# A Cooperative Framework for Information Browsing in Mobile Environment

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## INTRODUCTION

Through pervasive computing, users can access information and applications anytime, anywhere, using any device. But as mobile devices such as Personal Digital Assistant (PDA), SmartPhone, and consumer appliance continue to flourish, it becomes a significant challenge to provide more tailored and adaptable services for this diverse group. To make it easier for people to use mobile devices effectively, there exist many hurdles to be crossed. Among them is small display size, which is always a challenge.

Usually, applications and documents are mainly designed with desktop computers in mind. When browsing through mobile devices with small display areas, users' experiences will be greatly degraded (e.g., users have to continually scroll through a document to browse). However, as users acquire or gain access to an increasingly diverse range of portable devices (Coles, Deliot, & Melamed, 2003), the changes of the display area should not be limited to a single device any more, but extended to the display areas on all available devices.

As can be readily seen from practice, the simplest multi-device scenario is when a user begins an interaction on a first access device, then ceases to use the first device and completes the interaction using another access device. This simple scenario illustrates a general concern about a multi-device browsing framework: the second device should be able to work cooperatively to help users finish browsing tasks.

In this article, we propose a cooperative framework to facilitate information browsing among devices in *mobile environment*. We set out to overcome the display constraint in a single device by utilizing the cooperation of multiple displays. Such a novel scheme is characterized as: (1) establishing a communication mechanism to maintain *cooperative browsing* across devices; and (2) designing a *distributed user interface* across devices to cooperatively present information and overcome the small display area limited by a single device.

## BACKGROUND

To allow easy browsing of information on small devices, there is a need to develop efficient methods to support users. The problems that occur in information browsing on the small-form-factor devices include two aspects: (1) how to facilitate information browsing on small display areas; and (2) how to help user's access similar information on various devices.

For the first case, many methods have been proposed for adapting various media on small display areas. In Liu, Xie, Ma, and Zhang (2003), the author proposed to decompose an image into a set of spatial-temporal information elements and generate

an automatic image browsing path to display every image element serially for a brief period of time. In Chen, Ma, and Zhang (2003), a novel approach is devised to adapt large Web pages for tailored display on mobile device, where a page is organized into a two-level hierarchy with a thumbnail representation at the top level for providing a global view and index to a set of sub-pages at the bottom level for detail information. However, these methods have not considered utilizing multiple display areas in various devices to help information browsing.

For the second case, there exist a number of studies to search relevant information for various media. The traditional image retrieval techniques are mainly based on content analysis, such as those content-based image retrieval (CBIR) systems. In Dumais, Cutrell, Cadiz, Jancke, Sarin, and Robbins (2003), a desktop search tool called Stuff I've Seen (SIS) was developed to search desktop information including email, Web page, and documents (e.g., PDF, PS, MSDOC, etc.). However, these approaches have not yet taken into account the phase of information distribution in various devices. What's more, user interface needs further consideration such as to facilitate user's access to the information that distributes in various devices.

In this article, we propose a cooperative framework to facilitate user's information browsing in mobile environment. The details are to be discussed in the following sections.

## OUR FRAMEWORK

### Uniting Multiple Displays Together

Traditionally, the design of user interface for applications or documents mainly focus on desktop computers, which are commonly too large to display on small display areas of mobile devices. As a result, readability is greatly reduced, and users' interactions are heavily augmented such as continual scrolling and zooming.

However, as users acquire or gain access to an increasingly diverse range of the portable devices, the thing changes; the display area will not be limited to a single device any more, but extended to display areas on all available devices. According to existing studies, the user interface of future applications will exploit multiple coordinated modalities in contrast to today's uncoordinated interfaces (Coles et al., 2003). The exact combination of modalities will seamlessly and continually adapt to the user's context and preferences. This will enable greater mobility, a richer user experience of the Web application, and a more flexible user interface. In this article, we focus on overcoming display constraints rather than other *small form factors* (Ma, Bedner, Chang, Kuchinsky, & Zhang, 2000) on mobile devices.

The Ambient Intelligence technologies provide a vision for creating electronic environments sensitive and responsive to people. Brad (2001) proposed to unite desktop PCs and PDAs together, in which a PDA acts as a remote controller or an assistant input device for the desktop PC. They focused on the shift usage of mobile devices mainly like PDAs as extended controllers or peripheries according to their mobility and portability. However, it cannot work for many cases such as people on the move without access to desktop computers.

Though multiple displays are available for users, there still exist many tangles to make multiple devices work cooperatively to improve the user's experience of information browsing in mobile devices. In our framework, we design a distributed interface that crosses devices to cooperatively present information to mobile users. We believe our work will benefit users' browsing and accessing of the available information on mobile devices with small display areas.

### Communication Protocol

The rapid growth of wireless connection technologies, such as 802.11b or Bluetooth, has enabled mobile devices to stay connected online easily. We propose a communication protocol to maintain the cooperative browsing with multiple devices. When a user manipulates information in one device, our task is to let other devices work cooperatively. To better illustrate the communication, we introduce two notations as follows: (1) *Master device* is defined as the device that is currently operated on or manipulated by a user; and (2) *Slave device* refers to the device that displays cooperatively according to user's interactions with a master device.