Dynamic Connection of Wearable Computers to Companion Devices Using Near-Field Radio

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Hewlett-Packard Laboratories, Bristol and the University of Bristol Department of Computer Science are engaged in an initiative to explore the design, technology and use of wearable computers. In particular, we are interested in the technologies (both hardware and software) required to support wireless seamless plug-and-play of distributed peripherals and companion devices.

We describe a way of connecting a wearable computer to companion devices such as displays or cameras using near-field radio technology. Our objective is not just to remove wiring from the wearable, but to have the wearable manage configuration issues without the need for conscious intervention from the user. The short-range nature of near-field radio allows relatively high data rates (300 kbps – 1Mbit), low power consumption and the interpretation of gestures as configuration requests.

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ABSTRACT

Hewlett-Packard Laboratories, Bristol and the University of Bristol Department of Computer Science are engaged in an initiative to explore the design, technology and use of wearable computers. In particular, we are interested in the technologies (both hardware and software) required to support wireless seamless plug-and-play of distributed peripherals and companion devices.

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Keywords: Near-field radio, dynamic connectivity.

INTRODUCTION

If wearable computers are to succeed as multi-function devices in the mass market then they must be both compact enough to be "unconsciously portable" and at the same time, extensive enough to be useful. Given that user requirements vary across individuals and time, a good strategy is to build a highly configurable wearable. In this case users carry just the components they want, alternatively they can rely on components being available in other places. For example, a user may chose to carry only a small, low-resolution display with their wearable, relying on fridge-mounted displays, television displays or even public-phone box based displays for most needs. On another occasion they may take a specific display in anticipation of a particular task. The big catch is that configuration must be far simpler than for today's desktop computers. Users are unlikely to tolerate untangling wires or launching dialogue boxes. Unconscious configuration is crucial if wearable computers are to succeed in the mass market.

At one level, this is a paper about making wearables literally "wireless". In this case, it is worth comparing our near-field radio solution to those described in [1] and [2]. At another level, our ambition is to make the wearable configuration process work without conscious intervention from the wearer. There are three points at which the user may be conscious of involvement in the configuration process: physical interconnection, logical interconnection and configuration specification.

Physical interconnection. Wiring takes time to fit, can become tangled, can restrict movement and is unsightly. Wireless interconnection gets over these problems – there is simply no physical task to be done.

Logical interconnection. The user may have to load drivers onto their computer in order establish a common protocol for interaction between the computer and the peripheral. This can be overcome by employing a generic protocol for computer-peripheral interaction. In principle current protocols such as HTTP are adequate for this.

Configuration specification. Users normally specify configurations through dialogue box interactions. In any case the user must be given control over the configuration of their wearable, so you might expect that conscious involvement is inevitable. In our case we would like to be able to take advantage of natural physical gestures that imply a configuration request, for example, a user may pick up a display that they wish to use. Without wishing to be drawn into whether this is truly unconscious configuration, it is at any rate the least taxing way that the user can specify their needs.

CANDIDATES FOR SHORT-RANGE DYNAMIC CONNECTIVITY

We are particularly interested in communication technologies that exhibit low-power, short range (up to 1 foot) and modest data rates (300 kbps – 1 Mbs). The action of picking up a companion device (such as a display) establishes the communication link due to the very short range. An important aspect of a suitable communication technology is that the user is not required to touch an electrode and therefore

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handling of the companion/peripheral does not have to be measured or precise.

Zimmerman [1] has demonstrated a fringing-field technology termed PAN (Personal Area Network). Data rates of up to 50 kbps have been demonstrated with an elegant, low power circuit implementation [2]. However, PAN requires contact electrodes and the data rate is limited to the poor high frequency characteristics of the human body.

We have therefore chosen to use a near-field radio system, termed "Foot-Bridge" where explicit contact to an electrode is not required. Foot-Bridge is not a competitor to PAN; it is a complimentary technology where physical contact is not required and capable of relatively high data rates. Foot-Bridge and PAN can equally co-exist in a wearable computer.

NEAR-FIELD RADIO

The authors have previously discussed aspects of near-field radio in a previous paper at ISWC '97 as part of an active tagging technology (Pinger!) developed for an Ultra Portable Computer [3]. Briefly, a low bit-rate (10 kbps), magnetically coupled near-field radio link with a range of 3 metres was developed to identify people, places and objects. Foot-Bridge employs the same principle and is currently under development.

A comprehensive discussion on the issues involved in near-field radio design is given by Demers et al [4].

NEAR-FIELD FOR CONFIGURATION SUPPORT

The key to using near-field radio to support "configuration specification" as well as physical interconnection is to mount the wearable's radio transceiver on the user's wrist or shirt cuff. The radiating/receive antennae is a single turn loop of approximately 8-10 cms in diameter. The limited range of the transceiver now becomes an advantage since the wearable is able to identify near-field enabled devices touched or held by the wearer in preference to other devices within the general vacinity.

Picking up or touching a near-field device is taken as a hint that the wearer may wish to use that device with their wearable. The hint may be taken or ignored depending on what application is running on the wearable and the capabilities of the device.

Simple detection of touch and grasp in this way provides no support for subtle configuration details such as refresh rate or display mode. These must be established starting from defaults held in the device, application or wearable platform. We also need to plan what to do when the wearable and peripheral lose contact. It seems best to leave the last image on the display for some predetermined amount of time so that, for example, details may be copied onto paper once the display has been put down.

DIVERSE APPLICATIONS

There are many different applications of near-field radio as a grasp-sensitive, short-range peripheral link:

- Companion Display. With the transmit/receive coil mounted in the cuff of a wearable jacket, simply picking up a display allows information to be viewed.
- Digital camera support. After the user has taken a picture the image is transmitted directly to the store on the wearable computer. There is only the need for the camera to store a single image.
- Wireless earpiece or eye-glass display. A collar mounted near-field transceiver allows connection to head-mounted peripherals.
- Touching a station on a near-field enabled railway map instigates a ticket buying transaction between a ticket dispenser and a wearable computer with stored Ecash.
- Grasping a door knob causes interaction between a building security server and identification held on your wearable computer.
- After selecting an object stored on your own wearable, shaking hands with another person triggers a copy to be transmitted to their wearable.
- Placing your hand on your desktop computer's mouse causes synchronisation between data on your wearable and on your desktop.
- Placing your hand on a free-standing mouse causes the mouse to be used as a pointing device for your wearable.
- A speech enabled wearable is used to drive a vending machine. The vending machine specifies the vocabulary it supports and the wearable recognizes utterances within the vocabulary.

THE RULES OF ENGAGEMENT

The wearable connects to the first peripheral that it is able to detect and once a session is established, the wearable will not connect to other peripherals that come into range.

Initial contact is instigated by the wearable, which periodically broadcasts a short signal announcing its presence. This is preferable to having the device performing the initial transmission in order to conserve power on the device which is likely to be battery operated.

If the wearer approaches two acceptable handheld displays simultaneously, then the wearable may establish a connection with either. The user may pick up one of the devices only to find that the wearable has established a link with the other. In this case the wearer can either move away from the active display until it goes out of range and a new connection is established with selected display, or they may move the active display away (akin to clearing their working area).

FOOT-BRIDGE

Foot-Bridge is currently under development; results will be presented at conference. A block diagram is shown in Figure 1;operation is at 15 MHz.

From the point of view of circuit design, Foot-Bridge differs from a conventional digital radio link only in the respect of the near-field front-end. The signal processing preceding the front-end is entirely conventional. Of course, we benefit from the particular characteristics of a near-field radio link such as well defined range or cell size, low transmit power, modest bandwidth (300 kbps – 1Mbps) and license exempt (FCC 15.223). The design issues for a near-field radio link are described elsewhere [4][3].

The loop antennae is approximately 5-8cms in diameter and tuned for resonance with a relatively low Q (5-10).

The receive path employs a standard FM IF chip acting as a direct conversion receiver. This simplifies the receive path compared to a single conversion superhet.

The transmit path uses Gaussian Frequency Shift Keying (GFSK) and a loop driver stage. The use of GFSK reduces the transmitted bandwidth of the signal by shaping the binary data with a raised-cosine filter to ensure FCC compliance.

The Media Access Control (MAC) is handled by a low cost, low power Digital Signal Processor (DSP) from Texas Instruments (TMS320C203). Foot-Bridge is operated in Time Division Duplex.

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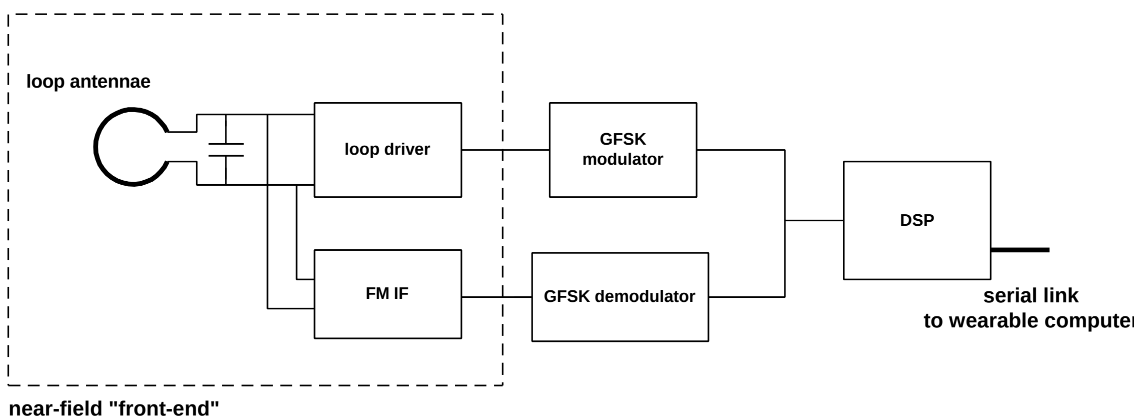

Figure 1: Foot-Bridge Block Diagram