iGrocer- A Ubiquitous and Pervasive Smart Grocery Shopping System

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ABSTRACT

Emerging Smart phones are poised to give a whole new dimension to the way we shop, bank, and go about many of our everyday activities. iGrocer is a smart grocery shopping assistant, that re-defines grocery shopping. It is capable of maintaining nutrition profiles of its users. Particularly useful for elders and disabled shoppers, iGrocer can aid and advice users on what products to buy and what to avoid based on nutrition criteria and price constraints. Implemented on a smart phone with a barcode scanner accessory, iGrocer has a number of killer features that include: (1) ubiquitous shopping list: adding items to the shopping list by different means (e.g. simply scanning them when near empty, scanning and storing manufacturer coupons, planning the weekly menu right on the phone or through the web, and shopping for the necessary ingredient of a particular recipe, (2) quick and assisted in-store shopping: while shopping in the grocery store, iGrocer maps out the shortest shopping path with a map indicating the location of the next item on the list, and (3)automated check-out: iGrocer is capable of acting on behalf of the store and the customer to perform a trusted queue-less checkout. In this "application-oriented" paper, we present the iGrocer concept and give details of its architecture and implementation. We also summarize the lessons learnt throughout its development and testing phases.

Keywords

Pervasive computing, mobile commerce, Ubiquitous computing, Smart phones, assistive devices.

1. INTRODUCTION

The next phase in wireless technology revolution, smart phones with killer applications, is certainly going to change our way of life. Ranging from online banking to home automation, applications as useful and powerful as these are convenient, attractive and cost-effective as well. iGrocer is a smart grocery-shopping assistant, that will probably re-define grocery shopping, as we know it.

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iGrocer is an application that has been designed for the next generation smart mobile phones that come with a bar code scanner. As the name suggests, iGrocer will help the user create and maintain comprehensive shopping lists to prepare and plan for the weekly grocery purchase. These shopping lists can be accessed both from the smart phone and also from the iGrocer website. What makes iGrocer really handy; especially for elders, visually impaired and disabled people, is how it can aid and advice users in making decisions of which food items to buy and which to avoid. iGrocer's recommendations are based on a compatibility check between the user's health profile and nutrition content of the food item. The user no longer has to bear the brunt of reading the small font nutrition information in the back of food cans. When the user enters the grocery store, iGrocer works out the shortest shopping path and provides an interactive map indicating the location of each of the items on the shopping list. The phone can also perform a trusted checkout and thereby act on behalf of the store and the customer.

Section 2 gives a description of the problem at hand. Section 3 describes our proposed solution to the problem and describes the features of iGrocer. The iGrocer system design and architecture are described in section 4. This section also discusses some of the major design decisions we had to make, and covers some implementation details. We conclude the paper with a short discussion of the potential market for iGrocer and compare its superiority to current state of the art, which is web-based e-grocery.

2. PROBLEM DESCRIPTION

Grocery shopping as it is today is a chore. The customer has the burden of maintaining shopping lists, managing coupons, reading the fine print on food cans, standing in check out queues, and even has to figure out in which aisle he or she might find that item. A significant percentage of the grocery shoppers would therefore be interested in a more convenient, faster grocery shopping option. Although e-grocery bring the groceries to one's door after simply submitting a grocery list on the store website it certainly has its drawbacks. Besides not being able to personally hand pick one's produce and meats, customers may have to present at certain times to take delivery of their grocery packages and they may not get to use manufacturer coupons. Mobile computing technologies have made it possible for us to think beyond e-grocery as the ultimate grocery shopping solution. In section 3 we describe iGrocer- a ubiquitous, pervasive smart grocery shopping system designed for the emerging breed of smart phones (connected Java enabled phones).

3. PROPOSED SOLUTION – iGrocer

iGrocer is designed to be much more than just a personal shopping assistant. Not only can it help the user shop healthy, it can also make grocery shopping convenient and quick. It even involves the children in the weekly grocery shopping. Based on client-proxy-server architecture, iGrocer uses wireless packet data technology to connect to the corporate network. Some of the features of iGrocer include:

- *Nutrition Profile*: Prompts the user to choose from a list of medical conditions and allows the user to customize his calorie intake.
- *Scan Item*: The user can add items to the shopping list by scanning the near empty item
- *Add by Recipe*: Items can be added to the shopping list by viewing recipe ingredients.
- *Wish List*: iGrocer allows the children to maintain all the items they need from the grocery store in a wish list. Items from this list are moved to the shopping list on parental confirmation.
- *Personalize Categories*: iGrocer gives the user the option of customizing his product categories based on his shopping habits.

The following sections detail the major features of iGrocer.

3.1 User Profile Creation

Users, who would like to register and use iGrocer, have to create for themselves an account. Profile creation in iGrocer is both quick and easy, and can be done through either the user-friendly interface on the phone or the web site. iGrocer restricts creation of profiles to a unique, common user-id for the family. To encourage family participation, iGrocer prompts the user to choose a different pin combination and access privilege for each member of the family. In general, adults get full access while the children get restricted access. Children get to add items to a wish list. Another advantage of having different pin combinations is the ability to allow and support simultaneous updates by more than one member of the family. iGrocer also accepts and stores credit card information at the time of profile creation. The user is prompted to enter the first twelve digits of his credit card number, the expiration date and the card type (visa/master card). This information is sent on a secure channel to the customer database on the proxy server and stored in an encrypted format.

3.2 Nutrition Profile

Healthy meals start in the grocery market when users make the right choices of items they buy for themselves and their family. While most grocery shoppers are price conscious, there are few who shop for food items as per their nutrition needs. iGrocer realizes that there might be people with special medical conditions who have to be careful of what food items they buy and consume. To relieve them of the burden of reading the nutrition information on food cans and verifying nutrition compatibility, iGrocer provides the user with an option of configuring his nutrition profile. During configuration, the user is asked to select all appropriate medical conditions from the given list (low fat, low sodium, liver disorder, pregnant etc) as shown in figure 1. Based on the choices selected, iGrocer sets up nutrition constraints for the user. For example, if the user has to maintain low sodium diet, iGrocer checks and recommends those items with potassium to sodium ratio of approximately 1:1 with a preference for potassium and sodium levels below a certain threshold. These constraints and thresholds are based on the recommendations of the American Dietetics Association. Some users may want to further configure their calorie intake with their medical representatives. For this reason, iGrocer provides an option on the website of customizing the total calories, total fat in grams, protein in grams etc.

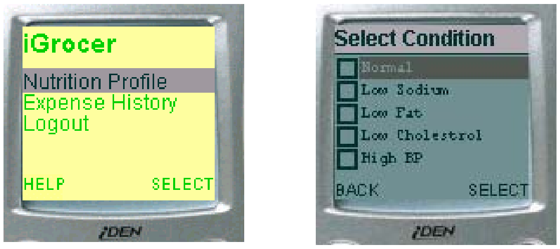


Figure1. Nutrition profile feature on the phone

3.3 Shopping List

The logical first step to grocery shopping is to put down a shopping list. Besides the obvious advantage of not having to run back to the grocery store for a forgotten ingredient, maintaining a shopping list also translates to healthy meals. An exhaustive shopping list is also one way to curb temptation to grab items off shelves on an impulse and keep the grocery bills under check. Research and market survey shows that both sexes attempt to prepare well for their grocery shopping. With more than three-quarters of men (77%) and even more women (84%) reporting they have prepared shopping lists [9], the shopping list becomes a very important feature of the application.

3.3.1 Personalize Categories

Most grocery shoppers have been found to be creatures of habit, people who tend to stick to what they know when it comes to name brands and types of food. Both men and women have been found to be hesitant to break their usual grocery shopping routine. With only 26% of the consumers buying a wide variety of foods and brands, compared to the 72% who say they always or often purchase the same items every time they go food shopping [9], its obvious that shopping patterns are definitely repetitive though may vary with demographics. Sensitive to these facts, iGrocer provides the option of personalizing shopping lists. The user is presented with all the product categories and asked to select all those categories he would typically go through to find his grocery item. For example, although most grocery stores carry cosmetics, the user may regularly buy her cosmetics supplies at a store in the Mall. With iGrocer, the user has the option of not choosing such categories such as cosmetics while customizing her categories. When the user wants to add an item to the shopping list the next time, he or she is presented only with the chosen categories. Such a customized category list helps people associate their needs with the categories and remember them, besides helping avoid an unnecessary purchase. However, the most important advantage of personalizing categories is the convenience of having to go through lesser amounts of information on the smart phone. This ensures fast access to the exact item one is usually after within the limited battery life of the cell phone.

Typically, almost every grocery shopper buys items like milk, butter, and eggs, bread every trip to the grocery store. In order to give the user the convenience of adding these items to his or her shopping list by default, iGrocer has the option called every time grocery. Every time grocery is a list of the top five grocery items that are common to most people's grocery lists based on area demographics. The user can check off all the items that should be added to the shopping list by default each time. The upside of this option is that it saves the user cell phone battery time, which could be used otherwise and at the same time ensures that these most common foods are not forgotten when putting down the list or shopping. Screen shots of the user interfaces are as shown in Figure 2.

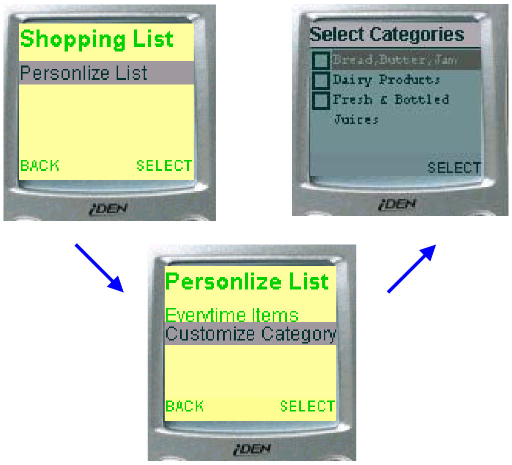


Figure 2. Customize category feature on the phone

3.3.2 *Surf Category*

While e-grocery web sites can afford to take their users through many levels of product categories before they hit upon the exact item they are looking for, on a cell phone a feature like this could be more annoying that convenient. iGrocer's *surf category* is a single level, individually tailored set of product categories. Compiled based on the user's choices while personalizing categories and updated based on past purchases and possibly new food items at the grocery store, iGrocer serves as a grocery store yellow pages. Adding the exact item you want is thus just two clicks away. Figure 4 is a screen shot of the surf category feature on the web site.

3.3.3 *By Recipe*

When grocery stores come up with catchy fliers, discounts and tempting food items it becomes very difficult for an average shopper not to spend great deal of time at the grocery store shopping for all those items he definitely doesn't need. iGrocer recognizes the fact that drawing out a weekly menu for your meals helps cut down on time in the grocery store and helps you feel more organized knowing your just shopping for the ingredients of your weekly menu. Recipes can be created and stored along with the user's profile via the iGrocer web site. On the cell phone, these recipes are displayed when the user chooses the 'by recipe' option. The most recently created recipe is displayed on top followed by the most recently used ones. On selection of a recipe, all the ingredients are displayed and the user simply has to check those ingredients that have to be bought at the grocery store. The real advantage of grocery shopping by recipe is the unnecessary calories it keeps away and the expense it cuts down. Figure 3 shows screen shots of the 'by recipe' feature on the cell phone.

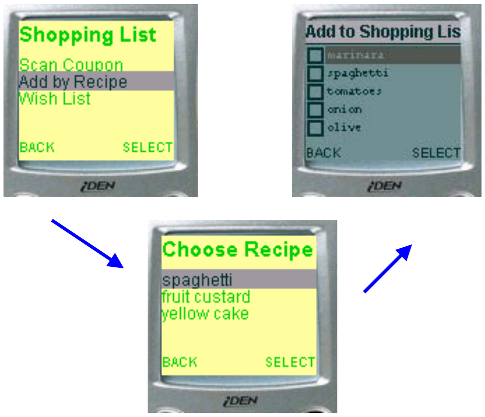


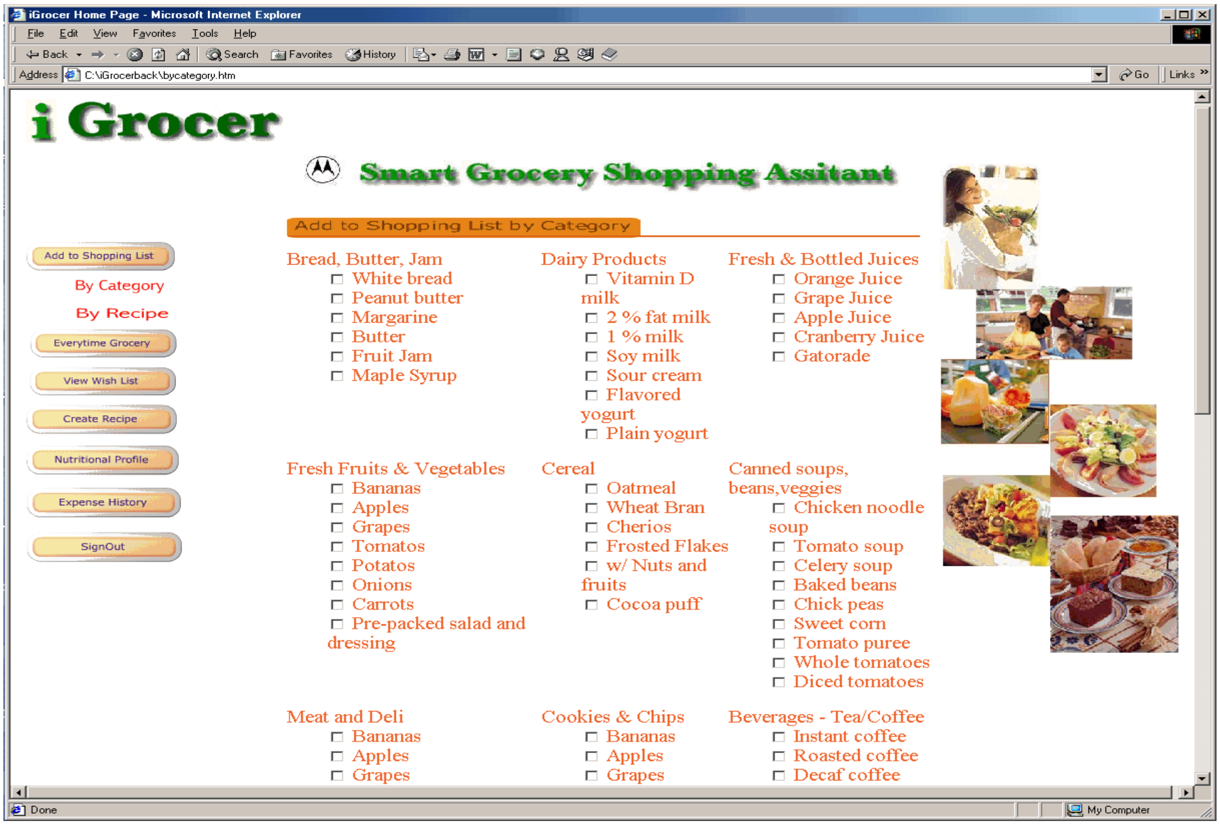
Figure 3. 'Add By Recipe' feature on the phone

3.3.4 *Wish List*

Children today have economic power. A recent Rand Youth Poll estimated expenditures by youth ages 7-18 to be $56 million in 1990, which is up a whopping $20 million compared to that in 1979 although the youth population dropped by 4 million [9]. A sizeable percentage of these children come from two-earner and single parent families and in most cases do their own weekly grocery shopping, which predominantly includes snacks and fast-food purchases. iGrocer recognizes the need to educate and teach children to shop with nutrition and cost and the two most important factors. The wish list is a shopping list created and maintained by the children of the household into which they can add all the items they need from the grocery store. Items in the wish list can be moved to the shopping list only parental acceptance. This keeps the adults aware of their children's grocery needs and also provides a chance to explain to them how to make healthy choices when it comes to food. Figure 5. shows the 'wish list' option.

3.3.5 *Scan Item/Coupon*

iGrocer has been implemented on a cell phone with a bar code scanner accessory, which opens out a whole new way to maintain a shopping list and save with coupons. When a food can or a milk carton is almost over, with a quick scan of the barcode the item can be added to the shopping list. According to an poll conducted by the Opinion Research Corporation in July 2000 [9], 72% of men and women say they always or often purchase the same items when the go grocery shopping. In such a scenario, the best way to make up the shopping list would be to simply scan the near-empty


iGrocer Home Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites History
Address C:\iGrocerback\bycategory.htm
Go Links
Done
My Computer

i Grocer

Smart Grocery Shopping Assitant

Add to Shopping List by Category

Add to Shopping List
By Category
By Recipe
Everytime Grocery
View Wish List
Create Recipe
Nutritional Profile
Expense History
SignOut

Bread, Butter, Jam
□ White bread
□ Peanut butter
□ Margarine
□ Butter
□ Fruit Jam
□ Maple Syrup

Dairy Products
□ Vitamin D milk
□ 2 % fat milk
□ 1 % milk
□ Soy milk
□ Sour cream
□ Flavored yogurt
□ Plain yogurt

Fresh & Bottled Juices
□ Orange Juice
□ Grape Juice
□ Apple Juice
□ Cranberry Juice
□ Gatorade

Fresh Fruits & Vegetables
□ Bananas
□ Apples
□ Grapes
□ Tomatos
□ Potatos
□ Onions
□ Carrots
□ Pre-packed salad and dressing

Cereal
□ Oatmeal
□ Wheat Bran
□ Cherios
□ Frosted Flakes
□ w/ Nuts and fruits
□ Cocoa puff

Canned soups, beans,veggies
□ Chicken noodle soup
□ Tomato soup
□ Celery soup
□ Baked beans
□ Chick peas
□ Sweet corn
□ Tomato puree
□ Whole tomatoes
□ Diced tomatoes

Meat and Deli
□ Bananas
□ Apples
□ Grapes

Cookies & Chips
□ Bananas
□ Apples
□ Grapes

Beverages - Tea/Coffee
□ Instant coffee
□ Roasted coffee
□ Decaf coffee

Figure 4. 'Add to Shopping List by Category' feature on the iGrocer website

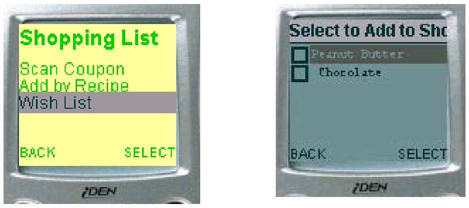


Figure 5. Screen shots of the 'Wish List' feature on the phone

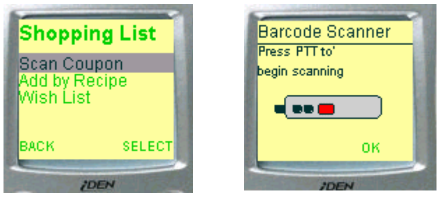


Figure 6. Screen shots of the 'Scan coupon' feature on the phone

item. The advantages are obvious: savings on cell phone battery time, convenience for the user and computation time saved on finding nutritional compatibility. Like wise, all manufacturer coupons that we many a time forget to take to the grocery store, can be scanned with the cell phone. These coupons are then sorted and stored by aisle. Screen shots of the scan coupon are as shown in Figure 6.

3.3.6 Short keys

For users who are familiar with iGrocer, going through the menu to access iGrocer's 'killer features' may be unnecessary. iGrocer has built in, easy to remember short keys for its powerful features such as scan item, scan coupon, view-shopping list, by recipe etc. So, by simply pressing the pound key, the user can scan an item and add it to the shopping list. Figure 7 shows screen shots of the short keys menu.

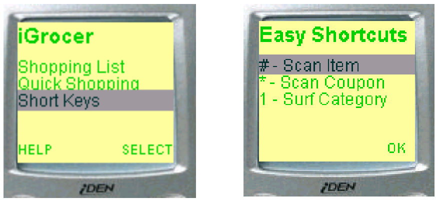


Figure 7. Short keys menu on the phone

3.4 Quick Shopping

For apathetic shoppers, who are just interested in purchasing items on their shopping list with maximum ease, the quick shopping feature of iGrocer would be a 'killer feature'. When at the grocery store, the user might want to take advantage of special deals at the store that day. For this reason, the iGrocer provides an option where by all special store deals are displayed to the user. Optionally, the user could just choose to start shopping, upon which the latest version of the shopping list is downloaded from the host server. Also downloaded is the entire aisle map of the grocery store. Each item's aisle number and relative location in the aisle is determined. The shopping list is now sorted to ensure that the user travels the shortest path to pick up all the items on the shopping list. While all this computation is going in the background, the user is shown an entire map of the grocery store with a blinking, little man indicating the user's position relative to the aisles. When the user is ready to start shopping, as shown in Figure 8, a blinking red dot appears on the map indicating the location of the first item. Once the user gets to the item's location, the three best products that match the user's nutrition needs (if the nutrition package has not been chosen or configured, by default iGrocer sorts items based on price) are displayed. These items are the results of queries to the store's product database and the nutrition database. Items are first sorted based on nutrition criteria and then on price (if a large number of products rank the same based on nutrition criteria, they are next sorted on price). The user no longer has the burden of going through all the nutrition and ingredient information on the food can to decide whether to throw the item into the shopping cart or not. By scanning the barcode on the food item, the user can add the item to his shopping cart. If the user has a coupon for the item, it is used automatically. Additionally, the user also has the option of viewing all the coupons he has for items in that aisle. The user is next shown a map where his position is advanced to the location of the previous item and the blinking red dot is moved to the location of the next item in the shopping list, as shown in figure 8. When the user has scanned the last item on the shopping list, he is presented with the total and a listing of all the items in his shopping cart. At this point, the user may choose to remove some items from the cart to decrease his grocery bill. Alternatively, the user could proceed to checkout where he is required to choose the credit card type and enter the last four digits of the credit card number. The advantages of quick shopping are many. Queue-less secure checkout, organized coupon management, healthy food choices, shortest path to pick up all items, interactive map indicating the 'aliveness' of the application are among some of the 'killer' features.

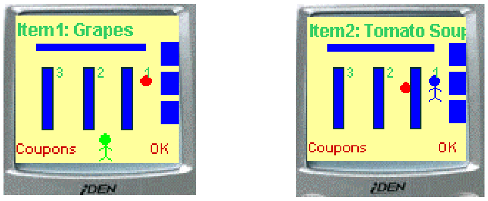


Figure 8. Interactive aisle map indicating location of items in the grocery store

3.5 Expense History

U.S. Statistical Abstract survey shows that an average American family spends about 7.4% of their income on groceries. This means that a family with an annual income of about $40,000 will spend nearly $3000 on groceries [8]. Expense monitoring has been found to be useful in keeping those unnecessary calories away. The *expense history* option in iGrocer, gives a report of the previous month spending statistics. While shopping in the store, just before checkout, a listing of all the items in the cart and the subtotal is displayed. In addition, the previous month's average grocery bill is also displayed. The user could use this statistic to decide if he is within his grocery budget limits and possibly remove some items before proceeding to final checkout.

4. SYSTEM DESIGN AND IMPLEMENTATION

iGrocer was developed using the MotoSDK wireless toolkit. The application was downloaded and tested on Motorola's i85s iDEN-based mobile phone with a bar code scanner accessory. The i85s is a Java enabled phone running the KVM Java Virtual Machine. It adheres to the CLDC configuration and supports the Mobile Information Device Profile (MIDP). The i85s offers wireless packet data with routable IP (a non-standardized version of Mobile-IP, in fact). The following sections describe the system architecture and some of the implementation details of iGrocer.

4.1 System Architecture

iGrocer architecture is a classic example of the client-proxy-server architecture with the proxy/host server handling all the intermediate communication. Users can create a profile on iGrocer from either the phone client or the through the iGrocer website as shown in figure 9. The new user information is then sent to the proxy, which then stores the information in the customer database. Also stored in the customer database are nutrition profile, wish list, recipes, expense history and the shopping list. Figure 9 shows the Motorola i85s phone with the bar code scanner accessory. The smart phone with the scanner can be used to scan near empty items to add them to the shopping list as shown in the figure. Every time the user logs in to iGrocer, the proxy downloads the latest version of the user's shopping list from the customer database. While quick shopping, for each item on the shopping list, the proxy queries the nutrition database via JDBC connectivity and retrieves the brands and their nutrition information. For each of these products, the store database is queried and the pricing information is retrieved. The products are sorted based on the user's nutrition constraints and/or price.

The nutrition database used in the present application is the ESHA Nutrient Database Version 7.7, which has nutrition information of over 40,000 food items and 177 nutrient factors. Our store database resembles product and point of sale databases of Publix (Grocery chain store in South Central Florida).

4.2 Code Features

There are three crucial factors that we kept in mind when developing iGrocer. While it might be really useful to have a smart grocery-shopping assistant, it would become a killer application only if packet transfer is minimized. Secondly, the recommended MIDlet size for the i85s Motorola smart phones is definitely less than 50 KB. Last but not least, the battery life of these phones could be as low as 27 minutes. Having stated these factors, we now list down some of the key design optimizations.

Custom Installation: Basic installation of iGrocer includes the two most important features: shopping list and quick shopping. Expense history and Nutrition profile are two separate MIDlets, which if installed and configured would amount to a full installation of iGrocer. There are two main reasons why nutrition profile and expense history were separated and made add-on features. First, market research tells us that for most grocery shoppers, price is the most important criteria and for whom nutrition compatibility may not be high on the priority list.

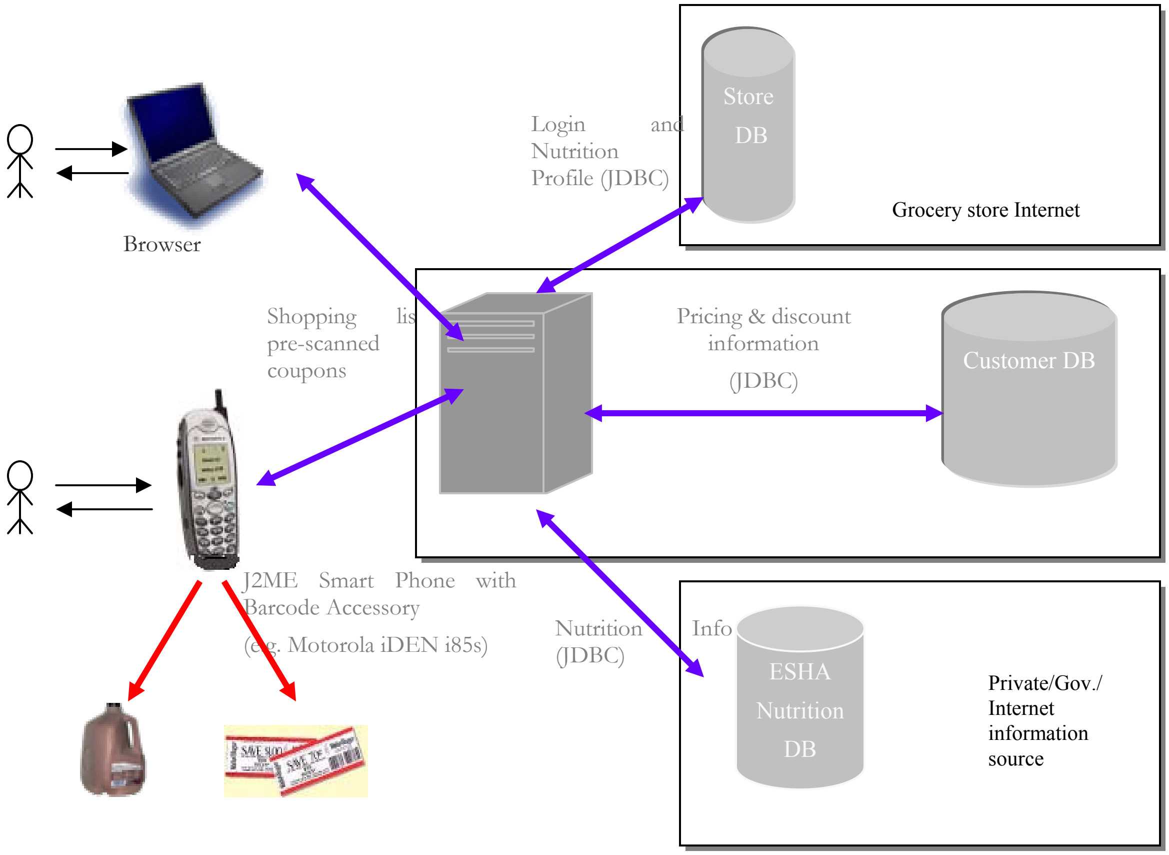

Login and Nutrition Profile (JDBC)
Store DB
Grocery store Internet
Browser
Shopping lis pre-scanned coupons
Pricing & discount information
(JDBC)
Customer DB
J2ME Smart Phone with Barcode Accessory
(e.g. Motorola iDEN i85s)
Nutrition Info (JDBC)
ESHA Nutrition DB
Private/Gov./ Internet information source

Figure 9. iGrocer system architecture

Secondly, by partitioning the application into three MIDlets, the MIDlet size can be kept under 50 KB without making any compromise on the 'killer' features.

Minimizing Packet Transfer: While designing iGrocer, one of our major concerns was to minimize IP packet transfer. For instance, when the user begins quick shopping, if the entire store aisle-map were to be downloaded each time, then that would incur a significant cost which might even override the advantage of having a map on the phone. To address this problem, we researched supermarket chains and found that Plano grams or store aisle-to-product maps are not stored electronically. (For example, it is important to know that cereals are found in aisle three on the left hand side, with respect to the store entrance and in the middle of aisle.) All the same, there is an on going effort in the industry to do the same. We also observed that Plano grams do not change frequently. We chose XML to represent the Plano grams conformant with the following DTD:

```
<!ELEMENT Aisle (ItemType+)>
<!ATTLIST Aisle Number CDATA>
<!ELEMENT ItemType (Location,
RightorLeftSide)>
<!ATTLIST ItemType Name CDATA>
```

We used XML to represent Plano grams as it is the simplest way to exchange information electronically on the web. Each time the user starts shopping at the grocery store, the difference (if any) in the Plano gram version that is found on the proxy/host sever and the version on the store database is sent to the phone client. Essentially, all that is sent back is the 'diff' of the two files.

A similar optimization is also applied to the shopping list. Instead of downloading the entire shopping list each time from the proxy server, the phone client stores the most recent version of the shopping list, in a record store. So, all that needs to be sent to the phone client is a 'diff' of the two versions of the shopping list.

Battery Life: Smart phones have a very limited battery life, which makes it important to design the application such that the user doesn't have to go through multiple levels of menus to access a certain feature. Short keys for the killer features such as *scan item, scan coupon, view-shopping list* and *by recipe* is one of the time saving alternatives. Product categories have been modified from as they appear on typical e-grocery web sites so that it is possible to access a certain item in just one click.

Each request from the phone client and response sent by the proxy is on a separate thread. This technique of extensive threading on the client side keeps the user interface 'alive'. On the server side, threading helps the server process requests from more than one client simultaneously. Canvas has been used to build the user interface so the full potential of a color display can be exploited.

4.3 Lessons Learned

It was highly gratifying to deal with a real application and with tangible mobile technology components, including the smart phone, J2ME, wireless packet data, and mobile-IP. But what was less exciting was having to deal with less than mature and evolving software development environment technology. A J2ME development toolkit and a smart phone emulator are just two of the tools that the developer must choose and train himself to use. Existing toolkits available to the developer are Sun's J2ME Wireless Toolkit, Zucotto Wireless' WHITEBOARD SDK, CodeWarrior 6.0 for Java, Borland's JBuilder 5.0 Personal/Mobileset and Siemens Mobility Toolkit. While most of these toolkits come with a packager, debugger, preverifier and emulator each of them have some unique features. Most of the toolkits especially Sun's J2ME and Code Warrior come with several emulator 'skins'. The Zucotto wireless toolkit has a PNG Painter to create colorful MIDP-compliant images and also has source level debugging and multilevel tracing. Borland's Jbuilder supports development for Nokia MIDP powered phones while Code Warrior provides several Motorola phone skins. The Siemens mobility toolkit has two emulators, one that even supports Chinese characters but compilation and pre-verification have to be done manually. The choice of toolkit is therefore tricky as the toolkits themselves are evolving.

But the real challenge is discrepancy between the smart phone emulator and an actual MIDlet client running on a MIDP phone. It is almost impossible to develop the application completely on the phone due to several reasons, including speed of development ad testing cycle, cost (connection charges) or legitimacy involved in downloading the MIDlets into the phone. Therefore, developers (ourselves included) are forced to make extensive use of a phone emulator (of the type and "skin" of the target hand-set) during development and testing phases, and postpone performing actual phone downloads towards the end. This unavoidable emulation is a major source of problems. For instance, many of the emulators have different width and height displays than the actual phones. Therefore all the graphics designed in canvas may look very different on the phone. Also, the emulators support a wide range of colors unlike the actual phones. Such discrepancies translate to a major slowdown in development.

The aforementioned problem could deepen if it is not possible to gain any access at all to download applications to the smart phones. Currently, providers and carriers attempt to stick to their business territories as much as possible, by drawing revenue streams by selling minutes (and/or packets) to subscribers and businesses. In fact, carriers are re-thinking this model fearing loss of future businesses if competitive third party applications somehow intercepts and redirects their business (e.g., a Voice or IP over Air MIDlet on a Bluetooth-equipped smart phone may do just that). Carriers are therefore not sure how to safely and competitively package and offer these cutting edge technologies (smart phones, J2ME, packet data) as services. Therefore, it may not be easy for third party application developers to gain access to Java phones without special arrangements and legal agreements and contracts. This may impede the pervasiveness of development activities and the spreading of this kind of smart phone networked applications.

Another issue that the developer has to constantly bear in mind is power restriction on the phone. Typically cell phones have a talk time of over three hours and can stay for days in standby mode. Smart phones, however cannot withstand more than one half hour of full operation (compute over 1/2 MB of memory and UDP packet transfers). For example, the Motorola i85s smart phone has a battery life of about twenty-seven minutes in "full operation" mode, according to [10]. Clearly "full operation" is not a well-defined industry benchmark. As a developer, one has to forget the lifetime data of the voice phone and must find and use the "smart" phone lifetime data as he develops the applications. By minimizing UDP transfers and by shrinking code size, significant power can be saved. We feel that ad-hoc benchmarking of the improved lifetime of the smart phone under full operation of the application should be performed. We feel this is necessary, at least until a standard power measurement benchmark is developed and accepted.

5. RELATED WORK

This paper presents a novel application based on the client-proxy-server architecture (as surveyed in [1]). Although the iGrocer system architecture relies on this model, the client platform is restricted to a smart phone. IBM designed and tested in Safeway, the world's first personalized remote shopping service. The customers could use hand held devices to build and submit grocery orders on-line. Although this service was a giant leap in the application of pervasive computing technologies to grocery shopping, clearly with smart phones much more could be achieved like *quick shopping, nutrition compatibility and queue less checkout*. Beeline Shopper, provides their customers with a barcode scanner accessory to scan grocery items to make shopping lists. The scanner then needs to be connected to a computer which will generates a printable version of the shopping list. iGrocer goes far beyond just being able to make up shopping lists by scanning near empty items. These two applications are based on an underlying client-proxy-sever architecture and Internet technologies.

6. BUSINESS CASE AND FUTURE WORK

Wireless and smart phones market has shown almost exponential growth in the last few decades. Potential market for iGrocer would be any family or individual who has a smart phone. Not only does iGrocer help one get organized for grocery shopping, it also adds up to savings in time and money. For apathetic shoppers, iGrocer could be a wish come true, where they get a guided tour to the grocery store on their smart phone, which can even help them make decisions on the best foods for them. When compared to e-grocery, iGrocer is more powerful as it has all the features of an online grocery store on the smart phone and more. For most people, e-grocery is not satisfying as they are unable to get the same satisfaction as running to the grocery store to hand pick their produce and meats. With iGrocer, one can actually go to the grocery store without having the hassle of waiting in long check out queues. As a part of future work, it should be possible to for iGrocer to advise the user on which local grocery store to head for the best grocery deals. iGrocer can be extended incorporate features such as pop up coupons for products in the aisle the user is currently walking through, suggestions on which products to take out from the shopping cart to reduce expenditure, among others little enhancements that might make iGrocer an even more must have shopping assistant.

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