Service Selection in Networks Based on Proximity Confirmation Using Infrared

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Abstract

There are protocols that can be used by mobile clients to discover service providers in foreign networks to which they get attached, e.g. SDP of Bluetooth and SLP of IETF. These protocols do address service discovery, but do not address the selection of a service provider among a set of candidates according to physical proximity of the client and service provider. The goal of the research described in this paper is to integrate proximity-based selection mechanisms to service discovery protocols. We present in this paper protocols that allow nomadic clients to discover and select service providers according to physical proximity.

1. Introduction

Service discovery protocols enable service providers to advertise capabilities to potential clients, while also providing to clients and service providers a means for entering into a relationship. Service Location Protocol (SLP) [Gutt 99], Jini [Sun 01], Bluetooth's Service Discovery Protocol (SDP) [Blue 01], Salutation [Salu 02], and Universal Plug and Play (UPnP) [Univ 00] are protocols addressing service discovery. They are all likely to discover many service providers, which are relatively useless to a client at a given time by virtue of the client's inability to determine the appropriate service provider to use. This could be due to physical inaccessibility of a service provider (not helpful in the case of a printing service provider) or the inability to determine its relative physical location (not helpful in the case of a desktop telephone that can handle forwarded calls).

The solution to the issue is not simply a matter of being able to map the service providers to their geographical location. For instance, let us consider a client looking for a desktop telephone to which calls will be forwarded. The client doesn't understand location information and is unaware of its exact location, i.e. it is a visitor with no maps. For the purpose of the selection according to close proximity, information about the geographical location of a service provider is not usable in the selection process. What is relevant is the relative location of the client with respect to a service provider. The detection of the existence of line of sight between the client and a service provider is a more useful piece of information as it confirms physical proximity, in indoor environments.

This issue is even more relevant in wireless networks where RF is used as a medium for communications. RF can traverse physical obstacles. This presents problems for service discovery and selection according to physical proximity. All service providers within communication range are discovered. This inevitably includes service providers located in other rooms, on other floors or in other buildings. Being inaccessible, a large number of them are useless.

The problem addressed in this paper is the selection of service providers according to physical accessibility and relative location.

In this article, we propose an integration of a close proximity detection protocol to service discovery protocols. It allows a client to select a service based on its physical proximity. Two approaches are presented, one that can leverage one-way infrared communications and another that requires two-way infrared communications.

The rest of this paper is organized as follows. In the second section, we review related work. The third section discusses existing service discovery protocols. The fourth section describes two proximity-based service selection protocols we have created. In the fifth section, we review an implementation of the protocols. Finally, the conclusion is given in the last section.

2. Related Work

Work related to ours is about physical location tracking of mobile nodes using infrared, RF or ultrasound. We review sample projects addressing location tracking. Work about using infrared for ad hoc communications is also related to ours and discussed in the sequel.

In the Active Badge Location System [Want 92], electronic badges periodically send using broadcast infrared their unique identity. A network of sensors receives the signals and reports locations of badges to a central database. The exact locations of people (wearing active badges) and pieces of equipment (tagged with active badges) within an organization can be tracked with this system.

Exact Location Identification [Sinh 00] is an infrastructure consisting of a master and base stations. Triangulation is used to find the exact location of mobile nodes. The system works well in the absence of signal reflection.

As in the Active Badge Location System, in the Active Bat System [Hart 99] there are wearable electronic badges. RF is used to trigger the ultrasound transmitters in the badges. According the authors, the accuracy of their system is better.

All the aforementioned work about location tracking relies on the deployment of an infrastructure. In contrast, our approach is of the ad hoc location sensing type [High 01]. It is does not require networks of sensors. Clients and service providers cooperate to determine their relative location.

Work leveraging infrared communications for the purpose of face-to-face contacts between users has inspired us, in particular the Meme Tag project [Boro 98]. A meme tag is an electronic name tag used to collect memes during informal gathering. A meme is an idea or an opinion expressed as short text. This device uses the IrDA infrared communications protocol to exchange memes in face-to-face contacts.

3. Service Discovery Protocols

Service discovery protocols play a key role in mobile and wireless networks. They provide to the mobile nodes a functionality that enables them to advertise and discover service providers. There is a number of existing service discovery protocols. These include Sun Microsystems' Jini [Sun 01], IETF's Service Location Protocol [Gutt 99], and Bluetooth's Service Discovery Protocol [Blue 01]. They are discussed in more detail in the sequel.

3.1 Jini

Sun Microsystems has developed a distributed service-oriented architecture called Jini for the Java programming environment. It runs above RMI (TCP and IP). Service providers can represent hardware devices, software programs or a combination of both. They are all accessed in a uniform manner. Service providers look for and register offers with lookup servers. Registration means uploading, in a lookup server, a service object and values of descriptive service attributes. Clients look for services by contacting the lookup servers and sending requests with conditions on service attributes. When requests can be granted, service objects are downloaded in the clients. They serve as local proxies to remote service providers.

Jini can work without lookup servers by using a technique called peer lookup. With the peer lookup approach, the clients request particular services by sending messages called identification. Registration messages are returned directly by the service providers to the clients, which hence get the service object and service attributes.

3.2 Service Location Protocol

The Service Location Protocol (SLP) is a service discovery protocol designed for IP networks. It runs above UDP. SLP defines three types of agents: User Agent (UA), Service Agent (SA), and Directory Agent (DA). UAs are clients, SAs are service providers, and DAs are repositories of service advertisements.

The flow of interactions in SLP is as follows. DAs advertise their presence to UAs or SAs with the Directory Agent Advertisement (DAAdvert) message. SAs respond to this message using the Service Registration (SrvReg) message to register service offers. A service offer consists of a URL and values of descriptive attributes. A URL is a service access point (SAP) to a service provider, in other words it provides all the information required to establish a communication.

UAs send using unicast the Service Request (SrvRqst) message to DAs, which respond with the Service Reply (SrvRply) message. A SrvRply message contains one or several URLs. UAs can communicate directly with the SAs, which are discovered by sending the SrvRqst message using broadcast. The SAs may reply with the SrvRply message or the Service Agent Advertisement (SAAdvert) message.

SLP is used in enterprise networks, but to the best of our knowledge it has not yet been augmented with mechanisms to select service providers according to close physical proximity.

3.3 Bluetooth's Service Discovery Protocol

The Service Discovery Protocol (SDP) provides a means to client applications for locating available server applications, and learning about their characteristics, on Bluetooth ad hoc networks. In contrast to Jini and SLP, the IP protocol is not involved.

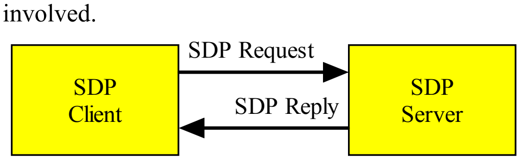

Figure 1. SDP Client-server Interaction.

A flow of interactions is pictured in Figure 1. A SDP client sends using unicast a SDP Request message to a SDP server. The SDP server maintains a list of service records that describe the characteristics of services, i.e. descriptive attributes. There is a maximum of one SDP server per Bluetooth device (there is no SDP server on a Bluetooth device that acts as a client only). The server returns a SDP Response message to the client. A client must open a separate connection to the service provider in order to use the service.

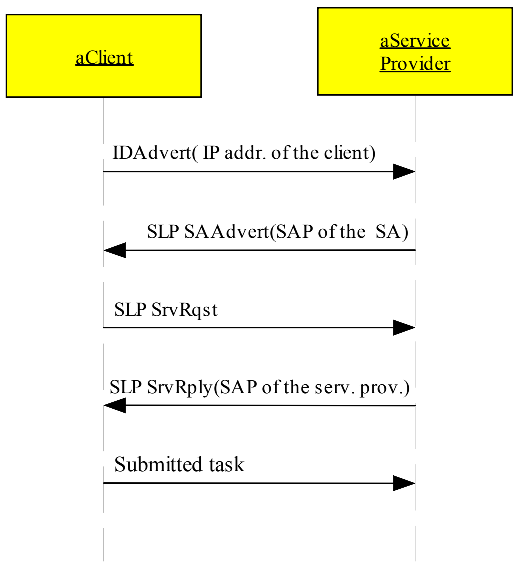

Figure 2. The IDAdvert protocol.

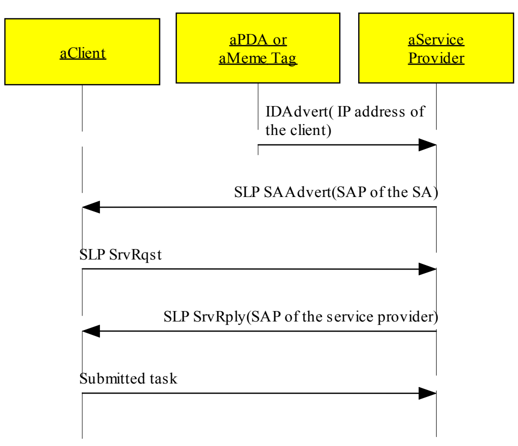

Figure 3. The IDAdvert protocol with distributed functionality on the client side.

4. Close Proximity-based Selection Protocols

Service discovery protocols can be augmented with close proximity-based selection elements. To this end, we define two protocols that exploit infrared communications, namely the IDAdvert and SetIrdLink protocols. We show how they can be integrated to SLP.

4.1 The IDAdvert Protocol

This IDAdvert protocol uses one-way infrared communications from clients to service providers. Each client must have an infrared transmitter and each service provider must have an infrared receiver. Clients and service providers must be attached to a common network and support a service discovery protocol. Hereafter, it is assumed that SLP plays that role. Figure 2 pictures a sequence diagram for this proximity-based selection protocol.

Possibly triggered by an human action, the client sends to the service provider the IDAdvert message using infrared. IDAdvert contains the IP address of the client. This message is received only if there is line of sight and close proximity between the client and service provider. Reception of the IDAdvert message triggers the SLP SA on the service provider. SLP operates over the common network. Upon reception of the IDAdvert, the service provider replies with a SLP SAAdvert message. Hence, the SAP of the SA is communicated to the client.

Upon reception of the SAAdvert message, the client sends a unicast SLP SrvRqst message to the service provider, which replies with a SLP SrvRply message containing a SAP and descriptive attributes of the service provider. The client then submits its task to the service provider using the SAP.

An alternative scenario is pictured in Figure 3. A separate device, such as a Personal Digital Assistant (PDA) or Meme Tag, transports the IP address of the client, has an infrared transmitter, and sends the IDAdvert message on behalf of the client. Apart from that, the rest of the scenario is as in Figure 2.

4.2 The SetIrdLink Protocol

The SetIrdLink protocol uses two-way infrared communications. The clients and service providers must have infrared transceivers. They must be attached to a common network and support a service discovery protocol. It is assumed that SLP plays that role. Figure 4 pictures a sequence diagram for this proximity-based selection protocol.

Firstly, a client sends, using broadcast, a SLP SrvRqst message to gather a list of SAPs of service providers attached to the network. SLP operates over the common network. A number of service providers reply with the SLP SrvRply message. In Figure 4, two service providers return a SrvRply. Each one contains the SAP of a service provider. One of them is *near* while the other is *far*.

To assess physical proximity, the client sends through its infrared transceiver the Set Infrared Link (SetIrdLink) message. It contains a list of the SAPs of the service providers that were obtained with the SrvRply messages. Since infrared is capable of only line of sight and short distance communications, only the near service providers (the ones within infrared reach) receives the SetIrdLink message and replies with a Set Infrared Link Confirmation (SetIrdLinkConf) message. The SetIrdLinkConf message contains the SAP of a service provider.

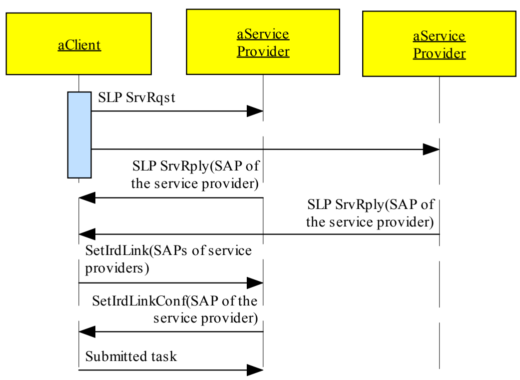

Figure 4. The SetIrdLink protocol.

The client then submits its task to the service provider.

An advantage of this protocol is that the entity advertising the service (e.g. a SA) and the service provider (participating in the infrared communications) do not have to be neither co-located nor synchronized during the discovery and selection process.

5. Implementation

Our primary interest for developing these protocols is the support of *follow-me* telephony applications. Mitel Networks has conference telephones equipped with infrared transceivers, as depicted in Figure 5.

Telephones are seen as service providers. Telephony applications, that can control telephones and running on PDAs, are clients. We have defined two applications that leverage the proximity-based selection protocols. The first application allows a user to configure a selected telephone with call forwarding preferences. The SetIrdLink protocol is used to discover a telephone, at close proximity, and its identification number. The identification is then passed to a Personal Policy Agent (PPA). A PPA is another service provider that allows a client to set up policies for incoming or outgoing calls. It makes use of the IETF Call Processing Language (CPL) and it interfaces to a Mitel Ipera 2000 using a proprietary telephony API called MiTAI (Mitel Telephony API).

Communications with the PPA is through a Web browser and therefore the PDA must have network connectivity in order to communicate. We use Bluetooth enabled Palm devices that support the LAN access profile. A PPP link is opened to the network. Following the invocation of the SetIrdLink protocol to select a telephone and resolve its identity, the application launches a Web browser on the PDA with the identity of the telephone as a parameter, as shown in Figure 6 (the telephone number is posted).

Figure 5. A conference telephone with an infrared transceiver.

The second application handles notifications of incoming calls. When such a notification is received, it discovers a telephone at close proximity, queries the telephone for its identification number, and instructs the telephone switch to forward the call to the selected telephone. The application uses the SetIrdLink protocol to confirm physical proximity.

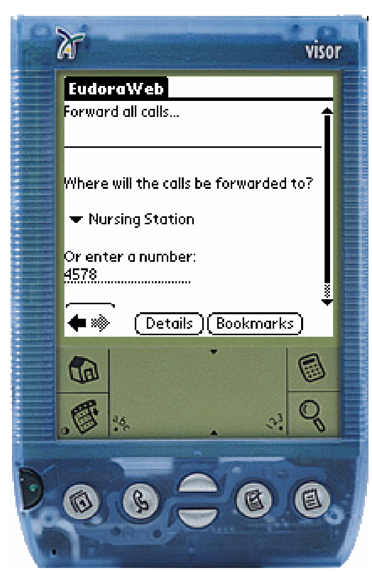

Figure 6. Window on the PPA.

We originally built the SLP and SetIrdLink protocols using Java 2 Micro Edition (J2ME) [Sun 02], K Virtual Machine (KVM), and the Spotlet extension. We soon discovered the existence of limitations of the KVM that are difficult to overcome. In the process of implementing the protocols, the following issues became apparent. The first and foremost is the inability of J2ME to handle broadcast and multicast of datagrams. Secondly, there is the inability of J2ME to specify the file name of an object when using the beamSend method of the Spotlet class on the Palm. The telephone sets use a predefined name that needs to be specified and that cannot be done so using beamSend.

Finally, we implemented with success the protocols in the C language.

6. Conclusion

Service discovery and selection according to physical proximity play an important role in networks. It lets mobile users, that have no clear understanding of their environment, find service providers that are physically close and accessible. We have reviewed a number of existing service discovery protocols. None of them offers a native support for proximity-based selection of service providers. This problem has received no attention in the past.

We have addressed this problem for the first time and developed two protocols, namely IDAdvert and SetIrdLink, which augment service discovery protocols, such has SLP, with proximity-based selection. The limited range and line of sight requirement of infrared communications are exploited. The IDAdvert protocol uses one-way infrared communications to trigger transmission of service advertisements, using the common network. Its advantage is simplicity. The SA and the service provider need to be synchronized and co-located. With the SetIrdLink protocol, service providers are discovered first using the common network then physical proximity is confirmed using two-way infrared communications. Its advantage is that the entity that advertises the service provider (the SA) and the entity that participates in the infrared communication (the service provider) are asynchronous and can be distributed.

Acknowledgements

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