MOVILTOOTH: CONTEXT-AWARE SYSTEM FOR MOBILE PHONES BASED ON BLUETOOTH TECHNOLOGY

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Abstract: Nowadays the amount of accessible information across Internet is enormous. Context-aware systems try to filter and to adapt that information to the environment of the user who requests it. This paper introduces a context-aware system that uses the physical location of the request origin. The system is designed for mobile devices using Bluetooth radio-frequency technology for data transfer and location system. The main feature of the system is its low cost and simplicity.

1 INTRODUCTION

Fast development and penetration of mobile terminals (phones and PDAs) are providing the necessary resources to the user for retrieving information anytime anywhere. Due to the inherent characteristics of mobility of those systems, a line of research arises in a natural way: context-aware systems (Chen and Kotz, 2000). From the first systems, as Cyberguide (Long, 1996), to Bluepulse project (Bluepulse, 2004), technologies have been changing, but the objectives are still the same: to provide local information based on the surrounding neighbourhood.

Before mobile technologies, information was extracted from fixed clients based on some limited parameters: date, time, kind of terminal, ip address, user profile, $\cdots$ However, when considering mobile terminals, a new dynamic parameter appears: geographic location. The introduction of location information opens a huge variety of new features services. Users at a specific place primarily use services based on information of their direct neighbourhood.

Location information is obtained from a system that estimates a mobile terminal position by using different physical phenomena and technologies (Hightower and Borriello, 2001). If we use the geometric properties of the received signal paths, we can make some triangulation to provide location. This technique is one of the most popular between location systems (Bahl and Padmanabhan, 2000),(Priyantha et al., 2000). However, triangulation techniques need complicated algorithms to estimate the position of a user. There exist simplified techniques to provide this location. For example, by using previously observed features of the environment and/or the presence/absence of some signal in a short range, can be enough to provide support for a context aware service. On the other hand, any of the mentioned techniques can be used with different technologies: radio-frequency, ultrasound, optical, proximity sensors, ...

Moviltooth, the system introduced in this paper, is based on a technology that allows the communication and, simultaneously, acts as a positioning system: Bluetooth (SIG, 2001c). This technology is widely extended and adapts itself very well to the context-aware problems (Ferrandez, 2003). Bluetooth is a low-cost radio-frequency solution that provides links between mobile terminals and a network. Coverage range of Bluetooth devices is between 10 to 100 meters (10 meters in mobile terminals). That makes Bluetooth a good and simple mechanism to be used as positioning system, based on the proximity to an access point whose position is previously determined. Moreover, Bluetooth gives us independence from the phone carriers, providing a free access network.

This paper is structured as follows: section 2 describes the features of the developed system, the resulting architecture and some implementation details; section 3 introduces a test scenario, illustrating the way Moviltooth works, and, finally, section 4 is devoted to the conclusions.

2 SYSTEM FEATURES

Moviltooth was developed with the following features in mind:

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- Simplicity and low cost. It is not necessary to consider complicated algorithms to make triangulation. Bluetooth network devices (network cards, access points, $\cdots$) are low cost. Moreover, Bluetooth communication is free for the final user.
- Common transport and location technology. Bluetooth technology allows us to use it for recovering information and to estimate positions.
- User transparency. Users ask for information by using a standard protocol (HTTP), without introducing any context information. Location system does not require any user interaction.

In order to provide these features it is necessary to solve three basic problems:

- Communication: The communication of the mobile with the system is made through Bluetooth. The system has several Bluetooth access points (AP) distributed in the neighbourhood of places of interest. This way, when a user, with its phone and the Moviltooth application started, arrives to a place of interest, it is connected to the closest access point and sends a generic request of information (i.e. a specific URL). The AP forwards the request to the central server to which it is connected by Internet or Intranet.
- Location: The user always gets connected to the system across an AP, whose position is known. The server will identify the AP originating the request and, therefore, it will obtain its location (neighborhood). To let server know which AP is the origin of the request, a parameter associated to it is sent to the server. In our case, it is transmitted the physical address of the AP. The server has a database mapping the APs physical addresses to their locations. Specific information, adapted to the context of location, is return as a response. Bluetooth is used, therefore, to solve the location with a simple system based on the proximity to an access point.
- Navigability: HTML language is very suitable to send information to the phone. This language allows to incorporate links that allow navigation between information. Information is generated by a content management system implemented as a Web application. The phone uses a Browser that allows to display the HTML pages and to use the links. For the development of the prototype, cHTML (compact HTML) (Kamada, 1998) was used. cHTML is a subset of HTML contemplated by the W3C (World Wide Web Consortium), very suitable to small devices as mobile phones.

2.1 Architecture

The proposed system consists of three hardware components. The global architecture scheme achieved is shown in figure 1

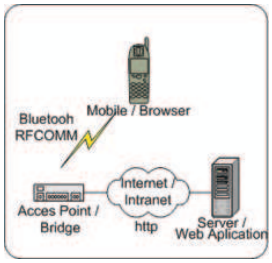

Figure 1: System's architecture

2.1.1 Components

Next we explain the three hardware components and their corresponding applications.

- Mobile phone: The main component of the mobile phone application is a small web browser. This browser uses Bluetooth to send and to receive the information. It is written en J2ME (Java 2 Micro Edition) and uses the standard Sun's JABWT API as Bluetooth protocol stack, (Klingsheim, 2004), (Qusay, 2003), (Hui, 2004).

  It looks for system access points and requests information when a connection is ready. Once it has got connected to an AP, the user can navigate trough the information using the links of the received pages. It is not allowed to the user to introduce URLs by himself, that means, it is only allowed to go to the main page URL, that have information depending on the location of that AP, then, navigate across the links. It is not a question of developing a web browser but a context-aware system with web interface, that makes use of a part of the already existing technologies in the Internet environment.
- Access Point: For the development of the prototype the AP was a PC with a bridge application. Its objective is to act as a connector between the application of the mobile, and the Web application.

  It is always waiting for connections and, when it receives one, it redirects the requests to the server adding its physical address as a parameter.

  Bridge application was written in C language and, to access to the Bluetooth adapter, it uses blueZ (Holtmann, 2003), the official Linux Bluetooth protocol stack.

  The design of the bridge application can be divided in three parts:

  – tohttp library: It contains the necessary functions for exchange information with the Web applications server, using the HTTP protocol.

  - tobt library: It contains the functions necessary for the exchange of information with the browser through Bluetooth, using the RFCOMM protocol.
  - sicd daemon: It is the main function. It uses the two previous libraries to act as a bridge between mobile and server. Also, the first time that is executed, it has to be registered in the Bluetooth services database of the device, to be visible from other devices.

- Server: Server subsystem is a Web application that provides the HTML content, according to the request and to the physical address, received from the bridge (as a URL parameter).

  It contains the information corresponding to the different neighborhoods. The sub-set of HTML, cHTML (compact HTML) was used to transmit the information.

  A XML file represents the map that relates the Bluetooth address of every AP to its physical location. The default URL of the Moviltooth application corresponds with a JSP code that uses JSTL tags read the content of the map described previously. Then, using the ”source” parameter that the URL should include, it chooses the correct point in the map and it configures the response. When AP address does not correspond with any point of the map, ”PAGE NOT FOUND” message is returned.

  There are other parameters that can be used to generate the response. One possibility is to adapt the information to the kind of target device, according to its characteristics (screen size, multimedia capabilities). Another possibility is to have a users database and to adapt the information to the profile of each user.

2.1.2 Communication between subsystems

Once a connection has been established between the mobile and the AP, the communication process begins and it has the following steps:

1. When the user fetches a link in a page of the system, the mobile sends the URL requested to the AP using the Bluetooth connection. The first time that the user requests information, the application uses a fixed URL defined by default.
2. When the AP receives a URL from the mobile, it adds its physical address as parameter. Then, it opens a socket against the server and it sends to the server a HTTP request, with the above mentioned URL.
3. The server receives the HTTP request, and processes it. Then, it sends the adapted response to the AP.
4. Finally, the AP receives the HTTP response (head and content) and sends it to the mobile using the Bluetooth connection.

Therefore, we have two communication process: Bluetooth communication and HTTP communication.

- Bluetooth Communication: A Bluetooth connection is established between the mobile device and the access point. This connection keeps opened while the mobile is inside the radio of Bluetooth coverage of the AP.

  There are two kinds of information exchanged between the mobile and the AP: requests of pages from the mobile to the AP (by using URLs) and server responses (that includes HTTP head and HTML content of the requested page) from the AP to the mobile. Two protocols can be used for establishing the connection between the bridge application and the browser of the mobile phone: L2CAP (SIG, 2001a) and RFCOMM (SIG, 2001b). RFCOMM was the selected protocol to be used in Moviltooth. This protocol was developed to transmit information as a stream, not by packets. Considering a stream between the two ending-points of the connection, information is transmitted any time from one side, and it is received on the other side asynchronously. Moreover, it is guaranteed the same order for reading and writing information. Thus, the mobile sends a URL for the stream and reads the response in the same stream, once the AP has written it.

- HTTP Communication: A HTTP connection is opened between the AP and the web server. The Web application is installed in a Web application server. HTTP connection is independent of the Bluetooth communication, so it is not necessary to develop anything special, just the web application.

2.2 Limitations

Since Moviltooth is in its first realese, it presents two main limitations:

First, the coverage range of Bluetooth mobile phones is 10 meters. Although it is a good feature that we use for the positioning system, it can be a problem if we want to give Bluetooth coverage in a wide range. The solution is quite simple: to place several APs in each interesting place. Moreover, bluetooth APs are not expensive.

Second the maximum number of active devices that can be connected to an Ap at the same time is 7, due to Bluetooth specification (the maximum number of devices in a piconet is 8). Again, if we place several access points in each place of interest, we can provide access to more users.

3 TEST SCENARIO

In order to test our prototype system, we designed the following test scenario. Two PCs, working as access points, were installed in two laboratories. Bridge application was running in both PCs. There was another PC working as a server. We started the mobile application near PC 1 in laboratory 1, and then we moved to PC 2 in laboratory 2.

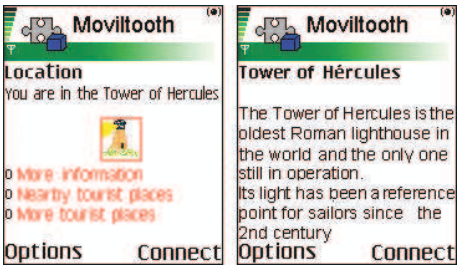

Figure 2: Screenshot

Figure 2 shows the phone screen when we are near PC 1. Once connected, we can follow the ”View information” link and go to the location page. Access point 1 is supposed to be in the tower of Hercules (a Roman lighthouse of La Coruña, Spain). We can see the information about the tower by following the link ”More information”.

While reading, we move from position 1 to position 2. At this moment the system automatically detects that the connection is disabled there. We have to press ”search AP” option. In about 10 seconds another AP is detected. Once connected to this AP the system will show us the page of the state house, as AP 2 is supposed to be near the state house.

4 CONCLUSION

This paper introduced a context-aware system based on Bluetooth technology for mobile phones, called: Moviltooth.

Moviltooth was developed to provide a simply low-cost context aware information system suitable for mobile devices (cellular phones, in particular). Bluetooth was selected as the medium access technology, since it provides at the same time transport and location mechanisms. Moreover, its low cost, independence of comercial networks and support in many mobile devices, give a promising future of Moviltooth.

A Moviltooth user only needs a mobile device running a J2ME application. When it arrives close to a place of interest, the device will connect with the systems, providing information adapted to that location.

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