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THE IMPACT OF MIGRATION OF DATA TO SMALL SCREENS ON NAVIGATION

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ABSTRACT

The increased use and growing popularity of Personal Digital Assistants (PDAs) means users now have access to information on a variety of platforms. As people move or migrate between devices, from their desktops, to their laptops and to their PDAs, there is a need to maintain the integrity and context of information designed for the large screen when displayed on the small screen. Four common approaches to migration are outlined: direct migration, data modification, data suppression and data overview. For each approach, the potential impact on subsequent navigation of a web page is examined with different data types performing both simple tasks of browsing and reading and complex tasks of comparison using small screen devices. Based on this analysis, a chart compares navigation for different migration techniques and web tasks. The chart can be used to guide the migration of information from the large screen to the small screen and optimize navigation for specific tasks.

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The widespread popularity of small-screen devices, such as Personal Digital Assistants (PDAs) and handheld devices has increased the demand for data when and where users want it. Most applications and Web resources have, however, been designed with full-screen PCs in mind. There is a range of techniques to migrate the data display from one size screen to another, possibly during a session. Understandably, if an original data display is fragmented so that only a portion of it will be displayable on a small screen, the effort of maintaining context needs to be addressed. A wide variety of navigational techniques have been developed and tested for users on regular-sized screens. This paper examines navigational techniques in the context of Web access on small-screen devices.

The main constraint for data use on these devices is the small screen, which can make it difficult for users to establish a mental model of the data, often leading to user disorientation and frustration (Albers and Kim 2000). Small-screen devices may also suffer from poor resolution, cumbersome data entry with the stylus (Albers and Kim 2000), less memory, and application restrictions (such as no applets or Javascript). In addition, users often are in environments with distractions of noise, interruptions and movement of the handheld device (Jameson et al. 1998).

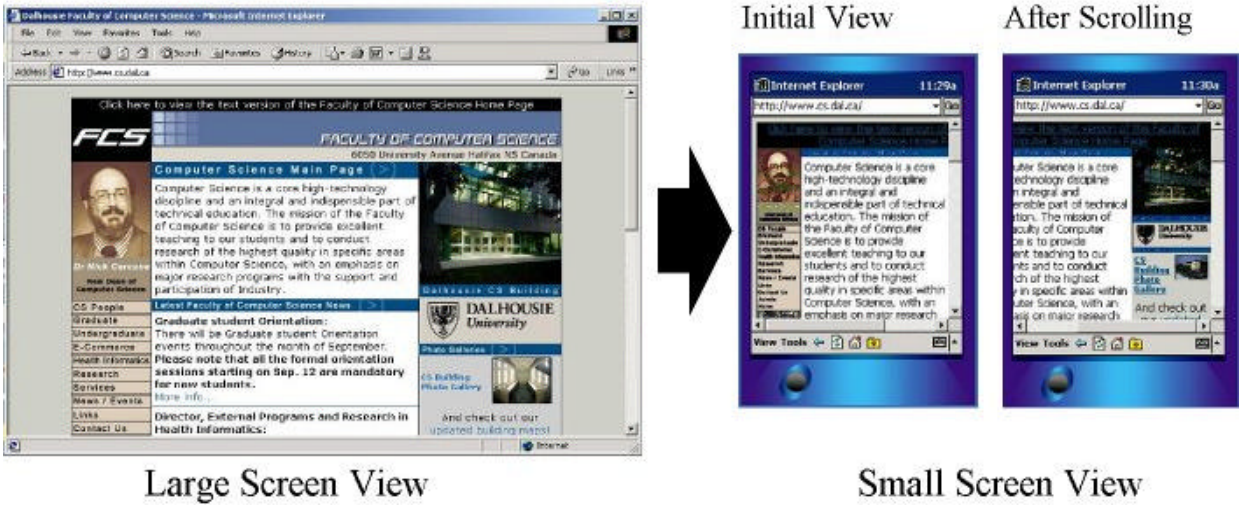
Migration is the process of taking data displayed on the large screen and transforming it to view on the small screen. Navigation is how users move through the information, once it has been migrated to the small screen. The general migration techniques are categorized into four broad types: direct migration, data modification, data suppression and data overview. For each of these techniques common navigation techniques are identified and analyzed for suitability across user tasks and data types.

DIRECT MIGRATION

The simplest and most frequent migration technique of data, particularly Web pages, is to send data to the device and let the user cope with it there. With direct migration, there is no change made to the actual data or its organization. This technique is a fast, cheap transformation requiring little system or human intervention. However, it fails spectacularly when the original is based on a table or frames as a whole, such as the Web page for the Dalhousie Computer Science Department, as illustrated in Figure 1.

To reduce the need for horizontal scrolling when data is migrated from a large to a small screen, some software, such as "dciper" (http://www.greenlightwireless.net), applies a wrapping technique that automatically removes horizontal scrolling. While this does eliminate the need to scroll right and left, wrapping the data onto the small screen may require a considerable amount of vertical scrolling for an entire row of data shown on the large screen.

FIGURE 1: DIRECT MIGRATION OF DALHOUSIE COMPUTER SCIENCE WEB SITE (HTTP://WWW.CS.DAL.CA)



A variation on this technique is the creation at source of duplicate Web pages that are intended for use on the small screen, for example Avantgo (http://www.avantgo.com). The disadvantages of this duplication are twofold. First, this technique requires human effort and duplication of maintenance effort, and second, with over a billion Web pages now in existence, the prospect of Web coverage is slight.

Navigation: There are two main navigational approaches when migrating data directly. If the data is presented as the original document, the user must scroll horizontally and/or vertically. If the original document is divided into pages, then the user navigates by clicking Next or Previous Page, rather than by scrolling.

Research on large-screen devices has shown that users cope better with vertical scrolling than they do with horizontal scrolling (Neilson 1997). Paging reduces scrolling and visual cues, such as page numbers or scrollbar labels (Olsen Jr. 1992), may provide context for the user (Spence 2001; Jones et al. 1999). Still, both scrolling and clicking have been found to negatively affect the completion of tasks (Albers and Kim 2000; Dyson and Haselgrove 2001, Jones et al. 1999). Scrolling, in particular, can obstruct the formation of relationships between pieces of information necessary for the creation of a mental model (Albers and Kim 2000). The limited display of information on a small screen increases the need for paging and scrolling, as illustrated in Figure 1.

Suitability: Simple migration techniques seem to support tasks relating to reading and browsing/scanning sequential data. In these cases, the data is

best understood within its local context. For example, when users fill out a form, they tend to read it in a consecutive order and can frame their answer from the questions that are near to the current entry. One might speculate that scrolling favors browsing and paging favors reading tasks because the text does not move. The presentation of data in the long, sequential format presents problems, however, with comparison tasks. The combination of the small screen and direct migration restricts the user's ability to conceptualize the context of the information when jumping to sections of the document; this can cause disorientation and errors (Albers and Kim 2000).

Direct migration with simple navigation is best suited for compact data types, such as short text, sequential text, lists and menus that can be displayed within the width constraints of the small screen. It is less suitable for tables (Watters and Duffy 2002), graphs, maps and diagrams/images that may require both vertical and horizontal scrolling, thus increasing the risk of navigational disorientation.

DATA MODIFICATION

A second method for migrating data to small screens is to modify the data, for example, reduce images, change tables to lists, or summarize text, thereby saving on download times and device memory (Mani 2001). Text summarization reduces paragraphs of text to a few key sentences, phrases or passages to provide a shorter, more concise representation of the original piece. For example, at the Wired News Web Site shown in Figure 2, users must scroll to see more summaries, and they can click a summary title to retrieve the full article.

Users can employ the summaries to quickly decide the relevance of a document or document set (Mani and Bloedorn 1999; Mani 2001). Generating good summarizations is a subjective process, accomplished either by a system or a human expert (Fukusima and Okumura 2001; Mani and Bloedorn 1999; Amitay and Paris 2000). Therefore, summaries may not be applicable for certain user tasks.

Navigation: The main navigational techniques for this migration method are to scroll or page through the summaries serially in their reduced form. Some sites provide only the summarized version of the components, whereas other sites allow users to click to retrieve the full data. This navigation process duplicates a serial looping action shown in Figure 3, where the loop represents clicking to view the original source data.

FIGURE 2: SUMMARIZATION ON THE WIRED NEWS WEB SITE (HTTP://WWW.WIRED.COM/NEWS_DROP/PALMPILOT/INDEX.HTML)

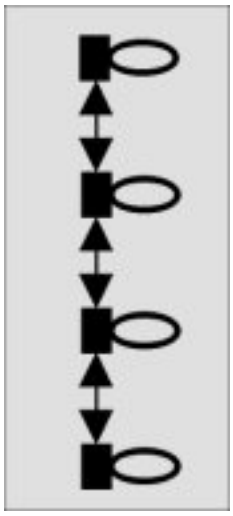
Suitability: This style is suited for Web-browsing tasks where the user wants a general notion or snapshot of the information available. Users can go directly to sections and quickly navigate the information, with little scrolling needed to determine the relevance of a document or document set. Most reading tasks rely on access to source information. Without all the data, it would be hard to locate specific information or to make logical comparisons of information within the document. Data modification may not be appropriate when users require access to exact, complete data, such as medical procedures or some legal documents.

Summaries must have a direct semantic relationship to the original information, making them more suitable for full text and data with a built-in hierarchy, such as lists and menus. Successfully transforming cross-referenced types of textual data, such as tables or graphs, could be challenging. Summaries would be less useful for numerical data, including dates, financial figures, weather and price—unless it was coupled with some visualization of the data.

DATA SUPPRESSION

This migration method removes data to make a small-screen version that displays skeleton information with some way of retrieving the source data. Displaying only skeleton information can simplify navigation and may reduce disorientation (Spence 2001). There are many approaches to suppressing data,

FIGURE 3: LOOPING NAVIGATION PATTERN FOR DATA MODIFICATION MIGRATION METHOD



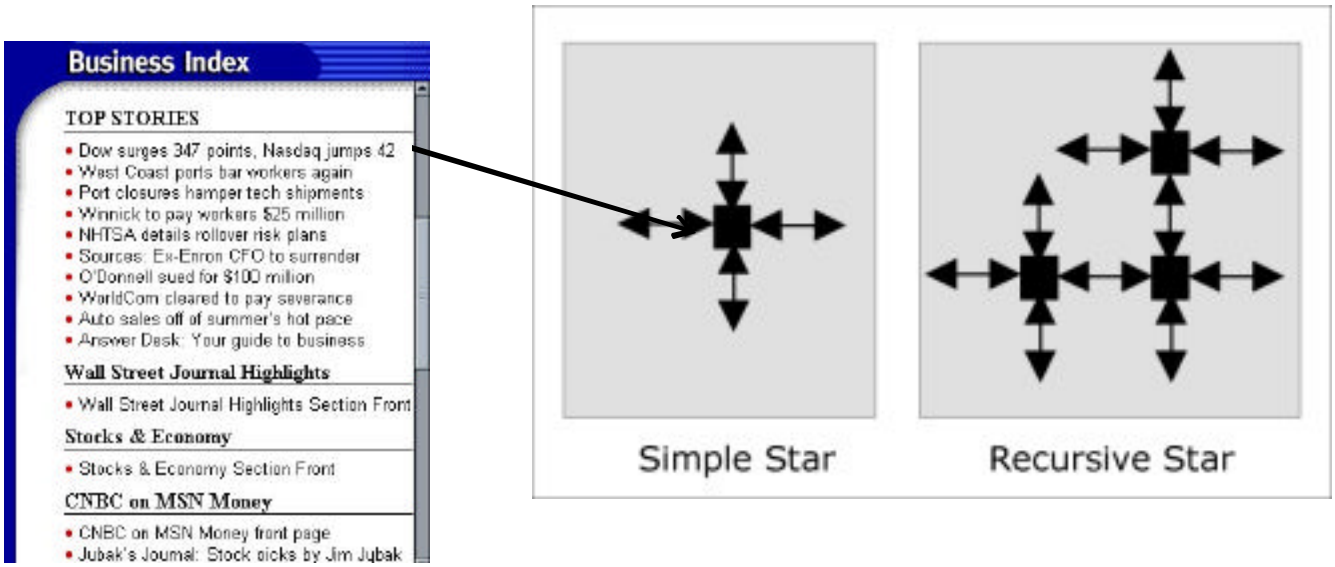
such as selecting keywords, using first *n* words or sentences (Drori 2001; Drori 2000) or Z-thru mapping that imposes selective display (Spence 2001).

Navigation: Users can navigate by clicking to expand or compress data selections, returning to the skeleton. Component markers, such as headings are viewed together and can be selected for expansion. After each selection, the user returns to the skeleton view to investigate other components. Navigation can be done in a simple star pattern, or in a recursive star pattern for multiple layers of suppression. The center of the star represents the skeleton view, as seen in Figure 4. The MSNB Web site (http://www.msnbc.com) uses titles of articles for its skeleton view. Each click takes the user to a full story and then back to the skeleton view.

Suitability: This approach allows the user to browse easily by suppressing unnecessary details. Users can choose to read specific sections or all the information, either sequentially or selectively, making it suitable for different reading tasks. Searching for specifics to compare items becomes difficult if the data is contained in the suppressed portion.

Data with structure or data with identifiable headings such as tables, graphs, maps, hierarchical menus or hyper-media text documents are suitable for this format. For example, suppression for an accounting spreadsheet in a table format could enable the user to display those columns with specific totals and to suppress entry rows with totals under a certain amount. Sequential data with little structure, such as lists and flat diagrams or images would be less compatible to manipulate into categories for suppression.

FIGURE 4: STAR NAVIGATION PATTERN FOR DATA-SUPPRESSION, MIGRATION METHOD



DATA OVERVIEW

For this migration method, an overview of the entire data set is generated for the user. The user can choose a focal point within that overview in which data is displayed at a fine-grain level, while a global representation of the entire data always remains visible. Information is not suppressed; rather information may be layered, distorted or shrunk, but it is always available. The construction of the overview can include a visual representation, hierarchical structure, text or list. This overview approach makes it easier to navigate large amounts of information and lessen disorientation (Spence 2001; Furnas 1986; Bartram et al. 1995; Storey et al. 1999). The most common techniques include the following:

- Focus + context (Spence 2001; Björk et al. 1999; Björk 2000; Buyukkokten et al. 2000; Mukherjea and Hara 1997; Mukherjea and Foley 1995),
- Fisheye techniques (Spence 2001; Furnas 1986; Storey et al. 1999; Bartram et al. 1995),
- Context maps (Spence 2001),
- Zoom and pan (Good et al. 2002; Spence 2001),
- Menu over page information (Kamba et al. 1996),
- Brushing techniques (allow users to brush their stylus over the overview to reveal more detail, such as riffling techniques (Spence 2001),
- Content lens (Dieberger et al. 2002) and,

- Image representation of the layout (Jones et al. 1997).

While this overview approach may be difficult on a small screen, it is an appealing approach. The small screen can limit the amount of global context to be viewed at one time or make the global context so distorted or small that it becomes useless. Movements while using a small-screen device could create further distortion, or could make it difficult to discern what has been distorted or shrunk. Still there has been some successful adaptation to the traditional approach for large screen to compensate for the screen size, such as the West Browser (Björk et al. 1999) and Flip Zooming (Björk 2000). Therefore, it merits further consideration.

Navigation: Users generally navigate through overviews using their stylus to select focus points. Users can click, click and drag or brush an area on the overview to display detail. There is however potential for new, innovative, navigational techniques to exploit this context.

Suitability: Users can navigate easily to browse through vast amounts of information by choosing different focus points to get an indication of the information and to locate specific information. The layout of the information can make it unsuitable for some reading tasks, depending on the data type and the clarity of the overview. On the large screen there are approaches that allow more than one focus point at a time to be viewed within the overview, for example continuous zoom (Bartram et al. 1995), making it easier to compare pieces of data within the whole. Although not practical on a small screen, data overviews allow users to compare details within context.

This overview format can be used with all types of data and may best suit types of data difficult to navigate with other approaches, such as graphs, tables, maps, long documents, diagrams or images, libraries of images and documents that contain a combination of many data types. For example, most users, when checking a map, will focus in on some relevant detail, such as a town or a street, but they still want to maintain the relationship with the context of the whole map, such as identifying close global landmarks. This approach enables users to locate specifics and relate how they fit within the whole, with little or no scrolling. Figure 5 demonstrates the focus and context approach with the Dalhousie University Computer Science Web site (http://www.cs.dal.ca). The site layout for a large screen is reduced to fit on the small screen, while maintaining the large screen layout and eliminating scrolling. Users select elements on the Web page, which are enlarged within pop-up windows, bringing focus to the context. This reduction method allows users to migrate easily with no changes to the visual layout of Web sites between devices.

FIGURE 5: FOCUS AND CONTEXT VIEW OF DALHOUSIE COMPUTER SCIENCE WEB SITE (HTTP://WWW.CS.DAL.CA)

SUMMARY

Trade-offs exist between what a user wants to do and the type of data to be displayed, when deciding whether to migrate information from a large screen to use on a small-screen device. Each migration technique has navigational advantages and constraints. A compilation of the migration techniques is presented below in Table 1, a "Best of Breed" chart to help choose the approach for particular user tasks. The chart can be expanded to include data types.

Both paging and scrolling are used to navigate data when migration is based on direct migration, data modification or data suppression. Scrolling is better suited for browsing, and paging enhances reading tasks. "Expand" can be used to navigate information after migration, using data modification or data suppression. "Expand" is suitable for all three tasks. The "focus + context" navigation technique is generally used with overview migration; it is suitable for both browsing and comparison tasks.

TABLE 1: BEST-OF-BREED CHART

Navigation Technique	Migration Technique				Task Types		
	Direct Migration	Data Modification	Data Suppression	Data Overview	Reading	Browsing	Comparison
Scrolling	✓	✓	✓			✓	
Paging	✓	✓	✓		✓		
Expand		✓	✓	✓	✓	✓	✓
Focus + Context				✓		✓	✓

Table 1 shows how to help identify suitable migration techniques from a large screen to small-screen devices, depending on the expected user tasks. Ongoing research will examine the benefits of using a combination of migration techniques and the feasibility of adapting the migration technique, dynamically based on the user task and data type. In particular, new and innovative navigational techniques will be explored for the data overview approach. A prototype will be developed and user studies will be conducted to find the most effective visual layout for comprehensive presentation and navigation on small-screen devices.

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