# Location-log: Bringing Online Shopping Benefits to the Physical World with Magnetic-based Proximity Detection

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## ABSTRACT

We present the design, implementation, and evaluation of Location-log – a mobile phone and cloud based system that brings the benefits of online shopping to the physical world. By utilizing magnetic-based proximity detection technology, Location-log is able to obtain the physical proximity relationships between customers and shops in a reliable and convenient manner. Building on top of this data, Location-log performs data analysis and creates visualizations to provide benefits to both customers and shop owners. Customers carrying smartphones attached with a small dongle can receive targeted advertisements and enjoy many other location-based services while shop owners are able to obtain statistics about customer behavior and react in real-time. We evaluate our system by deploying Location-log in a real food court inside a busy shopping center over multiple days. Results show that Location-log is effective in providing online shopping benefits – customers can receive accurate targeted advertisement based on their visiting histories and current locations while customer behavior statistics and visualizations provide greater insights for the owners.

## 1. INTRODUCTION

After Pizza Hut launched the first online pizza shop in 1994, people have begun to enjoy electronic commerce and benefited from this advance, such as the ability to view past transaction history and receive personalized advertisement. In the meantime, online shop owners are able to obtain statistics about customers' behaviors in their shops, thus employing promotion strategies to increase sales. While online shopping has provided convenience, it can never replace the joy and instant gratification of browsing through physical shops and looking for products. However, in physical stores, many of these online shopping benefits that we are accustomed to are not yet possible.

For example, in physical shops, customers do not have a list of their visiting history, can not receive targeted ads, or read other people's reviews of a specific shop, which has long been possible in online shopping websites. Similarly, shop owners may have records about their transactions, but these records cannot fully reflect customer behaviors, thus lacking the information for them to take effective measures to increase sales. In contrast, online shop owners know exactly how customers browse through their web pages, and which goods customers have shown interests in. In fact, the web site visiting history is the most valid and useful data to be mined and learned for future usage, which is impossible in physical stores.

While a number of previous efforts have demonstrated the benefits of targeted advertisements and location-based services, very few have gone beyond proof-of-concept, largely because most of these works are based on indoor-localization technologies such as WiFi fingerprinting, Bluetooth, IMU, GPS, or RFID, which are either inaccurate or inconvenient to use. Instead of using exact indoor positions, Location-log relies on precise proximity information, which we obtain through magnetic-based sensors. In addition, we focus not only on the benefits to the customers, but also to shop owners. By utilizing a combination of novel sensors, mobile phones, and the cloud, Location-log aims to bring online shopping benefits to the physical world.

The contributions of Location-log are as follows:

1. Demonstrate feasibility of using proximity information to provide a rich set of indoor services
2. Propose a scalable architecture for reliable data collection, mining, and analysis of physical shopping behaviors
3. Present design and implementation of a system that brings online shopping benefits to both customers and shop owners
4. Present findings and experiences from a real-world deployment inside a shopping center.


*2nd International Workshop on Mobile Sensing,* April 16, 2012, Beijing, China.

The rest of the paper is structured as follows: In Section 2, we present three interesting applications we would like to enable, followed by the system requirements for Location-log. Section 3 describes the system architecture and implementation for Location-log. In Section 4, we evaluate and present the initial results from a real food-court deployment inside a shopping center. Section 5 discusses related works, and Section 6 concludes our paper.

# 2. ENABLING APPLICATIONS AND SYSTEM REQUIREMENTS

The Location-log system keeps record of customers' location information and enables many novel applications that offer benefits to customers and shop owners. These applications come with different requirements but in general they take advantage of customers' past history and current location. In this section, we will first discuss several possible applications and summarize the requirements for the system.

## 2.1 Enabled Applications

We list three applications that Location-log enables.

### *2.1.1 Personalized Advertisement*

Customers would receive personalized notifications based on their current location and past history to augment shopping experience. These notifications may be advertisements sent by shop owners, reminders from shop administrators, or recommendations for wandering customers. To achieve this, the system should have the ability to mine the user's past history and associate with user's preference.

### *2.1.2 Indoor Navigation*

While several localization-based approaches to indoor navigation exist, our method of using proximity to "landmarks" is less error-prone and provides higher accuracy and consistency. In addition, this navigation, when correlating with other customers' location data, can provide the optimal routes, either with the shortest path or the smallest congestion.

### *2.1.3 Shop Statistics and Promotion Recommender*

There are many toolkits online for web masters to understand visiting events and analyzing those data. However, in the real world, with the exception of transaction records, shop owners have little evidence to understand customer behaviors. In order to know about customers' feelings or satisfactions level, surveys are now the main tool to get evidence. Our system can provide auto-generated data with appropriate visualization to help them analyze the underlying customer behavior. This analysis would assist shop owners in designing promotion strategies, like locating the optimal place inside a shopping mall for advertisement. The requirements for these owners-centric applications would require customers' past history together with data mining techniques.

These applications can benefit both customers and shop owners in the shopping mall. Without losing generality, we focus on one customer-centric application – Personalized Advertisement, and one owner-centric application – Promotion Recommender.

## 2.2 System Requirements

Based on the aforementioned applications we would like to enable with Location-log, we summarize system requirements below.

### *2.2.1 Consistent and adjustable proximity zones, with unique ID encoded*

These indoor sensing applications leverage knowledge of relative proximity between customers and shops, therefore do not require high-computational localization technologies such as camera analysis or inertial measurements. Various beaconing technology with the unique ID transmitted would be sufficient for this system. Due to the complicated real-world environment and shops' size variance, consistency and adjustability are required in providing reliable detection.

### *2.2.2 Real-time networking for location data communications*

Interactive applications on smartphones for users require small latency of location data. In general, people would expect status changes happen at least in one step. In the physical world, humans are walking around, with a step of approximately every 0.5 second. Therefore, the latency of data update should be no more than 0.5 second.

### *2.2.3 Data mining and visualization for end users*

To effectively manage user shopping patterns, it's important to choose adequate data mining schemes to extract events and underlying principles for end users. Though this is not the focus of this paper, we will present several possible ways in our deployment to demonstrate this requirements.

# 3. DESIGN AND IMPLEMENTATION

To satisfy requirements mentioned in 2.2, we design and implement the **Location-log** system. In this section, we will first introduce the system architecture, followed by our system implementation.

## 3.1 System Design

The architecture, as shown in Fig. 1, consists of four steps of providing online shopping benefits for both customers and shop owners.

First, indoor localization technology should enable the customer to know exactly his/her location for location-based service. We do not limit this part to any specific technology, but we adopt the magnetic-induction communication for proximity detection in our implementation. Details are in the next subsection.

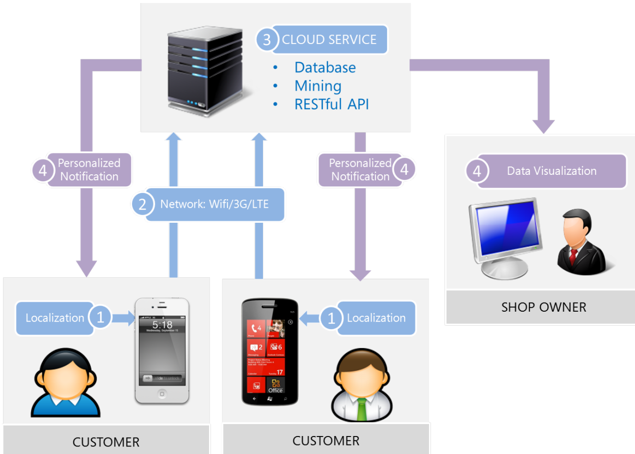


**Figure 1: Architecture of the Location-log system**

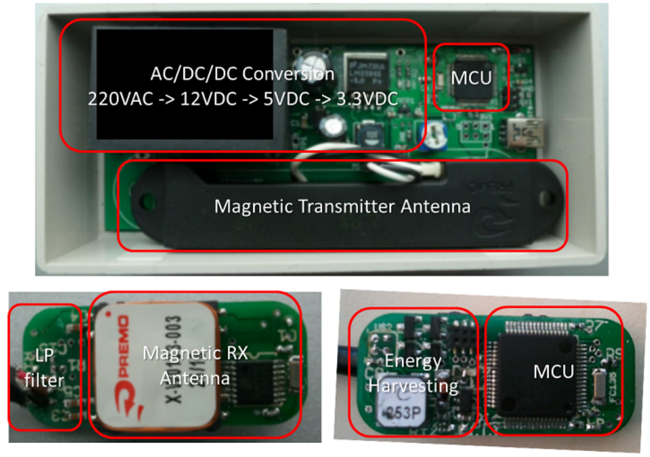


**Figure 2: Beacon (*upper*), and Dongle (*lower*).**


**Figure 3: The Food Court where we deployed our system and the snapshot of a user, who was walking with the phone and dongle in his hand.**

This data needs to be delivered with low latency to the cloud for analysis. As the most important accessory that customers are carrying everyday, it's reasonable to utilize the phone's own data connection for this communication. With WiFi/3G/LTE technology, the requirements of latency can be met in most cases.

The server runs data mining algorithms to extract useful information from the saved sensory database, and expose RESTful API for applications. Based on results from the data-mining algorithms, the last step is providing personalized notification/feedback for customers and sensible visualizations to shop owners.

## 3.2 Magnetic-based Implementation

We implemented the Location-log systems based on magnetic-induction beaconing technology. Previous works in [7] and [6] have demonstrated the suitability of this technology in creating consistent and adjustable zones. Inspired by the Hijack project [10], we augment this localization technology by connecting the magnetic sensors with smart phones through the standard audio jack.

Figure 2 is the hardware we implemented for proximity detection. The **beacon** is transmitting magnetic signals tuned at 125kHz to create virtual zones that represent shops/counters in the physical world. **Dongles**, with the magnetic sensors, are bundled with smart phones to detect customers' presence. As the front-end for customers, phones can also run applications to offer shopping services. The sensory data is then delivered to the cloud using WiFi or 3G.

# 4. DEPLOYMENT AND EVALUATION

## 4.1 Food Court Deployment

We deployed this system in a busy food court inside a shopping center, and asked for customers to participate in our experiment. Figure 3 shows the deployment environment and one of our users using the Location-log system. The map of the food court with beacons installed are presented in Figure 4 (to save space, we also use that figure to illustrate the benefits to users). In our deployment, each user is asked to carry a phone with our dongle attached, and proceed with normal purchases. In this case, the collected data would reflect their thought process in deciding what to buy, therefore function as the perfect source for shop owners to study customer behaviors.

During the one-week deployment, we installed 9 beacons, one in each food counter. We have collected 981 valid entries of location data from 18 users.

## 4.2 Evaluation

We evaluate our system using the two applications we have envisioned in Section 2.1 to demonstrate the effectiveness for both customers and shop owners.

### *4.2.1 Benefits to users*

While a number of applications can be enabled with Location-log, in this subsection, we will focus on personalized advertisement. Figure 4 shows the first three trails from the

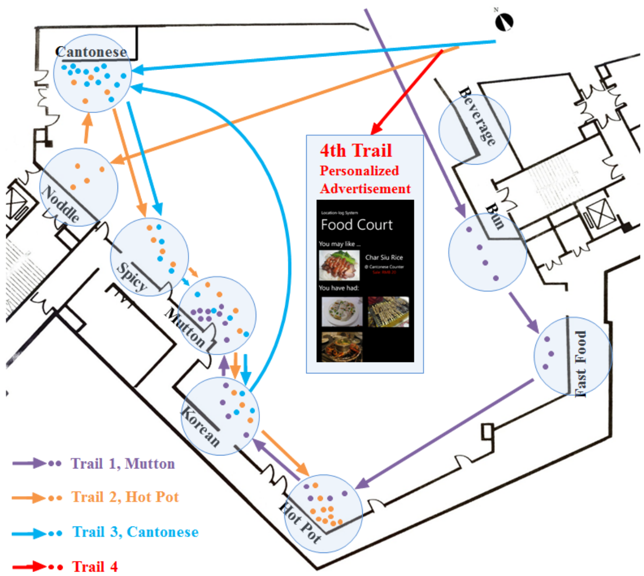


**Figure 4: Trails of a customer for three times. Based on his past history, the Personalized Advertisement system would push targeted messages to assist shopping experience.**

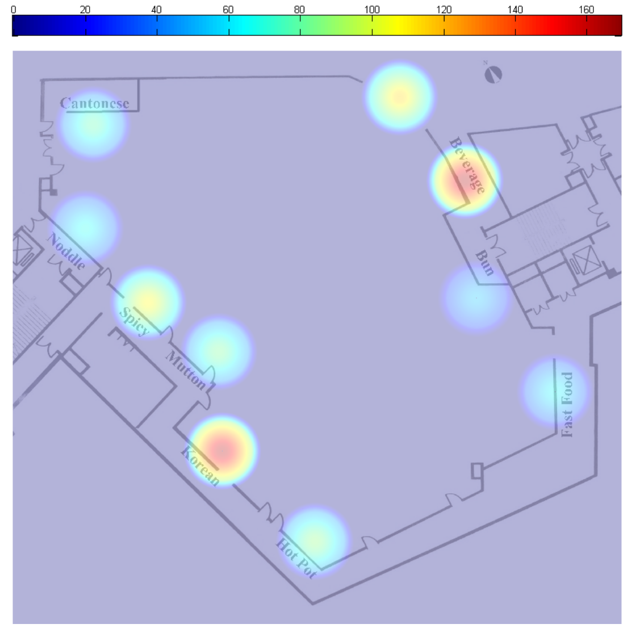


**Figure 5: The heatmap generated based on visiting occurrence at each counter. This would lend evidence in promotion strategy design.**

same user's trajectories in our experiment. Though currently our implementation using the proximity detection cannot tell clearly where the customers are inside the zone, we considered the RSSI data and time stamp to approximate customers trajectories and drew this figure. The number of dots represent the relative time that the customer has spent in front of a specific counter.

From these three trajectories, we can tell how this customer has moved and made decisions. In general, we know this customer shows little interest in Bun, Fast Food or Noodle, but had purchased Mutton, Hot Pot and Cantonese food. Therefore, in his fourth time coming for food, the Personalized Advertisement would push messages about new food or featured food (updated by the shop owners) for him, as shown in the screenshot in the center of Figure 4.

### 4.2.2 *Benefits to shop owners*

As enough people are sharing their location data with others and shop owners, these sensory data may be perfect for owners in mining customers' behavior. Based on the statistics from customers' location log, it's easy to build a Promotion Recommender application that can assist the shop owners in deciding the hottest place inside a mall. He may present posters or take other promotion strategies there. The system could provide him with evidence by showing the most-frequently visited places.

We use a heatmap to show the "hottest spot" inside the shopping mall. By calculating the visiting occurrence for each counter, as shown in Figure 5. It shows that most people would go to the Beverage and Korean counter during their meal time. It's reasonable that people would visit Beverage a lot because it's the only counter selling drinks and desserts. Korean being the winner of rest of the counters might suggest to the owner that either the food or the service at that counter attracts more people. Bun counter has the least visiting occurrence and our heatmap can give him the motivation to take some actions in increasing sales.

## 5. RELATED WORK

Many previous studies have been done to augment the shopping experience, from studying human mobility inside a shopping mall environment [3] to building real world systems (like the Social robot in [8] that can identify potential customers). And people have proposed many potentially powerful systems[2, 13] that can generate targeted advertisements to users based on the selected goods. However, these systems are not suitable for real deployments because the localization technologies they employ are not quite ready. Also, they are mainly focusing on the customers' benefits.

To achieve precise and consistent indoor localization (where GPS [4] is not feasible due tot he lack of clear line of sight to satellites), a number of technologies can be used. RFID [5] and NFC require users' direct action. Wi-Fi, Bluetooth beaconing technologies are largely influenced by the environment due to multi-path effect and Rayleigh fading [12]. Long-range RFID are typically unable to penetrate obstacles like human body and are expensive. Computer vision techniques using conventional cameras [1, 14] or Kinect-like depth cameras can also provide localization service. But they require higher computational cost, compromise customers' privacy, and are not able to provide customers with interactive systems. Therefore, in this work, we choose to use magnetic-based proximity detection, described in more detail in [7] and [6].

Chuang-Wen You *et al.* [15] adopted the place discovery methods proposed by Donnie H. Kim *et al.* in [9]. They are the first phone-based approach in detecting the amount of time that a user spends shopping. They converted the monitoring of shopping and non-shopping time into a classification problem. Their contribution is relatively focused, as opposed to a whole system solution for offering insights of the shopping behavior.

Based on many studies of online shopping data (e.g. [11]), the evidence of customers' past history are of great importance so that shop owners would have evidence in understanding customers behavior. To our knowledge, this is the first paper discussing such platform for bringing the online shopping benefits into the physical world, from the angle of both customers and shop owners.

## 6. CONCLUSION

In this paper, we present the Location-log system which enables a number of applications that benefit both customers and shop owners. Using data collected from a real-world deployment, we evaluate the whole system, and show that the Location-log system can effectively provide customers with personalized advertisement and enable owners to better understand customer behaviors. In the future, we hope to scale up to larger deployments in a smart shopping center scenario. We will also explore other benefits to shop owners, such as dynamic pricing based on demands.

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