RelateGateways: Using Spatial Context to Identify and Interact with Pervasive Services

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Abstract. Our everyday life is surrounded by pervasive services such as those offered by printers, public displays, multimedia systems, workstations, etc. While on the run we should be able to use the mobile devices we carry along to interact with these services. Yet, a number of studies have shown that it is rather complicated for users to *identify available services in an unknown context*. The RelateGateways project extends the mobile desktop with a new kind of widget: the gateways. These components are arranged around the edge of the screen, pointing towards the co-located services. Once identified, a service can be consumed in a consistent manner by dragging-and-dropping an object on the gateway, without the need for the user to install, configure or learn how to use yet another system for each service.

1 Introduction

One goal of ubiquitous computing is to let mobile users make spontaneous use of physically manifest services embedded in the environment. Ad hoc networking technologies already facilitate spontaneous connection of a user's device to encountered services. However it remains difficult for a user to match network-discovered services with a physically present device [6, 1], and initiating an interaction often involves a complex configuration phase. This is illustrated by the following example.

1.1 Use Case

Imagine Bob visiting a new research laboratory for a week. As a modern IT user, Bob brings his laptop, cellphone and PDA along. Having finished writing the presentation for the seminar he will be giving on the next day, Bob now wants to print it. While this task may be easy for the local researcher, Bob will have to go through various steps: 1. Physically locate the printer. 2. Find out about the printer's properties (brand, queue name, does it print four slides on a page, . . .). 3. Install and configure the printer on his personal laptop. 4. Print the document. As a result it is likely Bob will give up, frustrated by the clumsiness of (mobile) interaction with pervasive services.

From this use case, two basic challenges can be extracted: 1. The need for the user to identify (or discover in a physical sense) the device. 2. The need for providing natural and seamless interaction mechanisms.

1.2 Spatial Discovery with RelateGateways

As in ICrafter [8], Cooltown [5] or Speakeasy [7], we have developed a user interface concept to access the pervasive services. However, our system assumes a sensing technology that provides relative positioning information such that the spatial relationships between a mobile user's device and devices encountered in their environment are established and tracked in real-time. The RelateGateways interface uses the positioning information to dynamically and contextually display the services the user can interact with in their immediate environment. The devices providing these services appear as gateways in the interface (Fig. 1), taking the form of small widgets at the periphery of the user's screen as they move through an environment. The gateways are spatially arranged around the screen based on a compass metaphor (Fig. 2). They serve as "access points" for association and interaction with services, and are integrated with a mobile desktop interface to support direct manipulations such as "drag-and-drop" of documents to a service.

In our use case, Bob would see a printer gateway on the right of his PDA screen. More information and further options can be accessed by hovering over the gateway or clicking on it. Then he drags-and-drops his file onto the gateway and the printer to his right immediately prints it. The following day he enters the conference room, sees a projector icon on the top of his screen, drags his presentation onto it and it starts fullscreen on the big display. In addition a small window pops up on his PDA with which he can control the presentation.

Fig. 1. OQO handheld computer displaying three gateways (left). Gateway widgets for keyboard, printing, sound system and public display. Each gateway is clickable but also has a "hide" button and an "information" button (right).

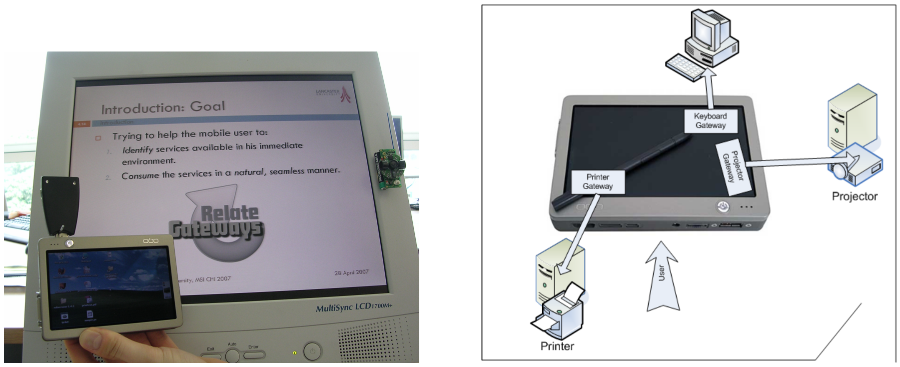

Fig. 2. OQO handheld computer with a Relate USB dongle in front of a public screen equipped with a Relate sensor node (left). Compass metaphor (right).

Three services have currently been implemented: a printing service, a public display service for presentations, a keyboard service where the user's mobile device can "borrow" the keyboard of a larger computer. Each service can define a set of spatial conditions which must be fulfilled before the corresponding gateway is displayed. For instance the public display service gateway may only be visible when the user is facing the display, and the keyboard gateway may only be visible when the user is a short distance away.

2 Features

Interface The gateway interface is designed to be a seamless extension of any existing desktop-style interface. The concept is to integrate the gateway in an unobtrusive manner at the perimeter of the screen but closely integrated such that direct interactions with the desktop or with other applications are facilitated. To achieve this, the user interface was implemented as a portable Java application using Swing GUI components. In order to control the position of the gateways on the screen, they are implemented as small borderless windows. The Gateways may be used as drag-and-drop targets for files or they may be clicked if more options are required.

Service Discovery As exposed in [2], a user-study conducted to evaluate the user interface and interaction techniques of this work emphasized the importance of the auto-configuration and installation. Indeed, for our users the fact that the system was taking care of all the technical details for them was the most significant step towards spontaneity. Thus, once the user identifies a service they would like to use via the Spatial Discovery layer the system also addresses network and service discovery in order to connect the mobile device to the machine providing the selected service.

Mobile Code Once the mobile user has identified a service and their mobile device has been successfully connected to the service provider the interaction is ready to occur. We propose a system based on packages of MobileCode containing everything a client needs to know in order to invoke a previously unknown service. These packages are dynamically downloaded and loaded by the mobile client at run time. This way, the client discovers the services "on the fly", and can use them in a "plug-and-play" fashion without any prior knowledge or configuration.

3 Sensor Integration

The application can operate with any suitably accurate positioning system but since only relative location information is needed it is being developed in tandem with Relate [4] sensing technology. Relate sensors directly capture the spatial arrangement between co-located devices. We have integrated the RelateGateways application with Relate sensor nodes to provide information about the relative positions of the mobile user and the nearby services, see Figure 2.

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