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Using handhelds for wireless remote control of PCs and appliances

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Abstract

This article provides an overview of the capabilities that we are developing as part of the Pebbles research project for wireless handheld devices such as mobile phones and palm size computers like Palm Organizers and PocketPCs. Instead of just being used as a phone or organizer, handheld devices can also be used as remote controls for computers and household and office appliances.

Keywords: Pebbles; Handhelds; Personal digital assistants; Remote control; Appliances

1. Introduction

We believe that handhelds can improve the user interfaces of many other devices, rather than just being another gadget to be learned. Imagine the following scenario:

> You come home and aim your Smartphone at your garage, and push a button on the phone. The garage door opens. As you enter, your phone displays a diagram of the lights and appliances in your home, and you tap on the entryway light to turn it on. When you walk into the family room, the phone display changes and shows various commands useful for the entertainment system. You hit 'Play DVD', and the phone turns the DVD player on, switches the TV to INPUT-3 where the DVD is connected,

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turns on the stereo and switches it to AUX input, and finally, the starts the DVD playing. Later, you go to your home office and put the phone in its recharging cradle next to the computer. The phone display changes to serve as an extra screen for the application that is currently in use on the PC. When browsing the web, for example, the phone display has big BACK and FORWARD buttons, as well as a scroll bar for swiftly moving through pages. Since the phone is conveniently located to the left of the keyboard, you can tap on the phone display without looking to scroll and change pages, while using the mouse in your right hand. In the evening, you use the Smartphone as the remote control for your bedroom television, and also to set the alarm on the clock beside the bed. Later, you get a call from a colleague to say that a meeting is delayed for an hour, so you can sleep later than expected. Changing the alarm time automatically adjusts the thermostat to keep the household temperatures at the nighttime setting for a little longer, thereby saving some energy. The coffee maker is also automatically delayed an hour. In the morning, when you enter your car, you put the phone into its cradle, and it sends the meeting location that you had been emailed to the car's navigation system. After arriving at your destination, you give your presentation using the Smartphone display as a remote control for the slide show. You see your notes and a thumbnail-size picture of your slide on the phone's display, and you write on the phone's screen to draw on your slides. Pressing buttons on your phone with your thumb allows you to easily move back and forward in the presentation and switch to demonstrations and back to the slide show without fumbling.

All of these ideas are being investigated by the Pebbles research project at Carnegie Mellon University. They can be demonstrated now, and may soon be available in commercial products. This article summarizes the Pebbles project, focusing on the applications we have created to allow handheld devices to be used as remote controls for applications running on PCs, and for everyday appliances.

2. What is a 'handheld' anyway?

What exactly is a 'handheld device'? I define a handheld device as *a computerized, electronic machine that is designed to be held in one hand*. The definition clearly includes calculators, organizers, pagers, mobile phones (generally called 'cell phones' in the US), and Personal Digital Assistants (PDAs) such as the Newton, Palm and PocketPC. All of these PDAs are designed to fit into one hand, and have a touch-sensitive screen on which a stylus can write. The built-in functions include a calendar, address book, a 'to-do' list, and memo pad for taking notes. These devices are programmable, and it is relatively easy to add other applications that can be downloaded from the Internet.

There are about 30 million PDAs in the world, but this pales in comparison to the 1.3 *billion* mobile phone devices worldwide (European Cellular Network, 2003). Increasingly, these mobile phones contain PDA-like capabilities, and are then often classified as 'Smartphones'. The sales of Smartphones were predicted to be 4 million units in Europe in 2003, beating the sales of PDAs, according to Canlys.com (RIMRoad News, 2003).

Clearly, handhelds are becoming devices used by an increasingly large percentage of the world's population.

What is *not* included by the term handheld? My definition excludes laptop computers, for example, since they cannot be easily used while being held in one hand; laptops are designed to be used while sitting, with the computer on a table or in your lap. Also excluded are so-called 'wearable' devices, such as special eye-glasses or heads-up displays, since these are not designed to be held. However, many of the applications and user interface issues discussed in this article could also apply to such wearable devices.

It is less clear whether or not to classify devices such as TabletPCs and 'clamshell' Windows CE devices as handhelds. TabletPCs run a full-functioning operating system (e.g. Windows XP), but are designed to be used like a writing tablet rather than with a keyboard (Fig. 1a). These might alternatively be called 'arm-helds' because they are too big to be held in one hand without using an arm. Another class of devices that are questionably called "handheld" is represented by the horizontal Windows CE devices such as the Jornada 680, which have built-in keyboards (Fig. 1b). Although small, these devices are very awkward to use while being held in one hand, and usually must be placed on a horizontal surface. Therefore, I do not call tablet computers or clamshell Windows CE devices "handhelds".

3. What makes this scenario possible now?

How can the opening scenario be possible? There are a large number of technologies in development today that will soon be ready for widespread use that will make scenarios like the one above possible. These can be broken into advances with handhelds, with communication, and with appliances.

3.1. Advances with handhelds

Handheld devices are getting more powerful. Today's PDAs often run at 400 MHz, which is as fast as the PCs of just 4 years ago. In fact, the speed of the processors for handhelds, and the size of their memories, is following the well-known Moore's law for computers; doubling about every year and a half. Therefore, almost any application that could be imagined running on a PC will find adequate performance on a handheld device.

Processors in mobile phones are also getting faster. Phone manufacturers are adding more functions and capabilities to phones, and most mobile phones today are capable of browsing the Internet and running a Java virtual machine. Manufacturers are pushing towards so-called Smartphones for which a variety of applications can be downloaded, just like for PDAs. Some Smartphones provide PalmOS or Windows CE operating systems and user interfaces, though such devices usually have a larger form-factor than conventional mobile phones. Other devices run operating systems specially designed for mobile phones, such as Symbian. Newer phones also include cameras, voice recognition, touch screens, and other technologies.

The displays on the Newton and the first Palms were black and white, but current versions of all PDAs increasingly use back-lit color screens, which are much easier to read

Fig 1 TabletPC (a) and HPC WindowsCE device (b)

in most lighting conditions. Back-lit screens can be harder to read in full sunlight, but many devices, such as the Compaq iPaqs, use side-lit color screens, which are readable even in bright light. Mobile phones were once limited to small five-line displays, but now increasingly have larger color displays. These displays are often smaller than PDA screens, however, since people prefer smaller phone devices.

Battery life continues to improve, with color-display devices lasting at least 1 or 2 days between recharging. However, color devices with back or side lights still do not get the long life of the older black-and-white devices.

3.2. Advances with communication technology

In the original vision for ubiquitous computing (Weiser, 1993), all the devices would be in continuous communication with each other. The original Xerox PARCTabs (Want et al., 1995) used a custom infrared (IR) network to stay connected to the rest of the computers in the environment. However, the first generation of commercial PDAs did not have any communication abilities. For example, Sharp 'organizers' often had tiny keyboards and a number of handheld functions, but did not communicate with PCs at all. The first model of the Apple Newton only provided connectivity with other computers as an extra-cost option. One reason for the great success of the first Palm, released in 1996, was that it could easily synchronize all of its data with a desktop computer using a one-button HotSync™. PalmOS devices had built-in infrared wireless communication starting about 1998, which allowed Palms to 'beam' information to each other. Limitations of IR include that the handheld must be carefully aimed at the receiver, and the IR in handhelds tend to be very short ranged. Often the sending and receiving devices need to be less than 2 ft apart. This makes communicating using IR inappropriate for most of the scenarios described in this article, where the handheld may be at some distance from the device to be controlled, and may not be pointing at it.

Meanwhile, laptops were starting to get access to wireless technologies such as 802.11, which first appeared around 1994, but did not become widespread until around 2000. The most popular version is 802.11b, which is now also called 'Wi-Fi'. Initially, getting Wi-Fi required using a PC card (also called PCMCIA) for a laptop. Few of the early handheld devices could accept a PC card, and none had driver support for Wi-Fi cards until the Compaq iPaq, in about 2000. Eventually, handhelds with built-in Wi-Fi appeared, and smaller Wi-Fi cards (such as the CompactFlash form-factor) allowed Wi-Fi to be used with more handheld devices. Now, it is possible to get Wi-Fi access on many different kinds of PDAs. A problem with Wi-Fi, however, continues to be its high power usage. Using Wi-Fi communication on a current iPaq 5455 drains the battery in less than an hour.

Other radio technologies have addressed the power problem. In addition to research systems (Shih et al., 2002), the BlueTooth™ radio network technology was designed from the beginning to have low power usage. BlueTooth research started in 1994, but the standard was not released until 1998 with the technology not becoming widespread until 2003. Handheld devices with built-in BlueTooth are now available, and are becoming particularly common in the mobile phone market. Unlike Wi-Fi, which connects devices to the internet, BlueTooth is used primarily for connecting one device to one other device such as a handheld to a personal computer which is all that is required to

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