A Bluetooth-enabled Digital Picture Frame

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This fall, devices carrying Bluetooth technology began shipping at a rate of 1 million a week. Seven out of 10 of those devices are cell phones [1]. Many of these phones are imaging-capable: in the 2003 Japanese market, only one of 10 phones did not contain a camera [2]. The trends for the North American and European markets are similar.

Camera phones represent an increasing fraction of the image capture devices that consumers use. Nokia expects images from camera phones to drive more printing than those from digital still cameras this year [2]. Consumers will demand convenient mechanisms to store, disseminate, print and view images from mobile phones.

In this paper, we address viewing images by consumers within the home. Our solution is a Bluetooth-enabled, digital “picture frame” that interacts easily with Bluetooth-enabled camera phones, cameras and PDA’s.

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Abstract

Problem Statement

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Our Solution

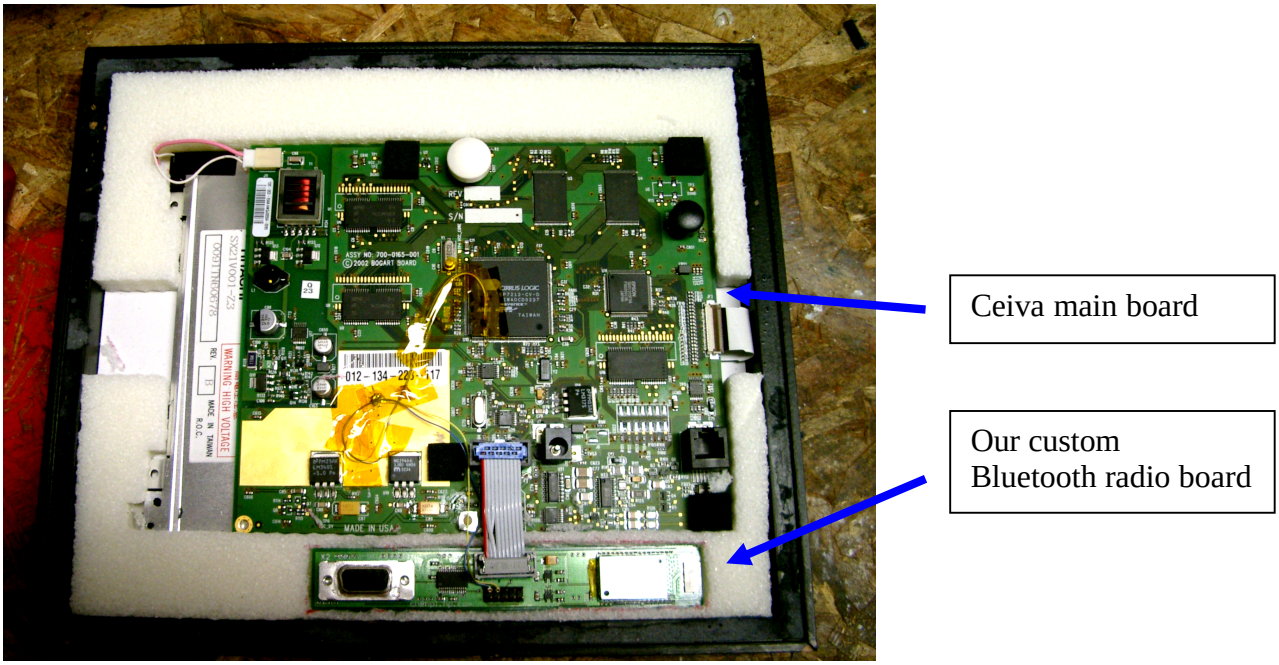
Our solution was built upon a commercially available digital picture frame marketed by Ceiva Logic. The first generation Ceiva contains the following electronics within an attractive 8"x10" matted, black, wooden picture frame:

- Cirrus Logic EP7212 System-on-Chip, containing an ARM720T core
- 8.2" diagonal VGA (640x480) resolution, STN, transmissive LCD screen
- 4 MiB EDO DRAM
- 4 MiB NOR FLASH
- Epson SED1355F LCD controller
- Analog modem

The viewable picture is approximately 5" x 7" within the matting, which overlaps the LCD panel slightly – the equivalent of bleed in conventional printing and framing.

We modified the picture frame by integrating a Bluetooth radio and replacing completely the Ceiva software stack with our own, based on the Linux 2.5/2.6 kernel. The integrated Bluetooth radio board fits nicely within the picture frame, so as not to disturb its aesthetics in any way.

Linux was chosen because of our familiarity with porting and using ARM Linux and because of its high-quality "BlueZ" Bluetooth stack. A frame buffer kernel driver for the Epson 1355 chip was written. Additional software, implemented within user space, was written to handle the Object Exchange (OBEX) protocol that phones and PDA's use to "push" objects such as images to devices, to resize the image, to write the image to the frame buffer, and to handle adjusting the contrast and brightness.



Getting Linux and a small user space to fit within 4MiB of flash and to run with 4MiB of RAM was challenging, but possible with a variety of tricks and techniques we discovered. We developed patches to remove extraneous subsystems such as FUTEX and EPOLL from the kernel that are unneeded in most embedded environments. We developed other patches to shrink caches and reduce statically allocated memory. Although there was an initially negative reaction to these patches from Linux Torvalds [5], they were eventually merged into the mainline Linux source tree and became the basis for the CONFIG_EMBEDDED configuration option that exists

in the Linux 2.6 kernel. Several developers in the community have continued this work with a "tiny" patch set that further reduces the kernel's memory footprint.

Status

Five frames have been produced. The software has been through several major revisions. The device works with all models of camera phones and PDA's we've tried Phones running the Symbian operating system, such as the Nokia 3650, require no additional software or setup to use one of these frames. The user simply selects "Send via Bluetooth," selects the frame as the target by name, and the picture appears a few seconds later.

We also developed a simple web-based interface that allows any Internet user (with appropriate access) to push an image to a frame or to any other Bluetooth device capable of accepting an image.

Each frame is also an Agile Computing device [6] and is integrated within that framework. This allows it to be a content display device for any data stored within the Agile system. Furthermore it allows the frame to be an entry mechanism into a distributed, peer-to-peer persistent store for media.

Evidence the solution works

No formal user studies have been performed, but anecdotal evidence suggests uniform acceptance of the concept and of the implementation. Remarks are typically of two forms: "Cool! Can I have one?" and "We should be selling that!"

Competitive approaches

Digital picture frames are sold by several companies. At least one contains a WiFi radio. None, however to the best of our knowledge, contain Bluetooth radios and none are focused on ease-of-use with camera phones and Bluetooth-enabled digital still cameras.

Next steps

We are investigating "hacking" the second-generation Ceiva 2 picture frame that contains a faster processor (still ARM based), additional RAM and FLASH, a USB host controller and a small hidden control panel. The extra resources available will allow us to add new features. We are considering an easy link to printing, SVG support and a better user interface.

[1] Bluetooth may be ready to break out in 2004, 24-Dec-2003, Miami Herald (FL)
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[3] IDC, Worldwide Mobile Phone Forecast and Analysis, 2003-2007
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[5] Linus Torvalds, http://www.ussg.iu.edu/hypermail/linux/kernel/0305.1/2105.html
[6] Agile Computing, ibid?