Indoor and Outdoor Localization Architecture for Pervasive Environment

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Abstract. Location awareness is one of the key aspects for pervasive computing environments. It enables location data to be accessed and used anywhere by any application. Major challenges to design effective localization solutions are pervasive deployment and support for heterogeneous technologies. In our efforts to design an effective localization solution, we present a dynamic and efficient infrastructure independent layered architecture. The architecture is highly distributed, integrates inference engine to provide best location estimation for multiple technologies. Our architecture is efficient and comes across challenges in localization process such as computational power, reusability and components dependency.

Keywords: Hybrid Localization Architecture, Smart Spaces, Pervasive Computing.

1 Introduction

Today pervasive computing became an active research area. Researchers around the globe have presented several models and architectures to make Weiser vision practical [7]. Pervasive computing environments are context-dependent and sensitive to any change in context information. Since location information is considered as one of the important part of the context, therefore it has to be managed so that context integrity can be maintained for supporting location dependant applications. In our attempt to provide a global localization solution for pervasive environments, we present three layered dynamic and efficient Localization System (LocSys) architecture that is infrastructure independent and highly distributed to support multiple applications, frameworks and technologies. The remainder of this paper is organized as follows: in section 2, we summarize the existing localization researches on the domain. In section 3, we introduce our location solution architecture making the emphasis on each layer and component. And we conclude by focusing on advantages and features in our solution with opening to future works in section 4.

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2 Related Work

The recent systems evolution and miniaturization led localization solutions migrate from telecommunication operators [3] to client side. These solutions present good positioning resolution and accuracy using their own beacons, receivers and specifying their own protocols and software [7, 1, 2] suitable in indoor environments. These solutions are one block designed and can't be upgraded or improved. They are sensitive to environment changes, costly, technology dependant and difficult to deploy. To overcome the above mentioned limitations, researchers provides solutions that take advantage of existing data and telecommunication infrastructure such as Wireless Local Area Networks (WLAN), Global System for Mobile communications (GSM). In such solutions, the position calculation is done in the client device [8, 7, 6, 5], not in dedicated servers. These solutions are Operating Systems (OS), wireless interfaces and/or internal components dependent, making them not suitable for heterogeneous components deployment. These solutions have computational power and memory limitations and were designed to perform maximum coverage without taking consideration neither on system complexity and dynamicity nor on internal components dependency.

3 LocSys Architecture

Our research objective is to provide a multi-technological localization solution that meets the requirements of end user applications in pervasive environments. Based on our observations, we took a hybrid approach and design a three layered architecture. This architecture supports already deployed infrastructure (infrared sensors and tactile carpets) in DOMUS laboratory and leverages wireless communication frameworks (Wi-Fi and Bluetooth). All LocSys components are implemented as OSGI services to support any environment change and facilitate their deployment and reusability. Fig. 1 shows Locsys architecture, which is composed of detection layer, decision and refinement layer, and presentation layer.

3.1 Detection Layer

The function of this layer is to collect, adapt and process information extracted from the environment. This layer is further divided in to three sub-layers.

Sensing: The sensing sub-layer contains functionalities to sense the real world and provides information of seen access points (APs) and their respective measured RSSI levels (Spotters). In this sub-layer, three types of technology can be distinguished; i) RF based technologies such as Wi-Fi and Bluetooth, ii) global technologies such as GPS, iii) close field technologies such as Infrared sensors, and tactile carpets that can provide relatively exact location information. Technologies management component is dynamic repository that provides functionalities such as installing, uninstalling, starting, stopping technologies and localization techniques.

Adaptation: The adaptation sub-layer transforms collected information to more useful data. This information is used to feed the trackers to provide location estimation. The adaptation sub-layer provides two major components; i) Distance

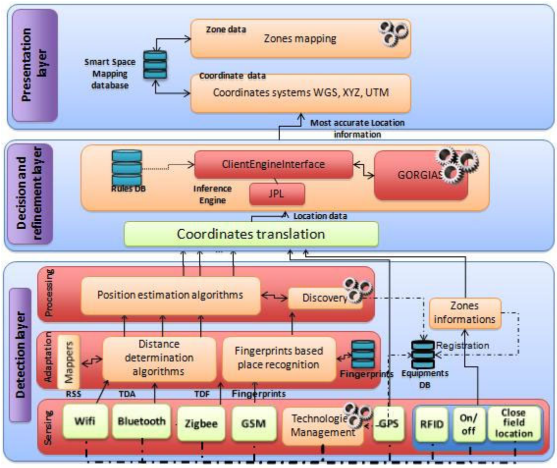

Fig. 1. LocSys architecture

determination algorithms; its function is to transform measurements (RSSI, Time of Arrival (TOA), and Time of Flight (TOF)) to ranging and distances estimation. ii) Fingerprints-based place recognition uses RSSI-based fingerprints to detect places by implementing data fusion and correlation to increase reusability and results pertinence.

Processing: The processing sub-layer contains components transforming adapted data to position estimations and discovery mechanisms providing functionalities to detect new reference points. i) Position estimation algorithms (Trackers), these algorithms are designed to be reusable and shared between different technologies. ii) Discovery module integrates mechanisms and techniques that collaborate with position estimation algorithms component to detect and store newly discovered reference points.

3.2 Decision and Refinement Layer

The main purpose of this layer is to put on equal footing all information recovered from the lower layer in coordinate systems point of view, and to extract the most accurate location information for each particular device; using predefined conditions based on researches on localization algorithms and technologies accuracies. This layer is divided into two major components;

Coordinate translation: Since we integrate different technologies suitable for various environments, we need to put all recovered location information on equal footing. This component prepares location estimation data so that the inference engine can perform the technology-technique combination choice, to support both indoor and outdoor environments and so that transfers between environments can be done in a smoother way.

Inference engine: Considering the system temporal constraint, the amount of data to process and dynamicity, an inference engine is integrated to extract the most accurate position estimation for each device. This task is done using prestored rules specifying algorithms and technologies combination accuracy. This component has an adaptative behavior; if some rules are added or modified, the engine operations will be modified to suit these changes.

3.3 Presentation Layer

For pervasive deployment and to meet application needs, LocSys provides location information with two different granularity levels; first, the coordinate data level provides components location information in different coordinates systems so that applications with interest to particular coordinates systems can be supported. Second, the zones data level provides more abstract location information using two methods; i) Using previously developed ontology [4] and by correlating coordinates-based location information and zones definitions, expressing referential and absolute localization. ii) Using geographic databases and correlating coordinates-based location information with areas geographic definition.

4 Conclusion and Future Work

In this paper, we proposed LocSys architecture for positioning systems to support location dependent applications in pervasive environments. In our design, the localization process is initiated in a collaborative mode between administrators and users to avoid privacy related issues. The distribution and dynamicity will lead to more efficient resources management and facilitate administration tasks. To support our architecture, a framework is under evaluation using real scenarios at Domus apartment. The results will be presented in future papers.

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