Towards a Semantic-aware Location Positioning for Smart-phones

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***Abstract*—Location-aware services and applications have become quite popular in the daily life of mobile users. Global Positioning System (GPS) is available in almost all new smart-phones as a mature and accurate positioning technique. GPS as a satellite-based navigation system, determines the current location of users by receiving signals from satellites. Satellite signals cannot propagate properly inside the buildings, which makes it unusable for indoor positioning. In addition, GPS consumes too much energy to be useful for many applications on mobile phones. There are many proposed alternatives for GPS but they are not as accurate. Combination of those alternatives can improve the accuracy, but varies widely depending on the user behavior and environment. This paper presents a novel architecture for semantic-aware positioning that chooses the best positioning method(s) by exploiting the semantic knowledge.**

I. Introduction

The popularity of using location-based services (LBS) on mobile phones is increasing. According to [4], 74 percent of smart-phone users determine their current location with mobile phones in order to find directions. It is necessary for the LBS applications to have accurate information about the current location of users, but the minimum accuracy rate is not equal for all services. For example, a user who wants to check the weather in his area does not require the same accuracy in comparison with a user searching for an object or shop. The current positioning methods on mobile phones are agnostic about service level requirement and provide the same level of accuracy to LBS applications, generally from GPS or WiFi-based positioning systems[5].

The most accurate positioning solution on mobile devices is GPS, which is widely used in smart-phones. It calculates the current location of users by comparing received and transmitted time of the received signals from GPS satellites. The main problem of using GPS, is limitation of satellites' signal propagation in indoor locations. Furthermore, GPS consumes too much energy from the battery of mobile phones, which makes it difficult to use constantly. There are many proposed alternative solutions to GPS such as Wi-Fi, Indoor Messaging System (IMES), Pedestrian Dead Reckoning (PDS), Visible Light Communication (VLC) and also detecting the location identifier tag by the camera or Near Field Communication (NFC). The accuracy rate of these solutions is different and can vary from one location to another, based on many different parameters such as user behavior and interference. In this paper a research on a novel architecture is described that chooses the best indoor positioning method(s) by exploiting the semantic knowledge together with the user and service level requirements.

II. Architecture

The proposed architecture in this paper has four main parts as illustrated in Fig.1.

A. Semantic Server

Semantic Server consists of four sections and is responsible to calculate the current position of the user.

1) Profile Detection Module: When a new positioning request is received in the system, Profile Detection Module assigns the related profiles based on the information received from the mobile devices.

2) Profile Module: Profile Module contains information about locations, users, devices, etc. The user profile stores information about users' demand from different services. Location Profile keeps track of locations and environments. Device Profile includes information about different device specifications including the available sensors.

3) Optimization Module: Optimization Module's task is choosing the best positioning technique(s) based on the semantic information from Profile Module along with the user and service level requirements. When the appropriate technique(s) is chosen, it sends a request to the mobile device, acquiring the necessary information to calculate the position. In case of choosing more than one technique, Optimization Module calculates the coefficient value for each of the techniques and send it to Calculation Module.

4) Calculation Module: Calculation module sends the received information from mobile phones to the appropriate positioning technique. Calculation Module is also responsible for calculating the final values when more than one technique is chose by Optimization Module based on the coefficient of techniques. Finally, the module sends the final calculated location to mobile devices.

B. Positioning Techniques

The proposed architecture is not limited to positioning techniques discussed in this paper but the following are a few examples that can be used in the architecture:

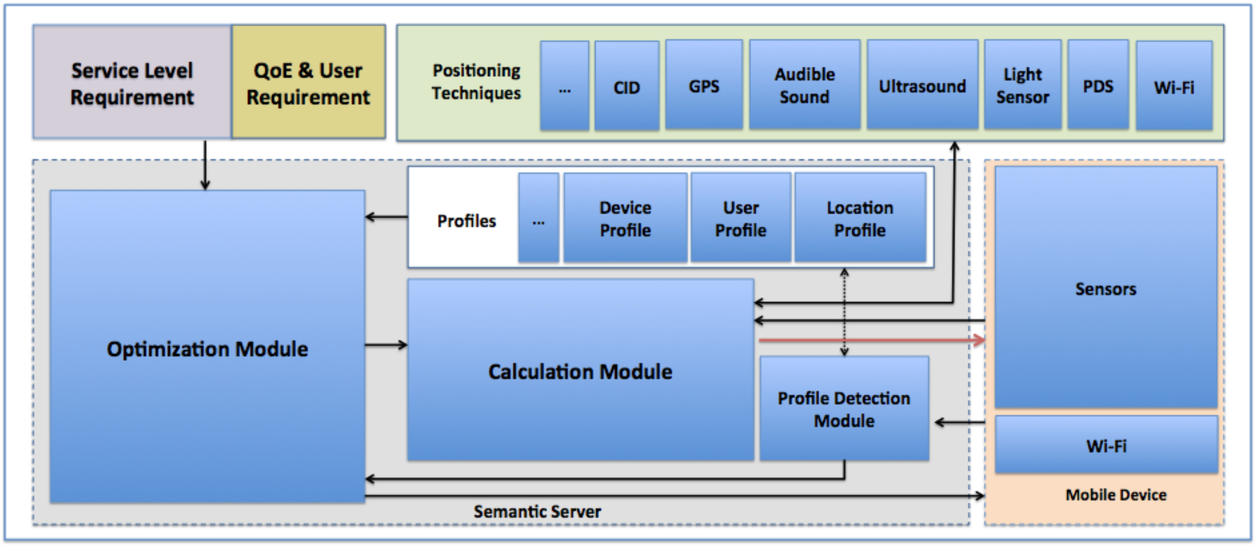

Fig. 1. Architecture

1) WiFi: Using WiFi signals to estimate current location of the user is proposed in [1], for the first time. It calculates the location by processing signal strength and signal-to-noise ratio (SNR) in the wireless local area network.

2) Pedestrian Dead Reckoning: Pedestrian Dead Reckoning is simply the estimation of a step length. In another words, " PDR mechanization exploits the kinematics of human walking " as discussed in [8],[3] and [2].

3) Audible Sound: Audible sound can be heard with the human ear. Smart-phones' microphones can capture audible sound. Comparison of the audio pattern captured by a mobile phone with the audio patterns captured by stationary microphones in that area can be used to find position of the user.

4) Ultrasound: Ultrasound can be used to identify the location of a user in a room as discussed in [6] and [7]. The human ear can not hear frequencies higher than 20KHz, while microphones and speakers can generate and capture these signals.

C. Mobile Device

Mobile Device in the architecture represents any smart-phone with the ability of using location-based applications. Smart-phones support different numbers of sensors and features, which can vary from one model to another. Mobile Devices send the requested information, retrieved from sensors and WiFi interface to the *Semantic Server*.

D. QoE and Requirements

1) Service Level Requirement: Each individual service has its own requirement. One service may need a very accurate position of the user while another service can accept low accuracy. Service Level Requirements are set by service providers. According to this requirement, the Optimization Module in the Semantic Server can make a decision about the best positioning technique(s).

2) User Level Requirement: A user may want to set the expected level from positioning. For instance, users who want to use check-in services in social applications may have different demands. One user may use it for checking-in locations in a city, while another may use it in different areas of a building, or even at a table in a restaurant.

3) Quality of Experience (QoE): Refers to a subjective measure of a user's experiences with a service. In the architecture we have information about user requirement in the User Profile. This profile can be updated from the QoE received from users. For instance, an application can ask about users' satisfaction from the positioning service accuracy, and update the user profile with the received responses.

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