User Localization for Intelligent Crisis Management

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Abstract. The proliferation of mobile computing devices and local-area wireless networks has fostered a growing interest in location-aware systems and services. Additionally, the ability to let a mobile device determine its location in an indoor environment at a fine-grained level supports the creation of a new range of mobile control system applications. Main area of interest is in model of radio-frequency (RF) based system enhancement for locating and tracking users of control system inside buildings. The locating and tracking of users is useful for rescue people to find closer way in unknown building. The software can navigate these people through the unknown space to accident place. The experimental framework prototype uses a WiFi network infrastructure to let a mobile device determine its indoor position as well as to deliver IP connectivity. Experiments show that location determination can be realized with a room level granularity.

1 Introduction

The usage of various wireless technologies that enable convenient continuous IP-level (packet switched) connectivity for mobile devices has increased dramatically and will continue to do so for the coming years. This will lead to the rise of new application domains each with their own specific features and needs. Also, these new domains will undoubtedly apply and reuse existing (software) paradigms, components and applications. Today, this is easily recognized in the miniaturized applications on network-connected PDAs that provide more or less the same functionality as their desktop application equivalents. The web browser application is such an example of reuse. Next to this, it is very likely that these new mobile application domains adapt new paradigms that specifically target the mobile environment. We believe that an important paradigm is context-awareness. Context is relevant to the mobile user, because in a mobile environment the context is often

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very dynamic and the user interacts differently with the applications on his mobile device when the context is different. While a desktop machine usually is in a fixed context, a mobile device goes from work, to on the road, to work in-a-meeting, to home, etc. Context is not limited to the physical world around the user, but also incorporates the user's behavior, and terminal and network characteristics.

Context-awareness concepts can be found as basic principles in long-term strategic research for mobile and wireless systems such as formulated in [6]. The majority of context-aware computing to date has been restricted to location-aware computing for mobile applications (location-based services). However, position or location information is a relatively simple form of contextual information. To name a few other indicators of context awareness that make up the parametric context space: identity, spatial information (location, speed), environmental information (temperature), resources that are nearby (accessible devices, hosts), availability of resources (battery, display, network, bandwidth), physiological measurements (blood pressure, hart rate), activity (walking, running), schedules and agenda settings. Context-awareness means that one is able to use context information.

We consider location as prime form of context information. Our focus here is on position determination in an indoor environment. Location information is used to determine an actual user position and his future position. We have performed a number of experiments with the control system, focusing on position determination, and are encouraged by the results. The remainder of this paper describes the conceptual and technical details of this.

2 Basic Concepts and Technologies of User Localization

The proliferation of mobile computing devices and local-area wireless networks has fostered a growing interest in location-aware systems and services. A key distinguishing feature of such systems is that the application information and/or interface presented to the user is, in general, a function of his physical location. The granularity of location information needed could vary from one application to another. For example, locating a nearby printer requires fairly coarse-grained location information whereas locating a book in a library would require fine-grained information.

While much research has been focused on development of services architectures for location-aware systems, less attention has been paid to the fundamental and challenging problem of locating and tracking mobile users, especially in in-building environments. We focus mainly on RF wireless networks in our research. Our goal is to complement the data networking capabilities of RF wireless LANs with accurate user location and tracking capabilities for user needed data pre-buffering. This property we use as information ground for extension of control system.

2.1 Location-Based Services

Location-based services (LBS) are touted as 'killer apps' for mobile systems. An important difference between fixed and mobile systems is that the latter operate in a

particular context, and may behave differently or offer different information and interaction possibilities depending on this context. Location is often the principal aspect determining the context. Many different technologies are used to provide location information. Very common is the GPS system, which uses a network of satellites and provides position information accurate within 10–20 m. However, due to its satellite based nature, it is not suited for indoor positioning. In cellular telecommunication networks such as GSM, the cell ID gives coarse-grained position information with an accuracy of about 200 m to 10 km. For fine-grained indoor location information, various technologies are available, based on infrared, RF, or ultrasonic technologies often using some type of beacon or active badge. Given the ubiquity of mobile devices like PDAs, however, active badges will probably be superseded by location technologies incorporated in these devices.

In the context of our experimental setup, we need indoor position information accurate enough to determine the room in which the user is located. We must deploy a separate location technology, where we use the information available from a WiFi network infrastructure to determine the location with room-level accuracy. By this information possible user track is estimate.

2.2 WiFi - IEEE 802.11

The Institute of Electrical and Electronics Engineers (IEEE) develops and approves standards for a wide variety of computer technologies. IEEE designates networking standards with the number 802. Wireless networking standards are designated by the number 11. Hence, IEEE wireless standards fall under the 802.11 umbrella. Ethernet, by the way, is called 802.3 [1].

802.11b is an updated and improved version of the original IEEE 802.11 standard. Most wireless networking products today are based on 802.11b. 802.11b networks operate at a maximum speed of 11 Mbps, slightly faster than 10-BASE-T Ethernet, providing a more than fivefold increase over the original 802.11 spec. The 802.11 standard provided for the use of DSSS and FHSS spread-spectrum methods. In 802.11b, DSSS is used. We use only 802.11b infrastructure (PDA has 802.11b standard) so other standards (802.11a or g) is not needed to describe. However, it can be possible to develop a PDPT framework with it.

2.3 Data Collection

A key step in the proposed research methodology is the data collection phase. We record information about the radio signal as a function of a user's location. The signal information is used to construct and validate models for signal propagation. Among other information, the WaveLAN NIC makes available the signal strength (SS) and the signal-to-noise ratio (SNR). SS is reported in units of dBm and SNR is expressed in dB. A signal strength of s Watts is equivalent to 10*log10(s/0.001) dBm. A signal strength of s Watts and a noise power of n Watts yields an SNR of 10*log10(s/n) dB. For example, signal strength of 1 Watt is equivalent to 30 dBm. Furthermore, if the noise power is 0.1 Watt, the SNR would be 10 dB. The WaveLAN driver extracts the SS and the SNR information from the WaveLAN

firmware each time a broadcast packet is received. It then makes the information available to user-level applications via system calls. It uses the *wlconfig* utility, which provides a wrapper around the calls, to extract the signal information.

2.4 Localization Methodology

The general principle is that if a WiFi-enabled mobile device is close to such a stationary device – Access Point (AP), it can "ask" the location provider's position by setting up a WiFi connection. If the mobile device knows the position of the stationary device, it also knows that its own position is within a 100-meter range of this location provider. Granularity of location can improve by triangulation of two or several visible WiFi APs as described on figure [Fig. 1].

The PDA client will support the application in automatically retrieving location information from nearby location providers, and in interacting with the server. Naturally, this principle can be applied to other wireless technologies.

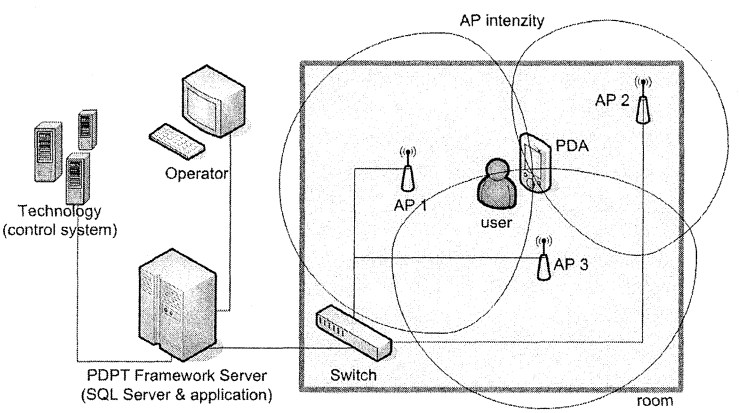

Fig. 1. Localization principle - triangulation.

The application (locator) based on .NET language is now created for testing. It is implemented in C# using the MS Visual Studio .NET 2003 with compact framework and a special OpenNETCF library enhancement [3] and [7]. Current application [Fig. 2] records just one set of signal strength measurements. By this set of value the actual user position is determined.

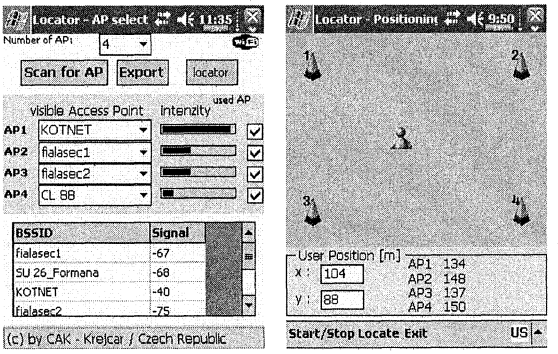

Fig. 2.PDA Locator – AP intensity & Positioning.

2.5 WiFi Middleware

The WiFi middleware implements the client's side of location determination mechanism on the Windows CE 3.0 PocketPC operating system and is part of the PDA client application. The libraries used to manage WiFi middleware are: AccessPoint, AccessPointCollection, Adapter, AdapterCollection, AdapterType, ConnectionStatus, Networking, NetworkType, and SignalStrength. Methods from the Net library are used for example to display Visible WiFi AP. See figure [Fig. 3].

```
dtVisibleAP = new DataTable("Visible AP");
DataRow drDataRow;
adptrColection = Networking.GetAdapters();
foreach (Adapter adptr in adptrColection)
{
  Application.DoEvents();
  if (adptr.Type==AdapterType.Ethernet)
  {
    foreach (AccessPoint ap in
            adptr.NearbyAccessPoints)
    {
       drDataRow = dtVisibleAP.NewRow();
       drDataRow["BSSID"] =
            (ap.Name.ToString());
       drDataRow["Signal [%]"] =
     ((ap.SignalStrength.Decibels).ToString());
       dtVisibleAP.Rows.Add(drDataRow);
    }
  }
}
```

Fig. 3 Sample code – signal strength from AP.

3 User Localization in Intelligent Crisis Management

Many people define crisis management as emergency response or business continuity, while other people will only consider the public relations aspect [8]. They

are all partially correct, but true crisis management has many facets. It must be thoroughly integrated into the organization's structure and operations. Achieving an effective level of crisis management requires a thorough internal analysis, strategic thinking and sufficient discussion.

Crisis Management is the umbrella term that encompasses all activities involved when an organization prepares for and responds to a significant critical incident. An effective crisis management program should be consistent with the organization's mission and integrate plans such as Emergency Response, Business Continuity, Crisis Communications, Disaster Recovery, Humanitarian Assistance, etc.

Fireman, police and rescue service are very important part of this crisis management. Management and coordination of this people is now practicable by shortwave communication (radio, transmitter), but new mobile communication technologies as PDA's can level up potential and speed of action in crisis situations. As discussed before, we can locate any people with PDA running client software. But how localization of these people can help them? Advantage is in tracking of these people. For example when fireman arrive to crisis place, his PDA will make an interconnection to crisis management system of building which fireman arrive and the software on PDA will guide the fireman by shortest safe way directly to the centre of problem in the crisis building. In this case function, the PDA has of navigator and it can help people to make a good orientation around unknown building.

4 Conclusion

The main objective of this paper is in the enhancement of control system for locating and tracking of users inside a building. It is possible to locate and track the users with high degree of accuracy.

In this paper, we presented the control system framework enhancement that uses and handles location information. The framework provides a model that deals with location. Furthermore, a mechanism for location determination is a part of the framework. The indoor location of a mobile user is obtained through an infrastructure of WiFi access points. This mechanism measures the link quality of nearby location provider access points to determine actual user position. User location is used in core of server application of PDPT framework.

The experiments show that the location determination mechanism provides a good indication of the actual location of the user in most cases. The median resolution of the system is approximately five meters, about the size of a typical office room. Some inaccuracy is inherent to the way location information is obtained using the WiFi infrastructure. For the framework application this was not found to be a big limitation.

The experiments also show that the current state of the basic technology used for the localization (mobile device hardware, PDA operating system, wireless network technology) is now at the level of a high usability of the localization applications.

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