A Tangible Difference: Participatory Design Studies Informing a Designers' Outpost

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ABSTRACT
In our previous studies into web design [11], we found that pens, paper, walls, and tables were the primary tools used for explaining, developing, and communicating ideas during the early phases of design. One common practice was to produce information architectures using paper on walls. This practice inspired us to work towards The Designers' Outpost, a tangible user interface that combines the affordances of paper and large physical workspaces with the advantages of electronic media to support information design. In this paper, we describe a series of three participatory design studies that explored the combination of physical and electronic media.

Keywords
Tangible Interfaces, Web Design, Sketching, Information Architecture, Computer Vision, Informal Interfaces, CSCW

BACKGROUND AND MOTIVATION
In our previous studies into web design [11], we found that pens, whiteboards, paper, walls, and tables were primary tools used during the early phases of design. Later phase design, where detailed page mockups are generated, occurs mostly on the computer. This finding is not surprising, and is consistent with work practice studies across many design and engineering domains [2, 5, 23]. In one common early-phase practice, designers collect ideas about what should be in a web site onto Post-it notes, and arrange them on the wall into categories. This technique, often called affinity diagramming, [3] is a form of collaborative sketching used to determine the site structure.

The large workspace offers several clear benefits for the task. It permits the representation of large, complex information spaces without the loss of contextual, peripheral information. Collaboration is aided both by the persistence of the artifact, which supports asynchronous collaboration and constant awareness of the state of the project, as well as by the greater-than-human-sized space allowing multiple people to simultaneously view, discuss, and modify the artifact.

However, there are drawbacks to a paper-centric representation. Much of the information exists in the *relationship* between information chunks (Post-it notes). Because structure must be maintained manually, marks the designers make about the data, such as links or groups, often fall out of sync as notes are shifted around. At some point, the paper is removed and the site structure display is lost. The designers in our studies also lamented that versioning is unfeasible in a paper only representation.

This work practice offers few opportunities for remote participants. We also found, as others have, the transition from the early paper-centric design stages to the later pixel-centric stages to be highly problematic [15]. Those who worked hard to architect the site feel a sense of lost ownership as the project is "thrown over the wall" to graphic designers and developers.

We describe a series of three participatory design studies to develop The Designers' Outpost. We first evaluated the basic concept with a paper prototype study. Next, we built interface mock-ups that envisioned the combination of physical artifact state with interactive feedback. Finally, we created a wall-scale prototype for a set of participatory design sessions with fifteen professional interface designers.

With Outpost, paper in the physical world becomes an input device for the electronic world. Projectors output electronic information onto surfaces in the physical world. A user has the same fundamental capabilities as in a paper-based system: she can create new pages by writing on Post-it notes and organize a site by moving notes around the wall. In addition to easing basic information architecture tasks, our system will support the transition from this early representation to later electronic artifacts, such as a formal sitemap.

RELATED WORK
Our research is inspired by previous work in two areas – early stage web site design and tangible user interfaces, a technology that seems well suited to this domain. We describe these two areas next.

Web Site Design Practice
The purpose of our earlier ethnographic study [11] was to inform the design of systems to better support web design practices. The study consisted of interviews with eleven professional web site designers from five different

companies. Each interview consisted of asking the designer to choose a recent project and walk the interviewer through the entire project, explaining what happened at each phase.

Three important observations were made during the course of this study. First, designers create many different representations of a web site. Second, the production and use of these *intermediate artifacts* dominate the day-to-day work practice for most of the design process. Third, we learned that web design is comprised of several sub-specialties, including information architecture and visual design, each of which has its own tools, products, and concerns. We found that information architecture is not well supported by current software tools.

DENIM

Based on the results of our studies, we developed DENIM, a sketch-based tool supporting information and navigation design of web sites [9]. DENIM (see Figure 1) supports sketching input, allows design at different refinement levels, and unifies the levels through zooming. In particular, DENIM supports visualizations matching the *sitemap*, *storyboard*, and *schematic* representations of a web site. While DENIM supports authoring site maps, it is best suited for storyboards and page schematics.

Tangible User Interfaces

Wellner and colleagues produced several prototypes of a DigitalDesk system that used ceiling mounted cameras to track documents and hands, and a ceiling mounted projector to augment a real desk with electronic information [15]. MIT's Tangible Media Group created the metaDESK [6], a digital desk employing tangible interfaces as the controls for and views of a map of the MIT campus. Another project, transBOARD [6], uses tagged whiteboard markers so remote users can view whiteboard contents on their desktop.

Researchers at Xerox PARC have investigated interactions

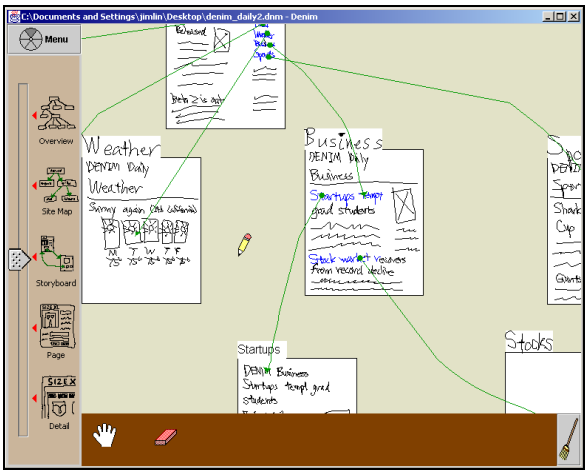

Figure 1. DENIM, shown here in "Storyboard View," allows designers to design web sites by sketching and integrates sitemap, storyboard, and individual page representations through zooming. Information spaces created in Outpost will be imported into DENIM, serving as baseline sitemaps.

Figure 2. The low-fidelity Designers' Outpost.

on walls and whiteboards, including the LiveBoard [4]. Recently, they developed Collaborage, "a collaborative collage of physically represented information on a surface that is connected with electronic information." [10]

Several other researchers have made important contributions in this area, including Streitz [13], Winograd [16], and Rekimoto [12]. This body of work motivates the concept that for many tasks, computer input is best performed by manipulating physical objects on large surfaces.

LOW-FIDELITY DESK: DESIGN STUDY

We created our initial low-fidelity prototype using cardboard the size of an ITI Digital Desk (41" diagonal), evaluating this paper prototype with two individual participants. The participants wrote on a pad of Post-it notes using an inking pen (see Figure 2). We gave the task of creating the information architecture for a web site about off-campus housing for college students. A wizard acting as the computer gave verbal feedback about what the computer recognized as groups, which groupings were being selected, and displayed widgets and dialog boxes when appropriate.

There were two key results. The participants forgot to upload new notes to the system explicitly; therefore the real system should do this automatically. The participants also wanted one pen, for both real and virtual inking.

PIXEL AND PAPER MOCK-UP

We then created an interface mock-up showing physical notes and corresponding system feedback [7] (see Figure 3). It became evident that a desk is too small a space for web information architecture; it affords for a maximum of fifty Post-its and two or three users. Information architects often use upwards of two hundred Post-its and four to eight people might be simultaneous participants in design sessions. To build the Designers' Outpost at a full collaborative scale, we moved to a SMART Board, a rear-projected surface in the form factor of a whiteboard [1].

INTERACTIVE WALL: INTERFACE PROTOTYPE

Our low-fidelity and mock-up prototypes informed the design of our first interactive prototype. We used this

Figure 3. Mock-up of the Designers' Outpost: Collaborating on an information hierarchy with Post-its on a digital desk.

system for design studies with fifteen professional interface designers.

The prototype was implemented as a Java application running on a rear-projected 72" diagonal touch-sensitive SMART Board [1] with a 1280x1024 LCD projector. Drawing a line from one note to another with the stylus creates a link. The stylus can also be used to create freehand electronic ink on the board.

Tapping on a note brings up a context menu that lets users either delete the note or define it as the label note for its group. (In the full Outpost, removing a note from the board will delete it.) Individual notes are outlined in gray. Notes that are close to each other are deemed to be in a group; these notes are outlined in blue.

INTERACTIVE WALL: DESIGN STUDY

We ran five design sessions with between two and five designers per session for a total of fifteen participants. Two of the five groups were information architects, two groups visual designers, and the fifth group had individuals who performed both roles. Information architects are mainly concerned with the information and navigation design of a web site. Visual designers typically focus on interaction and graphic design.

The sessions started with a high-level overview of the project and a demo of the prototype. The designers were then given an information architecture design task. During the session the researchers and designers often engaged in dialog. These design sessions lasted 45-60 minutes, followed by a fifteen demonstration of DENIM, a 45-minute discussion, and finishing with a written questionnaire.

INTERACTIVE WALL: DESIGN FINDINGS

Our findings from this study offer insight into the designers' collaborative process and suggest an appropriate interactivity model.

Existing Board Work Process

Every participant currently works with groups on whiteboards early in the site design process. The information architects all said they currently create sitemaps by placing Post-it notes on the board, while the visual designers talked about sketching page designs directly on the board. Whiteboard meeting capture was highly valued by all five teams. Three of the design teams currently use a digital camera, one uses a whiteboard capture device (the Virtual Ink Mimio), and one team assigns a scribe. Also, every designer said that they currently use either the Visio or Inspiration software packages for site map creation and refinement.

Interactive Board Work Process

We observed groups going through three general phases of design.

Phase I: Brainstorming

The goal of this phase is to quickly put a large number of concepts on the board. Similar information was placed close together. The designers were adamant about not wanting system feedback during this phase. "We didn't do anything here that we couldn't do on a normal whiteboard." One team actually turned off the board.

Phase II: Creating a Top-Level Information Architecture

In this phase, designers migrate from notes on the board to a high level information architecture by clustering related information, pruning unnecessary concepts, and linking notes together. The tool support was well suited to this phase. This was evident in how smoothly we observed the designers working, by their enthusiastic comments while designing, and on the post-test questionnaire.

Phase III: Drilling Down- Adding Information with Free Ink

The goal of the third phase is to "drill down to more detail." We saw work process differences begin to emerge. The visual designers began page-level design using the stylus. In contrast, the information architects fully fleshed out the page structure of the site, continuing to add notes. The key design implication from this phase is the ability to associate freeform ink with individual notes.

Overall Process

We observed two styles of interacting with the board. In the "facilitator" style, one person, usually the senior-most individual, stood at the board (see Figure 4). The second style was "open board." Here, several designers wrote notes simultaneously and everyone had a chance to put notes on the board (see Figure 5). We started the sessions with a single pad of notes and a single marker next to the board. One design team requested one pad and marker per person. In this paradigm, each person has his or her own "input device."

Figure 4. This is an example of the "facilitator" style.

Figure 5. This is an example of the "open board" style.

OUTPOST DESIGN IMPLICATIONS

This study underscored several important points about how "calm" [14] an informal design tool must be. The system feedback should not interrupt the designers flow state.

We originally felt that one of the benefits of the prototype was that the system automatically recognized groups based on note proximity and provided visual feedback. The designers unanimously felt that grouping by proximity was not useful; they already know where the notes are. The designers liked the idea of explicitly circling a set of objects to group them.

Furthermore, the feedback was considered distracting. One designer said, "I'm totally disturbed while I'm trying to concentrate on what we are doing. There are too many things flashing." In hindsight, this result is consistent with the negative user opinion about design time feedback in SILK [8], an informal GUI design tool.

Sweet Spot on the Tangible/Virtual Spectrum

We have seen wall-scale interfaces that are completely virtual [4] and we have seen interfaces that are completely physical [10]. One of our research goals was to leverage the advantages of both.

Fluidity and Physicality

One facilitator began authoring the sitemap virtually, sketching out square notes and their content. This has the advantage that there is no need to switch between an ink-based pen and a board stylus. The drawback is that the work process was noticeably slower. The low projector resolution and stylus difficulty impacted the artifact creation process, encouraging minimal input.

One of our concerns about a tangible/virtual interface was that designers would find it tedious to remove physical objects from the board as they began to flesh out the design in detail (phase III). We asked designers about this issue directly and also watched for frustration with this during the design sessions. Surprisingly, the designers did not mind removing the physical objects; on the contrary, removing them was a natural signifier of a shift in the design process.

Extending the Existing Work Process

For a system like Outpost to be successful, it must both support existing work practices and offer designers advantages that only electronic tools can provide.

Versioning

Our earlier study into web design practice showed that designers desired a way to manage different *versions* of design ideas [11]. Several of the design teams said they would like to replay a design meeting at a faster pace. The design solution of a shuttle dial, a la video editing, seemed natural to almost everyone. One designer said that replaying, "gives you an insight into the process you wouldn't normally get." People also liked the idea of a physical version jar to explicitly save checkpoints or finished designs; versioning is a central enough issue that having both techniques makes sense.

Transitioning to Other Tools

Every group mentioned that migrating the design artifact to other tools for further refinement would be an essential advantage of Outpost. We propose that an appropriate tool to transition to is DENIM. We intend to make Outpost and DENIM interoperable by using the same XML file format. This will also enable remote members of a design team to collaborate with the rest of the team.

Integrating Physical Images

During the sessions, the design teams often referenced earlier projects, work they'd seen, and personal experiences. As we discussed this referral process with them, we discovered that they often bring in photographs, pages of magazines, and other visual aids to help them design. Outpost should allow designers to stick these visual artifacts on the board, and associate them with pages in the information architecture.

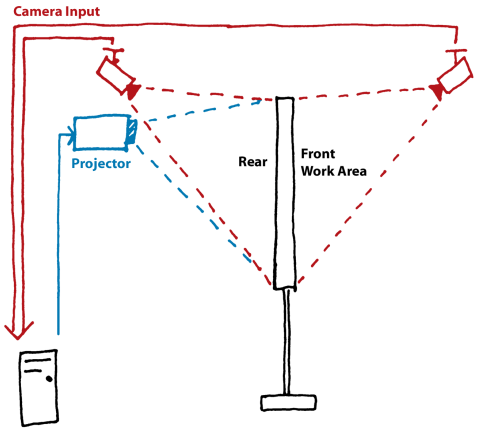

Figure 6. The Outpost system infrastructure.

OUTPOST SYSTEM INFRASTRUCTURE

Given what we learned from these design studies, we are now revising the interface, and improving the vision back-end. We are building a full Outpost using three sensors: a touch sensitive SMART Board, a rear-mounted 640x480 industrial digital video camera, and a front-mounted three megapixel USB still camera (see Figure 6). Our current goal is to build an Outpost prototype that is robust enough for us to deploy at a design firm.

CONCLUSION

We have described a sequence of three design studies, culminating in a study with fifteen professional designers. These studies show that the interaction techniques for working with electronic whiteboards should be calm and that there is substantial merit in a system that is simultaneously tangible and virtual. The designers we spoke with encouraged our pursuit of a versioning system for information architectures, and were enthusiastic about fluid transition to tools such as DENIM.

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