CoSearch: Leveraging Multiple Devices to Enhance Collaboration in Resource-Constrained Environments

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ABSTRACT
It is common for large groups of people to simultaneously share a single computer in resource-constrained communities in the developing world. However, sharing computing resources can be frustrating and can limit users' experience with and exposure to technology. In this paper, we present the motivation behind the CoSearch system, a tool to facilitate co-located group Web search in resource-constrained environments. CoSearch leverages additional devices that are cheap and pervasive even in developing countries in order to enhance the experience of all group members collaborating around a single computer. We also discuss possible avenues for further research on CoSearch-like applications within the context of the developing world.

INTRODUCTION
It is not unusual to see four, six or even ten people sharing a single computer at one time in the developing world. For example, economic constraints necessitate multi-user computer interaction in developing world schools where the student-to-computer ratio is 10 to 1 on average [10]. Lack of experience with technology also contributes to the prevalence of shared computing in such places as rural telecenters where single or multi-user computer interaction is mediated by a more knowledgeable individual [9].

Although there are benefits in multiple people collaborating around a single computer such as the communication fostered by shared context, there are also several disadvantages, particularly when the user-to-computer ratio is high. For example, the pedagogical value of hands-on interaction with technology is limited in these scenarios to the individual with access to the computer's single mouse and keyboard. Unbalanced access to the input devices can be frustrating for both the person controlling them, when they are inundated with commands from other members of the group, and for the other group members whose suggestions may go ignored. Also, shared computing does not support division of labor, and thus may impede groups' performance.

In this paper, we propose leveraging multiple mice and mobile phones to supplement the shared computer, in order to more evenly distribute control and promote interaction with the computer, providing a richer experience for all users. We chose mice and mobile phones as they are relatively cheap and increasingly pervasive, even in developing countries where 61% of the world's mobile phone users currently reside [4] and which includes some of the fastest growing mobile phone markets in the world [13].

We illustrate these enhanced shared computing scenarios in the context of group Web search. Multiple mice and cursor interaction has been explored in educational settings (*e.g.*, [5, 10, 11]), and has been shown to increase student motivation, engagement, and learning. Researchers have also explored mobile phone and PDA interaction with shared PCs or large displays for enhancing co-located group work (*e.g.*, [7, 8]), but none have investigated this in the context of Web search nor have they evaluated this type of interaction with people in developing countries. And, although internet access and Web content in the local languages of developing regions is currently limited, global connectivity enabled by the internet is essential for bridging the economic divide between developing and developed countries [12]. Accordingly, internet penetration and Web content creation continue to increase, justifying the early exploration of enhanced group Web search within these regions. Furthermore, because mobile phones are becoming commonplace even in developing regions, many believe the mobile phone will be the key platform for internet and Web access, helping to bridge the digital, and in turn the economic divide [2].

In the rest of this paper, we describe CoSearch, a tool for improving co-located collaborative Web search in resource-constrained environments, and then suggest further research on multi-device technologies such as CoSearch within developing world communities.

COSEARCH
CoSearch currently supports two main usage scenarios that promote direct engagement with technology by all users. In the first scenario, each collaborator controls a unique, color-coded cursor via an individual mouse (less than $5), in a Web browser explicitly customized for co-located group search on a shared computer. In this scenario, the only means for entering text is still through the single keyboard, and so search query entry must still be mediated by social protocols. However, entered queries are recorded on-screen so that any collaborator can use their individual mouse/cursor to execute a given query, producing a list of search results that the group can view. Each collaborator

can also use their own mouse/cursor to indicate Web content they wish the group to explore by clicking on on-screen links which opens up tabbed Web pages adjacent to the search results; the tabs are color-coded corresponding to each collaborator's mouse cursor to increase group awareness of the contributions of individual group members. Again, social protocols determine which of the open tabbed Web pages the group will view at any given time so as to maintain shared context and focus, but the ability to contribute by suggesting content to explore can increase hands-on participation by all group members. CoSearch also includes functionality for group members to add persistent notes to individual Web pages and to save important Web pages for later retrieval in order to help the group keep track of relevant information.

The second usage scenario offers an even richer set of collaboration features by using multiple mobile phones to interact with the shared Web browser via Bluetooth technology (using Bluetooth-enabled mobile phones and an inexpensive $15 Bluetooth USB dongle). In this scenario, one group member uses the shared computer's mouse, while other group members use mobile phones to control their own color-coded cursors (via the phone's joystick or keypad) thus mimicking all the functionality provided in the multiple mice scenario. In addition, this scenario enables all users to enter search queries via SMS/text-messaging from mobile phones (currently the most-used data service from mobile phones in developing countries [6]) or by using the shared computer's keyboard as in the first scenario. Again, search queries are recorded (and color-coded) in the shared Web browser. Mobile phone users can also select open Web pages from the shared computer's Web browser and view them on their phone's screen, thereby allowing users to read at their own pace or view different but related content than the group. Conversely, mobile phone users can share new Web pages that they find when navigating within their phones with the group by sending them to the shared computer's Web browser.

FUTURE WORK

We have conducted an initial evaluation of CoSearch and found that CoSearch enables division-of-labor while facilitating communication and collaboration during group Web search. However, this evaluation was not conducted in a developing world context. Unique characteristics of people in developing regions, including cultural differences and limited exposure to certain technologies may impact the effectiveness of CoSearch for groups of people in these areas, and thus a situated evaluation must be conducted.

Also, because internet access and Web content is currently limited in developing countries, at present it may be difficult to evaluate a technology intended for Web search. However, the interaction features implemented in CoSearch (such as sending SMS/text messages from phones to a shared display and capturing content from a shared display onto a mobile phone for personal viewing) could be applied to a broader set of applications. For example, agricultural extension is an important practice in developing countries for disseminating researched information about progressive agricultural techniques to rural farmers, often in groups [3]. Some researchers have explored the use of computer-based multimedia systems for group delivery [1], however, interactivity with these systems remains limited to a single user controlling the input devices. This may be a compelling application for a CoSearch-like system. Other possibilities for CoSearch-like systems may include applications for resource-constrained schools or workplaces in developing countries.

In this workshop we hope to brainstorm with other researchers interested in technologies for the developing world about extensions of CoSearch or alternative applications for CoSearch-like features. In addition, we hope this workshop will provide insight about appropriate evaluations of such systems for a developing world audience.

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