All in a Day's Work: User Interface Design for Multitasking, Resource Organization, and Collaboration in Knowledge Work

Stephen Voida
GVU Center, College of Computing
Georgia Institute of Technology
85 5th Street NW, Atlanta, GA 30332-0760 USA
svoida@cc.gatech.edu

ABSTRACT
Knowledge workers manage multiple tasks, collaborate effectively, and leverage the spatial organization of their work area; all of these practices have a relationship to the construct of *activity*. In this research, I have synthesized data about knowledge workers' practices, findings from the development and evaluation of early activity-based systems, and theoretical understandings of cognition and activity into a set of challenges for the research and development of activity-based systems. I am addressing these challenges and incorporating lessons learned from previous technological explorations in a research prototype, the Giornata system, a demonstration of how the traditional desktop metaphor can be re-envisioned to better match knowledge workers' practices by emphasizing activity as a primary organizing principle in GUI-based interaction.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces—Graphical user interfaces.

General terms: Design, Human Factors

Keywords: Activity-based computing, computer-supported cooperative work, context-aware computing, desktop computing, multitasking, task awareness, collaboration

INTRODUCTION
Knowledge workers manage multiple tasks, collaborate effectively among several colleagues or clients, and manipulate information most relevant to their current task by leveraging the spatial organization of their work area [10, 12]. The diversity of these work practices and the complexity of implementing flexible computing tools make it difficult to meet these workers' needs. However, a common thread among all of these practices that can be leveraged to provide more appropriate computational support for knowledge work is their relationship to the construct of an *activity*: a collection of tools (applications, documents, and other resources) within a social and organizational context and in service of an objective or goal (after [5]). Multitasking inherently reflects the boundaries between ongoing activities, collaboration with particular colleagues often takes place within the context of one or more activities, and the "files and piles" used to spatially organize the contents of a workspace are an important component in classifying information, also closely related to the activities at hand.

Many ongoing research programs are investigating the role of activity in desktop and ubiquitous computing environments (e.g., [2, 4, 7, 8, 9, 14]). Prototype activity-centered systems have been shown to match users' real-world work practices more closely than systems based on the traditional application/document metaphor. It is anticipated that these kinds of systems will provide a variety of benefits to users, including better task awareness, simpler multitasking, more natural organization of information, and improved collaboration.

In this research, I have synthesized empirical data about knowledge workers' work practices (both my own data [13] and those of other researchers, e.g., [1, 6]), initial findings from the development and evaluation of early activity-based systems (both my own systems [11, 13] and those of other researchers, e.g., [2, 4, 7, 8, 9, 14]), as well as theoretical understandings of cognition and activity suggested by decades of research in activity theory (e.g., [3, 5]). I have built two systems to explore facets of activity-based computing: Kimura, which focused on supporting multitasking and task awareness and exploring interactive, visual representations of activity [11], and the sharing palette, which focused primarily on supporting a broad variety of file-sharing practices but also featured an extensible user interface that could easily be adapted to support sharing and collaboration in the context of particular activities [15]. I have also identified a set of key challenges, grounded in theory and practice, for the research and development of activity-based systems. I am now addressing these challenges and incorporating lessons learned from my previous technological explorations in a new research prototype, the Giornata system[1]. Through Giornata, I seek to demonstrate how the traditional desktop metaphor can be re-envisioned to better match knowledge workers' practices by emphasizing activity as a primary organizing principle in GUI-based interaction.

UIST'06, October 15–18, 2006, Montreux, Switzerland.

[1] *Giornata* is Italian for "day's work," is used to denote both the time during the day that work takes place, and, in the context of *buon fresco* (wet plaster) painting, the physical region of a painting that can be completed in a single session.

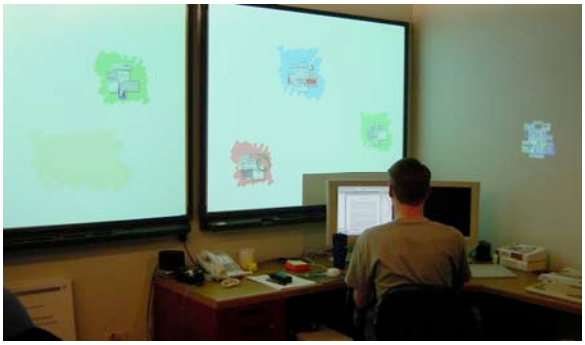

Figure 1: The Kimura system, including a desktop component, two interactive peripheral displays with electronic whiteboard capabilities, and a third, non-interactive peripheral display.

TECHNOLOGICAL EXPLORATIONS OF ACTIVITY-BASED COMPUTING

Kimura

The Kimura system was developed to explore how activity models, peripheral displays, and context-awareness could be used to support task-awareness and multitasking in knowledge work [11]. Kimura combined a desktop computer running a custom virtual desktop manager with one or more electronic whiteboards and a context-aware infrastructure (Figure 1). For a typical knowledge worker, Kimura might monitor a number of concurrent work activities, displaying a *montage* visual summary for each on the electronic whiteboard. Users could view the whiteboard as a passive peripheral display and monitor the state of all ongoing work activities. They could also interact with the whiteboard directly to annotate, organize, and switch among *working contexts*, Kimura's representations of activities as clusters of computational artifacts and contextual cues. The iterative design and informal evaluation of the Kimura system supported the claim that activity can be a potentially powerful organizing principle for dealing with the increasing complexity of knowledge work. In addition, the persistent visualizations of ongoing activities and informal interaction style enabled by the use of an electronic ink surface were found to be particularly compelling aspects of the system design.

The Sharing Palette

Early activity-based systems reported in the literature generally lacked sophisticated support for collaboration. However, most descriptions of knowledge work acknowledge information sharing as a critical component of collaboration for knowledge workers.

In research focused on user interface support for file sharing, I explored users' current file sharing practices and examined affordances and features of the tools used to share files [15]. Based on this analysis, I implemented an interface called a *sharing palette*, which provides a platform for exploration and experimentation with new modalities of sharing (Figure 2). While not directly related to supporting activities, the interface was designed to be extensible in ways that would enable its integration into activity-based desktop systems. This research also demonstrated user interface techniques that address reported breakdowns: giving users the flexibility to specify their own organizational structures (e.g., sharing groups) and providing persistent visualizations of the sharing state with notifications when changes have occurred.

CHALLENGES FOR THE RESEARCH AND DEVELOPMENT OF ACTIVITY-BASED SYSTEMS

I have identified three primary challenges for representing and supporting activity based on these technological explorations, as well as a review of the literature on activity theory (e.g., [3, 5]) and case studies of multitasking and task management in the workplace (e.g., [1, 6]):

***Challenge #1*: Activities are part of fluid work practice**

Activities represent individual, distinguishable components of a larger, fluidly interconnected knowledge work practice. Many studies of knowledge workers emphasize the fractured and frequently interrupted nature of the work environment (e.g., [6]). In order to provide support in these situations, activity-based computing systems must echo the agility of the human user in switching between and creating new activities. These systems must also play an active role in reminding the user of the state of ongoing activities. Finally, they must provide appropriate support for maintaining work relationships and managing interpersonal and inter-activity coordination, both being aspects of "metawork" that often extend across activity boundaries. Supporting fluid work practice is a significant challenge because activity-based systems must facilitate these practices without introducing a substantial amount of additional work in creating and managing the digital representations of ongoing activities—a trade-off that would constitute a serious hurdle to adoption.

***Challenge #2:* Activities encapsulate evolving work**

Boer, van Baalen and Kumar proposed a revised Activity Theory model, augmenting the traditional model—a triangular structure including an actor, a goal, mediating tools, and a social context—with representations of changes over time and relationships to other activities [3]. This revised model reflects the basis (directly or indirectly) for most contemporary activity-based systems research.

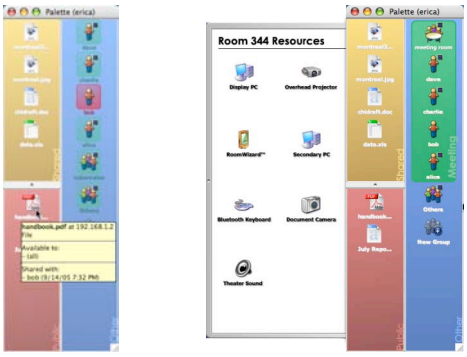

Figure 2: Two prototypes of the sharing palette user interface. On the left, a palette is being used to discover with whom the a file is currently shared. On the right, an initial (non-interactive) prototype of an activity-aware palette, providing sharing services and control over peripherals during a meeting.

Figure 3: An initial (non-interactive) prototype of the Giornata user interface. Notable features are the presence of free-form activity tags *(upper left)*, files specific to the activity and spatially grouped to indicate *public* or *visible to contacts* status, and a streamlined sharing palette interface *(right)*.

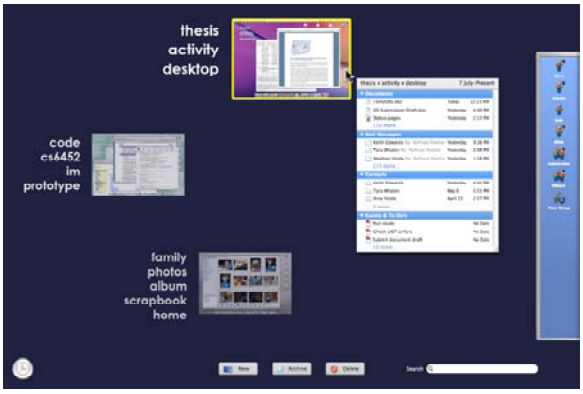

Figure 4: An initial prototype of the Giornata activity gallery user interface. This view provides a spatial, user-positioned summary of open activities; their tags (if specified); a summary of their contents; and controls to create new activities, deactivate and archive activities, destroy transient activities, and access tag-based search capabilities.

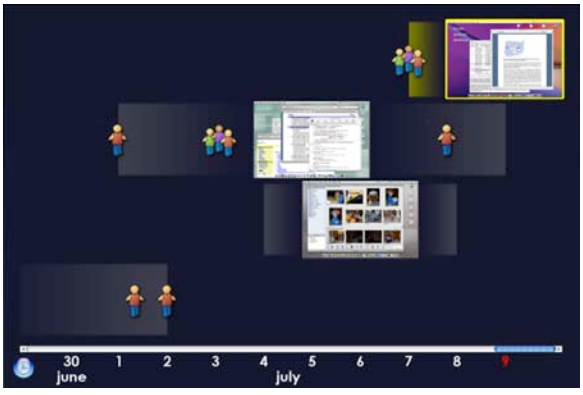

Figure 5: An initial prototype of the Giornata activity gallery user interface in timeline view, showing both individual and group meetings during the course of current and past activities.

The idea that activities encapsulate heterogeneous artifacts and relationships in knowledge work suggests a need for activity representations to span a variety of traditional data "silos," including the document file system, the email store, and databases containing calendar and contact information. Since activities change over time, both in actual composition and in how they are understood by their participants, activity-based systems need tools that allow users to work with initially-unnamed activities and to add and refine labels classifying them over time. These requirements constitute substantial technical challenges in the development of systems to support activity-based knowledge work.

***Challenge #3*: Activities are collaborative**

Most knowledge work is inherently collaborative. Even if collaboration isn't an integral part of a given activity, the activity almost certainly draws upon information that was created by others at some earlier point in time or results in some deliverable that is then handed off to others. Recognizing the *mediating* role of the digital work environment in enabling users to collaborate meaningfully is a critical step to ensuring the success of these systems.

However, as the large, diverse body of literature in the computer-supported collaborative work (CSCW) community suggests, supporting effective collaboration is rarely a trivial undertaking. Technical issues involving the exchange of information, preservation of state, and graceful operation in the face of network failures, coupled with social issues regarding awareness, negotiation about the roles that collaborators will play, and privacy—to name just a few—abound. The three most significant challenges in supporting collaboration with respect to activity-based computing are in situating work appropriately within the context of communication and information sharing, preventing the unintended disclosure of information, and accommodating differences among the ways that collaborators establish boundaries around their activities and groups of work artifacts.

THE GIORNATA SYSTEM

Giornata continues the use of virtual desktops to delineate activities, following in the design of the Kimura system. However, in the Giornata prototype, the desktop itself becomes an active interaction surface and plays a key role in managing activities. Additionally, no electronic whiteboard hardware is required to use the Giornata system as it was for Kimura; the "activity gallery" interface for accomplishing activity "meta-work"—naming activities, organizing them, and sharing them—takes place in a full-screen interface displayed upon request on the primary monitor.

In Giornata, the enhanced desktop serves not only as a display space for application windows, but also an active folder for documents and shortcuts associated with the current activity (Figure 3). The document icons on the desktop are also "swapped out" along with application windows when transitions are invoked in the virtual desktop software. Furthermore, individual applications are

notified of activity changes so that filters can be applied to the displayed information. This combination of capabilities scopes the information displayed on the screen at any one time to the most relevant applications, information resources, contacts, and communications when the user is immersed in a particular activity (*Challenges #1 and #2).*

A hotkey reveals a full-screen overview of activities and content in which the user is involved (similar in design to invoking Apple's *Front Row* software on Apple OS X). This "activity gallery" interface provides detailed, at-a-glance summaries of the complete contents of each activity, including those documents used previously and since closed. It also features multiple visualizations of the activity "space," including a spatial canvas that can be used to informally organize and prioritize ongoing activities (Figure 4) and a timeline-oriented version to enable temporal/historical browsing of activities (Figure 5). It also provides interaction mechanisms for creating and removing temporary, unnamed workspaces so that users can initiate new or transient activities without needing to know how to name or file the activity up front *(Challenges #1 and #2).*

Giornata also integrates a subset of the sharing palette interface to enable lightweight collaboration. This palette component, attached to one side of the display space, can be used to share individual electronic artifacts over a variety of sharing channels or to share entire activities with other close collaborators from the activity gallery interface. The desktop storage space can be physically divided into one or more regions, used to specify which portions of an activity are accessible to different individual (or groups of) collaborators. I hypothesize that providing varying levels of abstraction in the underlying activity representation will allow users to specify the level of detail most appropriate for sharing in a given situation. Functionality (not yet fully designed) will assist in resolving differences between activities specified at different granularities when shared among multiple collaborators *(Challenge #3).*

EVALUATION PLAN

The design of the Giornata system combines some capabilities of Kimura and the sharing palette and responds to the challenges articulated earlier in this research. For the remainder of my dissertation, I will continue to implement aspects of the Giornata system, evaluating the final design by comparing anticipated use of the system to actual use in a scenario focused on exposing the design's effectiveness in supporting knowledge work practices, particularly those associated with collaboration. Finally, I will revisit the challenges, refining them based on the lessons learned from implementing and using the Giornata system.

REFERENCES

1. Bannon, L., Cypher, A., Greenspan, S. and Monty, M.L. Evaluation and analysis of users' activity organization. In *Proc. of CHI '83* (December 12–15, Boston, MA), ACM/SIGCHI, NY, 1983, pp. 54–57.
2. Bardram, J.E. Activity-based computing: Support for mobility and collaboration in ubiquitous computing. *Personal and Ubiquitous Computing, 9*, 5 (September 2005), 312–322.
3. Boer, N., van Baalen, P.J. and Kumar, K. An activity theory approach for studying the situatedness of knowledge sharing. In *Proceedings of HICSS-35* (January 7–10, Big Island, HI), 2002.
4. Dragunov, A.N., Dietterich, T.G., Johnsrude, K., McLaughlin, M., Li, L. and Herlocker, J.L. Tasktracer: A desktop environment to support multi-tasking knowledge workers. In *Proc. of IUI '05* (January 9–12, San Diego, CA), ACM/SIGCHI, NY, 2005, pp. 75–82.
5. Engeström, Y. *Learning by Expanding*. Orienta-konsultit, Helsinki, 1987.
6. Gonzàlez, V.M. and Mark, G. "Constant, constant multi-tasking craziness": Managing multiple working spheres. In *Proc. of CHI 2004* (April 24–29, Vienna, Austria), ACM/SIGCHI, NY, 2004, pp. 113–120.
7. Henderson, J.D.A. and Card, S.K. Rooms: The use of multiple virtual workspaces to reduce space contention in window-based graphical user interfaces. *ACM Transactions on Graphics, 5*, 3 (July 1986), 211–241.
8. Kandogan E. and Schneiderman, B. Elastic windows: Evaluation of multi-window operations. In *Proc. of CHI '97* (March 22–27, Atlanta, GA), ACM/SIGCHI, NY, 1997, pp. 250–257.
9. Kaptelinin, V. UMEA: Translating interaction histories into project contexts. In *Proc. of CHI 2003* (April 5–10, Fort Lauderdale, FL), ACM/SIGCHI, NY, 2003, pp. 353–360.
10. Kidd, A. The marks are on the knowledge worker. In *Proc. of CHI '94* (April 24–28, Boston, MA), ACM/SIGCHI, NY, 1994, pp. 186–191.
11. MacIntyre, B., Mynatt, E.D., Voida, S., Hansen, K.M., Tullio, J. and Corso, G.M. Support for multitasking and background awareness using interactive peripheral displays. In *Proc. of UIST '01* (November 11–14, Orlando, FL), ACM/SIGCHI, NY, 2001, pp. 41–50.
12. Malone, T.W. How do people organize their desks? Implications for the design of office information systems. *ACM Transactions on Office Information Systems, 1*, 1 (January 1983), 99–112.
13. Nair, R., Voida, S. and Mynatt, E.D. Frequency-based detection of task switches. In *Proc. of HCI 2005* (September 6–9, Edinburgh, Scotland), Springer-Verlag, Berlin, 2005, pp. 94–99.
14. Smith, G., Baudisch, P., Robertson, G., Czerwinski, M., Meyers, B., Robbins, D. and Andrews, D. GroupBar: The TaskBar evolved. In *Proc. of OZCHI '03* (November 26–28, Brisbane, Australia), Univ. of Queensland, pp. 34–43.
15. Voida, S., Edwards, W.K., Newman, M.W., Grinter, R.E. and Ducheneaut, N. Share and share alike: Exploring the user interface affordances of file sharing. In *Proc. of CHI 2006* (April 22–27, Montréal, Québec), ACM/SIGCHI, NY, 2006, pp. 221–230.