iCube: a Tangible Interface for Mobile Interaction

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A simple tangible element called the iCube, based on Bluetooth and RFID, can act as an integrated interface to content stored on a user's personal mobile device. By properly orchestrating these technologies, the invocation and operation of basic applications can be significantly streamlined, greatly reducing the barrier to interaction. A prototype interface component has been created which can control several different applications.

Mobile Platform Interaction

The Personal Server (PS) [1] is a small mobile device designed to be a repository of personal content accessible by wireless access points in the environment, such as desktop PCs, laptop, kiosks, and conference room projectors. No direct physical contact is required and the device can remain in a pocket or a bag. Normally, a lightweight GUI on the access point is used to conveniently access and manipulate data through a standard WIMP interface. The PS uses Bluetooth to communicate directly with these access points and other smaller devices found in the environment. A companion to the Personal Server, is a key-fob sized RFID reader, which might be attached to a users key-chain or in the future may even be part of a watch, that can be used to scan RFID tags attached to devices in the environment, sending the results back to the user's PS for processing.

The iCube is a simple tangible interface element that combines Accelerometers, Bluetooth, and RFID tags to provide streamlined interaction with simple applications. The device, which is a simple 6-sided cube, communicates its orientation using Bluetooth to other devices, such as a PS. In a futuristic environment, iCubes might be found near a public display as a publicly available controller. To use the iCube, the user would scan the RFID tag on the cube with their personal hand-held RFID reader, communicating the Bluetooth ID of the cube directly to their Personal Server, which would then connect to the cube and begin retrieving its orientation information. By changing the cube's orientation (i.e., which side faces up), the user could issue simple tangible commands to the system. In this model, the iCube is an ad-hoc interaction device tightly coupled with the environment, while the RFID reader is associated with the person. By establishing an association with the device through its RFID tag, the user can temporarily use it as an interface while also connecting the user (through their Personal Server) directly to displays in the environment.

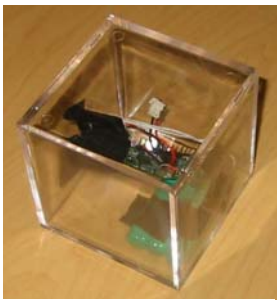
Interaction Model

The task *"Show your presentation on the projector and advance to slide 4"* involves answering several questions about the interaction:

- *what* needs to be done ("show"), indicating how to process the relevant document. In essence, when combined with *which*, below, specifies the application that should be executed.
- *whose* document is being accessed ("your"), specifying the set of objects that can potentially be accessed. The PS allows direct access to personal data instead of through a network file share.
- *which* document is to be accessed

The Personal Server

Hand-held RFID Reader



iCube Prototype

(images not to scale)

("presentation"). This specifies *which* one of *whose* documents is to be acted upon.
- *where* this document is to be accessed ("projector"). This differentiates it from, for example, showing it on your neighbor's laptop.
- *then* what needs to be done ("advance to slide 4"). Rarely is a task an isolated entity – instead, tasks are often part of a sequence of actions that are strung together. ("*then*" is really short for "*then what*".)

To execute this task successfully, the *what*, *who*, *which*, *where*, and *then* questions need to be answered. Traditionally, these are handled through a laborious process involving the standard WIMP interface. One first moves to the console for the projector (*where*), mounts the appropriate network drive (*who*), selects a document (*which)*, right-clicks and chooses to show it (*what*), and then presses the page-down key several times (*then*).

An iCube associated with a user through the RFID scanner can streamline this interaction process using physical operations to answer most of the questions. To show a presentation using an iCube coupled with a Personal Server, users can simply scan "Presentation" iCubes with their hand-held RFID readers, and manipulate the cubes to advance through the slides. Using this technique, many of these questions can be implicitly answered through the physical interface:

- *what* – the command "show" is associated with a particular iCube.
- *whose* – the personal hand-held RFID reader specified the source of material on the user's Personal Server.
- *where* – like *what*, this question is implicitly answered by association with the physical device.
- *then* – simple actions like advancing through slides can be accomplished by manipulating the physical device.

The mere action of reading the RFID tag on the iCube with one's personal RFID reader immediately answers the *what*, *whose*, and *where* questions. Rotating the cube, e.g., turning it so a different side is facing up, then can be used to indicate actions like advancing to the next slide, an area that is covered by prior tangible interface work [2][3]. Other work [4] focuses on bringing the physical devices to the user, while the iCube model brings the user and data to the physical device.

The one question that is not easily answered using this technique is *which* because there might be several presentations on a user's mobile device. However, this might be solved by using heuristics such as "last presentation shown" or "presentation pre-marked for public display." Alternatively, a separate interaction step involving the cube could be used as well, similar to advancing through the slides.

Discussion

The general iCube interaction model can be applied to many specific tasks. Reading email, simple web browsing by traversing a user's bookmarks, and music playback (Personal Server as mobile mp3 collection) are just a few possible applications. For example, a conference room might have several cubes, each corresponding to a different application (and/or public display).

Furthermore, this interaction model works well in collaborative environments, where a single cube can be used to mediate control over a presentation. The device can be passed to allow other people to change slides, or easily let them view their presentations. Similarly, multiple cubes can be used to easily control multiple screens.

For these situations, the Personal Server is necessary to provide truly mobile and/or ubiquitous interaction by enabling easy access to documents outside of a user's "home" network. Without the device, one would require an alternate data access mechanism, proffering the same basic interaction but requiring clumsy physical storage media or network data access (and changing the privacy requirements of the interaction).

Towards the development of a tangible user interface toolkit, the iCube concept outlines not only a specific domain of use, but represents a general-purpose TUI element that can be applied to many different applications. The underlying technologies of the iCube, RFID for association and configuration, and Bluetooth for data transmission, provide an ideal platform for more general TUITs.

References

[1] The Personal Server: Changing the way we think about ubiquitous computing, R. Want, et. Al., Ubicomp '02.

[2] Using an Autonomous Cube for Basic Navigation and Input; Kristof Van Laerhoven, et. al. International Conference On Multimodal Interfaces 2003.

[3] A bunch of papers by H. Ishii: http://tangible.media.mit.edu/papers.htm

[4] Bridging physical and virtual worlds with electronic tags, R. Want. et. al. CHI'99.