Multiple-Computer User Interfaces: "Beyond the Desktop" Direct Manipulation Environments

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ABSTRACT
Traditional graphical user interfaces (GUIs) are mainly designed for a single display and a set of single input devices. However, when we simultaneously use many and different types of computers (and electronic devices), such interfaces would often failed to work. As we can combine several physical devices to perform a task in a real world, we consider that it should also be possible to dynamically combine multiple digital devices. We named such concept "multiple computer user interfaces" (MCUIs). This video demonstrates several examples of MCUIs in personal and collaborative environments, including Pick-and-Drop, a digital whiteboard system with palmtop computers, and a digital table that can recognize objects placed on it.

KEYWORDS: multiple-device user interfaces, ubiquitous computing, pick-and-drop, digital whiteboard, digital table

Figure 1: Pick-and-Drop: picking-up and transfer digital information between computers

FROM A SINGLE-DEVICE UI TO MULTI-DEVICE UI

As Mark Weiser [4] and many other visionaries foresaw, our physical space is becoming filled with a number of digital devices. Some of them will be invisible (i.e., embedded in the environment); others will remain visible like today's desktop computers. In a meeting room, for example, participants often use a notebook PCs while a presenter uses a digital whiteboard. In individual work environments, we often use more than one computer at a time (such as a desktop PC and a PDA). However, it is not so easy to combine multiple computers and devices. For example, even simple GUI techniques such as drag-and-drop do not work across computer boundaries. Directory manipulation interfaces suddenly stop at the edge of one computer, and we are forced to manage several indirect and *symbolic* concept such as "machine addresses", "path names", even if target computers are physically placed in front of us.

We believe that future computer interfaces must accommodate to these situations and we named such interfaces "multiple-computer user interfaces", or MCUIs. In this video, we demonstrate our attempts in designing systems based-on the notion of MCUIs.

Pick-and-Drop: an interaction technique for transferring digital information within a physical environment

Pick-and-Drop [1] is our initial attempt for designing a MCUI, focusing on data transfer problems. Like the commonly used drag-and-drop, pick-and-drop is a pen-based direct manipulation technique for transferring digital data such as icons on a computer screen. It allows a user to physically pick up a digital object from one screen, carry it through real space, and drop it in a different place – typically a different computer screen (Figure 1). Just like chopsticks are used for moving a piece of food from one dish to another, pick-and-drop provides a method whereby a user can physically carry data as if it were a real object. Internally, this data transfer is implemented managing bindings of Pen IDs and carrying data over the networks. Pen itself does not have any storage.

Although these operations can also be implemented by using remote copy or shared file systems, we feel that pick-and-drop offers more natural and direct way to manipulate a digital object in a real space. On the other hand, with pick-and-drop, Users can be aware of physical position on computer screens, just like moving a physical object in a real world.

A multiple-device digital whiteboard design

The large display surface of the digital whiteboard makes conventional GUI design ineffective. For example, placement of menu bars or tool bars becomes a problem because they might be out-of-reach from users. Single thread features of current GUI design also prohibits parallel activities among collaborators.

We took a multiple-device approach to deal with these prob-

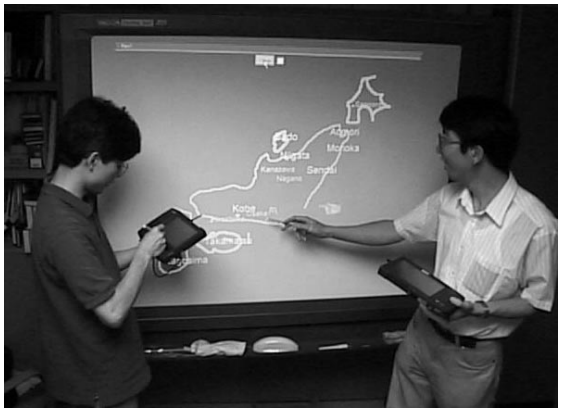

Figure 2: A digital whiteboard system using the multiple-device architecture. Note that two users are simultaneously using the same whiteboard, maintaining personal application states in their palmtops.

Figure 3: An collaborative environment with digital table and wall

lems [2]. Instead of using single display surface, we have built a digital whiteboard system using a palm-size computer as a control palette (Figure 2). A user can select a color and brush type for the pen by tapping the control panel on the palm-size computer. This metaphor is obtained from a work style of an oil painter using a canvas and a palette. This interaction style is advantageous for drawing on a large display, because users do not have to click on a tool-palette on the whiteboard, which might be out of reach. The user can also transfer digital data between any participating computers (e.g., whiteboard, palmtop, and other user's palmtop), using pick-and-drop operations.

Digital table and portable computers

We also developed a computer-augmented environment consisting of a digital table and a digital wall [3] (Figure 3). In designing this system, we paid particular attention on how the table can become a shared space for objects (such as portable computers, physical document and folders) are placed on the table.

For example, when a user sits at the table and puts his/her portable computer on the table, a video camera mounted above the table finds its attached visual marker and identifies the owner of the computer. The position of the computer (on the table) is also recognized. Then the user can use the table surface as an "extended" workspace for the notebook computer. When the user wishes to show his/her own data to other participants, for example, he/she can use an interaction technique called hyperdragging (Figure 4).

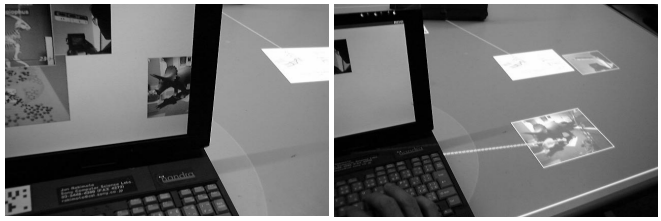

Figure 4: Moving information using "hyperdragging": A user can drag-and-drop a digital object between a notebook PC and a table surface.

A set of video cameras mounted above the table recognize real objects on the table with attached visual markers, enabling several hybrid interactions between digital and physical objects. For example, one can hyperdrag a digital data from his/her own PC toward a physical object (such as a VCR tape) and drop is to make a link between digital and physical objects. one can also hyperdrag furniture models from a portable PC to the table, or from the (physical) booklet with visual marker to the table. Then a mock-up camera (also attached a marker) is used to take a 3D snapshot of furniture layout on the table.

CONCLUSION

In this paper, we propose the importance of multiple-computer user interfaces and demonstrate several examples. Our primary goal of these systems is to extend the concept of direct manipulation into *beyond the desktop* environments. More specifically, we believe that interaction techniques must overcome the boundaries among multiple devices, and that environments must accommodate to the dynamic addition of new devices.

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