# The Less Communicated Story of Location Based Service in Retail Applications

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*Abstract -* **Location based applications have been on the front pages of technological innovations and business transformations in recent years. Retail among all has been the most mature industry where LBS have flourished. The ability to weave consumer location context into browsing, social sharing and buying activities is the common mandate of LBS, which presumably will drive online clicks into increased offline sales. It has become an inseparable part of behaviour based personalization in mobile marketing & commerce. This paper starts with a summary of major commercial LBS providers in this sector. To reach necessary depth of understanding, we have implemented a wireless indoor positioning system in an actual retail venue in Singapore to gather consumer location data. A mobile app is developed and rolled out in a small scale to connect customer location data with their loyalty status and the retailer's product sales. Through this research attempt we have discovered the less communicated aspects of LBS including the lack of accuracy, the response time lag, and most importantly the privacy concern which is beyond the help of technology advancement. We have found people to be far less willing to share their locations than expected or assumed in previous reports. It could turn out to be the ultimate road blocker for LBS applications to make significant market impact or drive noticeable behaviour change.**

*Index Terms -* **Location Based Service, Business Applications, Data Privacy, Mobile Marketing**

## I. INTRODUCTION

WITH the widespread adoption of mobile telephony, location based applications have been on the front pages of technological innovations and business transformations in recent years. Retail among all has been the most mature industry where LBS have flourished. Players in this field range from start-ups to MNCs. The ability to weave consumer location context into

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browsing, social sharing and buying activities is the common mandate of LBS, which presumably will drive online clicks into increased offline sales. It has become an inseparable part of behaviour based personalization in mobile marketing & commerce. Such concept and value are shared by many highly valuated tech companies, investors are betting multimillion dollars on them. This paper starts with a summary of major commercial LBS providers in the retail sector. The selected list only reflects the tip of a humongous iceberg. There are many more out there. To reach necessary depth of understanding, we have implemented a wireless indoor positioning system in an actual retail venue to gather consumer location data. A mobile app was developed and rolled out in a small scale to connect customer location data with their loyalty status and the retailer's product sales. Through this research attempt we have discovered certain less communicated aspects of LBS namely the lack of accuracy, the response time lag, and most importantly the privacy concern which is beyond the help of technology advancement. We have found people to be far less willing to share their locations than expected or assumed in previous reports. It could turn out to be the ultimate road blocker for LBS applications to make any significant market impact or drive noticeable behaviour change.

## II. EXISTING RETAIL LBS APPLICATIONS

In general, GPS, signal strength triangulation via Cell Tower locating, Wi-Fi network, BLE (Bluetooth low energy), scanning of RFID (radio frequency identification), UWB (ultra wideband), mapping of Magnetic Field, and processing of video content are some of the technologies adopted in LBS applications. For those interested in details of these technologies such as locating accuracy and setup effort, [7], [8] and [12] can be referred to. Another way to categorize such applications is by the type of usage in retail scenarios for example: venue navigation, crowd behaviour monitoring, vicinity marketing, and in-situ deal recommendation. We have picked a few from each of above categories. The adopted technologies, major value propositions, and limitations are also briefly covered below.

In the category of "venue navigation", *Meridian* has powered quite a few mobile apps for resorts, shopping malls and megastores to guide their customers using GPS or Wi-Fi signal strength triangulation. It has joined the Aruba Networks for the setup of Wi-Fi infrastructure, where a number of Wi-Fi access points form a mesh network through the 5 GHz Wi-Fi band together with master routers that communicate securely to the Internet. Note also in some cases, it serves only as the content provider of customized interactive maps. Users have to find their ways not much different from reading a traditional map made of paper. *Powell's*, *Home Depot*, *the Marina Bay Sands* shopping centre in Singapore, *the Venetian Casino* in Las Vegas are some of their retail and leisure group customers.

Users who have installed the venue apps will be able to receive turn-by-turn directions on an indoor map to find places of interest. While the nature of navigation requires no additional incentive for users to actively use their smartphones, the limitation of such application is equally obvious. People usually do not need repeated assistance in way finding, especially in an indoor retail setting where alternative sources of information are plenty. It is therefore unlikely to have users to open such apps for the 2nd time. These applications need to be subsidised instead of having a sustainable business model to maintain the operations.

*Point Inside*, *Aisle411, Ruckus Wireless and Motorola Solutions* are players in the fields of "crowd behaviour monitoring" and "vicinity marketing". They are mostly deployed in supermarkets in Europe & North Americas. Their key value propositions include visibility of non-transactional customer behaviour such as footfalls, and upsell opportunities through push of personalized offers when the customer is detected in the vicinity. A store app is necessary to send across the push notifications. The locating technologies adopted are usually either Wi-Fi signal strength triangulation (again), or through barcode scanning in which indoor product locations have been embedded. The store apps of *Casino Group*, *Walgreens*, *Meijer stores*, and *Shop'n Save* are examples of such implementations.

While store apps can guarantee a certain size of user base with repeated usage, the promised LBS features are still largely constrained. Number one obstacle is the location inaccuracy. When the locating is done through Wi-Fi signal strength triangulation, the signal attenuation caused by the tall shelves and moving crowd will seriously skew the detected location coordinates [2] [3]. Our own experiments have shown the locating error in a department store setting to be greater than 10 meters. The result becomes worse when there is no continuous and active data consumption through the Wi-Fi network, which is however the current norm. It effectively says the definition of vicinity cannot be product or aisle based but store based. And it leaves the analytics part based on crowd footfalls very much unaccountable. If the locating is done through barcode scanning, the locating is more accurate and naturally integrated with product types. However consumers have found it cumbersome to do mobile scanning, and there have even been voices claiming the death of QR codes [1].

More well-known names appear in the category of "in-situ deal recommendations" such as the likes of *Foursquare* and *Groupon*. Unlike applications in the previous two categories, this group of applications have established core functions such as socializing, sharing, and gaming with good level of user stickiness. Most of them access location data through GPS of smartphones which require the users to turn on the Location Service in Privacy Settings. *Apple* has also been working on the retrieval of micro locations through *iBeacon* which in essence is BLE locating [10]. Users have to enable their Bluetooth in their mobile phone settings.

This group among all is able to attract largest amount of users and longest time of active app usage. The deal recommendation usually considers both the user's click history and current location. However a recent Pew report has confirmed our observation that very few people enable Location Service for active usage. It said that only 9% of people making less than $30,000 enable Location Service in USA, and the percentage goes further down for people who are more affluent and better educated [11]. Bluetooth has been popular as the short range wireless technology to transfer data from device to device. People however will only turn the option on when there is an actual need to transfer files.

### III. RESEARCH PROOF OF CONCEPT

To further our understanding of this topic, we have developed a proof of concept system with a local retail customer in Singapore for research purposes. Six Wi-Fi access points and a master router for signal strength triangulation were implemented in their physical store. Relative coordinates were generated and passed to real time location server (RTLS) in the cloud through 3G network, and consumed by our internal server as a data service. Bayesian smoothing was applied to improve the locating accuracy as usually recommended by literatures such as [5], [6] and [9]. A mobile app was developed and rolled out in a small scale to connect customer location

data with their loyalty status and the retailer's product sales. This proof of concept system is able to do the following: (1) visualize in store customers' location in real time if they carry smart devices with Wi-Fi option enabled; (2) push marketing and sales notifications to selected group of users who have installed our mobile app and detected to be around the retail store; (3) allow such users of mobile app to navigate in the physical store; (4) connect to user's Facebook account for product and interest suggestions; (5) connect with the retailer's POS system to track the in store conversion rate. This POC basically covers most major use cases of existing LBS applications in retail scenarios: venue navigation, crowd behaviour monitoring, vicinity marketing, and in-situ deal recommendation.

Figure 1 below is a snapshot of the implemented real time system. Individual visitors are displayed as red dots once their smart devices are captured and their estimated positions overlaid on the indoor layout.
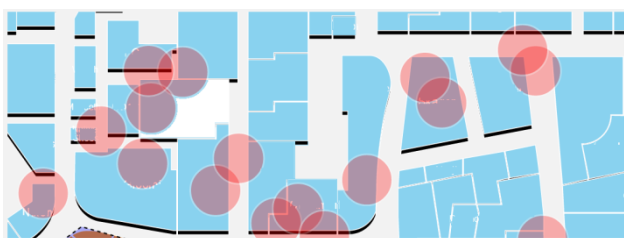


Fig 1.Snapshot of the implemented POC

Business analytics generated out of this POC includes: (1) association table of on-site footfalls in between the branded counters, and (2) Real time Conversion Rate of each branded counters. Figure 2 shows the visualization of the association table in the form of a ribbon chart. The business user can discover routing preferences of on-site visitors for example those who have visited "counter 5" first tend to visit "counter 1" next. Conversion Rate is computed by the Number of Purchases divided by the Number of footfalls for the same branded counter. Figure 3 clearly says some of the brands such as "counter 1" and "counter 4" outperform the others in this regard quite significantly.

One thing to add is the smartphone penetration rate in Singapore is fairly high – close to 150% as reported in mid of 2012 [4]. It is one of the most mobile savvy populations in Asia. People in general are open to try out new apps and share with their friends. After the development was done, we conducted several user tests. The users walked around the open plan retail venue around 900 square meters of size, while actively using

their mobile phone. The findings are summarized in the next section.



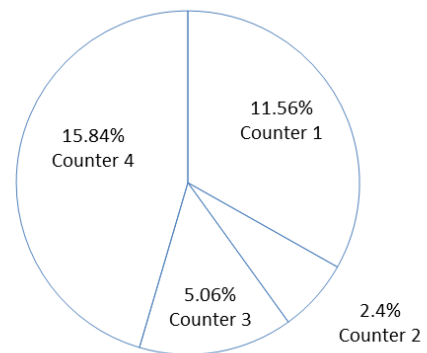Fig 2.Association ribbon chart in between the branded counters



Fig 3.Conversion rate during one of the test months

IV.  FINIDNGS

(1) The achieved locating accuracy which was comparable to commercial grade products from established providers, to be insufficient to support the real time navigation scenario. Our own experiments have shown the locating error to be around 5 to 10 meters. The result became worse when there was no continuous and active data consumption through Wi-Fi networks.

(2) That Bayesian smoothing had not significantly improved the locating accuracy due to the moving nature of on-site crowd. The crowd attenuated the Wi-Fi signal strength in all different directions. Also there were many walking paths in this open plan retail store. It was difficult to have link node models for drawing of Bayesian inferences.

(3) The time lag for access points to pick up the Wi-Fi signal search from individual smartphones varied from 1 to 10 minutes. This complicated the accuracy issue further more and led to larger locating bias. The users using the navigation app could not see their own location pins moving along most of the time.

When the pin did move, it jumped from place to place.

(4) The time lag and location bias had the least impact on the vicinity marketing scenario. 100% of users staying for longer than 10 minutes received the marketing push notification. For users merely walking by, the chance decreased to around 50%.

(5) When there was no Wi-Fi infrastructure to do signal fingerprinting, we tried built-in sensors in smartphone including GPS, compass and accelerometer for location estimation. The results were not satisfying because too many assumptions including starting point and walking pace need to be taken care of for the reading from these sensors to make sense.

(6) Considering both time lag and location bias, the location based crow behaviour analytics had low credibility in real time. However the accumulated statistics over a certain amount of time such as an hour or a day became more reliable.

(7) Similar to vicinity marketing, In-situ deal recommendation reached to users who have turned on the Location Service or stayed long enough in the venue with Wi-Fi locating infrastructure.

Additionally we have done a survey with the retail partner to conclude the research. The feedbacks can be summarized as: (1) Mobile LBS for end consumers are attractive but there is lack of evidence in the tracked conversion rate. (2) The micro location based crowd behaviour report is considered less useful. (3) The tracking of conversion rate is considered most useful for business users. (4) The business user prefers monthly subscription of above reports instead of owning and viewing of the real time location data.

## V.  SUMMARY

Through our research attempt we have come to a better understanding about the less communicated aspects of LBS including the lack of accuracy and the response time lag. Both have been elaborated in previous chapters. Other than these technical limitations, we have also found people to be far less willing to share their locations than expected or assumed in previous reports. While the overall percentage of smartphone owners who have used Location Service is quite high – 74% as reported in FactBrowser in year 2013, prolonged activation of it for non-outdoor navigation purposes is actually rare.

One reason behind such reluctance is people are wary of battery drain. GPS chip requires the biggest power consumption among all mobile sensors. Although experts have claimed the location based reminders consume less

power than commonly assumed because they request less accurate information and query less frequently than navigation, most smartphone owners prefer to turn off the Location Service option to save power. The same concern is held towards the Bluetooth option and Wi-Fi option. Relatively speaking, more people tend to leave the Wi-Fi option on which is an advantage of Wi-Fi signal strength triangulation.

Another contributing factor is the privacy concern and it is becoming increasingly prominent. Criticisms towards the possibility of revealing uniquely identifiable data in social sharing activities have never stopped. Their influence gradually shows both in country level regulations and individual level conversations. For the mobile phone users we have come across in this research project – from C-level users in their 50s to interns in their early 20s - all responded that they only checked in locations via mobile phones when necessary. Once they learnt Wi-Fi access points being able to pick up the Mac Addresses of their smart devices, the uniform reaction was that they would make sure the Wi-Fi option of their smartphones is turned off when not in use.

Tero Kuittinen [11] has cautioned that privacy concern could kill the mobile LBS market in a slow way. From what we have learnt about the existing technologies to enable LBS and mobile phone users' overall attitude towards location sharing, we tend to agree the limitations of LBS applications are still too many for them to make any significant market impact or drive noticeable behaviour change.

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