"Shopping Helper": Automated Navigation Application for Easy Shopping

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***Abstract*-**Shopping for household items is a tedious task since different members of a family will have different needs. If each member decides to go for shopping individually, it might be inefficient and time consuming. Some might prefer going to a shopping mall to purchase all the items that they need but since technology like Global Positioning System (GPS) doesn't work indoors accurately, people will find it difficult to navigate to the required store.Sometimes the user might find several items that fits the requirements and might have difficulties trying to choose between them. The purpose of this research is to overcome such issues and improve the overall experience of shopping with the use of an android application. This application wouldallow the users within a family to create and share a shopping list so that one member of the family could purchase items needed for the entire family.The application alsohelps the user to navigate to the store that sells those items within a shopping mall using Bluetooth low energy (BLE) beacons. Other functionalities of this application would be to be notified about the offers available at the stores based on the user as they enter a store and also to scan the barcodes of the items available and share reviews about those items. These reviews will be sorted using an algorithm so that others would find it easy when making purchasing decisions.

***Index Terms*-**Android, Shopping list, Indoor navigation, Bluetooth Beacon, Barcode scanner, review sorting algorithm, customized notifications

I. INTRODUCTION

The needs and wants of each family member might vary and if each one of them decides to go for shopping individually, it might be inefficient and if only one member decides to go shopping for the entire family, there might be confusion about buying which item to whom. This could also result in some members buying the same item more than once, unnecessarily. This will increase the cost of the entire family.

Once the shopping needs of the members have been sorted, the next issue would be about where to find which item in the shopping list. The buyer might have to visit several stores unnecessarily to find the items in the shopping list if the buyer doesn't know where to buy a certain item. Even if the member got to know where to buy a certain item, he/she might have difficulties locating that store.

Since almost anything can be purchased at shopping malls these days, buyers might prefer going there to fulfill all of their shopping needs as it would be more efficient but since GPS doesn't work well indoors, other forms of indoor navigation has to be looked into in order to allow a user to navigate within a shopping mall

Sometimes the user might find several items that fits the requirements and might find difficulties trying to choose the correct item. The user wouldn't have the option to get to know what others think about each item so that he/she might be able to make the purchasing decision with ease.

The shop owners also have difficulties in attracting customers and communicating certain information for specific types of customers so that their resources are spent efficiently and customers would not be annoyed by unnecessary and irrelevant information from the shops.

"Shopping Helper" is an android application with an overall objective of improving the shopping experience by overcoming all of the above mentioned problems. "Shopping Helper" would allow the users to share shopping lists with their family members and based on the items added to the shopping list, the application should navigate the user to the shops which sell those items. The application would also notify the users with offers available at stores based on certain conditions such as age, gender and user's interest in a that item when they enter a particular store as well as to allow the users to use the application and scan the barcode of the items in the store in order to get more details about those items and add or view reviews about those items.

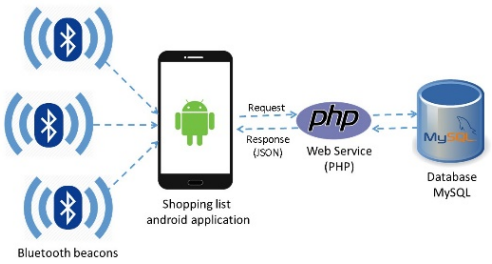

Figure 1: High Level Architecture Diagram

Figure 1 illustrates the high level architecture diagram of the system where the users can manage the data and their shopping list. As shown in the diagram the database that was chosen to store data was MySQL database and PHP was used to access that database. Bluetooth beacons would be placed around the shopping mall to enable indoor navigation. Signals received from these beacons would help the system decide user's location.

The research paper discusses about background and related work in the second chapter. Third chapter discusses the methodology that was used to develop a prototype system. Fourth chapter discuses about the implemented system. Fifth chapter discusses about the issues faced during the development of the system. The conclusion that was derived and the limitations are

discussed in the sixth chapter. Future work is discussed in theeighth chapter.

II. BACKGROUND

With the increase of smartphone development, the ways in which these smartphones can improve the lives of people have become limitless. One of the areas in which these smartphone applications can be used is to help the users keep track of the items that they need to purchase. Another way in which the smartphones can be used is to help the users navigate around and the most popular method in navigation is GPS. GPS is able to accurately locate the position of the users if the user is outdoors but when the user is indoors, due to the inability to get the line of sight from the satellites, makes it unusable indoors. Therefore, to assist the users find the location of the stores indoors, other methods of indoor navigation needs to be looked into. Cameras in the smartphones can be used as barcode scanners and this can be helpful for shoppers since users can scan the barcode of the item and get to know details about it. The users can also share reviews about the items so that it can be helpful for others when they cannot decide on which item to purchase.

There is no specific application which resembles “Shopping Helper” directly but there are several shopping list application and some of the do allow the users to share their shopping list with others but none of the shopping list applications available in the play store allow the users to navigate to the stores to purchase items or to allow the users to scan the barcode of the item and display details about it.

“Out of Milk Shopping List” is an android shopping list application which automatically calculates the grand total of all the items that you have added but the drawback is that some of the features are only limited within United States [1]. “Smart Shopping List – Listonic” is another android shopping list application with a unique feature which provides useful tips to the users regarding buying, preserving, and cooking to help its users make the most out of the groceries [2]. “Bring! Shopping List” is another shopping list app with support for android wear smartwatches [3].

BeaSmart, is a mobile application that has been deployed and tested in the IBM Almaden Research Center (ARC) which can be used to detect iBeacons. The application has different user perspectives for employees and visitors of ARC. The features of BeaSmart are a Stockroom Assistant, Role-based Navigation Guide, Differential Temperature Control, and Location-based Notifications [4].

Bluepass is an indoor Bluetooth-based localization system that relies on the RSSI (received signal strength indicator). The system main goal was to allow users in a given environment to locate and be located by other users through their mobile devices. The program that detects Bluetooth devices in its range runs on a PC USB Bluetooth adapter [5].

A system that can be used to easily locate newborn babies in hospital was developed using iBeacons, a Bluetooth Low Energy (BLE) based technology. The system works by putting an iBeacon on every baby’s leg and use the iBeacon to broadcast the unique ID information, which can identify babies on users’ smart phone [6]. Another system where iBeacons are used in hospital was proposed where the system helps the patients to find their departments or wards when seeing doctor or patient using shortest distance algorithm Floyd [12].

A research on the minimum number of beacons needed and where to locate them in order to locate a user in an area for maximum accuracy was done and was found out that having, five iBeacons gives the best performance. However, the improvement from three iBeacons to four iBeacons is significant while the improvement from four iBeacons to five iBeacons is negligible. Therefore, having four iBeacons in the middle area contains the highest efficiency [6].

To measure the position of the user a using Bluetooth, a process called Trilateration can be used which works by using at least three different Bluetooth transmitters to transmit Bluetooth signal and measure the distance from the beacon to the user to estimate the position of the user. A map overlay will be created to visually represent the position of the users by measuring the distance from the transmitters [4] [5] [6] [11].

Fingerprinting is another technique used for localization which requires offline calibration phase to build a radio map primitively. The building of the radio map involves collecting a multiple RSS of each access points or transmitters at every possible location in indoor environment. Since it is infeasible to collect RSSI at every possible location, the floor layout can be divided into grids. Within each grid, a signal vector of access points’ associated readings are collected [7] [8].

Mobile Barcode Scanning Applications was built which enabled consumers to share comments and ratings of products after scanning the product’s barcode. Consumers have access to other opinions about products via their smartphone and can share their own product experience with other consumers [10].

“ShopSavvy Barcode & QR Scanner” is an android application which allows users to scan barcodes of products and show which stores sells those items at which price along with the details of the products and help users decide where to buy those items for the cheapest price. It also notifies the users if there are sales at different stores by analyzing the different websites [9].

Most of the currently available shopping lists applications are mostly concerned on only providing basic features such as creating shopping lists to the user while few applications offer few unique features but none of the applications offer features like locating and directing users to the shops which sell the items listed in the shopping list. There are several ways to locate a store outdoors using GPS but there aren’t any ways for users to locate or navigate to shops, indoors. There are few barcode scanning applications which allow the users to scan items and get to know details about it but there aren’t any shopping list applicationsthat has integrated this feature into it.

Therefore “Shopping Helper” fills the above mentioned gap by creating a shopping list application which allows the users to share their shopping list with their family members and also to locate the items found on the shopping list by using Bluetooth

beacon navigation and also to allow the users to scan the bar code of available products and share reviews about those products which will help others to make decisions regarding purchasing it

III. METHODOLOGY

Prototype methodology was selected as the methodology in order to develop "Shopping Helper". Analysis, Designing and Implementation phases were executed concurrently and iteratively until all requirements were gathered and implemented in a manner where system fulfills all the functional and nonfunctional requirements of the system. The initial prototype was built with less amount of features, where then it was developed upon and features were added in every prototypes. This procedure helped the research group to be more accurate about requirements and was also helpful to figure out the defects and fine tune the functions which was developed.

A. Planning

Planning phase was started at the initiation of the project where the research group understood the system to be developed and how it can be built. Scope, problems and the objectives were discussed among group members in order to identify them accurately. A feasibility analysis was done to make sure that the project was feasible.

B. Requirement Gathering and Analysis

Analysis phase focused on gathering information and analyzing the difficulties faced by the shoppers in modern days which paved the way to develop the requirements of the system. Data sources which were used to gather data were categorized as primary and secondary data sources. As primary data source, an online questionnaire was created and distributed among public in order to obtain people's opinion about shopping and how it could be improved. The questionnaire contained only closed ended questions since most people preferred it. The gathered information from primary data source were more helpful to get a better understanding about the people's needs. Whereas secondary data are gathered from research journals, articles, book etc. The data gathered through research papers are discussed in detail in the previous section.

C. Design

The primary objective of the design phase was to create a design that satisfies the agreed application requirements. Initially overall design was done starting with the High level architecture diagram (Figure 1). Thereafter the physical design of the system was done which included the actual input and output process of the system. There will be Bluetooth signals transmitted from beacons and these will act as inputs to detect the location of the user. The barcode of the items available at the store will also act as input since they will be scanned using the smart phone's camera. Data from the database would also act as input for certain processes and all the other input will be touch inputs. These touch inputs will be performed via keyboard or the screen. All the outputs will be displayed on the screen.

Secondly the interface design was done which defined how the user interacts with the system including inputs and outputs of the system. The user interface was designed to be more understandable and easy to navigate. When designing UI, basic principles were followed such as the layout, aesthetics, content awareness, user experience, consistency and minimum user effort. Finally, the database design was done which defined how the data was to be stored in the database. Number of tables, relationships between each table, primary keys, foreign keys etc. were decided in this process.

D. Implementation

Implementation is the fourth stage of the SDLC where the project team transformed the design into a working system. Android studio was the IDE which was used to build "Shopping Helper" and several libraries were used to add the functionalizes required as well as to improve the performance of the system and ease the development of the application.

Since the users needed to share their shopping list with one another, the database had to be stored externally and for this purpose, MySQL database was chosen. To Communicate and integrate with the database, PHP scripts were used and this along with the database was hosted on Amazon Web Services.

For indoor navigation, Estimote branded Bluetooth beacons were used and the Software Development Kit (SDK) which was used to communicate with these beacons was Steerpath version 2.5. This SDK allowed the team to create a map for navigation using a Computer Aided Design(CAD) application called DraftSight and easily integrate it into the application. The beacons will transmit a Bluetooth signal continuously which will be read by the user's device. Along with the signals, a Major and Minor values will be transmitted which will help the system to identify from which beacon, the signal is being transmitted and the and the signal strength of these signals were used to estimate the location of the user within the shopping mall.

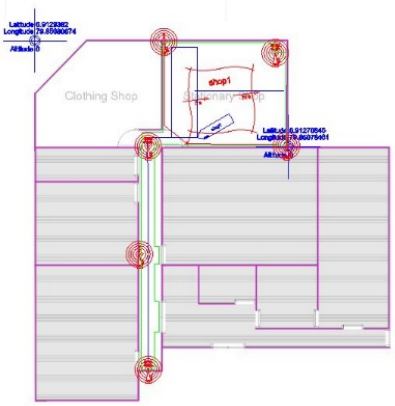

Figure 2: Indoor map for navigation

For location based notifications, a separate web interface was created for the shop owners where they can manage the notification message as well as the condition for the notification to appear on the user's phone. When the user enters a shop, a trigger will be triggered and a request would be sent to the server

along with the user's details and the shop ID. The server will sort out the notification suitable for the user and respond.

In order to identify items, found in the shops using barcode, Zxing library was used and once the item was scanned, the item description along with the reviews given for that item would be retrieved from the server and displayed to the user. These item details can also be managed by the shop owners through the web interface.

In order to sort the reviews made by the users, an algorithm called Grubb's Test was used [14]. This works by analyzing the ratings given for that item in the review and remove the reviews found to be outliers. Grubbs' test is a statistical test used to detect outliers in a data set assumed to come from a normally distributed population. Grubbs' test detects one outlier at a time. This outlier is expunged from the dataset and the test is iterated until no outliers are detected.

Following is the formula of the algorithm where Y_i is the value which we are testing for being an outlier or not. $\overline{Y}$ is the mean or average of the dataset. S is the standard deviation of the dataset. N is the number of elements in the dataset. $t_{\alpha/(2N),N-2}$ is the critical value of the t-distribution with N −2 degrees of freedom and a significance level of α/(2N). If the condition is found to be true, the record belonging to the Y_i value will be removed and the dataset will be checked for outlier again until no outliers are found

$$\frac{|Y_i - \overline{Y}|}{s} > \frac{(N-1)}{\sqrt{N}} \sqrt{\frac{(t_{\alpha/(2N),N-2})^2}{N-2+(t_{\alpha/(2N),N-2})^2}}$$

E. Testing

During the testing phase, the following testing were performed in order to test the functionality as well as to identify defects of the system which would result in a system with better quality, performance and accuracy.

- Unit testing is where the smallest testable parts of an application called units, which are individually and independently analyzed for proper operation.
- Integration testing focuses on testing whether the set of modules functions together without errors. Data flow and the data exchange between modules is mainly focused on this testing.
- System testing is where the completed and integrated system is tested to verify that the system meets functional and non-functional requirements.

IV. RESULTS

"Shopping helper" is an android application focusing on improving the shopping experience by providing several functionalizes such as a family shopping list, indoor navigation within a shopping mall, customized notification based on user's location, item identification using barcodes and sharing reviews of those items.

Family shopping list is one of the fundamental functionalities of "Shopping helper" which allows the user to share shopping list items with their family members in order to make shopping more efficient and effective. Figure 3 shows the implementation of this functionality

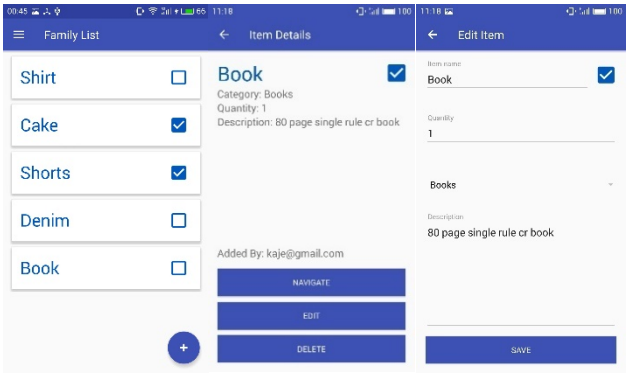

Figure 3: Family shopping list interface

Indoor navigation functionality of "Shopping helper" allows the user to locate themselves within the shopping as well as to locate and navigate to the stores which sell the items added to the shopping list. Figure 4 shows the implementation of this functionality. Steerpath SDK was used to implement the indoor navigation functionality.

Figure 4: Indoor navigation interface

Barcode scanning functionality of "Shopping helper" allows to scan and identify the details of the items found in the shopping mall as well as to share reviews about those items which would help the users to make purchasing decisions. The reviews added by the users would also be sorted using "Grubbs test" algorithm so that users would not be confused by any peculiar reviews. Figure 5 shows the implementation of the barcode scanning interface as well as the item details and review adding interface.

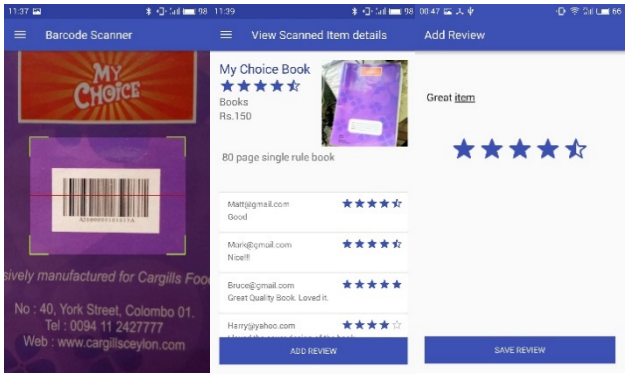

Figure 5:Barcode scanning and review sharing interface

Customized notification functionality of "Shopping Helper" allows the shop owners to create notifications specific for users by creating certain conditions for the notifications to be appeared on the user's phone when the user enters the shop. These notification conditions were based on user's age, gender, user's interest in the category of the shop that he/she entered and based on user's interest in a specific item. A separate interface was created and provided for the shop owners to manage these notifications. Figure 6 shows a sample notification appearing on the user's phone.

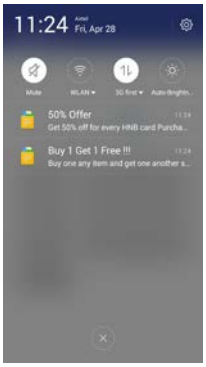

Figure 6: Received Notification

Figure 7 and Figure 8 shows the interface provided for the shop owners to manage the notifications.

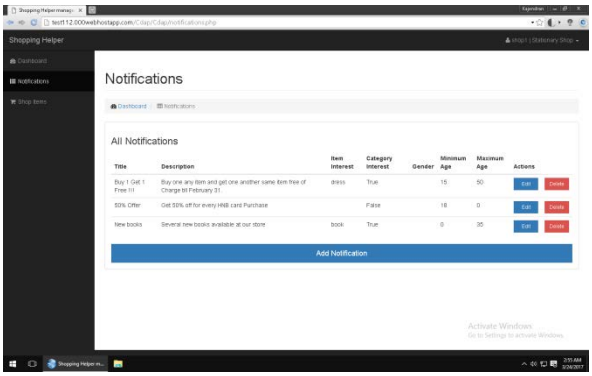

Figure 7: Notification Management interface

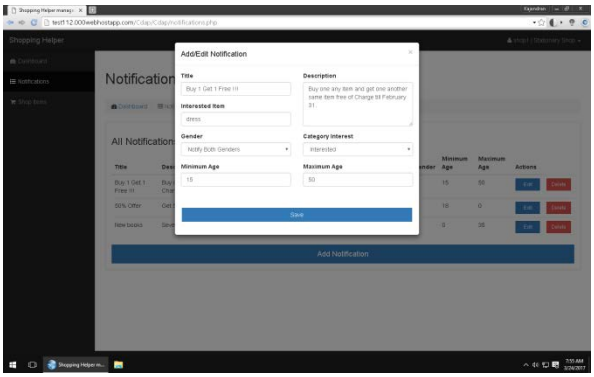

Figure 8: Notification add/edit interface

During the testing phase, it was foud out that the accuracy and reliability of the system was 95.65% and the cause for not achieving 100%was due to the indoor navigation functiality where the accuracy of user's positioning varied depending on the user's position. This was due to accuracy of bluetooth beacons being low which couldn't be improved.

V. DISCUSSION

"Shopping Helper" was developed with an overall objective to improve the shopping experience of family members and through the implemented system, family members can enjoy a more efficient and effective shopping experience.

While developing the system, the team had to experience some technical issues and following are those issues along with how the team managed to overcome those issues.

The most important issue was the level of accuracy of indoor navigation using Bluetooth beacons. The reason for this issue is that the location of the user is measure based on the signal strength received from the beacons and when a user is at a particular location the signal strength from the beacon kept on varying. The accuracy of navigation was acceptable when user was walking along a straight path but not when the user was in an open area. In order to improve the accuracy, the signal transmitting interval of the beacons were reduced. This improved the accuracy up to a certain extent but did not eradicate the issue completely.

Selecting an algorithm for sorting out peculiar reviews when showing the scanned item details was also an issue since there were several outlier detection algorithms with similar level of accuracy. We decided to choose Grubbs test algorithm since it was known to produce accurate results even with low number of records to check for outliers.

The assumptions made when developing the system are as follows,

- User has a basic knowledge of using android smartphone applications.
- User is within the mapped area when using indoor navigation

VI. CONCLUSION

As with the increasing popularity of shopping, the issues faced by modern shoppers have become more obvious and "Shopping Helper" has proved to be capable of solving these issues as well as to improve the overall shopping experience and to make shopping more enjoyable. Family members will no longer have to worry whether other members are aware of your needs and wants as they will be able to share it using this application so that one member can do the sopping for the entire family and be more efficient. The users will no longer have to waste time on finding the required shops and locate the needed shops with ease. When purchasing items on the shopping list, the users would no longer have to be confused on which item to choose when there are already reviews given by previous buyers regarding the product. Shop owners would no longer have trouble communicating and attracting the right customers as they will be able to target customers based on required condition and customers will no longer have to be annoyed by irrelevant notifications. Overall, this system has been capable of improving the efficiency and productivity in creating, sharing, locating and purchasing items needed for day to day life.

Following are the limitations that were figured out about "Shopping Helper" by the development team when developing the system.

- One of the main limitation is that if the user is outside the mapped area but still receive the Bluetooth signals from the beacons, the system will assume that the user is within the mapped area. The only solution for this would be to map every area that the user can reach which might be costly.
- Bluetooth beacon based navigation cannot be used on phones with android version below 4.3 as Bluetooth beacons support for android was only introduced with android version 4.3
- Bluetooth beacon based navigation only has an average accuracy of 4 meters and this can sometimes become worse depending on the location of the user and the placement of the beacons.
- Since "Steerpath" SDK was used for indoor navigation, the developers were restricted by functions available in the library.
- Even though Grubbs test algorithm works well even with a few number of records, it still needs at least 6 records to perform most accurately.

VII. FUTURE WORK

Following are some of the recommendations for future work for any parties who are interested in developing this system further

- Allow the users to select which items to be shared with which member of the family
- To use other indoor navigational techniques such as WI-FI and Geomagnetic readings to improve the accuracy.
- The System could be made compatible with other operating systems such as IOS, Windows, Blackberry and etc.
- Add GPS support so that the app would allow the user to navigate even when outside the shopping mall.
- Have an algorithm which would allow the user to go to the required shops in a sequence so that they will be spending the least amount of time.
- Add further conditions to sort out the notifications for the users

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