IoT based Proximity Marketing

Zanele Nicole Mndebele and Muthu Ramachandran
School of Computing, Creative Technologies and Engineering, Leeds Beckett University, Leeds, U.K.

Keywords: IoT, GCM, Google Cloud Messaging, Wi-Fi, Proximity Marketing, PMaaS.

Abstract: Modern communication is moving toward a digital paradigm influenced by increasing connectivity and the IoT. Digital communication can be improved by applying proximity rules to improve relevance especially for marketing messages. The objective of this study was to demonstrate how cloud based proximity marketing can be implemented as a service on existing wireless connectivity service platforms to deliver messages that are timely and relevant, using Wi-Fi broadcasts. Information about networking technologies and proximity determination was used to develop a prototype proximity marketing system to demonstrate the concepts of Proximity Marketing as a Service that can run on a wireless network. The prototype system Precinct PMaaS was successfully designed, implemented and tested. When compared to similar Bluetooth tools the cloud based WiFi driven Precinct PMaaS solution proved to be more efficient and effective, offering a better value proposition than Bluetooth proximity marketing tools. This study demonstrates how to achieve proximity communication cost effectively using network service information, demonstrated in a Wi-Fi only environment. This is ground work on which future projects can apply Big Data analytics to improve impact of proximity driven digital marketing.

1 INTRODUCTION

Today's society thrives on mobile connectivity and the convenience of communication on the move thanks to the internet of things (IoT). For this reason, many organizations use digital marketing platforms to connect to their customers. Digital marketing is when an organization uses websites, email, texts, mobile applications (mobile apps) and multimedia to communicate with customers. Digital marketing has gained popularity in proportion with increased market penetration of mobile devices, smart phone technology and mobile wireless internet services, supported by ever improving IoT technologies (Smith, 2011; Hoehle and Venkatesh, 2015)

Digital marketing can be augmented by applying proximity rules to target the appropriate audience at the right time and in a specified location. The term proximity refers to spatial displacement, i.e. how close one object is to another, or how close an object is to a certain point or destination (Hightower and Borriello, 2001). Proximity marketing is a form of targeted digital marketing that facilitates communication to a specific audience in a certain location or within a predetermined range of a marketing broadcast signal. This type of marketing is less intrusive than non proximity related communication, as it confines the communications to certain time and space to improve message timing and relevance for a specified target audience (Kurkovsky and Harihar, 2006).

This study explored the requirements for enabling IoT based proximity communication, in a cost effective manner using network information. The main deliverable was the development of Precinct PMaaS, a proximity communication system for broadcast messaging. This study was based in Leeds city, UK. In an urban setting like Leeds city, where free Wi-Fi connectivity is offered as a value-add service in many locations, proximity messaging would be a viable form of customer engagement.

2 BACKGROUND

Digital marketing is an attractive marketing channel is because it is relatively less expensive than other forms of advertising, and can give organizations unlimited personalised access to their customers, allowing them to send customized information right into each customer's preferred choice of communication device (Rettie et al., 2005; Shankar

Mndebele, Z. and Ramachandran, M.
IoT based Proximity Marketing .
DOI: 10.5220/0006347903250330
In *Proceedings of the 2nd International Conference on Internet of Things, Big Data and Security (IoTBDS 2017)*, pages 325-330
ISBN: 978-989-758-245-5

et al, 2010). However, this type of communication can become intrusive if it is not used appropriately, resulting in complaints regarding excessive marketing communication, lack of relevance and poor timing of the messages (Smith, 2011; O'Mahony 2012; Rogers 2015, Information Commissioner's Office, 2016)

Proximity related communication is a logical next step for businesses especially, if they already have a mobile app or e-commerce presence in the digital marketing space, as it addresses some of the issues relating to messages relevance and timing effectively (Kurkovsky and Harihar, 2006; Krum, 2010).

Three technologies; namely Bluetooth, Wi-Fi and RFID already have a strong presence in the digital marketing space. Initial investigations into proximity marketing indicated that proximity driven marketing systems have predominantly been developed with the use of Bluetooth beacons (Kurkovsky and Harihar, 2004; Krum, 2010). The burning question was whether it would be possible to provide simpler solution based on IoT and focussing on the prevalent Wi-Fi connectivity around Leeds. Wi-Fi was also appealing because it is the most prevalent form of wireless connectivity, provides fast connectivity and coverage over large areas (Friedman et al, 2013), and is commonly offered as a value-add internet connectivity service that people are already accustomed to accessing.

The potential for a solution based on wireless network information was investigated and as a result this study proposes the concept of Proximity Marketing as a Service, PMaaS for short. In PMaaS, proximity communication is a service that runs on an existing network and uses information about the network to deliver proximity driven communication. A prototype proximity marketing system Precinct PMaaS was created to demonstrate the concept.

3 PROXIMITY MARKETING AS A SERVICE (PMAAS)

Precinct PMaaS was envisioned as a system that would target a particular community of subscribers in a specific location, and deliver messages to their mobile devices, via wireless connectivity technology as long as they remained in the specified location and only while they were connected to a particular network segment or specific access point. The service framework diagram below shows the principle services that make up PMaaS.

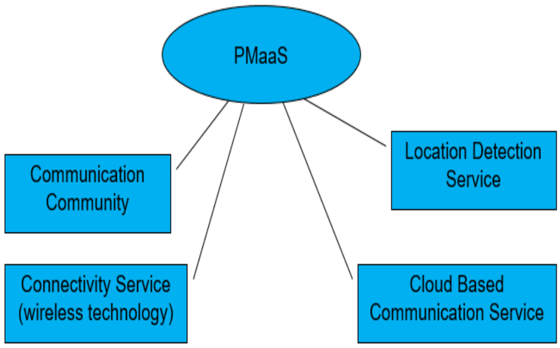

Figure 1: PMaaS Service Framework Diagram.

3.1 System Architecture

As shown in figure 2 below, Precinct PMaaS uses network information, i.e. the network name, and GPS parameters derived from the position of the mobile device to verify if the subscriber should receive proximity driven communication.

The network name is the primary criteria used to determine if the subscriber is connected to the proximity communication network. This is done by identifying the active network name or service set identifier, SSID, but could also be done by determining the access point name or basic service set identifier, BSSID, (Juniper Networks, 2013).

Precinct PMaaS makes use GPS parameters to verify the physical location of the subscriber. This is achieved through GPS, A-GPS (Assisted GPS), Wi-Fi positioning or cellular network positioning (Hightower and Borriello, 2001; Zandbergen, 2009; North, 2011). Nowadays many mobile devices are equipped location detection functions that are part of most mobile smart phone operating systems and use one or more of these technologies to determine device location.

Wireless broadcast messages are sent by a cloud based communications platform and a mobile app installed on the mobile phone listens for messages applicable to the subscriber, while the subscriber is in the relevant proximity. See figure 2 below, the Precinct PMaaS Architecture.

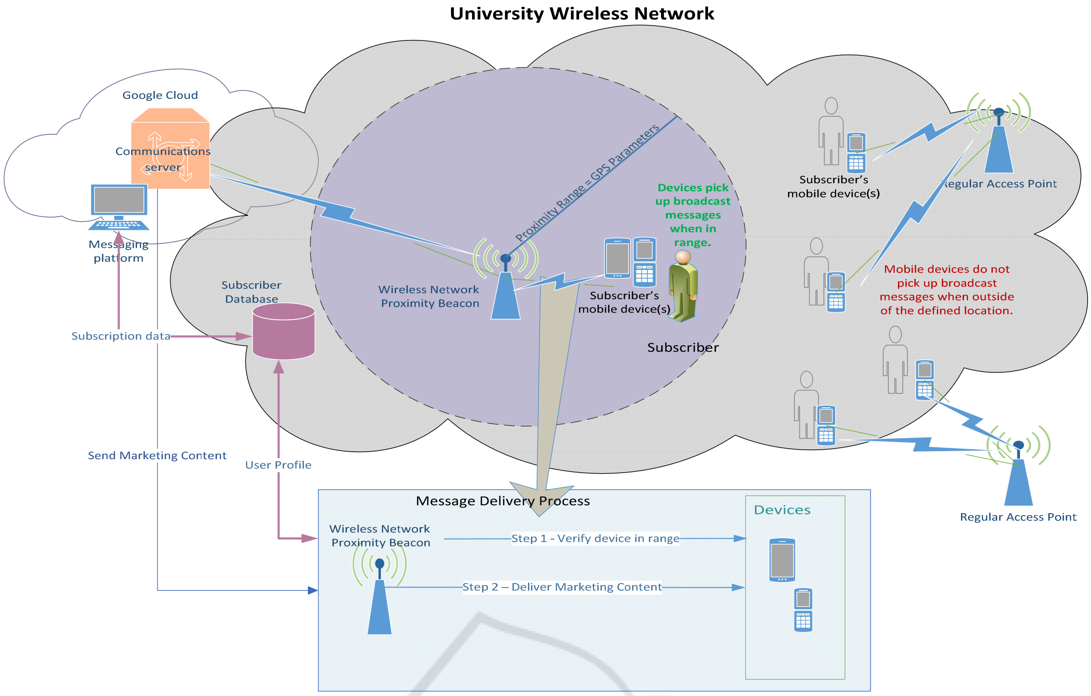

Figure 2: Precinct PMaaS Architecture.

4 DESIGN & IMPLEMENTATION

4.1 Implemented Design

Precinct PMaaS consists of the following components:

- **Data Storage**

The database holds two tables; one table stores user information and communication preferences and the other table stores a history of messages sent by the system, as well as the outcome of the message delivery attempts.

- **Mobile Application**

An Android mobile application was developed to cater for interfacing with the subscriber via their mobile phone. The subscriber uses the app to register and subscribe to notifications, and the app is also used to deliver messages to subscribers.

- **Messaging Service**

A cloud based communications platform, Google Cloud Messaging (GCM), is used for sending messages to mobile devices. The Mobile app connects to GMC via an API (Android Developer, 2016). GCM issues device registration ids, on registration of the app, which are later used to identify devices to which message broadcasts should be delivered. If the application is installed but the user registration step is not completed, the device will not receive messages.

- **Web Interfaces**

Web interfaces facilitate the creation of broadcast messages and act as a link between Precinct PMaaS and GCM. Messages are submitted on the web interface and outcomes of message delivery attempts are written to a delivery confirmation web interface.

- **Location Verification Engine**

A Location Verification engine was built into the mobile application and is used to determine the subscriber's location. The engine uses the network name and the most up-to-date device positioning information, to determine if the subscriber is connected to the proximity communication network and also currently in the correct location to receive proximity related messages.

4.2 Implementation Process

Precinct PMaaS is subscription driven to avoid being intrusive. The subscriber must install the Precinct PMaaS mobile application and register for the communication categories that are of interest to them. One registered, the mobile app will only receive message broadcasts from the subscribed categories when the subscriber is in the correct location and connected to the correct network.

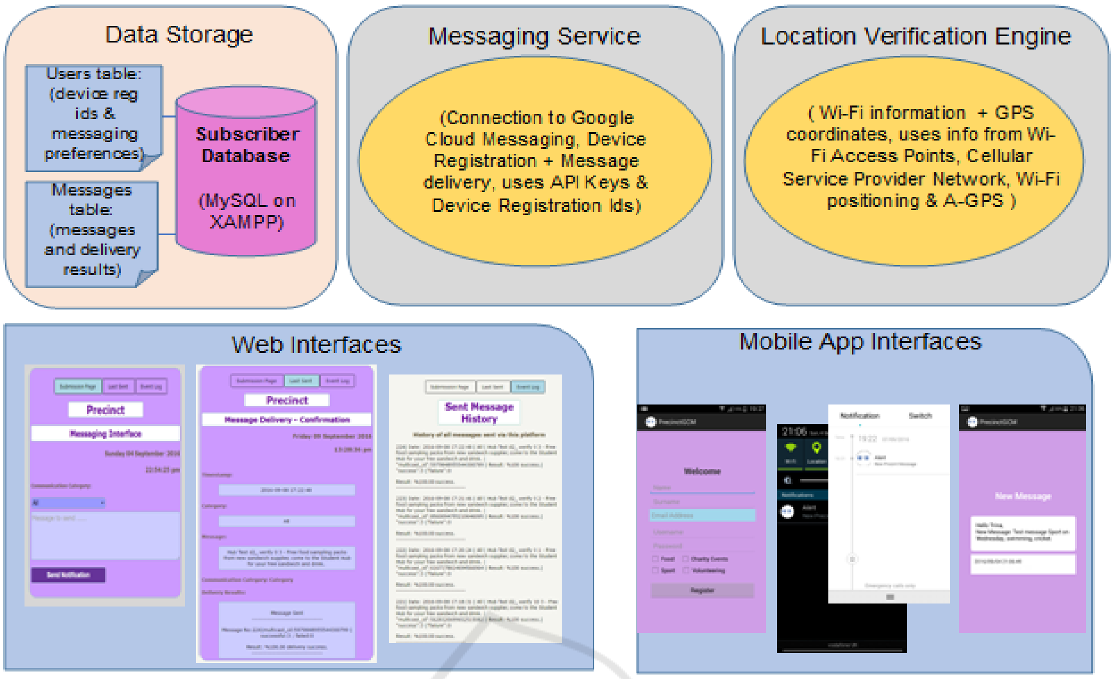

Figure 3: System Components.

5 SYSTEM TESTING AND EVALUATION

Precinct PMaaS was tested and also compared to similar Bluetooth solutions. All tests were conducted in the Student Hub at Leeds Beckett University Headingley Campus. Three mobile phone devices were used for testing; a Huawei Y360-U31, an Alcatel One Touch PIXI 3, and a Sony Xperia J. Findings are discussed in the section 6.

5.1 Unit Testing

Precinct PMaaS was developed as a modular system. All components and functionality were tested iteratively after each module was developed and added to the core. Then the final system was tested end to end and evaluated by end users.

5.2 Location Verification Testing

The mobile app was configured to show an alert that would confirm if the mobile phone was connected to the proximity network and was in the right location, as determined through GPS coordinates. All three mobile phones were used in testing the location verification engine. The Alcatel mobile phone was configured to produce negative results by altering values for expected GPS coordinates and expected network name alternately. When tests were run, broadcast messages were successfully delivered to the Huawei and Sony mobile devices. Alerts on the Alcatel indicated that it was not in the correct proximity; proving that the location verification engine worked.

5.3 Message Delivery Efficiency Tests on Bluetooth Software

Three free downloadable Bluetooth proximity marketing software tools, AreaBluetooth, FreeBlue, and Blue Magnet, were installed and tested to see how long it took to deliver messages. The aim was to explore these solutions and use the test results as a baseline to assess performance of Precinct PMaaS.

Message delivery was measured on a stopwatch for Bluetooth tool tests as well as for Precinct PMaaS tests in order to maintain testing consistency. Ten sets of test were run for each Bluetooth device over a course of 3 days, at a distance under 10 meters from the Bluetooth dongle.

5.4 Message Delivery Efficiency Tests on Precinct PMaaS

For Precinct PMaaS, three sets of tests were run at each of four distances from the access point, for 3 consecutive days. The tests were conducted at distances of 0 to 1 meters, 6.5 meters, 10 meters and 16.5 meters away from the access point. The Alcatel device was selected as the primary test device from which network signal strength was checked and recorded just before each test was run. All three mobile phones were included in the testing in order verify results through simultaneous message delivery.

5.5 End User Evaluation

The Precinct PMaaS system was demonstrated to a broad audience. The system was also evaluated by users who were satisfied that the basic principles of proximity marketing were addressed.

6 FINDINGS AND DATA ANALYSIS

6.1 Findings on System Performance

Results and findings from Precinct PMaaS and Bluetooth message delivery tests were as follows:

- On average messages were delivered faster over Precinct PMaaS than over Bluetooth solutions in equidistant tests and they arrived on all three devices simultaneously, see table 2.
- Bluetooth solutions needed to detect the device first before transmission; device detection took on average 10 seconds. The detection times were excluded from the test results.
- Bluetooth solutions had a shortcoming in that they indicated that they could only connect to a maximum number of seven devices at a time.
- Overall Precinct PMaaS offers better distance coverage, performance and capacity than the freeware Bluetooth solutions that were tested.

Table 1: Average Precinct PMaaS Message Delivery Times (in seconds) by Distance.

Distance	Day 1 Averages	Day 2 Averages	Day 3 Averages	Average
0 to 1 Meter	1.29	0.87	1.15	1.10
6.25 Meters	1.18	1.07	1.25	1.17
10 Meters	1.45	1.04	1.20	1.23
16.25 Meters	1.98	1.23	1.15	1.45
Overall Average :				1.24

Table 2: Comparison of Bluetooth and Precinct PMaaS text message delivery times.

Comparison of Bluetooth and Wi-Fi Text Message delivery times: max 10 meters from signal origin (10 tests per Bluetooth system)		
System	**Type**	**Average time in seconds**
Blue Magnet	Bluetooth	5.40
AreaBluetooth	Bluetooth	3.00
FreeBlue	Bluetooth	9.79
Precinct PMaaS	Wi-Fi	1.23

6.2 Statistical Analysis

Basic statistical analysis on data from the Precinct PMaaS messages delivery tests produced the following findings:

- Fastest message delivery time recorded was 0.8 seconds, and the slowest was 3.0 seconds
- Lowest signal strength recorded was -79dBm and the highest was -53dBm.
- The most frequent signal strength was -66dBm, and the most frequently recorded message delivery time was 1.13 seconds.
- Based on this data set, a message delivery time of 1.24 seconds is a realistic expectation for an average signal strength of -63dBm.
- The standard deviation figures were relatively low; which implies the data is reliable

Summary Statistics
Distance, Message Delivery Times and Signal Strength

The MEANS Procedure

Variable	N	Mean	Mode	Minimum	Maximum	Std Dev
Msg_Delivery_Time	36	1.24	1.13	0.80	3.00	0.39
Signal_Strength	36	-63.61	-66.00	-79.00	-53.00	6.69
Distance	36	8.50	1.00	1.00	16.50	5.70

Figure 4: Basic Statistical Measures.

7 CONCLUSIONS

Precinct PMaaS was developed based on literature about the IoT in four areas; wireless technology, location detection, proximity marketing and message broadcasting. This study found that cloud based Proximity marketing running as a service driven by network information is not only feasible, but offers better value than Bluetooth in terms of efficiency and cost effectiveness, as it can be used to implement IoT based proximity solutions that run on existing infrastructure. IoT based Proximity communication requires the following key information to work:

- The ability to identify and retrieve network service information.
- The ability to uniquely identify a device or subscriber that should receive the communications.
- The ability to determine if the device or subscriber is indeed connected the network associated with the proximity communications.

When configuring proximity rules, combining the SSID and GPS is recommended for a network with multiple access points at one site or a network with multiple sites and multiple access points. For a network with one site and one access point, a rule that checks the SSID or the BSSID would suffice.

7.1 Future Work

The nature of proximity marketing opens up many possibilities in terms of understanding how to track consumer habits and the impact of digital marketing messages. Information derived from digital footprints of mobile connectivity proximity driven by IoT can potentially provide insights to inform future mobile communications development. Future research should explore how Big Data can provide insights relating to consumer reactions to mobile proximity driven communication, and possibly contribute to future development of predictive and proactive proximity communication (Want and Schilit, 2001; Lee and Gnawali, 2015).

ACKNOWLEDGEMENTS

I would like to acknowledge Dr Mario Marino, from Leeds Beckett University, for his contributions, guidance and insightful feedback in the production of the dissertation on which this study is based.

REFERENCES

Android Developer (2016) Cloud Messaging. *Android Developer* [Online] Available from: <https://developers.google.com/> [Accessed 15 July 2016].

Friedman, R. Kogan, A. Krivolapov, Y. (2013) On Power and Throughput Tradeoffs of Wi-Fi and Bluetooth in Smart phones. *IEEE Transactions on Mobile Computing.* 12 (7), pp. 1363- 1376.

Hightower, J. and Borriello, G. (2001) Location Systems for Ubiquitous Computing. *Computer*, 34(8) August, pp. 57-66.

Hoehle, H. and Venkatesh, V. (2015) Mobile Application Usability; Conceptualization and Instrument Development. *MIS Quarterly*, 39(2), pp. 435-472.

Information Commissioner's Office (2016) *Guide to Privacy and Electronic Communications Regulations* [Online]. Available from Available from: <http://www. ico.org.uk/> [Accessed 28 May 2016].

Juniper Networks (2013) Understanding the Network Terms SSID, BSSID and ESSID. *Juniper Networks* [Online]. Available from: <https://www.juniper.net> [Accessed 06 June 2016].

Krum, C. (2010) Mobile Marketing: Finding Your Customers No Matter Where They Are. Pearson Education, USA.

Kurkovsky, S. and Harihar, K. (2006) Using Ubiquitous Computing in Interactive Mobile Marketing. *Personal and Ubiquitous Computing*, 10 (4) May, pp 227–240.

Lee, H.J. and Gnawali, O. (2015) Predictive Data Delivery to Mobile Users Through Mobility Learning in Wireless Sensor Networks. *IEEE Transactions on Vehicular Technology*, 64 (12), pp 5831 - 5849.

North, M.M. (2011) An Empirical Analysis Of Mobile Smart Device Accuracy and Efficiency in GPS-enabled Field Data Collection. *Issues in Information Systems*, 13 (1), pp 318 - 327.

O'Mahony, J. (2012) Spam text pair face £250000 fine. *Telegraph UK* [Online], 1 October. Available from: < http://www.telegraph.co.uk> [Accessed 16 May 2016].

Rettie R., Grandcolas, U. and Deakins, B. (2005) Text message advertising: Response Rates and Branding Effects. *Journal of Targeting, Measurement and Analysis for Marketing*, 13(4), pp. 304-312.

Rogers, K. (2015) LinkedIn Notorious for Sending Too Many Emails Cuts Back. *New York Times* [Online], 29 July. Available from :< http://www.nytimes.com/> [Accessed 05 May 2016].

Shankar, V. Venkatesh, A. Hofacker, C. and Naik, P. (2010) Mobile Marketing in the Retailing Environment: Current Insights and Future Research Avenues. *Journal of Interactive Marketing*, 24, pp. 111–120.

Smith, K. T. (2011) Digital Marketing Strategies that Millennials Find Appealing, Motivating, or Just Annoying. *Journal of Strategic Marketing*, 19 (6) October, pp. 489-499.

Want, R. and Schilit, B. (2001) Expanding the Horizons of Location-Aware Computing. *Computer*, pp. 31-34.

Zandbergen, P. (2009) Accuracy of iPhone Locations: A Comparison of Assisted GPS, Wi-Fi and Cellular Positioning. *Transactions in GIS*, 2009, 13, pp 5 - 26.