

# Supporting knowledge workers in practice: how do they understand and use work units?

**Simone Stumpf, Margaret Burnett, Vidya Rajaram, Jonathan Herlocker**

**School of Electrical Engineering and Computer Science, Oregon State University, Corvallis, OR**

**If basic assumptions about how knowledge workers conceptualize and use work units are wrong, then any solutions resting on those assumptions are unlikely to be successful since, instead of decreasing costs, they will lead to increasing them. This paper reports on how knowledge workers understand, use and switch between units of work. We furthermore identify where current computing support causes problems and discuss implications for designing intelligent user interfaces.**

## 1 Introduction

Projects, tasks, activities, and to-do items, which we will here term *work units*, have been identified as playing an important role to knowledge workers as structuring devices [Bannon et al. 1983], [Bellotti et al. 2004], [Gonzalez & Mark 2004]. (Knowledge workers are computer users who spend the majority of their working hours creating and processing information.) There are now a number of prototype implementations that aim to support working practices by exploiting the structure of work units to organise information and to enable easier multitasking [Kaptelinin 2003], [Dragunov et al. 2005], [Bellotti et al. 2003], [Gwizdka 2002], [Smith et al. 2003], [Card & Henderson 1987], [Robertson et al. 2000], [Freeman & Gelernter 1996], [Dourish et al. 1999] [Boardman et al. 2003].

One critical aspect to the development of possible solutions is tailoring them to the current practice of knowledge workers. In trying to understand the working practices of knowledge workers, there is now a proliferation of concepts, such as tasks, activities, to-dos, and the different nuances of these concepts have implications on any solutions which are developed. If basic assumptions about how knowledge workers conceptualise and use work units are wrong, then any solutions resting on those assumptions are unlikely to be successful since, instead of decreasing costs, they will lead to increasing them.

It is important to understand not only how work units are structured but also what costs and errors knowledge workers currently face in their working environments. This information will help develop technology that targets the issues which cause most problems, and will avoid adding costs at times when knowledge workers are already overloaded.

To inform the research that aims to build cost-sensitive, intelligent user interfaces that engage strongly with knowledge workers' practices, we are conducting a range of studies that look at knowledge workers "in the wild". This paper presents the results of an interview study with knowledge workers on what they perceive as units of work and how they organize their information accordingly. We also present findings on what strategies they currently employ to recover from having to switch between work units and their failures. We highlight instances that identify costs and errors associated with use of work units. We discuss these findings on the nature of work units and recovery from switching between them in relation to intelligent user interface development.

## 2 Related Work

In addition to research dealing with the importance of work units in knowledge workers' practices, it has been noted that interruptions frequently cause knowledge workers to switch between work units [Mark et al. 2005], [Czerwinski et al. 2004], [Gonzalez & Mark 2004]. Each switch entails some cost; this has driven research on the management of interruptions, to support and help with switches between tasks.

Previous work has identified immediate, negotiated, mediated and scheduled interruption styles [McFarlane & Latorella 2002]. The timing and amount of attention that the user must direct to either what they are working on or the interruption varies with each of these styles and affects their performance. Therefore, none of these interruption styles is suitable for every situation. To make informed choices about which style to use, we need to understand knowledge workers' prevalent or preferred interruption styles used in practice.

The point at which interruptions occur can be crucial. It has been found that, if work units are hierarchically composed of subunits, then an interruption between high-level components is less disruptive than between low-level components, and that interruptions during subunits are more challenging than interruptions occurring in natural divisions between subtasks [Iqbal et al. 2005], [Czerwinski et al. 2000], [Adamczyk & Bailey 2004]. recovery on work units that span a longer time frame is perceived as more difficult since they usually are more complex and require more, and more diverse, information [Czerwinski et al. 2004]. Research has also been dedicated to making interruptions coincide with opportune times for users. For example, it has been investigated how to help people become aware when it is a good time to initiate an interruption in communications tools, such as Instant Messaging (IM), email, and phone calls [Tang et al. 2001].

However, it has been pointed out that trying to time interruptions appropriately is still problematic, as an indication of presence does not equate with availability, and that, in any case, people tend to ignore signs of unavailability and interrupt [Fogarty et al. 2004]. While certain mechanisms may reduce interruptions, they will still happen. Hence, research directed at helping users recover from switching between work units could significantly reduce overhead costs, errors and frustration.

Two variables of interest in understanding the effects of interruptions are *interruption lag* and *cues*. Interruption lag is the time between an interruption occurring and the user responding to that interruption. If this time is long enough, the user has a chance to form or associate cues, which in turn shortens the *resumption lag*, i.e., the time it takes between the end of the interruption and starting again on the work unit [Altmann & Trafton 2004].

### 3 Study Setup

We are interested in both how knowledge workers understand work units and how they switch between them. Our data was gathered by conducting semi-structured interviews with nine participants who were recruited via email invitations. (A list of potential participants had been compiled by surveying related mailing lists, blogs, organizations employing knowledge workers, and enquiries about our own work unit-centric software prototypes.) All participants had been knowledge workers for a considerable number of years (mean=14.57, SD=7.32) and were recognized by peers as highly multi-tasking. Participants were employed in a cross-section of professions (two software engineers, two technical writers, two non-academic researchers, one project coordinator, one event manager). One participant was excluded from analysis since he had retired from professional work some time ago.

The interviews lasted from 45 minutes to 1 hour 30 minutes. Each concluded with a brief background questionnaire to gather data on professional background, computer experience and details of their computer environment. All phone interviews were audio-taped and transcribed for data analysis.

Our goal was to develop a rich understanding of the work units, how they were used and how they fit into knowledge workers' practices. The nature of our findings, which draws on common responses from a variety of professional backgrounds, can give pointers to potential solution development even though they are based on a small quantity of interviews. We adopted a qualitative approach [Strauss & Corbin 1998], and, in line with this approach, the questions were carefully worded to ensure that answers were grounded in specific examples and that we did not tamper with users' concepts in their own language (e.g. "how many *things* did you work on *today*?"). Our results are exemplified with quotes from participant transcripts.

## 4 Results

### 4.1 What Are Work Units?

We were interested in what participants defined as and termed their units of work in order to understand how the set-up of units of work and related information organization could be better supported. To avoid participants parroting our own pre-existing concepts, we asked them to describe what they were doing without introducing any name for work units. Of particular interest were the specific concepts that were mentioned by participants. Furthermore, during the analysis we looked for clues on how they defined units of work through the way that they organized information around them.

The participants referred to their work units by a variety of names. A very common descriptor for a unit of work was "project". "Activity" or "task" were also sometimes used. Less frequently, "deliverable" and "module" were used. A significant point is that they often used these terms interchangeably, much like

synonyms. This is in contrast to the way that research and some prototype solutions have approached this, where these concepts have often different meanings (and functions) assigned to them. It should not be assumed that a user will differentiate between them, and confusion may arise if they exist in a system at the same time.

Interestingly, a “client” was also a term for a unit of work, expressed in how information was organized around them in the folder structure. The use of roles as organizational principles has recently been explored [Plaisant et al. 2006]. In this view, roles are the prime concepts and smaller tasks can be carried out as part of a role. In our interviews however, no such hierarchical distinction was found, and organization by role was mentioned only rarely—but always as an equivalent of a unit of work.

*Interviewee 5: “I have like a clients folder and then all the different clients have separate folders in there”*  
*Interviewer: “those client folders, do they map onto the project that you're doing?” Interviewee: “Yeah”.*

Participants also used highly individual, sometimes job-related, descriptions of what they were doing as units of work. These were usually terms for high-level work, stages or phases, such as “research”, “plan/attend/prepare meetings”, “writing reports/documentation”, “writing/reading email”, “doing maintenance/bug fixing” and “doing interviews/observations”.

*Interviewee 4: “And that has many phases. It's phone calls. It's emails. It's, it's writing time. And I wanted to be able to break it into a discrete metric. You know, so much time spent on writing versus so much time spent on researching.”*

It should be noted that these individual action descriptions were also not on a par with each other, as the quote shows. Dealing with email, for example, can be part of other actions. It appears that although units of work play an important role for knowledge workers, what they understand as units of work and how they structure and divide them up is highly individualistic.

Flexibility was also important to participants due to the shifting nature of work units over time. They reported that they evolve and change as they progress. These changes could involve not only different ways of thinking about a work unit, but also changes in relationships to other units of work, indicating a shift in granularity.

*Interviewee 7: “what last year what we might have called User Roles, would now be part of what we would call a Persona Project. So, you know, things evolve and change and transform.”*

Defining units of work up-front may also be a problem for users. A unit of work sometimes emerges out the organization of information bottom-up, instead of being clear from the outset top-down.

*Interviewee 7: “the idea of me telling my computer I am now working on this. And now I'm working on this...um, I think that would be really problematic for me because there, when you are creating something you may not know what it is or how to categorize it when you begin it.”*

*Interviewee 3: “I have a temp folder usually which is what I am working on at the moment that doesn't actually fit into anything and that can be a mix of text files or notes to myself.”*

*Interviewee 6: “how do I decide where something actually belongs and what happens if it belongs in multiple places. Or, you know, do I trust what I feel about it at that moment or, you know, am I going to want to feel, or am I going to feel like I, ‘Oh I have to maintain this by going back in and changing that,’ as I realize the thing I thought was about, only about this paper over there was actually the presentation I'm building over here kind of thing. So I think that the categories, making it too discrete, is where, is the problem I have, I guess, in general with, sort of, computers and computer directories and folders and, um, why I have my notebook”.*

Forcing a premature definition of units of works was seen as a hindrance and that later organization – and reorganization – of information allowed units of work to surface.

Although most resources were used to look up or refer to information, a contributing factor for later reorganization was that these documents were also used as patterns or templates either to provide structure or to supply content to new resources, but that these new resources may not necessarily belong to the same unit of work. Hence, the organization of the information and units of tasks must be flexible enough to deal with shifting granularity, multiple inheritances and later refinement.

*Interviewee 9: “The reason it's categorized is because I can put three or four categories onto an email. But I can only file it in one folder. And well, I could file copies into a 100 places if I really wanted to but, you know, who wants to take the time?”*

## 4.2 How Important Are Work Units?

Is supporting work units even important? One way to gain insights into this question is to consider how long work units persist, because a very short-lived work unit may not persist long enough to be worth any effort to organize it. Another way is to consider the involvement of multiple people: if a work unit influences more than just one person, the clarity of organization may be more critical than if only a single person works on it, since a single person might reasonably be expected to remember some of a work unit's context and status.

All of the people interviewed worked as part of a team and had to collaborate to a greater or lesser extent with other people on a unit of work. Most participants reported that they had to collaborate with one to seven people on a unit of work, but it was not uncommon to find that this extended in a loose network to ten to eighteen

people. Coordinating information about a work unit and collaborating with others therefore played an important role and participants made use of a variety of communication tools throughout their work. These communication tools were evenly distributed between electronic ones, such as email or IM, or non-electronic, such as phone calls or face-to-face meetings. Note that varied tools are firmly established as part of the work routine, so that any solutions supporting work units need to take account of any communications on start date, end date, duration, and periodicity, whatever the medium.

Surprisingly, even the most straightforward of these, start date, can be problematic for users. Sometimes there is a set start date, provided by a team lead or client. Many participants, however, told us that start dates evolve, reciting cases in which, in the beginning, it had not been quite clear that this will become a unit of work for them. They also recalled instances in which a work unit may take up time but there it was no clear job responsibility associated with it. This appears to be similar to the difficulties encountered in defining units of tasks up-front, where early organization of information was avoided by participants.

*Interviewee 6: "Uh, and usually that will be because it's just easiest to put it there and I'll deal with it later, is where I think it should go and, and how to manage it or I, or because I think it's just kind of one off and there's no folder to put it in".*

Although some units of work have a set finish date, this means that users have to schedule and prioritize their different units of work.

*Interviewee 4: "I more or less juggle things. I know when the deadlines are and I know what the penalties are for not meeting deadlines."*

Other units of work may have open or rolling finish dates, with no clear final deadline. This was sometimes frustrating to participants, as they were unable to schedule and prioritize accordingly.

*Interviewee 2: "And so there never, ever seems to be any deadline, and people pretty much define what they've done as what they were supposed to have done."*

What knowledge workers defined as units of work was quite variable in duration. Although the term was mainly used to refer to units that spanned a longer time period ranging from two months to three years, some units of work only took one hour to fourteen days to complete. Most participants reported that they worked on short units of work continuously, although it is surprising that they did not take dealing with priority-driven interruptions into account when they described this working style. If the unit of work is of longer duration, then the periodicity of working on it changed to whatever was deemed necessary. However, this may present a problem: if this unit of work has open or rolling deadlines, and therefore does not provide adequate cues for work resumption, how do participants keep aware of what they should be working on?

### **4.3 What Is the "Radar Screen" for Work Units and What Needs to Be on It?**

We also asked the participants how they maintain awareness of their work units to elicit what cues they used. Obviously, almost all of the participants reported that they used some form of to-do lists or reminders. Some participants also put important information on their computer desktop to maintain a visual cue. Most of these cues were used by participants to return to or schedule units of work. This variety of mechanisms confirms findings by other researchers [Bellotti et al. 2004].

In addition, our participants identified particular costs and errors with reminders, which are not currently well-supported by computing systems. We found that collaboration with others played an important role in maintaining awareness for our participants. One method to stay aware of units of work was to watch for activity in shared project folders, which allowed them to regularly monitor what their collaborators did. This way required some cost on their part, since they needed to remember, firstly, what units of work are important to monitor and, secondly, what had changed.

*Interviewee 4: "And so me and the other writer [...] kind of groped our way around, and our manager was very intent on us getting organized and having processes so that if we hired more writers, could bring them in rapidly rather than trial and error. And as a result of that, one of the things we set up was what we called a Doc Clues area because we found a whole bunch of old email they'd just been shoving all together with random naming schemes and stuff; and we had to throw out a whole bunch because we couldn't figure out what it related to."*

A shared repository is an approach to solving this problem, but even this is not perfect due to distributed information organization:

*Interviewee 4: "So, um, there's two places a Doc Clue might go. If we got it in Outlook it goes into the public folders in Outlook. And if it was something that we got on the UNIX side, um, like a file [...], then we can also go there. It's sort of a shared information repository and it's arranged along the same lines as a documentation structure might be."*

Furthermore, email messages played a large role as cues, to prompt action on units of work. The need for collaboration reacted to work units to be supported was expressed by many participants, especially when email was used for exchange of resources or information.

*Interviewee 8: "Well another thing I would want tracked, I think, is who I've shared stuff with."*

On average, participants needed to be aware of two to six work units at a time, which appears to be a manageable amount for them. Some participants, however, reported that they needed to be aware of ten to twenty. Support may be most helpful to these participants, to provide cues to keep aware of a high number of units of work.

It became clear that all approaches to maintain awareness failed at certain points, since many relied on prompting initiated by outside sources, such as phone calls, to remind them to switch their attention to other work units.

#### **4.4 When Do Knowledge Workers Switch Between Work Units?**

Interruptions and switching between work units have become so common in knowledge workers' lives that we had to modify our language that we initially used in pilot trials. On being questioned about their problems with switch between work units, pilot participants reported that they don't have any real problems. It suggested to us that switching had become so habitual to them that they no longer perceived this as an obstacle. Furthermore, it suggests that they have devised some effective strategies to minimize most difficulties (we changed our language by asking them to report what happened the last time that they had to switch between units of work, and participants were more forthcoming after that modification was made). This has a strong bearing on what kinds of support to offer knowledge workers, since they have already develop their own solutions to some of their problems.

Participants reported switching between work units only if those work units were at a high granularity. Although they had already talked about breaking work units into smaller pieces conceptually, switching between these smaller subunits was not mentioned. It suggests that only these high-level switches cause problems to knowledge workers, whereas they switch fluidly between units of smaller granularity within work units.

A very large number reported *internal* causes, such as "dread" or "guilt", which made them switch, again pointing to the necessity of juggling work and the constant need for awareness. All of the participants were interrupted through *external* sources, such as IM, phone calls, emails, and impromptu face-to-face meetings. A strategy that was reported by one participant for decreasing the severity of such an external interruption was by switching to a different communication mode that did not involve high "social bandwidth" [Donath 2004], e.g. substituting IM for face-to-face meetings. However, only a few of our participants reported managing external interruptions explicitly and when they did, they preferred negotiated and scheduled interruptions, for example, by checking emails only at certain times. This may seem initially surprising, yet it needs to be noted that some interruptions are unavoidable. Furthermore, as previously pointed out, participants were constantly juggling their work units. Awareness of work units' progress appears to be traded against potential switching between work units.

#### **4.5 How Hard Is It to Switch Between Work Units?**

Not all interruptions were perceived as hard to recover from; instead participants thought it was easy but "tedious". This was a reoccurring theme, as the following emblematic views describe:

*Interviewee 3: "Well to do the software it takes you awhile to get in the mind set with all. There's like 10 things you're trying to remember while you are writing it. And you just get to the sweet spot and then someone is calling you away to switch to a totally different task[...] And it's a totally different set of information[...] Then you have to track down a lot of information. And for me I will have other utilities that I run that are my personal utilities. There's a checklist and I will have to go find my checklist or keep it in my brain of things I'll do. And when you get done with that then you have to remember shoot I was working on what part of that module...I had a strategy in mind two hours ago now I can't remember what I am doing. I would also say that, I'm actually spending time in three different environments[...] So I have to go back, reconnect to the database server, go back open up my sources code and then pull up all my notes whether they be on a remote or back on Outlook or, it just takes time and also it's just a matter of getting your screens configured right."*

A particular difficulty for participants appeared to be recovering after a face-to-face interruption. It could be that this particular difficulty is due to not having enough interruption lag to establish cues that could allow one to recover easily.

*Interviewee 4: "Um, shoot. What was I working on when the IT guys showed up unexpectedly? That's what I'm trying to remember."*

#### **4.6 What Are The Current Strategies For Recovery and When Do They Fail?**

The participants in our study were able to provide strategies that they have used for recovering from interruptions. These strategies involved *internal* cues or explicit *external* cues that they prepared either in

anticipation of an interruption or because the interruption lag was long enough. For example, people sent emails to themselves, or created post-it notes or markers within computer files.

A very popular method was to leave visual cues, such as open windows or icons on desktops, to allow recovery of details on a task, such as the last state before the interruption or where to find information that allows one to resume:

*Interviewee 4: "It's one of the things that I'll do a lot. I leave Exceed, that's our way of connecting to UNIX, up usually the entire week because that way I've got like six different desktops going. And I can open it and say, Okay, on [project X], I was doing this."*

It appears that the visual cue from screen configurations helped our participants, since the mental state information was encapsulated in the visual cue. Participants reported that costs increased when they did not have these visual cues available and instead had to rely on searching or browsing through folders, files and emails to retrieve their last current state.

Some work has been carried out in understanding how knowledge workers recover from interruptions and switching between work units. For example, it has been noted that people use a variety of artifacts as reminders to pick up where they left off [Bellotti et al. 2004] and that these reminders are sometimes placed before an interruption actually occurs to maintain a cue [Mark et al. 2005]. Computer-based prototypes to aid in recovery have mainly involved the use of visual snapshots to act as reminders and containers for project-specific information [Smith et al. 2003].

Our study found that all of these recovery strategies rely on some kind of cue and only rarely did participants report that there is no time to leave a cue at all. However, they also reported that they incurred costs because sometimes their strategies would fail because the cue was impossible or difficult to retrieve. For example, most participants voiced that they had problems to find their reminders again. When these reminders were available, a new challenge presented itself to our participants. The shorthand reminders did not carry enough information to recover their last state, or the names or locations of the files that they needed to resume their work.

Visual cues had drawbacks, as many participants pointed out. Firstly, there may not be enough screen real estate to display all the cues needed. Secondly, and more disastrously, visual cues on the computer screen do not currently persist long enough for them to be used reliably:

*Interviewee 3: "The problem is whenever you have to stop what you were doing or restart your machine all that gets lost so you have to bring it back up and reposition it."*

Even when there was a visual cue, the most recent cue displayed was not valuable to our participants, as it did not carry the right mental state information:

*Interviewee 5: "In what I'm doing I'm making changes to several files at the same time and just because something was the last thing doesn't mean I was really working there[...] I'm coding in one file and I needed to look at something quick in another file. And then I've got a phone call, and when I come back here I see this file in front of me but it wasn't really what I was working on. It just happened to be the last thing I had on my screen."*

Our study has identified that that visual cues are most helpful when they coincide with the last *mental* state. If this cannot be guaranteed, for example if the visual cue does not persist long enough or if there is a time lag that allows a substantial difference between the mental state and the visual cue, then retrieval of the last mental state on a work unit adds substantially to the cost of recovery from switching between work units.

## 5 Costs and Errors Encountered with Work Units

Solutions could improve knowledge workers' practice if they can help minimise common costs and errors, without adding risk or more costs. All participants voiced dissatisfaction with the way that current environments impeded their productivity. The participants cited several ways in which current computer systems do not support knowledge workers well, which introduces overheads. Consequently, it is also illuminating to consider what support participants wanted, since it gives further indications of what costs and errors could be addressed.

Many problematic situations were caused by the way that participants were forced to organize their information. A frequent complaint was that it was very costly and error-prone to be able to find information again. Only by their own explicit filing and organization, which does not directly contribute to productivity, could they circumvent this to some degree. A complicating factor in this respect is the lack of connection between emails and documents created in other applications, which caused some of the participants' major problems in replication, especially when they switched between work units.

*Interviewee 8: "An unfortunate artifact of software design and, and whatnot, is the sort of compartmentalization of different types of information [...]. I mean, I've got a number of emails about this, um, the current customer phasing project. Um, I've got a number of Word documents and PowerPoint presentations and whatnot in, uh, folders on my desktop. And, um, that alone, the fact that those are separated and the fact that many of the emails referencing documents on, you know, my desktop; uh, okay, ideally I'd like to be able to have other related material for a particular project or a particular topic in one place, rather than have it be application-specific stuff."*

*Interviewee 8: “Even though the email is related to the project, it's all contained in one place. And then the other kinds of documents are contained in another place and, you know, they'll never, the two just never meet.[...] So that would be one thing. I would love[...], it would be great to break down the barriers between the applications themselves.”*

To address this particular cost, participants wanted support for information that is associated with and related to units of work, in particular in finding and accessing this information. Some would like also like to see the relationship between information items, and the degree of relationship between units of works themselves.

*Interviewee 3:” Yeah what, what I would have to have, what I would like to have is to make my tasks hierarchical. So that two tasks would be under a super task. So they could allow me to relate two tasks together. That way I could say these tasks are either [...] one task is the parent of the other or maybe they are just loosely related or maybe they're tightly related. That way if I am in a task, and I know there's another task that is really hierarchical I could hit a button or hit a thing and it would stream me right into a task you know, the related task and if there's any information that would be pulled with it, it would be pulled over with it. You know?”*

It appears that in particular the management of *multiple* units of work needs to be supported. This is also evidenced by the fact that participants asked for help with prioritization.

In our aim of developing intelligent user interfaces, it is interesting to note that while some automation may be helpful in providing support for units of work, participants feared that an extensively automated approach may generate a structure for them that they will be forced to adopt and learn – which will increase their already existing costs. Furthermore, although participants were willing to bear some cost of training the system initially, this cost needs to be directly offset by immediate rewards. A constant fear of participants was the added mental costs of committing (prematurely) to an organizational structure and interruptions by the system to force them to use this structure.

A major theme in the participants' responses were cognitive overload and lack of support to alleviate it: too many things need to be remembered at one time and it was difficult for them to get back into the “mindset”. A general reduction of mental costs by ensuring the recovery of mental state was suggested by participants, for example by providing better facilities for notes and showing or marking up recent changes.

*Interviewee 2:” And so I've wanted a tool that helps capture those thoughts and encapsulate them in a way that they can be, uh, retrieved, uh, grouped, classified, uh, attributes. 'Cause that's what I'm doing manually.”*

Another category of errors that were mentioned by participants – and which incurred further costs to rectify – were encountered in collaboration efforts, such as information getting lost, either in email folders, or by mistaken deletion from email and/or filing systems. These kinds of errors incurred considerable costs when dealing with huge amounts of emails, where participants needed to remember that they were waiting on information to be provided to them or needed to respond to a request for information. In the attempt to avoid these errors, the other extreme also occurred – redundant information being kept and swamping items of interest, or the information becoming out of date.

*Interviewee 7: “And then I feel that it would be really nice to be able to quickly link without creating folders, or putting things in folders because folders hide things. And [...] if I put an email in the folder I will never see it again because it, when I search for something it doesn't also search the folders. So to me it's just like putting something in a, in a keep sake box and you'll see it again, maybe, in twenty years.”*

## **6 Discussion of Implications for Intelligent User Interfaces**

Flexibility was a point raised by *all* of the interviewees. What people defined as units of work and how they were further subdivided into smaller granularity was highly individual. Whereas researchers and designers may have a crisp definition about how a “project” is different from a “task,” users may not find these definitions intuitive, as participants treated these terms merely as synonyms. Hierarchies were sometimes useful, but sometimes a hierarchy did not go far enough, as “child” work units had multiple parents or work units were used as templates for other, not necessarily closely related units. Work units' content and organization evolved and changed frequently. Sometimes, there was no initial organization at all: forcing premature definition of work units can be a bad thing, and there is a need to support easy organization and reorganization at a later point. This suggests the need for flexibility in naming, structuring and granularity choices for any intelligent user interface. Automatic organization by an intelligent system may sometimes be helpful, however the individualistic nature of work units needs to be taken into account and makes this a difficult challenge.

There were many problems related to knowing when a work unit starts or ends and what its actual priority is, relating to the participants' experience of always juggling numerous work units at one time. A system supporting scheduling may not be able to solve some of these issues directly, but supporting a high degree of flexibility in naming, granularity, monitoring, organization, and reorganization, may help with these issues. In addition, systems that support scheduling might trade away support of short-duration tasks to increase the

support of long-duration tasks. The key question to help with this decision is whether there is a useful reward for supporting short-duration tasks, other than time tracking.

In the juggling experience, the “radar screen” seems to be problematic, particularly in a collaboration context. In particular, collaboration-oriented work units and the need for awareness in teams had not been very well supported for these participants. Although there is research in collaborative groupware that would help with some aspects [Convertino et al. 2004] [Millen et al. 2005] [DeLine et al. 2005], support of additional context information for collaborators who have not yet or not recently seen the work unit’s documents would be one item of particular interest to intelligent systems based on work units, given group contexts.

Support for switching between multiple work units was important to our participants and intelligent systems and their user interfaces need to support recovery from both internal interruptions (i.e., when the user controls when to switch tasks) and external interruptions (i.e., when the user does not control when to switch tasks).

Our study found that interruption lag makes a significant contribution to the ability of our participants to switch between work units successfully. Some interruption styles allow the user to create and manage interruption lag and form cues. For external interruptions in particular, users preferred negotiated or scheduled interruption styles, returning some form of control back to them.

Existing strategies by knowledge workers underline the importance of visual cues. These visual cues encapsulate the last computer state before the interruption and hence function as a breadcrumb trail to information on the interrupted task. However, to have reliable value, these visual cues need to be persistent on the system and compact enough to not take up screen real estate. Ideally, visual cues could facilitate recovering not only computer state, but also the user’s last *mental* state in a work unit.

Providing an ideal combination of interruption lag and cues, which depend on each other, is a challenge for intelligent user interfaces. Careful management of these two variables could provide increased benefit to the user. For instance, intelligent systems could facilitate an interruption lag long enough for the user to form adequate cues or automatically form cues on the user’s behalf during interruption lag. However, there is a price to pay: this interruption lag must not be too long for cues to become disconnected from the user’s last mental state on a work unit.

## 7 Conclusion

In this paper, we have reported on results from interviews with knowledge workers on how, in practice, they understand work units and how they switch between them. In particular, we have found that:

- flexibility is important. Knowledge workers had a variety of individualistic work units, shifting granularities and continuous evolution;
- maintaining awareness of collaborative efforts was particularly costly to our participants;
- participants created and managed interruption lag to form cues, and preferred negotiated or scheduled interruption styles to do so;
- visual cues were most valuable to participants when they coincided with the last mental state.

At the moment, current computing support for units of work is simply not flexible enough, and, if not implemented in a sensitive way, could in fact increase cost and lower benefits. The findings of our study can be used as a starting point for considerations that play an important role for knowledge workers.

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