Interfaces for Managing Applications and Input in Multi-Device Environments

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Introduction

A multiple-device environment (MDE) is a physical workspace in which independent devices are networked through a software infrastructure [6, 11]. In an MDE, users should be able to create, exchange, and organize digital artifacts (documents, photos, Web pages, etc.) across devices. MDEs have great potential to improve how users collaborate with digital information.

However, to be effective, interfaces and interaction techniques used in an MDE must allow users to easily manage digital artifacts in ways that meet and extend how traditional artifacts are used in current practice. Additionally, to stay coordinated, users need advanced visualizations to help them maintain awareness of the state of devices, artifacts, and tasks in the MDE.

Our research focuses on designing and evaluating iconic interfaces to support application relocation and input redirection, two common and frequent tasks performed in MDEs. Because iconic interfaces provide a visual representation of the workspace, users are able to leverage their spatial reasoning abilities to perform necessary tasks, while also giving users a perspective of the current state of the entire workspace.

Existing Approaches

Tools like UbiTable [12] and ConnecTables [13] allow users to share applications among personal devices using virtual paths (VP). To relocate applications using

a VP interaction, users drag an application to the edge of a screen causing it to appear on the screen of an adjacent device. PointRight [7] and other projects use unified geometric paths to enable input redirection across devices. Users can move the cursor implicitly (without a UI control) among local and shared devices, and interact with applications.

In iCrafter [10], a user relocates an application by migrating the service that supports it to another device. Using an interface with a strict top-down view of the workspace, the user drags a textual identifier of the service and drops it onto the destination screen. In [8] and others, users manipulate text-based lists of devices and applications to perform relocation and redirection tasks.

In our interfaces, users manipulate a 2D iconic map of the workspace allowing relocation and redirection tasks between any two devices, regardless of the devices' physical location and without having to mentally map textual identifiers to physical devices and applications.

Iconic Interfaces

An iconic interface provides users a visual, world-in-miniature representation of the entire workspace. In an iconic interface, the walls of the workspace appear pulled down on their backsides and salient physical features such as doors, tables and desks are shown relative to their physical location in the workspace. Devices are shown face-up within the representation, providing users a distortion free view of their content. Applications running in the workspace appear on the devices sized and positioned relative to how they are arranged in the physical workspace.

To relocate an application with an iconic interface, a user selects an application's representation, drags it to the destination device in the interface, and drops it. To redirect input to a remote screen, the user right clicks on the destination device. Once clicked, the user's keyboard and mouse actions are sent to the remote device. To end input redirection, the user can use the iconic interface on the remote screen to right click on his local device, or invoke a hot-key sequence.

Advantages of iconic interfaces over existing solutions include:

- Its spatial representation supports recognition over recall [9], allowing users to leverage their spatial reasoning abilities when performing relocation tasks.

- Because it's visual, users can quickly glance at the interface to acquire and maintain an awareness of the workspace, important during collaborative work [5].

- Absolute positioning devices (e.g. stylus and touch-based input) are easily supported for performing relocation tasks. These devices are common in MDEs.

In our research, we have created several functional prototypes of iconic interfaces. In the following sections we describe two initial implementations and discuss current limitations.

ARIS

As shown in Figure 1, the ARIS (Application Relocator for Interactive Workspace) interface [2] provides users a abstract representation of the workspace. Devices, applications and other salient features in the workspace are shown in the interface. The interface also provides a yellow arrow to visually cue them to their current location and orientation in the workspace.
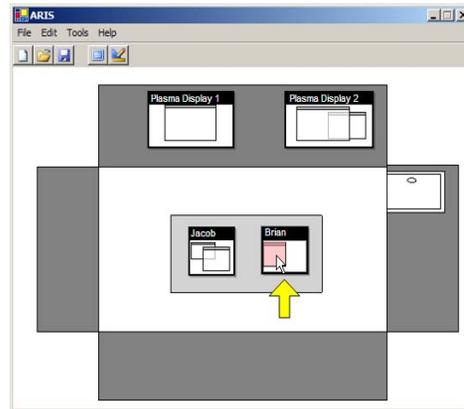
Figure 1. The ARIS interface. The interface shows each wall in the workspace pulled down on its back side so that the attached screens face upwards. The rectangle in the middle of the room represents the table which has two graphics tablets on it. Labels on personal devices can identify ownership.
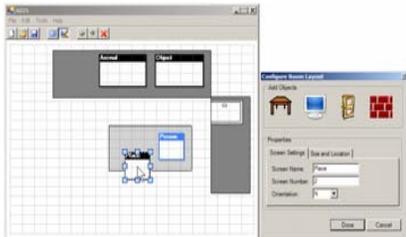
Figure 2. Our graphical construction tool enables users to quickly construct or modify a representation of the workspace. In this screen shot, the user has partially constructed the representation shown in Figure 1.

ARIS stores a workspace's configuration inside of an XML file. To create or change the configuration a user can directly edit the XML file or use the graphical construction tool included with the interface (Figure 2). With the tool, a user can drag and drop workspace components to create the representation. Because the tool is part of the overall toolset, users can quickly construct and edit a representation of a workspace.

Through several evaluations, we learned what aspects of the interface's design worked well, and which did not [1, 4]. Users found the spatial metaphor easy to use and were able to complete relocation and redirection task with little error and reasonable completion times. However, our evaluations also showed that ARIS does

not scale to a larger number of applications and fails to provide adequate awareness in cluttered situations.

SEAPort
To address the above problems, we developed the SEAPort (Scalable, Enhanced Awareness, Portal-based) interface [3]. SEAPort (Figure 3) uses zooming and animation-based interactions to improve scalability and icons and portal views with real-time updates to improve workspace awareness.

To allow users to interact with a device when some applications may be occluded (Figure 4a), we create a fan-out view that allows users to see the applications in a non-occluded view. From this view, a user can easily select and relocate the desired application (Figure 4b).

To see a larger, more detailed view of a device, a user performs a *pull-out* gesture by selecting the border of the device's representation and gesturing outward. A zooming action then centers and increases the size of the selected device (Figure 5). When a user drags an application across the zoomed device's boundary, it quickly animates back to its normal view, and the user can complete the relocation without a mode switch.

Results from a study show that SEAPort is more usable in cluttered situations and enables better recall of which artifacts are on which screens relative to ARIS [3].

Contribution to Workshop Goals
Through our experience designing, constructing, and evaluating interfaces for MDEs, we have gained a better understanding of the challenges that exist in this design space. At the workshop, we intend to share lessons learned form our experiences and discuss methods to

(a)   (b)
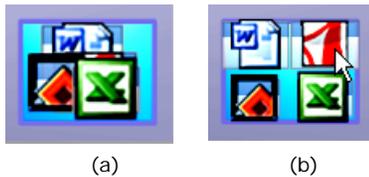
Figure 4. (a) A representation of a device with many applications, some of which are occluded. (b) The same device, but now shown in the fan-out view which eliminates the occlusion.

Figure 3. SEAPort also shows a spatial representation of the workspace. However, this interface uses fan-out views, zooming, and animation-based interactions to improve scalability and icons and portal views to improve awareness.

Figure 5. SEAPort with the rightmost screen on the desk shown in close-up view (compare to Figure 3). The thumbnails provide a live, detailed view of another screen's contents.

create better interfaces and interaction techniques for exchanging digital information across devices. We will also work with participants to better understand how MDEs can be used to improve collaborative work and devise a better understanding for how MDEs, and the activities they support, can be evaluated.

Demos, Videos and Additional Information

We have demos and videos of our interfaces at: http://orchid.cs.uiuc.edu/projects/seaport/

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