Ubiquitous indoor wireless geo-location system

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Abstract—Positioning systems are an established need in the current world. The ability to identify the position of a given object in a given context is a common service in our fast-paced, online and always-connect global community. For normal day-to-day usage outdoor systems have a matured and integrated usage, from destination guidance to social media applications status updates, all can use the current positioning systems to enhance its services. For inside systems the same does not happen, there is a clear gap in the applicability and usage of positioning systems for indoor locations.

This aims to address that gap, that opportunity and discusses an ubiquitous Indoor Positioning systems (IPS) solution by studying the technologies, systems, techniques and algorithms used for in current locations systems. It proposes and implements a platform for indoor positioning that locates clients using a mix of techniques which is called Nearest Neighbours and Trilateration with pre-mapped points (NNTP) in order to offer the easiest implementation and extensibility in new environments and offers a strongly orientated for services platform .

Index Terms—geolocation; wireless; positioning; ubiquity; indoor location

1 Introduction

'**Geolocation**: *The process or technique of identifying the geographical location of a person or device by means of digital information*.

Positioning systems are an established need in the current world. The ability to identify the position of a given object in a given context is a requirement for our fast-paced, online and always-connect global community.

Indoor Positioning systems (IPS) for normal day-to-day usage still need maturing, targeting objects position inside a building is still fallible mainly because of the lack of Line-of-Sight (LOS) and also because the current widely spread wireless technologies do not strive for indoor location. In contrast, Outdoor Positioning Systems (OPS) exist with a well matured technology platforms and techniques such as Global Positioning System (GPS), and their current evolution is towards the enhancement of the positioning process itself, with the help of hybrid techniques or systems since its usage is well integrated in our lifes.

This article discusses the thesis made on an ubiquitous IPS solution by studying the current locations systems. It proposes and implements a platform for indoor positioning, locates clients using a mix of algorithms namely Nearest Neighbours and Trilateration with pre-mapped points (NNTP) in order to offer the easiest implementation and extensibility in new environments. Technological-wise the platform is strongly orientated for servicing in a ubiquitous fashion by having a great modularity emphasis and ease of requirements from the communications and interventionists(users, systems, infrastructures) view point.

Reinforcing the need for a solution of this kind, during this thesis development Google announced it was working on Google Indoor Maps, having it launched earlier this year.

2 State of the Art

The state of art is divided in three parts; the first, presents an overview of the major Geo-Location Systems types such as GPS or Cellular-Based Location, the second part focuses on the techniques for radio based positioning location, and the last part discusses the key algorithms used in location processment.

2.1 Global Positioning System Technology

GPS satellites transmit two radio signals. These are designated as L1 and L2. The signals travel by line of sight, meaning they will pass through clouds, glass, plastic, etc, but will not travel through solid objects such as buildings and mountains. The GPS signal contains three different bits of information: a pseudo random code that identifies which satellite is transmitting information; an almanac data that describes the orbital courses of the satellites; and ephemeris data that tells the GPS receiver where each GPS satellite should be at any time throughout the day. Using these informations a GPS device pinpoints its own location in reference with the above satellites.

Given the requirements, the GPS offers little in the strict technological sense since the usage is limited to an outdoor with Line-of-Sight (LOS) area. Even taking this fact into account, it is a good example of a Geo-Location Systems (GLS), mainly because of it is reliability; thought most mobile devices have special GPS components, its ubiquity makes GPS a standard in almost all mobile platforms nowadays.

2.2 Ultra-Sound Systems

Either indoor or outdoor, the system works by having one or several emitters and one or several receivers which relates to cost/effectiveness in deployment. Ultra-Sound (US) is known to be better than InfraRed (IR) in cost/efficiency, resistance to interference and scalability, although IR have better accuracy (several millimetres against several centimetres)[1], the applicability of US technology is considerably larger in the GLS field. Active Bats[2] developed by AT&T Cambridge and Crickets[3] by MIT Laboratories switch these stances to locate an object, being the second more accurate and scalable [4]. While both must relie on these roles, the Distributed Object Locating System for Physical space Inter networking (DOLPHIN)[5] targets a more ubiquitous system using distributed positioning algorithm on each nodes, making each element an emitter and a receiver at the same time.

Ultra-Sound (US) systems offer a great accuracy in a large indoor space; but as commonly seen, this is a specific technology which is not usual nor used in typical infrastructures. This requires a great consideration in the cost of implementing it into existing platforms.

2.3 Ultra-WideBand

Multi-path distortion of radio signals or even full reflection by walls in indoor environments is an inherent problem in Radio-Frequence (RF) systems, a problem which UltraWideBand (UWB)[6] solves, to some extent. By having pulses of a short duration (less than 1 ns) UWB GLS makes it possible to filter the reflected signals from the original signal, which naturally offers greater accuracy. The modulation is done in small bursts and spread in the band, this offers greater chance for the signal to pass different types of objects without interference. This technology is enhanced by taking advantage of both the Time Difference Of Arrival (TDoA) and Angle of Arrival (AoA) techniques, providing a flexible capability of location sensing. Since it measures signal angles and difference in arrival times, complex indoor environments including walls and doors do not significantly influence the performance[6] .

Ubisense[7] is one implementation of a GLS using UWB. The Ubisense system consists of three parts: The sensors, which are fixed in the known locations, receive the UWB signals from the tracked tags. Then the location data of the tags is forwarded from these sensors via existing Ethernet to the Ubisense software platform, which analyses and displays the location of the tags.

Although strategized to be implemented in PC peripherals and mobile devices due to it is low power emissions and advantages in indoor environments; the slow progress in UWB standards development; the cost of initial implementation; it presents several reasons for the limited use of UWB in consumer products (which caused several UWB vendors to cease operations in 2008 and 2009)[8], raising the implementation cost for a GLS with this technology.

Given that the current state-of-art is not mature, nor deployed enough to build an easily deployable and usable Indoor Positioning systems (IPS) around it, these systems will not be considered as a viable solution.

2.4 Cellular Network

In a cellular radio system, a land area to be supplied with radio service is divided into regular shaped cells; using the transmission power as a delimiter, it enables for a mobile device to change the cell in use. Each of these cells is assigned multiple frequencies which have corresponding radio base stations.

Being one of the most in-use technology on this study, and having many GLS that use this technology with different techniques, it is important to enumerate the main techniques to achieve geo-location, such as: The Cell Identification (Cell-ID) or Cell Of Origin (COO) method which relies on the mobile cellular networks identification of the the approximate position of a mobile handset by knowing which cell site the device is using at a given time[9]; Smart-antenna-based location systems use the Angle Of Arrival (AOA) as the measurement parameter and the position of an mobile station is calculated from the intersection of a minimum of two lines of bearing using smart antennas techniques.[10]; Similar to A-GPS, this system uses the radios signals, such as 802.11 Wireless Beacons, Cell-ID, and corresponding multipathed signals around the MS, computes a position and stores it in a database for future assist in the geo-location of the device.

Although this technology represent a good GLS considering the reliability, deployment and ubiquity aspects, there is a major problem which is the difficulty to track a position for indoor. This difficulty is due to the need of several base stations overlapping same area with low signal interference, and because of the cost of each base station, this is not a good technology taking into account the proposed requirements.

2.5 Radio-Frequency Identification

An Radio-Frequency IDentification (RFID) system has several basic components, including a number of RFID readers, RFID tags, and the communication between them. The RFID reader is able to read the data emitted from RFID tags. RFID readers and tags use a defined RF and protocol to transmit and receive data. RFID tags are categorized as either: passive which operate without a battery and are mainly used to replace the traditional bar code technology by reflecting the RF signal transmitted to them from a reader and add information by modulating the reflected signal[9]; and active which can actively transmit their ID (or other additional data) in reply to an interrogation with the advantages of having smaller antennae[9] and longer range .

SpotON[11] is a well-known GLS uses an aggregation algorithm for 3-D location sensing based on radio signal strength analysis. Objects are located by homogeneous sensor nodes without central control, i.e., Ad Hoc manner. Another well-known GLS is called LANDMARC (indoor location sensing using active RFID)[12]. In order to increase accuracy without placing more readers, the system employs the idea of having extra fixed location reference tags to help location calibration.

Wireless and non-line-of-site characteristics are the advantages of this technology. They can work in high speeds; their RF tags can be read in any environment and are also very cost effective. On the down side, the typical reading range is 12 meters in passive RFID tags and up to tens of meters in active RFID tags combining the cost of the readers which is relatively high [9] and the technology is not found on most mobile devices. There are few home/business standard technologies that aggregate RFID in its standarts, narrowing down its availability in which to deploy an GLS.

2.6 Wireless LAN (IEEE 802.11)

One of the worldwide most deployed technology for wireless access [13], Wireless Local Area Network (WLAN) was obviously not designed and deployed for the purpose of positioning. However, measurements from the Signal Strength (SS) of the signal transmitted by either Access Point (AP) or station, can result in the location of a mobile user [14], with knowledge of the coordinates of the WLAN APs, the method of trilateration/multilateration can then be used to compute the position of the mobile user. The other category of WLAN positioning is known as location fingerprinting. Both explained further ahead in greater detail.

RADAR[14] is a system for position location using WLAN that records and processes the signal strength information received from base stations. It uses signal propagation modelling to estimate the object location. Signal strength information collected at multiple receiver locations are triangulated to find the user coordinates. Using a different approach the COMPASS[1] system requires a pre-mapped location-space and uses fingerprinting location technique with a probabilistic positioning algorithm to determine the location of a user.

This technology gathers two key features for an indoor GLS: it is widely deployed, a standard in every home/business infrastructure; and the platforms that support it (for the most cases AP and mobile devices) are mature enough to offer high customizability. It also has two main disadvantages: it is very sensible to bodys of water or metallic surfaces which distort or stop the signal propagation and the power measurement in standard devices is a non normed 8-bit level flag[9].

2.7 Bluetooth (IEEE 802.15)

Ratified in IEEE 802.15 standard, Bluetooth (BT) is a specification for Wireless Personal Area Network (WPAN). Bluetooth enables a range of 100 m (Bluetooth 2.0 Standards) in Class 1, but typically used in Class 2 (10 meter) or Class 3 (1 meter) communications on mobile devices[1]. Piconets are formed under Bluetooth specifications by using a master/slave based MAC protocol. Bluetooth technology has been embedded in various types of mobile and stationary devices.

As a GLS in Bluetooth-based positioning systems [15],[1],[16], various Bluetooth clusters are formed as infrastructures for positioning. The position of a Bluetooth mobile device is located by the effort of other mobile terminals in the same cluster. One of the implementations of a GLS with BT is the Topaz local positioning solution. This modular positioning solution is made up of three types of elements: positioning server(s), wireless access points, and wireless tags. This system provides room-wise accuracy (2-m spatial accuracy), with positioning delay of 15 to 30 s[1].

Having good properties for an indoor GLS, this technology has a high latency, and its reliant of density of tags in an area to position a device increasing the costs for an IPS system. Since the range of the signal is in the 10-15m range[9], the coverage of an entire building will require a high amount of tags and subsequently will increase the cost of the solution.

2.8 State of the art: Conclusion

Several technologies can be eliminated such as GPS and Cellular Network (CN) given their need of LOS, US, and UWB, could be promising, however the low usage, and high cost are not suitable. In RFID and BT, the infrastructural need for the first, and the density of devices needed by the second, make these systems less suitable as well. Resulting in WLAN the most suited technology, given its high availability, low cost, and a considerable accuracy for an IPS.

3 Proposed Solution

The proposed solution is an agnostic view of the implementation. The proposed core feature for this solution is the position determination, where the assessment of the requesters position is made; the ubiquity, implementability and extensibility are important proposed features in the platform-side defining the degree of possible usage of the proposed solution. The position visualization is also an important feature for the human interaction with the proposed solution as well as the guidance where an additional service is offered. The requirements for this proposed solution are two making a high trade-off valued solution, the pre-mapping survey that will render the basic positioning nodes on which the platform will render its calculations and positioning; and the wireless communication that will allow for the requester to communicate with the platform and vice-versa.

3.1 Proposed Platform

The architecture of the proposed platform relies in the layering, modules and interoperability between them. The proposed architecture in the higher level is a client-server service. Where the client should communicate with a single service and be able to execute the desired operations. The modular approach into this platform, as seen in figure 1, enables for a better understanding, extensibility in the future and provides a clear differentiation in project-wise operations.

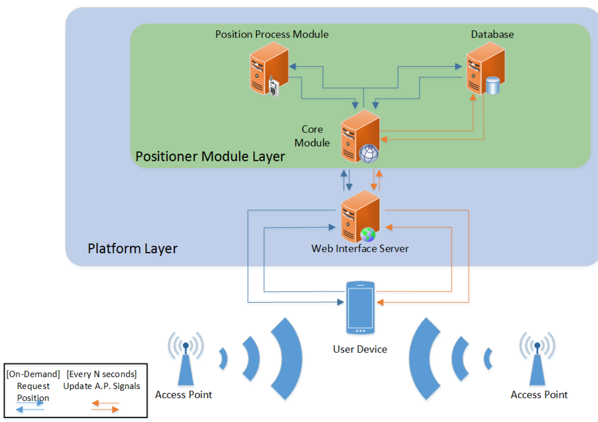

Figure 1. The main layers of the proposed solution, the main access platform layer and the location process layer.

Web Interface Server This is the main module responsible for receiving and responding to clients requests and providing interaction.
Core Module The main module in the positioner layer, this module is responsible for managing the operations related with positioning.
Position Process Module An individual module that upon request renders the computation process of calculating the position, in order to respond to the key-feature of position determination.
Database A module to access the storage of the relevant information.

3.2 Platform Key-Processes

The proposed platform key-processes architecture are the high level component overview of the interactions between the modules that render the required features to operate successfully within the determined requirements. There are two main processes necessary for the proposed solution to function, the update of access point signals that work as the input of information by the client concerning its surroundings (which can work as a pre-mapping tool); and the request of position that triggers the location process and returns the clients position .

3.3 Proposed Location Processing

The location processing algorithm is the process in the proposed platform responsible for processing the final positioning of the requester and for processing the guidance information that the requester should receive.

3.3.1 Nearest Neighbours and Trilateration with pre-mapped points

The proposed location process is the combination of Nearest Neighbours and Trilateration algorithms in order to maximize the flexibility in the process while reducing the requirements. By combining both location processes, the resulting algorithm requires a survey, but not a full extent grid-survey and can use the trilateration euclidean(or any sub-variation) calculation for achieving a finer granularity to the possible calculated positions.

The proposed visualisation for this approach is seen in figure 2. Where the AP are in an unknown physical location, and a hollow grid with the surveyed points is constructed.

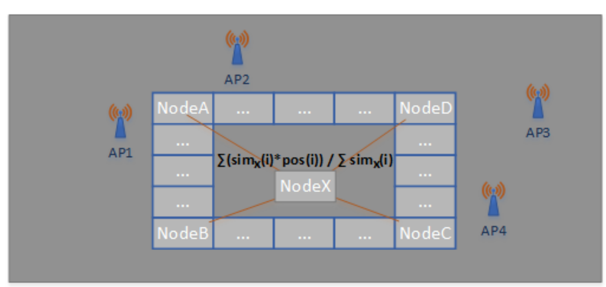

Figure 2. The proposed location algorithm with the pre-mapped positions (each Node A-D) rendering the position of Node X through the formula

To render the location with the node information the equation 1 is used. Using the pre-mapped nodes locations and pondering them with the similiarity to the unknown Node X its position can be calculated.

$$pos(NodeX) = \frac{\sum_{i=NodeA}^{NodeD}(sim_X(i) * pos(i))}{\sum_{i=NodeA}^{NodeD}(sim_X(i)} \quad (1)$$

The proposed algorithm requires a pre-mapping of the area which renders into a position/access-point-power database. Afterwords, when a positioning is requested, the requester must send its scan of the surrounding signals; this allows to compare the scanned signals with the database, through similarity and the euclidean distance it renders the requested position.

One of the key variables of this proposed location process is the distance between the pre-mapped nodes. Which should depend on the implementation, specifically on the area where the project is implemented.

3.3.2 Location Guidance

The Location Guidance is a proposed location process that guides the requester from its current calculated position to the location target which was required. The process works by having the location of and the information on where to guide the requester, by having the geo-magnetic orientation of the device, it allows to calculate the angle to which the device should turn in order to face the desired location. In figure 3 it is explained how the angle works and in 2 the theoretical equations for this calculations are shown.

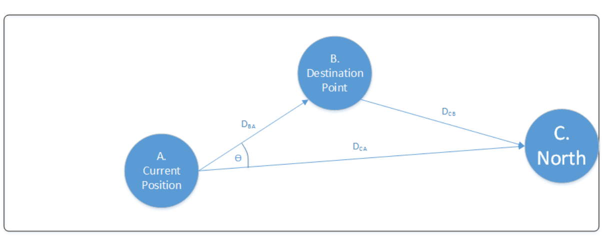

Figure 3. The angles used for finding the rotation angle on which the requester should turn in order to be facing straight at the desired location.

The above figure displays the three important positions to calculate the angle which the device should turn in order to face the desired destination point. Point A is the calculated current position of the requester, Point B where the requester desires to be guided and Point C is the North point, which is a point where the requesters device holds its geo-magnetic variance .

By having a steady information of the variation to the North point, and knowing the position of the three points, the equation 2 can be used to calculate which is the angle that the proposed platform module for requester visualization should rotate in order to offer guidance.

$$D_{BA} = \sqrt{(A_x - B_x)^2 + (A_y - B_y)^2}$$
$$D_{CA} = \sqrt{(A_x - C_x)^2 + (A_y - C_y)^2}$$
$$D_{CB} = \sqrt{(B_x - C_x)^2 + (B_y - C_y)^2}$$

$$\theta = \arccos \frac{BA * BA + CB * CB - CA * CA}{2 * BA * CB} \quad (2)$$

By knowing all the positions, calculating their distances (D_{BA}, D_{CA},D_{CB}) and applying the rotation angle (θ) to the North orientation of the requesters device will it point directly to the requested guidance point.

3.4 Proposed Solution: Conclusion

The required for this proposed solution are: the determination and visualization of position location, the guidance service and in terms of platform the ease of deployment, extensibility and ubiquity. These requirements should be rendered by specific modules and across the proposed platform in a clear and concise manner .

The proposed solution is a modular platform, which has two key-process: it should calculate the position of the requester through the proposed algorithm NNTP and it should use the discussed location guidance to offer orientation from the requesters position until he reaches its desired location.

The modular approach for this proposed solution should render four core modules that are responsible for calculations of position, communications, retrieval of informations and interactions. This implementation will allow for a platform that can be easily extensible and greatly ubiquitous.

4 Implemented Solution

The implementation section explains the implementation made of the proposed solution previously discussed.

4.1 Enviroment Analysis

Three iterations in the instruments used for this implementation took place: the first tool Wlanlist allowed to notice the slow scan rate (because of hardware) and it was difficult to properly arrange the information of the scanned area, the second was the IndoorPositionr API that visually rendered better information and with a higher rate of scan was used as a basis for the final implemented API but lacked the mobility and ubiquity, the third tool was the implemented IndoorPositionr platform that was the agglomeration of the previous IndoorPositionr API into a ubiquitous, cloud-based service platform.

These tools allowed to characterize the Instituto Superior Tecnico - Taguspark (IST-TP) main and southern lobby in terms of 802.11 signals and provide the minimal optimal distance of five meters between surveyed nodes for the pre-mapping process.

4.2 IndoorPositionr Platform

The IndoorPositionr platform is the functional implementation of a platform that offers the position determination, visualization and location guidance features in a ubiquitous and extensible environment while respecting the necessary requirements .

In the IndoorPositionr after surveying the area (using the platform tools), it is ready to locate a client, update its location and guide him to one of the pre-designed locations. The implemented platform has a ubiquitous, extensible and easily deployable architecture divided into the three main modules that communicate through the Web API modules, the IndoorPositionr that render the key-features of the platform, the Client Browser that enable the interaction of the client with the platform and the Client IndoorPositionr that allow for the background signalling update from client to the platform.

This high-level view as seen in figure 4 is compartmentalized in modules that function to serve a individual purpose, and in types of communication that give a better understanding on which level those modules communicate and why.

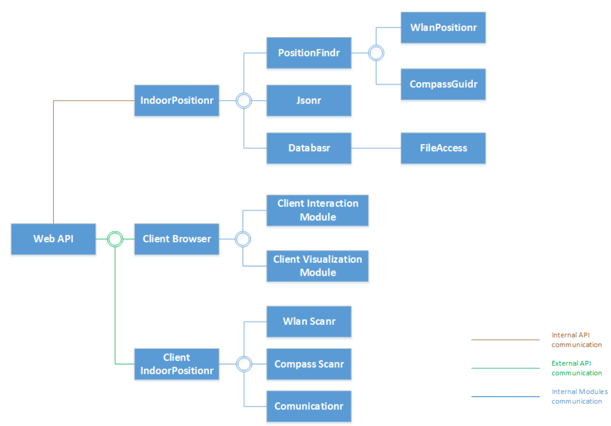

Figure 4. The architecture of the IndoorPositionr Platform with the communication types between modules.

The Internal API communication (in red) represents the communication between the Web API and the IndoorPositionr core module that works as a separate instantiation-calling of the last. The External API communication use normal HTTP requests with the JavaScript Object Notation (JSON) formation. The Internal Modules communication use normal calls and responses for each technology environment.

Both of the External and the Internal communication carry the identification of the user, the platform supports multiple users at the same time, and once the identification is provided the orchestrator modules function accordantly.

For this implementation it were used five main technologies, Python 2.7, Java for Android, Javascript and HTML+CSS. The Web API, IndoorPositionr and IndoorPositionr child modules were developed in Python with the nuance of using the Flask framework for the HTTP service in the Web API. The Client IndoorPositionr was developed in Java for Android. And all the visualization and interaction in the Client Browser is through the Javascript components in a HTML+CSS rendering.

4.3 Key Processes

There are two main processes necessary for the proposed solution to function, the update of access point signals that work as the input of information by the client concerning its surroundings; and the request of position that triggers the location process and returns the clients location information.

4.3.1 Update Access Point Signals

The update of access point signals key-process is the implementation of the earlier proposed process that continually receives the 802.11 broadcasted signals which the client receives in the mobile device. By running a background application in the mobile device named Client IndoorPositionr, the application scans with the cadence of one second, the broadcasted signals, and the geo-magnetic orientation of the device. After the compilation of information, it render an external request to the Web API supplying the client identification and the retrieved information.

4.3.2 Request Position

The request position key-process is the implementation of the earlier proposed process that upon triggered requests the position of the client regarding its last information in the system and renders it in a user-friendly view of the clients location. The request can be made in a one-time or using active/non-active stance, this allows for a one time position request or a continuous position display. By default the requests in the continuous location have the minimum wait time of one second, which is the maximum time for the Client IndoorPositionr app to scan the surrounding signals. The two main interviewees in this process are the Client Browser module that requests the position and displays the location; and the IndoorPositionr that recevies the request and returns the calculated position based on its current and previous information.

4.4 Location Process Algorithms

The locations process algorithms are the core processes that render the both services of location positioning and location guidance. The first uses the proposed method of Nearest Neighbours and Trilateration with pre-mapped points (NNTP) with a previous surveyed data to calculate the position of the client, the second uses this calculated position and with the information of the clients geo-magnetic orientation offers guidance to the desired location.

4.4.1 Nearest Neighbours and Trilateration with pre-mapped points

In the implemented IndoorPositionr platform the PositionFindr is the module responsible for executing this algorithm. Fed with the pre-mapping points/signals, with the current client signals and (if available) its previous location, the PositionFindr renders the below described algorithm into the position latter visualized as a location by the Client Visualization module.

For the NNTP to work, a previous survey of the area must be made as show in figure 5 were its depicted the points used in this implementation which are used as the basic location information. Once this survey is available, the platform is ready to receive the clients information and combine it with the previous location (if available) to render the clients position.

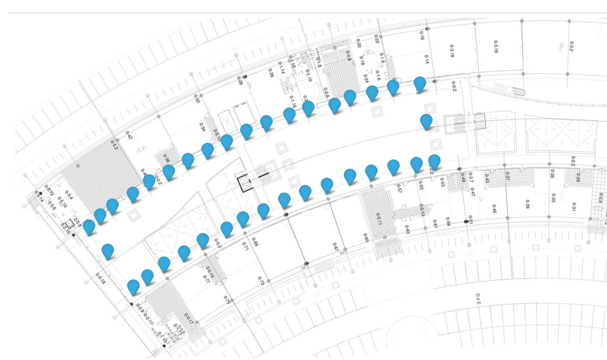

Figure 5. The location of the pre-mapped points in IST-Taguspark.

As discussed in the Results sections, in order to calculate the position of a sample scan of signals not all nodes can be used, in the tests done this rendered a always-centred point because of all the contributions. The options was to use the top-N most similar points, which by evaluation lead to use the 5 more similar nodes for the given sample.

4.4.2 Location Guide Compass

In terms of implementation, the request guidance process is an activate/deactivate process started by the Client Interaction Module that follows the same module flow as the key-process Request position. The difference is that on the payload of the request the desired destination is added and in such, the response is changed to arbour the angle on which the compass displayed by the Client Visualization module should rotate.

4.5 Implemented Solution: Conclusion

The IndoorPositionr platform was build using the knowledge of the previous iterations and with a ubiquitous, easily deployable and extensible orientations, this rendered a platform highly modularized, with four core modules: The IndoorPositionr API where the positioning actions are calculated, the Web API responsible for the ubiquity in access and communication to the platform, the Client IndoorPositionr, a service which continually informs the platform of required data such as 802.11 signals or geomagnetic information and the Client Browser, where the crucial visualization and interaction for the client takes place.

The implemented platform has two key-processes, the Update Access Point Signals on which the client informs the platform broadcasted signals he scans, and the Request Position where the client request the location from the platform. The platform uses the two implemented location process, the NNTP for rendering the location of the client and the Location Guide Compass for orienting what is the direction for the desired destination, to render its featured offered services.

5 Evaluation

The location accuracy for the tested path had an outcome of a median 7.05 meters which was a good value for positioning in a room-wise scale. This evaluation also allowed to test for the best number of nodes for the NNTP algorithm rendering a usage of 5 nodes in the positioning calculations. The compass guide worked as expected, although some misuse can provide some problems. The tilting is very difficult to adjust/compensate but the landscape mode should not be very difficult to accommodate. The solution evaluation provided for a positive evaluation of the implemented solution because of its ease of deployment, low cost and high features ratio and a non probabilist algorithm that always renders the same position.

In the overall the implemented solution is a good, stable, low-demanding and with high features and extensibility platform.

6 Conclusion

As this stated, there is a lack of indoor positioning systems, this is proven by the recent launch of Google Map Indoors. Due to the lack of line-of-sight a IPS platform must used several techniques and adjustments to achieve the best results, and because of the cost of implementing new systems for each indoor location a good choice is to adapt commonly used wireless systems to track indoor locations.

The proposed solution rendered a solid, extensible and usable platform that had room to innovate by creating the NNTP algorithm in order to bring down the cost of implementation in different locations while offering promising precision.

The implemented solution is a complex tool yet offers simple usage, and allows for an easy usage and can also be easily used for building-wide indoor location. The achieved results are not as good as thought, but for a indoor locations service offer the enough precision to guide a person inside a building. This platform can easily be a basis for a big project, due to its scalability and allow services based on the user location for indoors.

In the overall this was a scientifical learning experience which the outcome was what it set out to be, a functional system that offers location for users inside a building.

GLS Geo-Location Systems
GPS Global Positioning System
US Ultra-Sound
TDoA Time Difference Of Arrival
AoA Angle of Arrival
IR InfraRed
UWB UltraWide-Band
RF Radio-Frequence
WLAN Wireless Local Area Network
DOLPHIN Distributed Object Locating System for Physical space Inter networking
CN Cellular Network
RFID Radio-Frequency IDentification
WLAN Wireless Local Area Network
SS Signal Strength
AP Access Point
BT Bluetooth
WPAN Wireless Personal Area Network
IPS Indoor Positioning systems
LOS Line-of-Sight
OPS Outdoor Positioning Systems
IST-TP Instituto Superior Tecnico - Taguspark

JSON JavaScript Object Notation
NNTP Nearest Neighbours and Trilateration with pre-mapped points

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