Facilitating Context Switching Through Tangible Artifacts

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Abstract
Modern information workers typically juggle multiple tasks at the same time and manage these multiple task threads or working contexts through either physical or digital artifacts. These artifacts help the worker to keep track of the identity and state of the tasks. This practice of using artifacts in this manner isn't as well supported for digital representations of work contexts. This paper details work on a prototype system, "Context Manager", that creates explicit representations of work contexts and their related documents and links them to physical RFID-infused artifacts. An evaluative study of the system was conducted and its findings are analyzed in accordance to grounded theory.

Author Keywords
Project management; context switching; context recollection; physical interfaces; tangible interaction

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces. Physical user interfaces.

Introduction
A commonality shared between modern information workers across fields and positions is the demand to handle multiple ongoing projects, each one possessing

Example Challenges to Context Switching in Digital Work:

Application Model for Events Instead of Activity: Information technology supports individual tasks like word processing but not for the integration across tasks for a given work context [1].

Challenges to Integration of Resources Across Digital/Physical Divide: Documents related to a project are often distributed across physical (e.g., a notecard) and digital media (e.g., an spreadsheet), making it challenging to keep them together without converting them into another medium [2].

Recovery of Resources but Not Mental Context: Existing work on task management has focused on resource retrieval and less on the recreation of a particular mental work context [3].

its own constellation of goals, resources, people involved, and time framework [1]. When information workers engage in any of these projects or "working contexts" they frequently need to switch between one another either by choice (e.g., adhering to a schedule) or by demand from the environment (e.g., an officemate asks for information pertaining a work context out of current focus). Information workers return focus to projects through strategic use of special artifacts such as post-it notes and email to aid in the prioritization and maintenance of attention when changing or resuming to a particular project. Artifacts such as these act as containers that hold information relevant to their respective working context as well as its status either implicitly as a result of its lifespan within specific tasks as is the case of files and piles present in one's physical desktop, or explicitly as when users write notes to themselves. [2, 4]. Generally, these strategies work by overcoming working memory overheads [5] by offloading reference to projects into the environment [6].

Use of these context management strategies are challenging with respect to digitally represented elements of a work context as described in the sidebar. Altogether, these issues prevent users from engaging in embodied visuo-spatial organization [7] of their working context; making the task of reminding and re-finding difficult.

Taking consideration to how physical artifacts are used in context switching of projects, this paper seeks to understand how the re-representation of "working context" through physical proxies can better support the context switching strategies of information workers. A prototype system referred to in this paper as "Context Manager" is studied, to help us to understand how users interact with physically represented digital work contexts. In this investigation, two key research questions are posed: **RQ1** ("*What physical properties of the proxies do users recognize in aiding context switching?")* and **RQ2** (*"How does digital context switching by physical proxy compare to other existing strategies employed by users?"*). In answering these two research questions, the paper is organized as follows. First, the implementation of a "Context Manager" is detailed. Next, the evaluation study is described. The results of the evaluation study are analyzed in accordance to grounded theory approach. Finally, findings are discussed, highlighting user's reactions and suggestions for the design of the system.

Context Manager System

"Context Manager" is a tangible user interface that creates digital work contexts and links them to blank credit-card-sized RFID-infused physical cards [8]. The digital work contexts in the system are modeled as consisting as the set of webpages, applications, and documents involved in engagement of a task. When a digital work context is created and named, a user can drag related documents and folders into the "Context Information" bar as seen in the middle of the screenshot in Figure 3. Alternatively, users can save a digital work context by pressing "save session", resulting in saving the set of documents, applications, browsers alongside their spatial position within the display within that given work session. A work context can be linked to an RFID card by tapping the card and pressing the "associate" button on the right half of the interface. When switching to a specific work context or between them, users can do this by either tapping a

Figure 1 Context Manager System

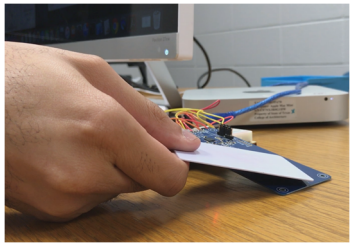

Figure 2 RFID Card Interaction

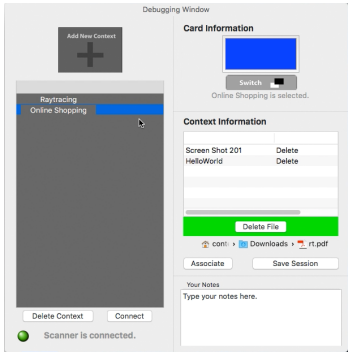

Figure 3 Context Manager Application

card on the reader (Figure 2) or pressing the switch button on the right top half of the screen. (Figure 3).

Context Manager as a interactive system is organized in between two major components. Hardware implementation consists of multiples of RFID cards [8] (Each card possesses a unique 16 digit identification number), an PN-532 breakout board [9] (receives data from RFID cards), and a Arduino Uno microcontroller [10] (transfers data from the breakout board to a PC by serial link). Software side (Figure 3) development was written for MacOS in the Swift programming language [11]. ORSSerialPort library [12] was used to handle serial port communications with the Arduino. and Apple's CoreData framework [13] was included to support database management.

Evaluation

The goal of the evaluation was to elicit a reaction from the user's engagement with the system. We sought to find out how the system compares to their existing practices or how it might be appropriated into them. A total of eight graduate students participants from Computer Science or related fields were recruited.

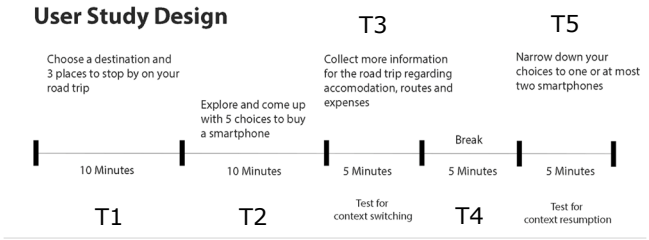

Figure 4 Evaluative Study Procedure

Each participant followed a sequence of timed activities for each observation session conducted (See Figure 4). Parts T1 and T2 alternate between two conceptually different tasks, serving the purpose of creating the initial work contexts (Figure 4). When switching tasks from T2 to T3, it acted as a test for context switching as they return to task established in T1. During T4, the participant is given a 5 minute break and is removed from the study room. As the participant returns to the room in T5, the participant is being tested for context resumption, as they resume the work that was started during phase, T2.

After the main study, participants are asked two sets of questions. The first set of questions (Figure 5), serves the purpose of triggering participants to access either one of the two generated work contexts in the system to answer the question. The second set of questions were for a semi-structured interview to account for the participant's experience and thoughts towards the prototype system (Figure 6).

Transcription of audio recorded data was handled by Inqscribe [14] and subsequently generated documents underwent qualitative coding through Max QDA [15]. During qualitative coding, the grounded theory approach used by Charmaz and Strauss [16] was used to generate codes during the "open coding" phase. Next, codes were organized with similar codes under related categories in "focused coding" phase. Finally, categories were organized from thematically related categories to broader themes in the "axial coding" phase (Figure 7).

Question No.	Task No.	Context Specific Question
1	1	"How distant is your destination and what is the route you will be taking?"
2	2	"Which mobile deivce has the higest screen/display resolution?"
3	1	"What are your cheapest options for travel accomodations?"
4	2	"Which of your chosen potential smartphone purchases has the greatest procesing power?"

Figure 5 Context Trigger Questions Used in Recall Phase

Question No.	Interview Question:
1	*"If you had the opportunity to use this device/application solution in your day to day practice, how exactly would you useit? How useful would it be?"*
2	*"How does this means of interaction compare to your current strategy in managing multiple project contexts?"*
3	*"What would you suggest for future iterations? If you had the power to change any element, what would it be?"*
4	*"Recall how swiching is peformed through the application. You have the option to perform this through either the digital "Switch"button or through the cards. What are your thoughts on the use of the cards in of themselves? Do you see any benefit in using them?"*

Figure 6 Questions Used in Semi-Structured Post Study Interview

Open Coding	Focused Coding	Selective Coding
"P2-States cards are a key that brings him back to work", "P4-User is not sure how having many RFID cards would be useful","P0-Helpful to have a physical copy of workspace","P1-Says that each project is a card"	*"Understanding of Card Representation"*	*"User Response to Card Switching"*
"P7-User prefers switch buttons because of potential need for several cards", "P6-Preferred to use the switch button because the cards have dependencies","P2-User asked if there way to switch without cards"	*"User Preference of Switch Button Over Card"*	
can scan and have everything available", "P2-Nice to work around lab and scan card to resume everything", "P0-Can use card to continue where I was working"	*"User Reported Benefits of Card Switching"*	
...	...	

Figure 7 Sample of Three Stage Coding Approach for Data

Results

Following the analysis, generated codes were organized into four major high level categories.

Current Context Management Strategies

This category highlights comments users made in reference to their existing strategies for digital context switching after engaging with the prototype system.

"Multiple Computing Device Use": One user, who regularly finds themselves working with multiple computing devices, manages his contexts by way of the cloud based services such as "Google Drive", taking it upon himself to assemble his project's contents and reintegrating them with their cloud-based representations (P0: "*I use Google drive folders to manage multiple projects...I make sure to update to the file with version names and dates.*").

"Workspaces and Virtual Desktops": Some users manage multiple work contexts through the use of "Virtual Desktops" as common in "Windows" and "Linux" operating systems or "Spaces" in MacOS. One user maintained his work contexts by keeping certain project collections running for extended periods and organizing them in specific "Spaces". This approach however, was not without its own issues (P2-"*Because the apps will be opening and closing, it takes time to do it. Also, one of the biggest issues in switching between tasks because you wind up switching basically all the desktops spaces until I find the one that I was looking for.*").

"Window Management Strategies": Other users manage contexts in a similar manner as those using "virtual desktops", where instead the unit of organization could be a single window manifesting in the foreground as tabs (P0- *"I usually organize my work with one browser. I click a bunch of tabs to find out what I'm doing."*) or as bookmarks to be accessed (P4- *"In managing multiple projects for websites I would save bookmarks but those can get quite cluttered quite easily."*).

User Response to Content Saving

Participants of the study noted the immediate benefit of saving a session where for some, its benefit was derived from being able to persist a work session between shutdown (P2-"*Also the idea that maybe I can save between sessions between my computer turning off and on again, that would be very useful.*") and subsequently resuming it as before (P6-"*We do a lot of programming on web applications like Cloud 9. We use it when we have multiple projects. Being able to save a sessions and resume it would be pretty exciting and I have never used anything like that before.*")

Following from their experiences, participants provided suggestions on how to better improve the session saving functionality of the current system. A request shared by participants "P1", "P6", and "P7" is the expansion of the kind of application sessions save (P6- "Right now your functionality extends only to browser. If it extends to other software then it would be definitely really more helpful. ") as well as the quantity of saved session windows. Another idea proposed by two separate participants suggested supporting the saving of not just one session per context but to contain several time displaced versions of the same context, acting as a rollback feature of sorts (P5 - "*If I forget to save a session, when I come back, it might not be there. Also if I saved it, there is no way of going*

back to previously saved versions. If there is an option of rolling back to what session it was before that would be great.")

One noted issue observed during one study was the tendency of users to forget to save a context unless otherwise told to do so before switching. This issue could be explained by a sentiment expressed by one participant stating (P5- "*Right now, I have to maintain a context, create a context, and save it. If there is some way that I can bypass like an interface that you can do all that like save it.*").

User Response to Switching

The switching functionality of the application, broadly seen as a benefit across participants for managing multiple tasks, held diverse opinions of which implementation was preferred.

"User Reported Benefits of Switching": Users noted that the card's benefit in context switching was the reduced amount of time in gathering one's resources (P4-"*Whereas it would take me a couple of minutes to load up everything but if I could save the project on here so all I had to do was swipe this thing and 10 seconds later I was back to where I used to be.*"). For some participants, it was the reduced effort in searching that the switching functionality derived its benefit (P2-"*I like that I don't have to be searching for the workspace I was going to do the work in. I can just scan it and have everything available.*").

"Reported Benefits of Card Based Switching": Broadly, users noted that the card offers an immediate means of re-accessing one's information (P7-"*It was more work to move my mouse and find where to click, choose it click it, change sessions. With this you can just tap it and it brings it up. If I'm giving a presentation or something, I can just use the card and tap rather than using the mouse and click on it.*")

"Physicality of the Cards": Users when reflecting on how the card was used in supporting context switching, frequently noted the card's physical attributes contributing to user experience.

For some users, being able to hold the card enhanced the experience of switching by notion of simply being able to hold the interaction means (P4-"*Uh right now with the current iteration, the switch button on the application itself and the cards perform the same task so there isn't much of a difference rather than hitting the button, the switch on here. Swiping the card. But I will say that swiping the card feels a lot more better than just hitting the button. Interviewer: And why is that? Participant: Why is that? You can hold it. Its tangible. It feels nice. It also feels faster*"). The previous sentiment was not shared by other participants, where they saw the card's physicality as a burden in the switching experience either in terms of its size (P1-"*Limited space on the card to write and Sometimes have to remember what project the card denotes.*"), appearance (P6-"*But the cards are not always distinct. So I would have to search for them on my own.*"), or what it entails in potential space consumption (P1- "*Cards need physical space to store all of them.*").

"Understanding of Card Representation": Users based on how they described their interaction with the system suggested their own understanding of what the

Future Directions:

Short Term: With respect to application development, a wider array of applications to support the re-access of context will be supported, focusing first on consumer wide applications such as Adobe Photoshop or popular word processing programs. In terms of study design, we plan on using the existing design and compare how users engage in context switching strategies by solutions such as virtual desktops.

Long Term: Longer term interests within the project is concerned with the direct study of the "Context Management" system in real world settings such as an office where such a system should see applied use and appropriation.

cards themselves represent with respect to supporting context switching.

Three users thought of the cards as physical analogs of their respective projects, with one user extending this line of thinking as to why cards would not be effective in scaling with the quantity of projects (P1- "*One card per tasks will make me have lots of cards for multiple tasks.*"). Another user provided a different mental model, likening the card as not a representation of the project itself, but rather serving as a key to re-access those contents and consequently regain context (P2- "*What does the card represent to me? It kind of represents a shortcut. But at the same time, it's more than a shortcut. It opens everything. Automatically. So it's a "key", that brings you back to where I was.*").

Discussion

RQ 1

Users as a whole when engaging with "Context Manager" noted that the spatial, visual, and tangible attributes supported context switching. The notion of the cards consuming space can be considered both beneficial in terms of searching by it being visibly seen or detrimental in just one more item taking up space within one's physical workspace, as claimed by one participant. The tangible properties of the cards inspired different meanings from users ranging as a kind of key to a work context or as a handle to it. As one user stated, he was well aware that switching between both card and button had the same result, but the difference was that being able to handle the card enabled him to give it a special kind of regard as a real entity, the context, than what it might be possible if it were purely digitally represented.

RQ 2

The system's approach to digital context management differed from user's reported existing strategies in regards to how it handles notions of spatial organization and persistence of work. While spatial organization was simulated by digital representation, this was limited as one's display would allow. A technique like a "virtual desktop" aids by creating space and persisting content, this is in a destructive manner, removing a work context of an unrelated working context out of view. The "Context Manager" system attempts to support both issues by moving organization out into the physical work desk, allowing for multiple contexts to be in focus but also in one's periphery.

Conclusions

Context switching through the use of artifacts throughout physical and digital media is key to this practice. When engaging in context switching in regards to digital contexts, issues of visuospatial organization alongside screen space and content persistence pose a challenge to this activity. Noting the use of physical attributes of the artifacts that users employ when context switching between projects, this study sought to understand how these same attribute can be used to support digitally represented work contexts. The initial results of our system, "Context Manager", suggests that the use of physical proxies by way of cards potentially allows users to organize elements of a digital work contexts in a manner similar to their physical counterparts. Future studies, as detailed in the sidebar, seek to further understand the user's experiential understanding of this approach. In addition, we will compare our system directly to existing user defined context management strategies.

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