What Makes Difference in WiFi-based Positioning Services: The Importance of Establishing a Reliable Database

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Abstract

WiFi-based positioning systems (WPS) are designed to support the acquisition of accurate location information with technology other than Global Positioning System (GPS). These systems have the potential to supplement GPS where GPS is unreliable, specifically, indoor environments. Recently, Location Based Services (LBS) have become increasingly popular for many mobile device users. These new mobile devices incorporate various wireless technologies, such as WiFi, A-GPS, Bluetooth, and GSM. While each of these technologies contributes to the integration and development of LBS, WiFi has been most widely employed as an alternative positioning service. Indoor location uncertainty with WiFi stems from utilizing an unreliable database for wireless router locations and not fully utilizing and correcting received signal strength. Furthermore, database information is often collected using unreliable and unsecure methods. The purpose of this study is to validate the advantages of using a reliable database for SaskEPS (a small area WPS) from indoor environments. This research has been implemented within two multi-floor buildings in the University of Saskatchewan. The results of the location finding service test with WPS show that using a reliable database for WPS significantly increased location certainty from indoors.

Background and Relevance

After the removal of selective availability in 1996, the use of personal GPS dramatically increased due to its ability to provide accurate location information to the user (Clinton, 2000). GPS is capable of providing location information with high certainty (within 10 metres) and consistency in almost all outdoor environments. However, GPS has some significant weaknesses in isolated spaces which contain urban canyons, natural canyons, and most indoor environments where its service is generally unreliable and unavailable.

Although the GPS-based positioning system has problems in several specific environments (specifically indoors), these can be replaced or supported with an increased array of available radio technology (Ishikawa, Fujiwara, Imai, & Okabe, 2008). Many other fixed radio signals, including WiFi, are available in many places and those radio signals can be easily used for positioning without employing new infrastructure (LaMarca, Hightower, Smith, & Consolvo, 2005). Recently, wireless Internet services have become available in many indoor spaces; therefore, existing WiFi service can be used to develop indoor positioning systems as an alternative, or supplement, to GPS. WiFi can be a very efficient and cost effective indoor navigation system because it provides very dense wireless coverage in different types of indoor spaces such as universities, airports, and shopping centres. Once a proper positioning algorithm is developed, WiFi-based location services can be easily established providing an indoor positioning solution without building additional infrastructure.

Many WiFi-based location finding services fail to provide sufficient accuracy or clear communication with location uncertainty (Bell & Jung, 2010). This failure could be caused by an unreliable database as most WiFi-based location services collect required database information using unreliable and unsecure methods (unreliable wireless Access Points (APs) information collection methods include: wardriving, third party sources and volunteered Geographic Information). If a WiFi-based location finding service employs a reliable and valid database which includes the accurate x-y coordinates of all APs in the area of coverage, the level of location certainty can be improved. With a goal of increasing location certainty in indoor environments, the University of Saskatchewan Enhanced Positioning System (SaskEPS) has created such a database and an accompanying positioning algorithm that returns GPS-like accuracy for indoor spaces.

Methods and Data

This research validates SaskEPS (with a well-structured database) with the hopes of providing efficient indoor positioning service in campus buildings at the U of Saskatchewan. WiFi signal strength mapping is required for validation of the WiFi signal as it helps to identify WiFi availability in each building. The SaskEPS database contains accurate geographic coordinates, floor information, router type information, and each AP's Media Access Control (MAC) address as an unique identifier. This optimized database for SaskEPS provides GPS-like positioning in indoor environments. Below we will compare this accuracy with currently available WiFi based systems (Skyhook and Loki).

This positioning comparison test took place in two multi-floor buildings (Kirk Hall and the Engineering building) where dense WiFi APs are available. Furthermore, these two study areas can be used to study the impact of building structure on indoor positioning services (Kirk Hall is a relatively simply structured building whereas the Engineering Building is a relatively complex structured indoor setting). Our test is also capable of showing position certainty based on indoor structure and composition. 25 random points on each floor were generated using ArcGIS™ for the comparison test. Skyhook running on a 3Gs iPhone and Loki running on a laptop were used for data comparison. SaskEPS ran on two laptops with/without an 802.11 N capable wireless modem that provide positioning service with a reliable database.

Results

SaskEPS successfully provided sub-10m positioning accuracy for both Kirk Hall and the Engineering Building; Skyhook and Loki positions were consistently returning locations over 20 meters of error. Positioning in all systems was somewhat more accurate in Kirk Hall, a building which has a relatively straight forward (orthogonal) indoor layout (SaskEPS: average 5m, Skyhook and Loki: over 15m). Both Skyhook and Loki were egregiously inaccurate as positioning services in the Engineering building (over 50 meters of error). Although SaskEPS's location certainty also decreased at Engineering Building, it still provided sub-10m accuracy positioning service (average 8 meters of error).

Conclusions

In this test SaskEPS provides better location services than other WiFi-based positioning services. Although SaskEPS is primarily designed for providing WiFi-based location service indoors, SaskEPS can also support seamless positioning service from indoor to outdoor environments (and vice versa) when its service is integrated with a GPS-based positioning service. In addition, in the past, the use of GPS usually required a specific device. Currently many mobile devices have integrated A-GPS and WiFi modems. SaskEPS is a software-based positioning system, so any mobile device user can have seamless positioning services if their devices have integrated A-GPS and WiFi modems: GPS (outdoors) and SaskEPS (indoors). SaskEPS is distinguished from other WiFi-based positioning systems due to the combination of the trilateration with an accurate and reliable database. SaskEPS can maintain a GPS-like positioning system in indoor environments as long as the database provides up-to-date APs data in support of the location finding algorithm. Updating the database must include nominal changes in wireless routers, technology changes in WiFi services, as well as accurate location for new and relocated routers. For this reason, the availability of a reliable database is the most critical criteria for SaskEPS in terms of providing GPS-like positioning services in many environments where a dense WiFi network exists. If SaskEPS were to employ a larger database an extended indoor environment, it could easily expand its service coverage to such spaces.

References

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