Federated Devices: Augmenting Mobility with Ambient Resources

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Abstract

Mobile devices are limited by their very nature in terms of the user experience they can provide: to remain portable, mobile devices require a small form factor. With increased demand for powerful mobile software, small screens and clumsy keypads quickly become liabilities for users. The Federated Devices project balances portability and usability in mobile computing by augmenting portable devices with ambient resources, such as large displays, desktop computers, and kiosks. Federation can also give user interfaces to very small devices (e.g., sensors), allowing users to manipulate otherwise inaccessible data.

Keywords

mobile, ambient computing

ACM Classification Keywords

H.5.2 [**Information Interfaces and Presentation (e.g., HCI)**]: User Interfaces; H.5.1 [**Information Interfaces and Presentation (e.g., HCI)**]: Multimedia Information Systems – Audio input/output

Introduction

Today's computer users are becoming increasingly more mobile. Market data indicates that an ever-larger number of computer users are mobile while working, including not only traditional mobile workers (e.g., "traveling salesmen"), but also workers who spend

most of their time in an office without being at their own desk, blue-collar field workers, etc. [1]

However, mobile devices are limited by their very nature in terms of the user experience they can provide. In order to remain portable, mobile devices are constrained to a small form factor, but small screens and clumsy keypads quickly become liabilities for users. Speech input and output capabilities can enhance the usability of mobile devices, but many applications are not well suited for audio interaction, for example, applications requiring rich visual output (maps or analytics) or sensitive input (password entry).

The Federated Devices project seeks to extend the usability and functionality of devices through connection with other resources. Portable, personal devices (e.g., smart phones) can be augmented with ambient resources, such as large displays, desktop computers, and keyboards. Personal devices establish the user's identity, run applications, or connect to back-end systems, while ambient resources provide input and output. Conversely, ambient or mobile devices connected to extremely small devices with little or no user interfaces of their own can allow users to view or manipulate otherwise inaccessible data. This paper describes the types of federation, indicating where current work may be used to prototype the ideas.

Input and Output Federation
Input and output federation is the combination of devices to augment the I/O capabilities of one or the other. In particular, we focus on the augmentation of small, portable (personal) devices with ambient resources to improve mobile interaction.

Output Federation
Mobile devices often have screens that are too small to adequately display information, especially if the information involves complicated visualizations, graphics, or large quantities of text. Output federation can solve this problem by connecting with a nearby display to present the information. Federated displays can also be used for sharing data, by federating a mobile device with a projector or wall display.

The technology for display federation is already being investigated. The "Personal Server," from Intel's Ubiquity project, is a "small lightweight computer with high-density data storage capability."[1] Its primary purpose is to store data and provide computing power that can be leveraged by other devices using a wireless network, and acts as a web server to push content to the connected device through a web browser. [2] WinCuts from Microsoft Research allows users to push shared areas of live screen content to other machines, which are controlled locally. [3] PdaReach by June Fabrics[2] displays the contents of a PDA screen on a computer connected via the PDA synchronization cable.

What remains to be investigated are usage scenarios and design for display federation. For example, should *all* content automatically be routed to a federated large display, or should users explicitly control the portions of the output to be displayed? Such considerations likely depend on the applications involved, the security or privacy of the environment, and other factors.

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[1]http://www.intel.com/research/exploratory/personal_server.htm

[2]http://www.junefabrics.com/index.php

Mobile device output can be augmented using other modalities, as well. Mobile providers are already exploring multimodality to prevent competition over the visual channel between primary mobility tasks (e.g., driving) and secondary computing tasks. Federation with external audio devices would allow users to share the audio stream or improve the quality of the output. MP3 players (in particular, the Apple iPod[3]) are creating demand for audio federation, so that users can balance portability of their music with high-quality output.

Input Federation
Device federation also has the potential to give users the ability to choose which input devices to use with various computing resources. This idea was initially proposed almost a decade ago as a solution to the accessibility problem. [4] The basic concept was to provide users with a portable device that exactly met their needs in terms of input capabilities: low-mobility users could use single-switch or voice entry, low-vision users could use Braille entry devices, etc.

Within more general use cases, we foresee a need for users to federate input devices to enhance productivity. For example, mobile e-mail devices allow increased connectivity and productivity, but typically at the expense of awkward input mechanisms. Federation of keyboards or other input devices could be used to overcome these limitations.

At the other end of the spectrum, input mechanisms to large screen displays have been investigated by many research groups (see [5] for a recent example).

Federation offers another alternative, by allowing input through a mobile device to control a large-screen display. Our group has sponsored an initial study on input strategies for mobile devices federated with large displays, to explore whether input should come from the mobile device or via a touch-screen on the display. Initial results indicate the answer is task-dependent; further investigation is required to define the properties of tasks that lend themselves to input via one device over the other, independently of modality.

For input federation, the Apple iPod is again a good example. The iPod is portable and allows self-contained functionality, but its input and output functionality increase when federated with other devices such as computers and car stereos. Federation with car stereos is especially interesting in regards to the distribution of I/O: some products federate the iPod to a car stereo's *speakers*, handling input via the iPod itself, while others use the car's output *and* input. User satisfaction with the different products can provide insight into federation for other consumer or business applications.

Data Source Federation
Data sources, in the form of sensors, RFID tags, and other "smart items" are becoming more prevalent in today's environment. Sensors and tags can be used to track objects and provide real-time information in ways unheard of even 5 or 10 years ago. However, the devices are so tiny and so numerous that it is difficult for users to interact with them directly. Federated devices can provide new opportunities to access these nearly invisible information sources by federating them with PDAs and laptop computers that can display their state, or even modify their behavior.

[3] http://www.apple.com/ipod/ipod.html

Research projects that investigate software updates for embedded and networked devices point the way for data source federation. The OSGi Alliance is creating an open service delivery and management platform so that "software components can be installed, updated, or removed on the fly without having to disrupt the operation of the device."[4] Similarly, Sun Labs is researching "Small Programmable Object Technology," or Sun SPOT[5], which allows running Java programs to be moved between sensors. The flexibility inherent in these projects opens the possibility of federating devices to access to data from nearby sensors or tags.

In data source federation, it will be important to investigate the process of connecting and disconnecting devices. This topic of course also arises in input and output federation scenarios, but the sheer volume of sensors and tags available within a local area increases the magnitude of the problem. If the user is required to search for nearby devices and explicitly grant pairing rights, selecting a few sensors (or a nearby display) from a list of thousands of possible devices becomes overwhelming. On the other hand, automatically pairing with thousands of nearby devices will generally be undesirable, as the user is unlikely to *want* to interact with all of them and may be uncomfortable not knowing which devices are connecting at any given time.

Summary

Federated devices offers many opportunities for HCI research. The different types of federation, along with the required infrastructure, hardware, and software, also bring into play related research in computer security, data privacy, and trust.

Our approach will be to constrain initial investigations and scenarios to users within trusted environments, for example, enterprise workers whose work does not involve sitting at a desk, but who do need to access and update computer systems. Such intra-enterprise scenarios lessen the security and privacy risks (as well as the infrastructure requirements), allowing us to focus on interaction design and user scenarios. Wider-reaching scenarios in unconstrained environments can follow on later, adding rich new layers of investigation.

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[4] http://www.osgi.org/

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