Date Received:	SRA-SV Docket No.:

SAMSUNG ELECTRONICS

SAMSUNG RESEARCH AMERICA – SILICON VALLEY
INVENTION DISCLOSURE FORM

1. INVENTION

Invention Title:
Triangulation based Indoor Location Tracking using Bluetooth LE

Lab:	Project Name:	Project Code (PLM):	Cost Center:
UX Services			
Project Related HQ Person:	Related HQ Project (if applicable):	Project Funding HQ Business Unit:	
Check if urgent: ☐ Yes	Reason:		

2. INVENTOR(S)

Full Name (Last, First MI)	Home Address (Street Address, City, State, Zip)	Work Phone & Email Address	Citizenship (Country)	Empl. Status (Employee/Dispatcher/Contractor)
Dewan,Abhishek	370 Elan Village Lane, San Jose, CA, 95134	a.dewan@partner.samsung.com	India	Employee(Intern)

3. CONCEPTION OF THE INVENTION

a. Was the invention conceived in the United States? ☐ Yes ☐ No	If not, in what country was the invention conceived?
b. Date of first written description: 6/30/2014	Where can this description be found? Personal Notes
c. Was invention developed using non-Samsung (e.g., university, government) funding? ☐ Yes ☐ No	If so, what was the source of funding?

4. CONSTRUCTION OF THE INVENTION

Was a model or prototype made? ☐ Yes ☐ No	If so, when was it constructed and where can it be found? 7/10/2014 Code located in Stash Repositories 1) API - https://stash.sisa.samsung.com:8443/users/a.dewan/repos/beaconlocationapi/browse 2) Dashboard - https://stash.sisa.samsung.com:8443/users/a.dewan/repos/beaconlocation/browse

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5. USE OF THE INVENTION

Are there specific plans for its use? ☐ Yes ☐ No	If so, when was it (or will it be) used? Planned for use in the next 12 months

For what purpose will it be used? (e.g., project/product name, industry standard)
The invention would form a core framework for providing Samsung customers with contextual services.

6. DISCLOSURE/SALE OF INVENTION (EITHER PAST OR NEAR FUTURE)

a-1. Has invention been (or will it be) disclosed to others outside Samsung? ☐ Yes ☐ No	If so, to whom was it (or will it be) disclosed? (e.g., vendor, conference, standards body)
If so, when was it (or will it be) disclosed?	
a-2. Was the disclosure or will the disclosure be made under a Non-Disclosure Agreement? ☐ Yes ☐ No	If so, when was it (or will it be) executed?
b. Has Samsung actually sold (or will it be selling) any product using the invention? ☐ Yes ☐ No	If so, when was (or will) the product be first sold?

7. RELATED INVENTION DISCLOSURES OR PATENT APPLICATIONS BY INVENTORS (BRIEFLY EXPLAIN RELATION)

8. INVENTION OVERVIEW

a) Background of Invention
Briefly describe technical field and objects of (or problems addressed by) the invention.

Bluetooth low energy(BLE) is a technology,that enables the creation of a personal area network, is designed by the Bluetooth Special Interests Group. Inteded to provide a low power alternative to normal Bluetooth while mainting a similar communication range, BLE devices(now reffered to as beacons) has become an interesting area for developing applications and services.

One of the major uses of beacons that has emerged nowadays is in the field of proximity sensing and indoor location tracking. BLE's system architecture allows for beacons advertise their presence to other devices that are listening for those signals. Using these signals an application or service is able to detect the presence or absence of a beacon and use that to perform further functions. However, due to noisy advertising signals, the functions that allow users to calculate the distance and presence of beacons is highly inaccurate especially for the scenario where a location is densely populated with a number of such beacons.

The invention outlined in this document provides a more accurate method of calculating the location of a user in a area that is densely populated by said beacons. The methods uses a combination of heuristics to improves the accuracy of the distance calculations and thereby increasing the accuracy of the measurements.

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b) Summary of Invention
Briefly describe the "gist" of the invention. To the extent possible, the invention should be described in terms of a general concept rather than a specific application or implementation.

This documents details a framework of using multiple heuristics in combination with each other as a way of dealing with the noisy nature of the signals received from beacons. The removal of the noise from the received signal translates into a more accurate measurement of the distance between the device receiving the signal and the beacon itself. This can then be used to create a system that can locate a user using the array of beacons within that environment.

The frameworks consist of a mobile application that is capable of detecting beacons on Android Phones, using the Android Library provided by Radius Networks (http://developer.radiusnetworks.com/ibeacon/android/pro/download.html). The application responsible for detecting all the beacons present near the user and uploading the nessecary heuristics to a backend data server running in the cloud.

The second component of the framework consists of a set of HTML,JS and CSS files that download the data from the backend servers and performs data analysis on the multiple heuristics to find the location of the user. This part of the framework uses the following open source libraries

1) Circle.js (http://www.benfrederickson.com/calculating-the-intersection-of-3-or-more-circles/) - This allows to calculate the intersection points of multiple circles.
2) d3.js (http://d3js.org/) – This is used to create visualizations for the location that the user is present in and to show the users locations within an environment.

c) Primary Value of Invention to Samsung

☐ Improves the performance, features or cost of a product?

☐ Covers a core/fundamental technology?

☐ Covers an industry standard?

☐ Creates a new class of product? ☐ Other:

d) Closest Existing Technologies to Invention
In general, "big picture" terms, describe existing technologies most closely relevant to the invention that are known to inventor. In determining what technologies are relevant to your invention, it is not necessary to discuss specific prior art references unless they are particularly relevant to the invention.

The closest technology present to the invention outlined in this document is the ranging and monitoring functions present in the CLBeacon Class (https://developer.apple.com/library/ios/documentation/CoreLocation/Reference/CLBeacon_class/Reference/Reference.html) in iOS.

e) New Features of Invention
Briefly describe the key specific structural or functional features of your invention that differentiate it from the closest existing technologies identified in item 8(d).

The other methods of distance measurement and location tracking currently present are not highly accurate. The noise within the BLE signal causes the measurement calculations to be highly fluctuating and hence cannot be directly used for the purpose of indoor location tracking.

The invention described here, helps in removing said noise, by passing the raw data from the beacons through a combination of heuristics. The framework uses the following heuristics,triangulation, previous location knowledge and a low pass band filter,

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in a unique way and combines them to form a more accurate prediction of the location of the user with in the given area.

f) Advantages/Disadvantages of Invention

List key advantages (and disadvantages, if any) of invention over the closest existing technologies identified in item 8(d) in addressing the objects/problems identified in item 8(a).

The major core advantage of this invention is that it allows to more accurately predict the location of a user within an area that is densely populated with beacons. The idea has potential applications into the smart device market where the ability to detect the proximity to such smart devices will help provide a more emmersive user experience and help in creating better services.

9. DETAILED DESCRIPTION OF INVENTION

Describe construction and operation of the preferred embodiment of the invention, focusing on the key features identified in item 8(d). Please provide at least one diagram of the invention with the key features clearly labeled. For algorithm or process-related inventions, also provide at least one flow chart (or pseudo code). Additional materials, such as reports, emails, specifications, schematics, models or test results may be attached but be sure to reference them in this section.

The Traingulation based Location Tracking system has three separate modules that work together to form the framework. The following will details these modules further:

Backend Server – The framework relies on a ruby on rails server running in the cloud that is attached to a MongoDB database. The server exposes custom API's that allow the phone and the dashboard module to access the data that is stored on the MongoDB servers.

Phone Application – The phone module is an Android application that runs on Android phones with Bluetooth 4.0 support. The application uses the iBeacon Library from Radius Network as a methods of connecting to the Bluetooth beacons.

Figure B represents the lifecycle of the phone application and the various functions it performs. According to figure B, the application starts by querying the backend MongoDB server to figure out whether the user has been registered with the server or not. The unique id used to determine the identity of the user is a combined value derived from the model type and the serial number of the phone. Since serial number of the phones are different this ensures that no two users will have the same unique id. If the user has not been registered before with the server, the application registers the user with the server and then sets the name of the user to the application window. Once the user is registered the application is put into a monitoring mode where it starts to scan for all the various beacons that may be present in the vicinity of the user.

Once beacons get detected, the list of the detected beacons is sent to the "closestBeacon" function. The "closestBeacon" function checks the raw distance measurements of all the beacons in the list to determine whether the beacons are within 0.20 m of the user. This steps ensures that fluctuating Bluetooth signals do not mess with the system. Of all the beacons that are within 0.20m of the user, the closest beacon is the beacon with the shortest distance value. This step is used to find out the current active beacon for the user. In other words we are trying to determine the beacon that is closest to the user. In cases where none of the beacons are within the 0.20m range, the phone makes a check to see if the last location of the user is known to the application. If yes, then the last known location is assumed to be the closest beacon for the user. Once the closest beacon is determined, it is uploaded to the server.

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Dashboard Application – The dashboard module consists of a set of HTML,CSS and Javascript files that perform data analysis and help visualize the location of the user. The dashboard application uses D3.js to help create the visualizations and circle.js to help in determining the intersection points of various circles. Figure C shows the flowchart for the lifecyle of the dashboard application.

According to figure C, the application starts by creating the coordinate system for the area that is being mapped. Once that is done, the application pulls data off the backend server and stores it locally. To help remove the noise from the data the system ensures that atleast 15 readings distinct readings have been pulled of the server. This makes the application a little slow, as it waits for new data to be uploaded by the phone module, however, it helps improve accuracy. Once 15 readings have been taken, the data is assumed to be quite noisy, due to the fluctuating nature of the Bluetooth signal and hence is put through a low pass filter with a low alpha value to ensure a smoother data set. Using the output of the low pass filter, the average distance of each beacon from the user is determined by the averaging function.

Assuming the distance of the beacon from the user as radius and the location of the beacon as the center, we create the equation of the area of influence of the beacon. This equation is equivalent to the equation of a circle, and hence we use these equations to find where these area of influences intersect. The intersection points are possible locations the user could be present at. However, this is still inaccurate. To further enhance the accuracy of the system, the last known location of user is pulled of the server. Using distance measurement techniques, the point of intersection that is closest to the last known position of the user is found out and this represents the predicted location of the user. Due to the speed at which the system runs, the assumption of finding the closest intersection point from the last known location plays on the idea that "the user could not have gone far from his last known position since we last saw him".

Using D3.js the location of the user is drawn on the maps to be visualized to the user.

10. ALTERNATIVE EMBODIMENTS OF INVENTION

Describe any alternatives to the embodiment described in item 9. Drawings, diagrams and/or flowcharts can be helpful to illustrate your invention.

11. SIGNATURES

a) Inventors
I/we, the undersigned, are the sole and original inventor(s) of this invention.

Inventor 1 Abhishek Dewan	Date		Inventor 2	Date
Inventor 3	Date		Inventor 4	Date

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b) Witnesses I/we, the undersigned, have reviewed this invention disclosure and understand its contents.				
Witness 1	Date		Witness 2	Date
c) SRA-SV Management We, the undersigned, have reviewed and approve of this invention disclosure as to its scope and completeness.				
Project Lead	Date		Lab Manager	Date

Inventors (and witnesses) should initial and date each page of Invention Disclosure and any attachments. Submit completed Invention Disclosure to SRA-SV Patent Dept. If you have any questions, please contact Jade Sche at (408) 544-5945 (j.sche@samsung.com), Jasenka Eminovic at (408) 544-5603 (j.eminovic@samsung.com), Louisa Toy at (408) 544-5083 (louisa.toy@samsung.com), Ruke Wang at (408) 544-5615 (ruke.wang@samsung.com) or Justin Chang at (408) 544-5677 (Justin.chang@samsung.com).