Model Driven Dynamic Resources Finder (*MDD_RF*) The University of Novi Sad Campus Case Study

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Abstract— **Wireless indoor/outdoor positioning systems have become very popular in recent years. These systems have been successfully used in many applications such as asset tracking and inventory management. The essential component of such systems is a resource repository that has to be dynamically rendered on demand. The other challenging path is the design and implementation an active service framework that supports service requests. In this paper The Model Driven Dynamic Resource Finder (MDD_RF) as a generic solution for dynamic finding of arbitrary resources is presented. The prototype is verified on developed service framework skeleton based on The University of Novi Sad Campus as a case study.**

Key words: Patfinding; General Positioning; Model Driven Development, Dynamic Resource Finder, Wireless Sensor Networks

I. THE PROBLEM OF NAVIGATING THROUGHT BUILDINGS

Navigation is the ability to plan and follow routes between locations, often with an internal or external map of the environment. Navigation is complex because it relies on mechanisms from several brain subsystems, including perception, movement, and memory. [12]

Although we can say that the today's' world is mapped, this is fare for being trough when buildings are concerned. Studies have found that people spend 80-90% of their time indoors. So it's no surprise that one of the most promising technologies for buildings is Indoor Positioning Systems (IPS). An IPS simply locates resources (objects and people) in a building and provides location dependent information.[6]

On the other hand, public organizations, like museums, stadiums as well as town halls, are always looking for ways to represent their assets online in a most attractive and interesting way. The available methods are videos, pictures or panoramic images streamed via the Internet. In those cases, a user can see the assets only from predefined points of view. This limits a full user-involvement, prevents from getting a comprehensive knowledge of the assets (pictures and sculptures) and, as a result, makes such online demos less appealing and informative for the public organizations.[7]

In 2010, around 45% of hotel bookings were made via the Internet (and this share is growing) [1], thus the quality of online presentation of hotels and real-estates is of critical importance for such companies.

As technologies become easier to use and more cost effective their use can become almost ubiquitous. The use of Global Navigation Satellite Systems (GNSS) for deriving position, navigation and timing (PNT) data is such a case. The Global Positioning System (GPS) is currently the most widely used and best known example of GNSS.[13]

When we want to navigate thought building a problem arises simply because in building GPS and maps do not work the same way. Since the buildings in modern times are getting bigger and more elaborate it is becoming ever more difficult to navigate them.

The idea of locating objects and people in buildings is not new. Back in the 1990s Real Time Locating Systems (RTLS) entered the market. These systems allowed hospitals to track equipment such as wheelchairs and gurneys, warehouses to track merchandise, etc. These systems initially used active RFID tags on objects and eventually used active RFID tags in employee or visitor badges to track people. IT companies also started providing RTLS via Wi-Fi systems in the building. Initially the density of Wi-Fi access points in buildings had to be significantly increased to allow the system to "triangulate" the object or person and the Wi-Fi "tags" on objects were fairly bulky. [6]

An IPS is really just a data acquisition system, obtaining information as to where people or objects are within the building and primarily providing data to occupants to assist in way finding. It has much more potential, such as providing valuable information to businesses and building owners, and at the same time presenting some legitimate concerns.

A. *IPS Technology*

Whereas GPS depends on satellites IPS is based on "reference anchors", essentially network nodes with a known position in the building. At least three nodes are needed to triangulate and locate a "target" with the aid of a software application to calculate location.

There are a number of technology approaches that have the potential for being the basis of indoor positioning: radio frequencies, acoustic, optical, electromagnetic radiation, etc. These methods measure the signal strength or power levels of

the radio waves or signals to calculate distance from the anchor to the object. One approach to the architecture of the IPS is "Bluetooth Beaconing". Bluetooth was created in 1994 to essentially replace short cables. Today every Smartphone is Bluetooth enabled and we're all familiar with using Bluetooth to connect ear buds, headsets, printers, game consoles, keyboards, etc. It is the Bluetooth capabilities of Smartphones together with the Bluetooth beacons that can provide the location of the Smartphone users.

Figure 1. shows some of the devices that can be used for positioning inside a building.

Figure 1. Representing some of a device that can be used for positioning a person inside of a building.

In 2010 Nokia introduced an indoor positioning system based on Bluetooth Low Energy (BLE) technology (basically the latest Bluetooth technology operating on low power with low latency in communications). The density of the Bluetooth beacons is roughly the same as a typical Wi-Fi deployment, with accuracy around 0.3 meters (1 foot), with no latency. (http://research.nokia.com/news/9505).

B. Companies in the IPS Space

Recently twenty-two international companies formed the In-Location Alliance to standardize and commercialize the technology. The alliance includes large multi-national companies such as Nokia, Samsung, Qualcomm and Sony. The list also contains Broadcom, Dialog Semiconductor, Eptisa, Geomobile, Genasys, Indra, Insiteo, Nomadic Solutions, Nordic Semiconductor, Nordic Technology Group, NowOn, Primax Electronics, RapidBlue Solutions, Seolane Innovation, TamperSeal AB, Team Action Zone and Visioglobe.

Some tech giants, such as Google, are pursuing and developing the technology but are not part of the alliance. Apple has hinted and is expected to be a major player in indoor positioning with their iOS devices as well. [6]

Some of the companies involved in IPS are high tech companies motivated to extend their existing outdoor mapping applications to the indoor environment where GPS doesn't work well due to signal attenuation. In addition to extending their mapping applications and advertising revenue the companies have an opportunity to create a treasure trove of data that would assist businesses, primarily retail, in identifying customers and product placement.

The IPS technology could be used for almost any size building, but appears to be particularly well-fitted for large commercial buildings, educational campuses, malls, airports and guided tours of museums.

Google launched their Indoor Maps and Indoor Location in late 2011. They already have over 10,000 floor plans for a variety of buildings in North America, Europe and Japan and claim 5-10 m accuracy indoors inside buildings. (http://maps.google.com/help/maps/indoormaps/). [6]

Walgreens has a partnership with a startup called "aisle411". Any Walgreen shopper using a Smartphone can view maps of any of 8,000 Walgreen stores and locate products down to a section of an aisle. [6]

Zonith has an IPS offering also using Bluetooth beaconing, but it is targeting a different market; it focuses on security, safety, and situational awareness applications. They have an application call "Lone Worker", focusing on large utilities, production plants and commercial buildings which can locate lone workers and keep track of employees for safety purposes. [6]

II. THE SOLUTION FOR NAVIGATING PERSONS THROUGHT BUILDINGS

An indoor positioning system (IPS) is a network of devices used to wirelessly locate objects or people inside a building. Generally the products offered under this term do not comply with the International standard ISO/IEC 24730 on real-time locating systems (RTLS). There is currently no de facto standard for an IPS systems design, so deployment has been slow. Nevertheless, there are several commercial systems on the market. Instead of using satellites, an IPS relies on nearby anchors (nodes with a known position), which either actively locate tags or provide environmental context for devices to sense. The localized nature of an IPS has resulted in design fragmentation, with systems making use of various optical, radio, or even acoustic technologies.

The visual information in an environment that is useful for navigation can be categorized as two types: geometric (visual information conveying layout geometry such as hallways and intersections), and non-geometric (features other than geometry such as lighting, texture, and object landmarks). [12] Successful navigation requires the seamless integration of several brain subsystems, including perception, movement, and memory, thus making it a challenging topic of study.

To provide users with their position inside of a building and provide them with maps are two different problems:

- how to position and track people inside of the building;
- how to utilize pre existing maps of resources that have to be reached;

A. *Positioning people inside of a building*

The best way of positioning a person inside of a building in through Wi-Fi nodes. A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may, but need not, connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. (Figure 2.)

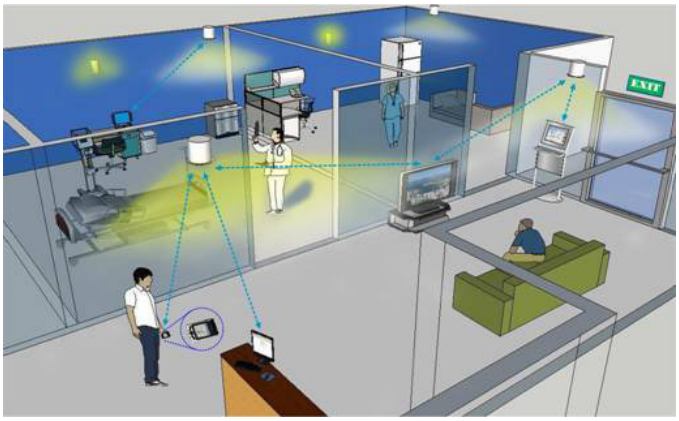

Figure 2. Illustration of indoor positioning system.

B. *How to utilize pre existing maps*

The best way of utilizing maps is to draw them from blueprints of buildings ad existing tureen. By doing this the results are detailed 3D building models width doors windows hallways. It is best to keep the drawing simplified so the user can concentrate on positioning himself easily inside of a building.

C. *Multilevel environments*

The finding that vertical space is encoded differently in the brain also serves to counter an occasional but reoccurring criticism of space syntax methods, namely that such methods are essentially two-dimensional and are therefore unable to sufficiently address the third dimension in buildings. The response has typically been that humans navigate in two dimensions rather than three.

What had remained an open question for some time after the discovery of grid cells was how they 'stacked up', i.e. what would be the effect of vertical movement? This finding aligns particularly neatly with recent work by Hölscher **[9]** on the navigation of complex, multistory buildings, where he discovered that subjects tend to assume that different floors, stacked vertically, will more or less resemble each other, and when a building is encountered that radically departs from this model then subjects can become rapidly disorientated. (Figure 3.)

Fig. 3 Stacked, diagrammatic floor plan used by Hölscher. for their study of multi-level way finding. [9]

D. *General sollution topisc of MDD_RF 3D map Data Base construction*

The Model Driven Dynamic Resource Finder (*MDD_RF*) is a service that orchestrates these two aspects of IPS. It relies on WMN as a orientation anchors that are fired in order to help tracking inside the building and active route holder extracted from 3D map Data Base containing the resources as active objects with augmented set of attributes (meta data). The most challenging aspect of the MDD_RF platform is the creation of 3D map Data Base that helps creating the pool of augmented active resources (AAR).

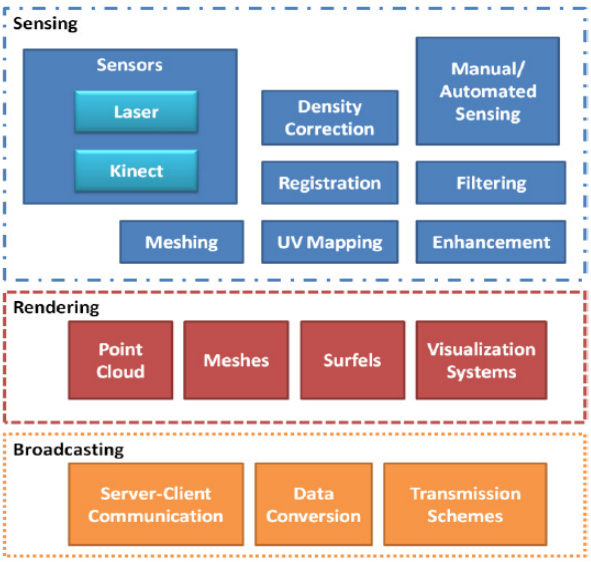

Figure 3. Three main topics related to 3D reconstruction [7]

The general solution, upon which Model Driven Dynamic Resource Finder (*MDD_RF*) is based, has its foundation in 3D reconstruction paradigm. [7] Figure 3. shows the tree main topics that 3D reconstruction is based on.

The Sensing block is comprised of all the techniques involved in acquiring suitable and high-quality information from the world. The main idea within this block is to exploit the nature of sensors to obtain different types of samples from the environment (e.g. color information, depth information). Thus this block is in charge of extracting suitable information from the world and converting it into high-quality models for visualization.

The Rendering block consists of techniques for 3D models visualization. The main focus of this block is to determine the best way of displaying the 3D model to the user

The Broadcasting block is focused on the mechanisms to transmit the information to the end-user.

Figure 4. represents the architecture model og MDD_RF founding components.

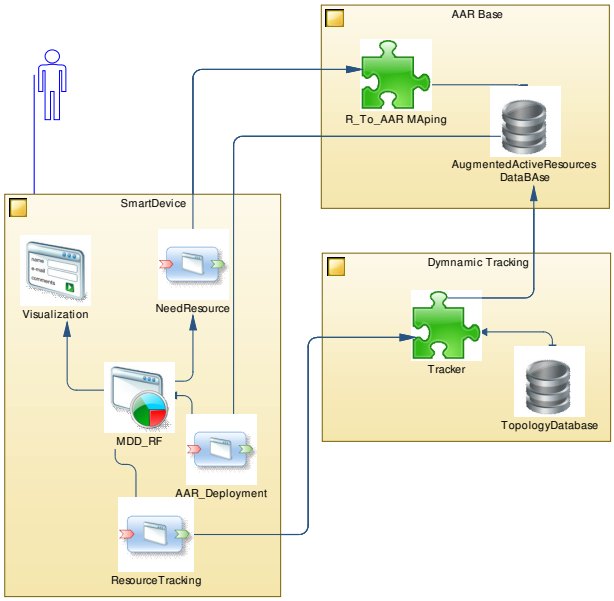

Figure 4. The Architecture of MDD_RF

III. THE MDD_RF CASE STUDY

A. *Locating and positioning*

All known indoor positioning systems (IPS) neither affects nor detects a direction nor offers the option to change the position. Also other various systems titled as e.g. local positioning system and so on do not offer other but detecting an object in a certain known fixed location, report a measured location or just report the presence of the object in such location.

B. *Locating and tracking*

One of the methods to thrive for sufficient operational suitability, is "tracking". Whether a sequence of locations determined form a trajectory from the first to the most actual location. Statistical methods then serve for smoothing the locations determined in a track resembling the physical capabilities of the object to move. This smoothing must be applied, when a target moves and also for a resident target, to compensate erratic measures. Otherwise the single resident location or even the followed trajectory would compose of an irritant sequence of jumps.

C. *Identification and segregation*

In most applications the population of targets is larger than just one. Hence the IPS must serve a proper specific identification for each observed target and must be capable to segregate and separate the targets individually within the group.

An IPS must be able to identify the entities being tracked, despite the "non-interesting" neighbors. Depending on the design, either a sensor network must know from which tag it has received information, or a locating device must be able to identify the targets directly.

Figure 5. shows the Map of University of Novi Sad Campus. The idea is the every student, visitor, professor and employ should have indoor maps and their position on own device Smartphone, tablet on a laptop.

Figure 5. Map of the University of Novi Sad

MDD_RF service first establishes the referent position of the user via TopologyDataBase. After that it prompts for resource of interest, via NeedResource Service. This service is a Façade that enables multilevel resource discovery and selection. After the selection resource (R) is mapped to its corresponding AAR. AAR is transferred to MDD_RF service and fired in order to start track following from dynamic current position to 2D model in Campus and 3D building models in the building where targeted resource is located..

IV. CONCLUSSION AND THE USES OF INDOOR POSITIONING

The major consumer benefit of indoor positioning is the expansion of location-aware mobile computing indoors. As mobile devices become ubiquitous, contextual awareness for applications has become a priority for developers. Most applications currently rely on GPS, however, and function poorly indoors using depersonalized. The use of WMN with Augmented Active Resources Data Base and Model Driven Dynamic Resource Finder mobile service are the promising way in order to build an indoor infrastructure that should support locating, positioning and tracking of arbitrary resources. There are some additional benefits of using such systems.

For example positioning people in side of a building can be used to gather data about movement and number of subjects. By analyzing depersonalized data of subject movement important and useful data can be gathered.

For the university it is important to establish fervently used roots by the students. Having this information it is vital for positioning information desks for students.

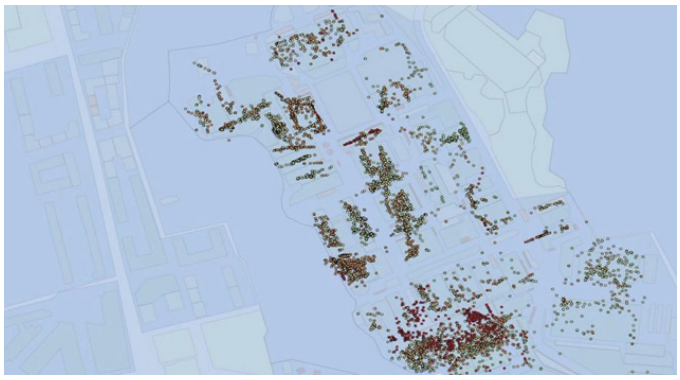

Figure 6. Map of spots representing movement of people at the University of Novi Sad Campus.

Figure 6. represents a Map of people movement at University of Novi Sad Campus established via statistical analysis of operational data.

The other possibility is the monitoring of the availability of classrooms or the information about the actual numbers of students and collecting the information about their positions. (See Figure 7.)

In a case of an emergency, for example a fire, data can be used to quickly locate people inside of a building and safely escort them out of a burning building.

Figure 7. The use of positioning for establishing the number of students in side of a classroom.

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