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Indoor Location and Navigation System in Mobile Services in cloud computing

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ABSTRACT

Indoor Positioning and Navigation Systems (IPNS) has been subject of intense study and research ought to it has become a blind spot with regard to Positioning and Navigation Software. An indoor solution has been as successful outdoor systems like Global Position System (GPS). This paper proposes the design and implementation on mobile device (the most common), of a 3D positioning and navigation system for indoor based on the use of Bluetooth (BT) radio technology. This paper details the development of an indoor navigation system on a web-enabled smart phone. A routing algorithm calculates the optimal path from user position to destination. This system using commercial smart phones with Bluetooth capabilities to investigate the feasibility of range-free localization for indoor positioning. We have developed an Android application for smart phones. A routing algorithm calculates the optimal path from user position to destination. Testing verified that two meter accuracy, sufficient for navigation, was achieved. This technique shows promise for future handheld indoor navigation systems. This 3D model can be build using the most common 3D Design tools with M3G formats support. Location is implemented on BT with distributed estimation (the mobile device performs it).

Keywords: *Indoor Environments, Radio Navigation, BT, Mobile Devices, 3D Models.*

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I. INTRODUCTION

Many applications require Knowledge about the environment to locate and identify the position of an entity (user, device, and so on), some areas where these needs can be found from industry , e-marketing ,health and emergency services to automatic activation services . An important part of these environments is the use of location systems, identification and navigation targeted to mobile devices with wireless capability, which enable to use applications automatically based on an authorization given by the user previously located in a certain position within the system coverage area. To estimate the location we decided to use BT technology because it is widespread in typical mobile devices and has as main hardware features: low power consumption, low cost and low interference with devices that work on the same frequency range. In this project, an indoor navigation system that provides positioning and navigation capabilities is proposed and tested. The hardware installation requirement is alleviated through the use of existing Wi-Fi access points and through the integration of the final software application with a popular smart phone. While previous systems that make use of Wi-Fi access points require a lengthy period of data collection and calibration, this system does not. Data on the positions of walls and Wi-Fi access points in the building is used to simulate Wi-Fi fingerprint data without a time-consuming measurement requirement

The Wi-Fi positioning capability is augmented through the use of two other sensors common to smart phones: an inertial sensor typically used to characterize phone motion, and a magnetic sensor that acts as the phones compass in traditional navigation applications. Taken together, these sensors can be used to form a rudimentary inertial navigation system (INS) that estimates the nature and direction of a user's motion. Tracking a moving user's location in the building is better accomplished by combining this information with the output of the Wi-Fi positioning system. In addition to the positioning subsystem, a database and a navigation system are implemented to increase system usability. The database allows the user to search a directory of people and places within the building. The navigation subsystem informs the user of the optimal route to their destination. These system components form a software application that is accessible through an intuitive user interface.

Related work:

IPNS in the last years have become an important subject in several areas, like:

Industry:

enterprises seek to increase the value of their products or services, through competitive advantages such as improving the safety of employees, reducing delivery errors, streamlining of the production and supervision, among other aspects. This is made by using GPS and tracing through Radio Frequency Identification systems (RFIDs) to locate, identify and navigate to monitor employees and company's products .

E-marketing:

Companies use systems to locate and identify users who offer products or services based on their position inside (or near) the store or previous customer's preferences. The system detects the closest way to arrive to certain position for example a box to make a payment, among others .

Health and emergency services:

a common task for this systems is get the location and send information concerning to patients, health personnel, medical equipment, emergency routes, among others .

II. CLASSIFICATION AND LIMITS OF LOCATION SYSTEMS

Location systems can be classified by the type of working environment: outdoor and indoor systems.

2.1 Location Systems And Methods For Outdoor Environments

GPS: It is a global navigation satellite-based GPS receivers process the signal to determine the 3D position

Cell Identification (Cell-ID): This method takes into account the fact that mobile networks can provide an approximate position of a mobile device based on information about the nearest cell (it's necessary a cell network connection).

Angle of Arrival (AOA): This technique uses an array of addressable antennas (at least two), the objective of them is to calculate the AOA of the signal. This technique commonly is used in conjunction with others to obtain a better approximation of the location .

Time of Arrival (TOA): This technique is based on the fact that electromagnetic waves travel at a constant speed in space. Therefore the distance between two points can be calculated using the time delay between the transmitted waves. There is a linear relationship between arriving time and distance. In a similar way, TOA technique is used in conjunction with other techniques.

2.2 Location Systems And Methods For Indoor Environments

Infrared-based systems: These systems use the proximity among electronic devices using infrared technology .

Ultrasound-based systems: These systems are based on tags for the items to be controlled, using the ultrasonic signals that they emit and receive. The simplest method to calculate the orientation, is based on the calculation of the relative orientation .

Electromagnetic-based systems: These systems generate electromagnetic pulses in a transmitter antenna. The system estimates the position and orientation of the receiving antennas; this is done by measuring the response in three orthogonal axes (x, y, z) of the transmitted pulse .

Vision-based systems: Computer vision technology is used to detect the location of an object/person. Recently, these systems are directed towards the use of augmented reality techniques and tracking markers

Physical contact-based systems: These systems are based on physical contact between a person/object and the system (pressure sensors). The function of these sensors is to detect the presence of a specific kind of pressure on them to be used later in the tracking .

Radio frequency-based systems: These systems use receptor-emitter devices that read and send RF signals. These signals can be fixed or mobile at 2.4 GHz or 5.8GHz (depending on the technology: Wi-Fi, BT, GSM, RFID and others).

2.3 Most Common Location Techniques In Indoor RF-Based Systems

Geometric: this technique uses geometric properties to tract a location problem . Main geometric techniques are:

Trilateration: the position of a mobile receiver-transmitter can be calculated based on the distance among this one and other receiver-transmitters placed in fixed positions.

Triangulation: This technique uses triangles trigonometry to determine the location of objects. Triangulation can be divided into subcategories: Lateration and Angle. Application examples' of these techniques can be found in .

Pattern Recognition (PR) or fingerprinting: these techniques attempt to engage a received power levels vector (RSS, Received Signal Strength) obtained from multiple access points with a defined calibration test, once a time without the need for geometric algorithms. Specific techniques that use PR are:

K-Nearest Neighbors (KNN) methods: This method is based on the idea that while the RSS was received at the mobile transmitter-receiver, it doesn't depend linearly on the distance to the fixed receiver-transmitter, but some relation exists; can be ensured that if the receiver transmitter is very close to fixed-mobile emitter receiver, the received power is high, and vice versa. Exploiting this idea, a database of locations or radio map (a set of test vectors) can be created, it contains the position of each location (coordinate of reference) and the RSS of the access points. To locate a mobile transmitter-receiver, a vector of powers and coordinates is read, and then compared with the database of locations. The next step is to search the closest test vector to the received one. After this, a vote can identify what is the most likely location.

Finally, the euclidean distance can be used to estimate the distance between the received vector and the closest test vector (other measures of distance also can be used).

Neural Networks Methods: this method uses a Neural Network (NN) to estimate the location through processing distinct RSS emitted from fixed receptor-emitters. The NN is implemented by a multilayer perceptron in which the inputs entries may be the RSS of each fixed receptor emitters and the output is likely to be in each of the locations.

2.4 3D Modeling: Basic Concepts

In order to perform 3D modeling of objects is necessary to have some basic knowledge of concepts such as :

Three Dimensional spaces (3D): A virtual mathematical space which is represented into a program, it is defined by a Cartesian system of three axes (X, Y, Z), where the crossroad of these is called the origin whose coordinates are (0, 0, 0). Modeling: It consists on creating a scene from the mainstream of individual objects to which have certain properties. To do it, it's common to draw on modeling techniques such as: *NURBS (Non Uniform Rational B-Splines)*: a complex mesh is created using splines to represent an object with a more curved or organic appearance.

Predefined Structures Modeling: predefined structures given by the software are used to create other complex objects or scenes starting from them.

Extrude Modeling: replicas of points, lines or planes that form a mesh are expanded or contracted in one of the Cartesian coordinates (X, Y, Z) obtaining a complex mesh.

Modeling with Boolean Operations: a boolean operation (subtraction, intersection or union) is applied between two meshes, a new and different mesh is obtained from this operation.

Polygon mesh modeling: meshes are designed to satisfy with the rule that each line is shared at most by two planes.

Boundary Representation Modeling (B-Rep): an object is represented by the boundary of it. In other words this object is described in terms of the elements that are part of its surface (points, lines and planes).

III. OVERVIEW

Overview contains goal and objectives.

The main goal is to facilitate for indoor navigation. The system will be easy to implement in building that have existing wireless connectivity.

The systems have three primary Objectives.

The devices must be able to accurately determine its location in a building.

The device must guide a user along optimal path to their destination.

The device must have an intuitive user interface.

These objectives will be accomplished through the design and integration of a number of subsystems. The first objective is to be able to locate the handheld device in a building. The device should be able to use signal strength measurements of the available wireless networks to accurately locate itself in a building. The device should be able to look up its exact location in relation to the map according to the wireless propagation model. The second objective is to use routing algorithms to be able to lead the user to their final destination by finding the shortest possible route and leading the user along it.

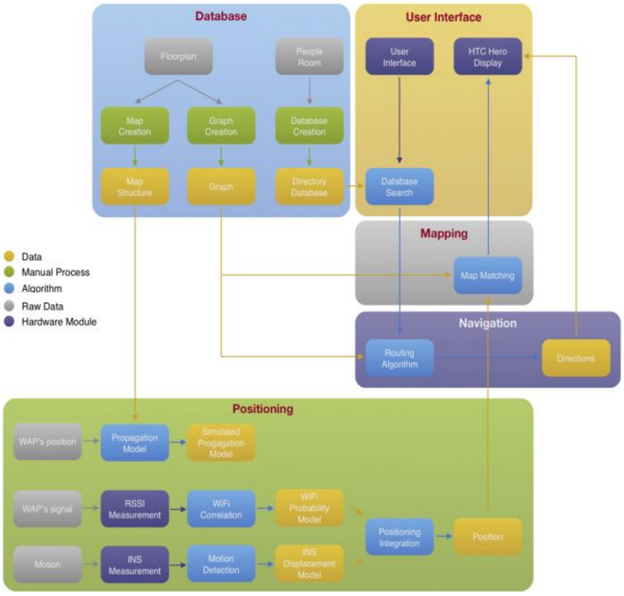

Fig. Of System Design Block Diagram

Finding the optimal algorithm for determining the correct path with a minimum requirement for computing resources is necessary. The third and final objective is to create a user interface that is intuitive. The user should be able to look up a desired destination and the device should be able to show the user a route to it. A database of possible destinations should be provided. In the building that we will be testing this application in, the device should support searching of the database by multiple parameters.
The system consist of five subsystem as illustrated in figure of System Design Block Diagram .The system design include five subsystems. The design requirements include four subsystems and their descriptions as below.

Positioning – Locate the user in the building.
Navigation – Determine optimal route to destination.
Mapping – Mapping the estimated position to the map.

User interface

Allow user access to all provided functionality. It inform to user of their current location as well as destination. It allow user to select destination from database in the building.

Location Database
Directory of people and places in the Building.

IV. PROPOSED SYSTEM

The Indoor navigation system that provides positioning and navigation capabilities is proposed and tested. Wi-Fi positioning capability increase through using through two sensors. Inertial sensor used to characterize phone motion. Magnetic sensor that acts as phone compass. In positioning subsystem, a database and navigation system are implemented to increase system usability .Database allow to user to search directory of people and places within the building. Navigation subsystem informs to user optimal route to their destination.

4.1 Positioning

The capability to determine a user's position within building is a necessary part of navigation system. The system described in this project uses measurement from Wi-Fi, magnet and inertial sensors.
The Wi-Fi positioning system consists of two primary subsystems, the propagation model and the location search algorithm. The Propagation model is run on a computer and is used to pre-generate an estimate of wireless signal strengths at each location. The Location search algorithm combines information from all detected wireless access points.

Inertial Navigation System:
The INS computes a new position .It uses data from the motion sensors to detect movement.

The INS involves four different phases

Calibration, Alignment, Initial Value, Evaluation.

Calibration: This stage provides coefficient for use in the interpretation of the raw motion sensor output.
Alignment: This stage provides axis and orientation.

State Initialization: This stage provides the initial position and velocity.

Current state Evaluation: This stage computes the position.

Combining output of Wi-Fi and inertial system: The Wi-Fi positioning and inertial navigation system contributes different types of information regarding the user's position.

4.2 Navigation

Navigation system is responsible for determining an optimal route to a destination. It consists of graphing functionality and a routing algorithm.

4.3 Graphing

A graph can be a complex system of nodes and links that are connected in a tree like data structure. A node represents a specific position in a building and tells the information about that position.

4.4 Routing Algorithm

The routing algorithm that we chose to find the shortest path between two nodes in a graph system is Dijkstra's algorithm. Dijkstra's algorithm has the characteristic that fit our requirement for a shortest path algorithm: it finds the shortest path from a single source to one or multiple destinations.

The advantages of Dijkstra's algorithm are:
The algorithm always provides the shortest path (compared with A* which does not always yield the shortest path)
The complexity of Dijkstra when well implemented is O (N log N) which is suitable for campus like environments with a moderate number of nodes. With computing ability of mobile device nowadays, the algorithm could be performed for millions nodes.
The nature of the floor plan within the building is a sparse graph where most of the nodes are connected with two other nodes, which makes the number of edges are approximately equal to the number of nodes. The Dijkstra algorithm can be run very efficiently on sparse graph with much better performance.

V . METHODOLOGY

After analyzing the related work to location of IPNS, we chose to design our system using radio frequency technology. Analyzing costs (energy and economic), technology diffusion, signal range, the use in tracking systems, programming complexity, interference among other devices that work with the same type of signals (see Table 1) that produces packet loss, among other aspects, the option we have selected as best is BT

Table 1. BT vs Wi-Fi, comparative of packet loss

Traffic BT	Traffic Wi- Fi	BT Loss	Wi-Fi Loss
30%	30%	0.007	0.574
30%	60%	0.006	0.580
60%	30%	0.007	0.576
60%	60%	0.006	0.580

KNN method determined as the most appropriate method to calculate locations, the system is running on mobile devices and this method requires few computational resources and provide a good estimate of the location and approach . Other feature required is portability, that's why several languages and development tools were analyzed (C, C++, C, J2ME and Android) and their support to BT and 3D Modeling.
BT support:
• C/C++: BT Engine API, Microsoft BT y BT Library (BtLib).

• C: 32feet.Net, desarrolloMobile.NET, BT Access, BTW-CE SDK for Windows Mobile Development Platform y Blue Tools.

• J2ME: JSR-82.
• Android: Android BT API
3D modeling support:
• C/C++: OpenGL-ES y Managed Direct3D Mobile (MD3DM).
• C: OpenGL-ES y Managed Direct3D Mobile (MD3DM).
• J2ME: Java building for OpenGL-ES (JSR-239) y Mobile 3D Graphics (M3G o JSR-184).
• Android: OpenGL-ES.
The IC 3D model was made using techniques for polygon meshes, B-Rep, boolean operations , textures and extrudes .

The KNN method running on the client has the task to create the radio map pattern, to do it we draw on a DataBase (DB), so we made a survey of available DB supporter by J2ME. We detected PerstLite as the most complete and suitable to our application. A second server application was designed for sample collection, this application runs on the mobile devices and get the RSSI from the original server, in a similar way, once the samples were collected another server application was implemented to establish a connection with the sample collector to generate a flat file which serves as radio map for the first original client during the location process.

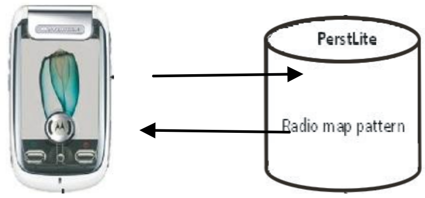

Figure of Database Architecture

VI. PROTOTYPE IMPLEMENTATION

6.1 Android Platform Architectures:

The software application is implemented on the Google Android phone the HTC Hero. The HTC Hero is running the Google Android Operating System. The operating system is a Java virtual machine called Dalvik running on a Linux Kernel. The application is written in Java and its system files will be managed by the Dalvik Virtual Machine. Application thread is running under the framework activity and is called at the beginning of the software launch. The Activity is a thread responsible for processing information and communicating inside the software. It also manages View framework responsible for graphical representation of information to be displayed to user. The view is running its own thread to be refreshed periodically to display the information.
Application can be viewed as four major blocks of processing Positioning, Navigation, Database and Interfaces

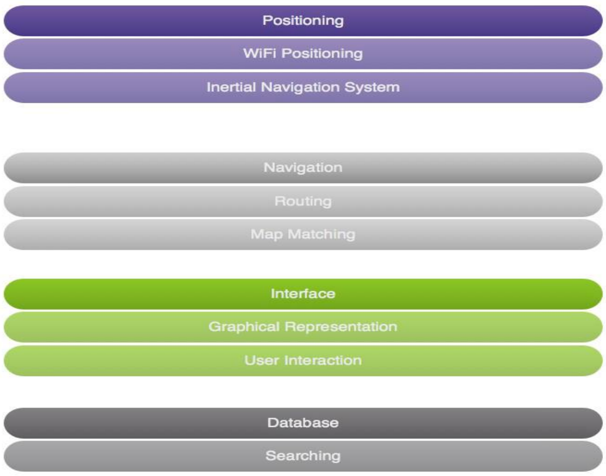

Fig Of Application Software General Functional Blocks

6.2 Software System Design :

The software application is implemented on the Google Android phone the HTC Hero. The HTC Hero is running the Google Android Operating System. The operating system is a Java virtual machine called Dalvik running on a Linux Kernel. The application is written in Java and its system files will be managed by the Dalvik Virtual Machine .Application thread is running under the framework activity and is called at the beginning of the software launch. The Activity is a thread responsible for processing information and communicating inside the software. It also manages View framework responsible for graphical representation of information to be displayed to user. The view is running its own thread to be refreshed periodically to display the information.

6.3 Graphical User Interface :

The HTC Hero phone is a smart phone device with touch screen interface and six physical buttons excluding the volume buttons. The physical buttons of the phone are illustrated in the Figure. Later in the software implementation of our user interface, we will refer to these buttons.

Figure Of HTC Hero Physical I/O Device for User Interaction

The application can be started from the HTC Hero application list. At the home screen of the application, the user will have three options: view the map of the building, browsing the database and get directions. The home screen is shown in the Figure of Application Home Screen. The user can start each option by pressing the button on the screen through the touch screen interface. By clicking the button, the user will be redirected to the accordingly screen of that function.

The following sections will describe about what the user can perform in each option. The Directory button will help the user to access the database. The Get Directions button will help the user to find the shortest path to go between places inside the building. The Map View button will display a graphical view of the map floor plan with information attributed with it. The user interface state map is displayed in Figure of Application State Map.

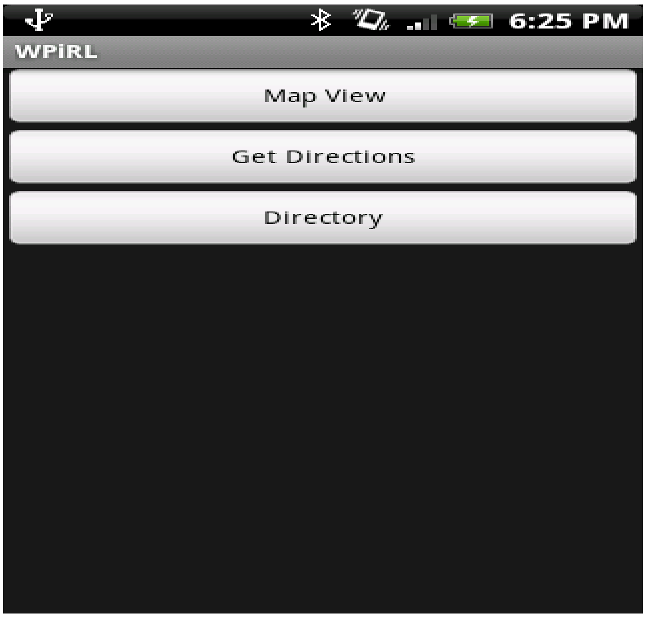

Figure Of Application Home Screen

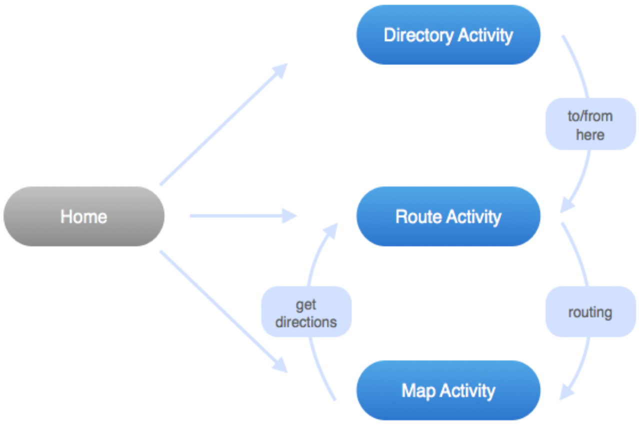

Figure of Application State Map

The application is implemented completely in Java and run in the Google Android operating system of the HTC Hero. The application is a multi threaded object oriented programming project. The INS, WiFi positioning and positioning integration algorithms are all implemented as a discrete probability distribution using two dimensional data structure. The positioning integration uses most of the computational capability of the device. The routing algorithm Dijkstra is implemented using Fibonacci Heap and achieves optimal result contributing little to the computational load. The application can help the user to determine the current location and find direction from there to the desired destination. The user also can browse the directory, view the map and search for a customed route between any locations inside the building.

VII. RESULTS

The results show that by using few computational resources and a location calculation acceptable considering that application is focused on mobile devices. It's possible to improve the calculation times for location if mobile devices manufacturers would change the BT implement in hardware/software by implementing multiple connections in parallel.. An additional feature, user can navigate and display 3D model at any time. 3D IPNS executed on 2 laptops working as servers ; the tests performed with 3 BT USB with a coverage range of 10m (all class 2). The range within the offices was about 6m (due to signal attenuation produced by the walls). Taking into account that there is an ability to receive the signal in the second floor from the same BT devices, we observed a range decrement of 2m inside the offices and the corridors. The BT USB were fixed in the ceiling of the 1st floor in order to obtain the largest possible coverage, the first device was placed 6m from the wall at one extreme of the building and the next two devices at a distance of 12m in a straight line giving an area coverage of 36m long for the first floor, while for the 2nd floor a 32m long area was obtained (due to signal attenuation suffered when passing through the ceiling of the first floor).

VIII. CONCLUSION

Based on our test and results we can conclude, that working parameter for system are acceptable (indoor locations), by using few computational resources and a location calculation acceptable considering that in application is focused on mobile devices. It's possible to improve the calculation times for location if mobile devices manufacturers would change the BT implementation in hardware/software by implementing multiple connections in parallel. This paper proposes three objectives were identified that First, the device must be capable of determining its location in the building. Second, it must be capable of determining the optimal route to a destination. Third, an intuitive user interface must provide the user with access to these features .Determine an optimal path to the user's destination, the rooms of building User interface provides user with the ability to determine their location. Development of these techniques made possible an innovative approach to the challenge of indoor positioning and navigation i.e. less difficult to implement and is compatible with existing handheld device.

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