are presented.

1 INTRODUCTION

In order to improve productivity and operational efficiency, today more and more enterprises pour their investments in mobile solutions. The technology of mobile computing today is matured. When mobile computing devices are available throughout the physical environment, finally they become effectively invisible to the users (Weiser, 1993) because they are so familiar with them that they just ignore computing devices' existence.

Obviously the conduct of business and services over portable, wireless devices has lots of advantages. The miniature size of mobile terminals and the fact that they have light weight and can be carried everywhere makes them an ideal channel for offering personalized and localized services. Some companies developed wireless solutions for inventory management, Point-of-Sale (POS), traffic management and so on (Stanford, 2003). Their approaches are all based on wireless Client/Server architecture, which rely largely on computing capability of mobile devices. Therefore they face the problem of scalability and compatibility, although in small scale application, it perhaps appears not a serious problem.

To build wireless applications, web-based information access technology is a fairly good choice (Catarci, 1999). By web-based technology, we can develop a friendly and easy-to-use system with least administrative work. In this paper, we present a wireless web-based ordering system, named iMenu, which has advantages of flexible functions, easy to operate, and easy to learn. It saves a restaurant's human resource and improves working efficiency. We find our system is one of the first approaches that use wireless multi-tiered Internet architecture to build commercial pervasive computing systems in the restaurant industry. It does not need a powerful mobile client in a pervasive computing environment, while keeping a modest thin client has many benefits (Satyanarayanan, 2001), as shown later.

2 ORDERING IN A RESTAURANT

The business process of ordering in a restaurant is not complicated. However, in a large size restaurant it takes tens or even hundreds of people to work together to serve a single customer. The first step is that customers browse printed menu, choose their favourite foods, and then tell waiters what they want. At the same time, waiters are busy writing what customers order on an order pad. After finish ordering, waiters transfer the paper of ordering to kitchen or cashier (later cashier will pass it to kitchen). When chefs in kitchen receive orders, they check if there are enough materials for cooking from stock staff. If items are run out, they inform waiters. Afterwards, waiters may apologize for sold out items and customers may make new orders. If the food is ready, chefs transmit it to waiters for serving, or, in large size restaurant, there are special workers who do this transmitting job from kitchen to waiters. At the meantime, waiters check the ready foods on

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the copy of order list. After finish their dinner, customers make payment with waiters' help. Restaurant managers then read business report, arrange human resource, and handle accidental situations.

Here we only describe the simplified business process of ordering in a restaurant. In real condition, some orders may be transferred to not only kitchens but also bars, which provide wines and so on. From the analysis we can see waiters are under high pressure to provide good services because they have too much work to do and too many places to run. And all the information is recorded on paper, mistakes may be easily generated, say nothing of disaster when one piece of these papers is lost during transmission. If customers are not satisfied with services, they may ask for changing or returning foods. It is not always restaurant's fault, but this situation is a real case. So waiters, chefs, cashiers have to change all things according to the changed order. Generally, the business flow is quite simple; however, to accomplish all these tasks is burdensome for both the customers' side and the restaurant side without an efficient ordering system.

Our initial thinking to develop this wireless web-based order system, iMenu, is to minimize the work of restaurant staff and to eliminate working error as much as possible. Since most of restaurants have POS system today, it should be able to access previous system's database. Let's see how iMenu works as follows. Customers browse menu, make orders, enjoy their foods and pay as before. The only changed customers can feel is that the response time is shortened and error is reduced. The waiter hold a mobile device (PDA or WebPad), which is easy to carry, and a pen to tap the small glimmer screen. With the handwriting recognition technology and soft keyboard, waiters can input words easily. By using our system, waiters can record customers' order even faster than traditional tools such as pen and paper. When ordering is finished, the waiter strokes a button; all information is transferred to kitchen, stock room and cashier. If some items are run out, a small alert message box is shown on screen of mobile device in a second to let waiters and customers know. To change an order is also a simple job. Waiters just need to recall the order, modify and transmit it again. Chefs, stock staff and cashiers can know everything clearly on screens in their rooms. As an alternative of output device in kitchen, we also use the printer. It may be better for chefs to get information from printers because it is easy to take notes or comments on papers when needed. And computer monitors don't work well for a long time in a relative high temperature and dirty atmosphere environment. Without walking from place to place, talking in noise, waiters, chefs, stock staff, and cashiers can work together in an easy and calm manner. iMenu offers clear benefits for restaurant's customers, restaurant managers and servers. It minimizes the human interaction with information systems.

3 IMENU SYSTEM

3.1 Requirement Analysis

Every category of restaurant staff has its own requirements. Restaurant managers are eager for more business profits, less human resource and easy management of both restaurant assets and staff. They want to compress cost as much as they can. So, reducing staff's working error by iMenu becomes the key issue to get better inventory management and less waste. All items in inventory should be stored in a database, which keeps management in an orderly way. On the other hand, human resource management is also the same way. Managers should be able to fetch any staff's information and track their working time by iMenu's login system. Moreover, as an example of "calm technology", managers could send instruction to staff without facing them, taking benefits of wireless system. Therefore, iMenu should have built-in instant message system to let managers communicate with their staff, which is a trivial work they must do before.

Chefs need fast and accurate orders. Printers in kitchen give them many benefits. They just tick the items on papers when they are finished. Touch screen is also helpful when they need input message, for example, when items are run out. In a word, iMenu system should save their time and help them avoiding mistakes.

For waiters, they need an easy-to-use ordering system that helps them minimize working error. First, at any time they will know which tables are empty and which ones are being occupied. iMenu needs a real-time table map to show table status. Second, they need find items quickly and select them into temporary order list (just like shopping trolley). Instead of writing the name of item, they choose item from screen with a touch pen. Besides, modification of order should be easy. Third, they want to make sure items are served or not. So when one item is put on table, it should be checked simultaneously. Finally, it should be compatible to conventional order process, and need little time to learn the new system. If training time is too long, neither managers nor waiters will think iMenu is a successful application.

Customers need better services just at tableside. By using iMenu, customers should get response more quickly than before. It's the best that ordering, changing items, adding beverages, paying for foods, everything can be done at tableside. With card readers connected to mobile devices, waiters could help customers finish payment transaction effortlessly, which means customers can make payment anywhere in the restaurant.

3.2 System Architecture

To satisfy all above requirements is a challenge. However, as a pervasive computing application in restaurants, iMenu does improve greatly the experiences of both restaurant staff and customers. The first design issue we concerned is to integrate it into existing system. Since most medium to large size restaurants use POS system nowadays, iMenu should be able to access previous database. So, multi-tiered web-based architecture becomes our choice. Without touch any source code of previous system, we integrate iMenu into the POS system with an easy manner. System architecture of iMenu is shown in figure 1. The hardware needed for this system is a web server, wireless network, and some mobile devices such as palm-top PDAs and WebPads. The web server is a link between mobile devices and existed database, which allows people to manipulate the database wirelessly. Moreover, with web services technology, it is also a bridge to exchange data with other enterprises' databases located in difference places.

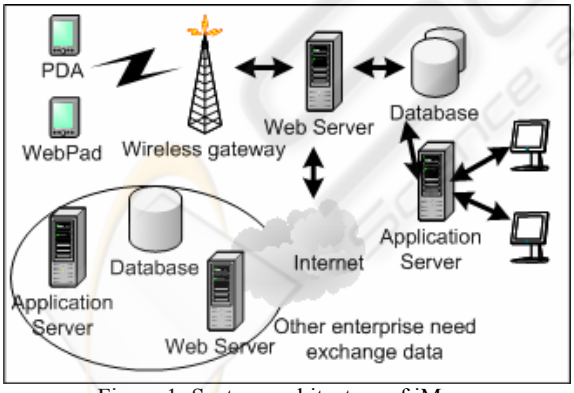

Figure 1: System architecture of iMenu

3.3 Interface

The second issue we concerned to design iMenu is user interface. Input in small screen is not an easy work, so minimizing interaction between people and devices becomes our design emphasis. Nowadays many PDAs integrate handwriting recognition, which is very helpful when input characters. However, to input a word is not enough at all, our aim is in fact how to record quickly what customers order. So, we use help code. With help code, waiters can find "Live Lobster" by only input two letters "l" and "l". The beauty of help code is that it is irrespective to what language people use, no matter it is Germany or Greek. It could be just the initial letter of each word's pronunciation in their native language, which is a convenient way to input and remember. Other alternative methods are also adopted, if waiters are familiar with restaurants existing menu code system, they can use Arabic numerals code. Or, the way that may cost more time, they just input full item name and search. When waiters find the item that customer orders, they tap the item name. Then it is selected into a temporary list. After confirm items with customers, waiters just need click one button, everybody who needs the ordering information can get it.

Figure 2: User interface of iMenu on PDAs

Figure 2 shows the interface of iMenu on PDAs. We use Compaq iPAQ pocket PC as the mobile client. In fact, any device with an Internet browser can be used as a client. This is a clear advantage of a web-based system. Figure 2(a) is the interface for waiters to find and input items. When waiters perform the search task, the search result list shows in the screen; in other time the order list shows in the screen. Figure 2(b) is a map of table status. We use different colors to distinguish status. Blue means the table is not occupied by anyone; yellow means the table is booked by somebody; and pink means currently there are customers occupying the table. When blue button is stroked, an empty temporary list is open for ordering (from point of view of business, a new bill generated). While the red is stroked, waiters can recall current information of ordering of that table. Detail reservation information can be found if the yellow is stroked.

We not only developed iMenu's interface on PDAs but also on WebPads. The high quality display of WebPads expands the use of iMenu from restaurant staff to customers. 10.4" TFT, touch-screen with 800x600 resolution (SVGA) gives users new ordering experience just like their own PC. If users know how to surf on the Internet by computers, they are already able to use iMenu. An exciting merit is that we can embed multimedia features into this system, since WebPad's computing capability is relatively better than small PDA. When customers choose an item, the recipe, story, picture and even movie about this item is shown. So customers may enjoy ordering meals by themselves. Now, interestingly, Waiser's calm technology (Weiser, 1993) is not really "calm", people can appreciate movie and music before their dinner coming. Shortcoming of WebPad is that it has heavy weight to some extent. Although today mobile devices become lighter and lighter, 1.7 kg is still too heavy for waiters to carry for more than 2 hours. The So, mainly it is used on table for customer self-service. Figure 3 shows the WebPad we use in our system and the interface of iMenu on WebPads. Since the screen is large enough, we can display item introduction and work zone in one screen.

3.4 Analysis

There are about 70 database tables used in our system. Stored procedures and triggers are used to fulfil some tasks. It could help to lighten the load of web server.

Table 1: Database tables used in the system

Table Name	***Description***
shiftdef	Definition of restaurant staff shifts
auth_login	Staff information, control of login
auth_group	Staff group definition
pos_pda	Information of PDA, for example, name, address and region
pos_tblsta	Information of table
pos_reg	Information of region, one work region may have several PDA
pos_tblav	Information of table status
pos_pluid	Menu category
pos_plu	Menu
pos_dish_add	Special cuisine requirement of guests
pos_dish_none	Record of run-out items
pos_tempsession	Template ordering list

During the development period, we find multi-tiered architecture design has many benefits. Our system needs the least investment on hardware and maintenance. Before deploy the system, restaurant owners would like to purchase the hardware as cheap as possible. iMenu only needs thin client, which is good for both technical and commercial consideration. Any device with a browser can be used as client. For instance, some kinds of PDAs that have monochrome screen, which is inexpensive, can be used as client devices. After deploy the system, restaurant owners would like save cost on maintenance as much as possible. Our system need almost no maintenance work on client side and the central web server is easy to maintain. We find some other systems store an inventory database and client application in mobile devices, which make it very difficult to upgrade, because every client-side software should be re-install, and every client database should be updated. Besides, client-side applications increase the load of mobile devices that require higher performance equipments, which have higher prices.

To system developers, this web-based architecture is also helpful. For example, it is simple to obtain pleasant user interface by web page designing. And it has good scalability because it is composed of several clear layers such as data access layer, business logic layer, business presentation layer, and user interface layer. Another benefit is that programmers can debug the source code on computers, and then check the compatibility between the web page and mobile device's browser. It is much easier than to debug the client program on mobile device simulator first and on real mobile device later.

Generally speaking, compared with other client/server pervasive computing applications, our mobile ordering system has many advantages as follows.

- It is simple to manage, and therefore more reliable, because it doesn't need different configurations and installations on different client mobile devices;
- It is more secure, in that all the access should pass the central authentication; while the information stored on different mobile devices is at risk, in that back-up and archiving procedures are less stringent than on servers or mainframes;
- It supports universal access to applications and a common user interface, decreasing training costs and minimizing confusion to system use;
- It costs less to upgrade and change, in that no applications have to be installed one device at a time; and
- It accelerates application development, because business rules can be focused on server side programming.

Performance is concerned when we develop iMenu. If the client device is strong enough, client

applications running on client device can almost response real-time. So we tested the response time of iMenu to see the performance of web-base application. We find the response time of every request is no more than 0.7 second. And the load of web server is not heavy for intranet use, because the number of connections at one time is small. Besides, we avoid using complicated script in web page when programming, for alleviating load of both server and clients, and providing better compatibility to client browser.

3.5 Evaluation

We have deployed iMenu in two restaurant enterprises. Then we conducted an evaluation study focusing on the staff performance of ordering and consumer experience. The first quarter after deployment both of these two enterprises make more than eleven percent profit than last year. We found that by using this system the time staff spent in service per customer reduced significantly. According to the observation of 151 waiters in the first hotel group in 1 month, the average ordering cycle time per table is shortened from 12 minutes to 10 minutes; the waiting time after order is reduced from 7 minutes to 5 minutes. The same results are obtained in the chain enterprise group's restaurants.

Not only time is saved, but working efficiency is also improved. With iMenu, staff in restaurants can cooperate more easily and smoothly. All the ordering information is transferred wirelessly, with least effort staff can work precisely. Moreover, staff can communicate with short messages on mobile device, but all for free, not like mobile phone text message service that charges according to the message sent. Therefore, they work more efficiently than before.

On the side of consumers, it also greatly improves the ordering experience. With iMenu, people can get better and faster services, which is the most desirable in restaurants. Moreover, people may try to order dinner easily by themselves on WebPad. Many young people would like this mode of service.

The system is compared with other wireless ordering systems. System 1 and system 2 are wireless products of current world leading companies in industry. System 1 is based on Pocket PC, with 801.11b and integrating with the company's restaurant information system. System 2 uses Infrared as communication channel, with local database and client application installed in mobile device. We choose each system's latest version. Compared with these current commercial ordering systems, iMenu has lots of advantages. The most strength of iMenu is its scalability and client operating system independence, which gives enterprise much freedom to deploy and expand the system. It also has better multimedia and integration features than others.

Table 2: Comparison with other systems

Features	*System 1*	*System 2*	*iMenu*
Infrastructure	Wireless Client/Server	Wireless Client/Server	Wireless Multi-tiered web-based
Wireless networking	IEEE 801.11b	Infrared	IEEE 801.11b
Mobile devices	PDA	PDA	PDA and WebPad
Client operating system	Windows CE	Palm OS	OS independent
Multimedia features	No	No	Yes
Pervasive database	Integrated DB	Local DB	Integrated DB
User authentication	Password	Password	Password
Integrated Reservation System	No	No	Yes
Integrated Credit Card System	No	No	Mobile card reader
Integrated Enterprise Information System	Client access	No	Web-based access

3.6 Future Development

With pervasive computing, using information technology will progressively feel more like using the everyday objects than using personal computers (Fano, 2002). Nowadays people may notice that the restaurant using mobile device instead of traditional menu, but later when the way of accessing and using information is totally changed, people will not think iMenu is a fangle of information technology.

Although our research successfully brings people new ideas of restaurant ordering, we still have lots of challenges in future development.

First of all, pervasive computing implicates that devices are aware of their surroundings and peers, and to be capable of effectively providing services to, and using services from, peers (Cheng, 2002). While our application still has low rating in device discovery and service discovery because it uses predefined network address and predefined application specific access. In this mode, it is not difficult to manage the limited number of mobile devices. However, when there are a huge number of devices, say, "pervasive", only the configuration work of IP address, subnet masks, gateways and so on would become a very cumbersome job. We need automated techniques to dynamically reconfigure the network when required (Saha, 2003). We noticed

that pervasive computing retail system applications may offer benefits for both retail consumers and suppliers (Kourouthanassis, 2003). So next step we plan to develop a radio frequency identification (RFID) system to detect the distribution of dishes in restaurant, which will help to sense the service event and capture related data without human interaction with system. Since dishes with RFID tag of restaurant are reusable, it has no cost problem like retail system.

Secondly, security is another important and complicated challenge related to our work. In addition to contending with the usual Internet security threats in online applications, wireless devices introduce new hazards specific to their mobility and communication medium (Ghosh, 2001). Now we mostly rely on built-in wireless hardware security features and Secure HTTP (HTTPS) implemented over Secure Sockets Layer (SSL). However, to provide a secure pervasive computing environment is not an easy job. Some conceptual models of pervasive computing environment are introduced (Kagal, 2001). But we still face practical security problems such as insider attacks, man-in-middle attacks, viruses attacks, Distributed Denial-of-Service (DDoS) attacks (Xiang, 2004) and so on. DDoS is possible in wireless realm, and is as dangerous as in wired Internet.

Security and privacy are intimately linked together. From the view of technology, privacy can be protected by secure communication channels and data storage. Beside the technical issues, there are also social issues on security and privacy. By pervasive computing, more customer information can be easily collected than before. So how to use the personal data gathered by pervasive system still need cultural or legislation solution (Beresford, 2003).

4 CONCLUSION

In this paper, iMenu, a web-based wireless ordering system is presented. As we have seen, it has lots of advantages such as offering customers fast and accurate services, reducing restaurant staff working errors, providing enterprise owners more profits and so on. However, this is only the first step toward realizing pervasive computing at tableside. Some problems such as dynamic reconfigurable adaptation of mobile devices, security and privacy issues, scalabilities, integration to existed enterprise information systems and so on remain open for research.

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