Using Task Context to Achieve Effective Information Delivery

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ABSTRACT

The use of task context to guide the delivery of information to knowledge workers is valuable for improving their efficiency and effectiveness. Moreover, the sharing of context between individuals can aid the sharing of knowledge. This paper describes research in the ACTIVE project which uses context to support information delivery and sharing. Machine intelligence techniques are used to learn the association between information objects and context; and to learn how to partition a user's information objects into a set of contexts. Informal processes are also important to knowledge workers, and another research challenge is to understand how context influences the choice of steps in a process. Other research questions relate to the user interface for context-driven information delivery. Chief amongst these questions is whether the user wishes or needs to be aware of the concepts of context and process; or whether only the system should be aware.

Categories and Subject Descriptors

H.5.2 [**Information systems applications**]: User interfaces – *Prototyping, theory and methods*

General Terms

Human Factors

Keywords

Context, process, machine learning, information delivery

1. INTRODUCTION

This paper is concerned with what we believe to be one of the key issues for knowledge workers; that of having relevant information easily available. Today, most knowledge workers have access to an overwhelming quantity of information. The challenge is to locate what they need at any given time. We believe that a significant solution to this problem is to prioritise information delivery according to the user's context. By information delivery we mean all the channels which a user employs to access information, both 'push' and 'pull'. This includes email, instant messaging and search. It also includes how files are displayed in the user's filing system and how files are displayed when the user is in an application like wordprocessing. We believe the user will want to have the option of seeing first those files which are relevant to his or her current context. Context has different meanings to different authors and different research communities; this is discussed in section 2 below. In our work we are

concerned with task context, i.e. the context of the user's current activities.

The work described here is taking place within the ACTIVE project (http://www.active-project.eu), an overview of which is provided in [1]. ACTIVE is a three year European integrating project, which began in March 2008, addressing three key challenges of knowledge management:

- *Effective knowledge sharing* We are achieving this through a synergy of the formal and informal approaches, i.e. an approach combining the strengths of ontologies and folksonomies.
- *Sharing and reuse of informal processes* By informal processes we mean the kinds of processes which individuals create for themselves. Unlike the formal business processes which are owned by the organization, informal processes are not formally described. Because of this they are often not shared with colleagues and hence not reused. We are investigating both how such processes can be easily described by their creators and also how we can automatically learn such processes from user behavior.
- *Context driven information delivery* This is the subject of our paper; what it means within ACTIVE is described in detail in section 3.

These three research challenges are not seen in isolation; each one interacts on each of the others. At any given time knowledge sharing needs to take account of the user's current context, and also the process being navigated. On the other hand, both context and processes can be shared. Finally, when negotiating a particular process the context may also be relevant; this is discussed in more detail in section 4. As an example of this last point, we imagine someone preparing a business proposal and following the 'prepare business proposal' process. In such a situation, the particular customer context may be relevant.

Within ACTIVE we are employing and validating our technology in three case studies. In two of these case studies context has a very significant role to play. In BT we are providing tools to help customer-facing telecommunications staff. Here the current context will often equate to the customer currently being considered. In Accenture we are working with consultants and we believe that here also current context will often equate to current customer. In any case, the feedback from these two case studies is shaping our understanding of how our technology should implement and use context.

2. CONTEXT BASED COMPUTING

Context is a very broad term used in different areas of research. In general, context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including users and applications themselves [2, 3]. A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevance depends on the task being accomplished.

Context-aware computing is traditionally concerned with the impact that contextual information has on the behavior of devices and software entities in terms of simple parameters such as location, light and noise levels and their interaction with humans. Nowadays we are witnessing a rise of applications where notions of context are already being applied e.g. in the arena of mobile services. In fact, much effort is being accomplished in order to exploit context by telecommunication operators and national bodies.

ACTIVE, however, focuses on a different domain for the application of context, related to the activities of knowledge workers. A user's context denotes her behaviour performing different tasks in everyday work, referring to all information related to the user's interaction with the desktop and knowledge tools, and including any communication with members of the community.

According to [4] the following contextual aspects are interesting for the task context:

- **informational** aspect: relevant and touched documents, accessed or created by the user during a task; subject or corresponding domains/topics;
- **organizational** aspect: organizational structures involved into or relevant to the task: person(s), roles, skills, interests of a user, projects and organizational units she belongs to;
- **behavioural** aspect: the behaviour of the user – her performed operations and actions;
- **operational** aspect: applications and tools used by the user (to accomplish her task);
- **causal** aspect: task goals and estimated user goals;
- **chronological** aspect: timeline of events occurred in the system, e.g., recently processed workflow tasks.

ACTIVE builds on previous experiences [5] in order to provide knowledge workers with the means required to focus on the really relevant tasks, while reducing distractions produced by other activities.

3. CONTEXT IN ACTIVE

3.1 Defining context

We define a user's context to be characterized by a set of information objects which are frequently accessed concurrently, or within a very short time-span. Here information objects could be files (e.g. word-processing documents or spreadsheets), emails or any other item of information with which the user interacts via his computer or in principle any other electronic device. An information object could also be a person, viewed as a source of or destination for information, and typically represented by an item in a contacts database. Moreover, some information objects may be in more than one context, i.e. contexts may be

overlapping. This definition clearly relates to the first of the contextual aspects listed above. It also relates to the behavioural aspect, since we observe the user's behaviour in relation to the information objects; to the operational aspect since we are concerned with the applications used; and to the causal and chronological aspects since we are concerned with the relationship between context and process.

The intention is to understand in which context a user is operating and use this to guide the delivery of information. In essence this is a clustering problem. The overriding criterion is whether the user accesses the information objects within a relatively short time interval. Here 'relatively' relates to the timescale within which the user is normally accessing information objects, i.e. are these two objects frequently accessed within a shorter time interval than would occur randomly. We can also be guided by similarities in the objects themselves, e.g. similarities between text documents using the normal information retrieval measures such as the cosine similarity measure. Thus, to give a simple example, imagine the user habitually refers at the same time to documents A, B, C and information retrieval techniques tell us that document D is related to A, B and C. When the user is in this context, and opens a file in his or her wordprocessing application, then he might be offered as first priority the choice between documents A, B, C and also D.

Context may be personal to an individual or may be shared. If a group of co-workers are accessing a shared repository then we may make use of the way they access information to infer a shared context. Imagine that we deduce a context C_1 from the way which user U_1 access information and we deduce a context C_2 from the way which user U_2 accesses information. Then if there is a significant overlap between C_1 and C_2, we may deduce that they are the same and merge them. This is clearly useful for knowledge sharing. U_1 may become aware of objects in the shared context which he was not previously aware of, but which U_2 has created or accessed.

We can extend this to information objects on users' own machines, so that we can arrive at a context which contains objects on the repository and on users' hard drives. Of course, whether individual users can see all the objects in a context is determined by their privacy policies.

3.2 Using and visualizing context

Figure 1 illustrates how context might appear to the user. He or she is in the context 'design work'. On the left, he is opening a file in a word-processing application and he sees the files in the current context, possibly with the most recently accessed first. He is also able to switch to other contexts to access other files. The same approach could be applied to other applications; in an email application the emails could be prioritized with those relating to the current context at the top.

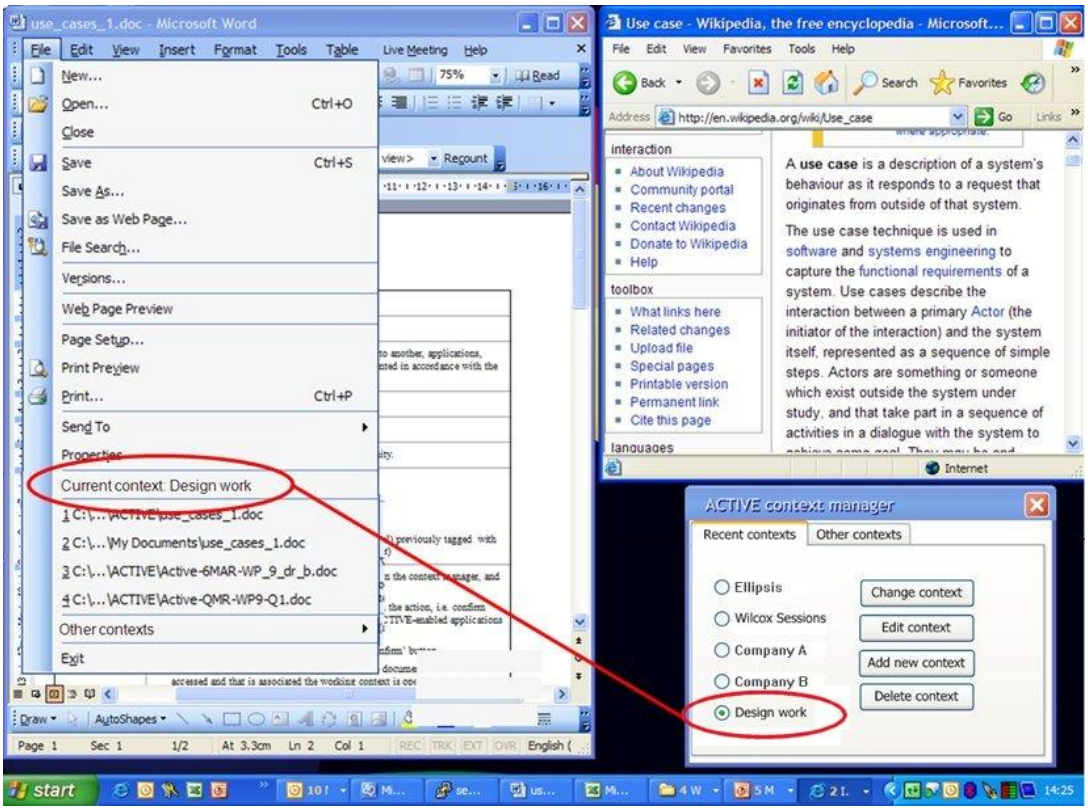

Fig. 1. Ilustrating how context is used to prioritise the presentation of information objects

The system can be aware of the user's current context either because it is explicitly told that context by the user, or by deducing ('learning') the context from user behavior. For the former we use an 'ACTIVE context manager' which appears as a small bar on the user's screen, displaying the various contexts available, emphasizing the current context, and enabling the user to change context.

This is our initial model of user interaction, and it is one in which the user is explicitly aware of the concept of context, and aware of the current context. In an alternative approach the user is not aware of his current context or even of the concept of context. In this approach the system learns the current context and uses this to prioritise the delivery of information without the user being aware of context. In this model, in a word-processing application the user sees a list of files which are ordered according to their 'closeness' to the current context without being aware of the rationale by which this list is compiled. He is simply aware that the system is offering him files which might be useful to his current work.

Which of these two models better suits the user is an open research question within ACTIVE. It may be that different types of users have different requirements, or that the same user has different requirements in different situations. Within the project we are obtaining feedback through user trials to answer these questions.

3.3 Associating information objects with context and learning context

From the technical perspective we have two research challenges:

- to deduce the existence of individual contexts from user behavior, and
- to automatically associate objects with contexts.

One way how to formalize functioning of an enterprise (representing one or more people) is to define it through two types of objects: contexts (C) and tasks (T). We can say, an enterprise has one or several contexts and within each of the contexts one or several tasks can happen.

Contexts and tasks can be labeled explicitly which makes the problem of identifying contexts and tasks simple. If information about contexts and tasks is not given, one needs to identify them with automatic or semi-automatic methods.

A general setting for an automatic context and task identification is the following. Each execution of a task Tj within an environment can be described with some characteristic data which can further be summarized as a set of features. This feature set is further split into two parts: (a) context specific features, and (b) task specific features. Context identification can be seen as a clustering of task instances on context specific features only. Once we identify contexts through clustering, we assign each task instance to one or several contexts. Next, we perform task identification as an additional clustering of task instances within each context with task specific features only. The result is set of contexts and for each context we have set of tasks.

An example of the above setting is e.g. email communication, where each email message can be seen as a separate task. Each email message can be described with a feature set coming from three parts: (1) textual part of the message, (2) social part of the message (senders and recipients), and (3) temporal information. One possibility to identify contexts is to cluster email messages based on the social and textual part while for identifying tasks one can cluster only on textual and temporal part.

3.4 Research challenges when dealing with contexts

When dealing with the notion of 'context' one needs to address several orthogonal dimensions which constitute an actual instance of context used in a particular application. Most of the dimensions listed below include open research issues and many possible instances of contexts (defined along the dimensions below) have not yet been explored.

We propose nine dimensions along which a particular context could be defined and used.

1) **Formalism**: Context is generally a model described in any of the formalisms ranging from first order logic to softer probabilistic descriptions. Depending on an application, the most suitable formalism needs to be selected. An example of the first order logic formalism for contexts are micro-theories in Cyc system while an example of soft probabilistic contextual model can be personalization model in search engines consisting typically of weighted feature vectors.

2) **Dynamics**: Contexts can be statically defined or can dynamically change through time. Many applications require dynamic contexts which adapt based on the changing environment. In such dynamic environments an important issue is a mechanism for adaptation and context detection.

3) **Scenarios**: Since contexts are models, it is an important issue what kind of scope these models cover. One option is to have one global contextual model which covers all situations within the targeted data world. The other option is to have multiple local models possibly organized in a hierarchy which cover and organize particular situations of the world and inherit properties from each other.

4) **Cross-modality**: An operational definition of a context always includes dealing with actual data which are interpreted through eyes of a contextual model. Therefore, an important issue is modeling contexts across different data modalities. The most typical modalities are text, multilingual texts, social networks, audio, images, video, sensors. Each data modality has its specifics which influence most of the other dimensions.

5) **User aspects**: In terms of the usage perspective we can build contextual models for a single user, user communities or for machine processing. Single user contexts are completely independent of a modeled environment and typically increase

usability of an application for an individual person. Community contexts (such as groups of users) have a function to optimize communication among the users while contextual models used by machines optimize some application specific criteria.

6) **Efficiency**: In contextual modeling, as in many other applications, we often have a tradeoff between expressivity and scalability. This trade-off stems from the formalism used and the operation one wants to perform using contextual models.

7) **Acquisition:** We differentiate manual, semi automatic and automatic approaches to the way in which information about a context is acquired. In the case of manual context acquisition a user explicitly provides information about the context he is operating with, while in semi automatic and automatic context acquisition the system proposes contextual models based on observed data in a target environment.

8) **Evaluation**: For the same situation one can define different contexts for different evaluation metrics. Typically, context evaluation metrics include more or less abstract intuition of some kind of data compression. Namely, the function of a contextual model is typically to represent observed data in a more efficient way to avoid retaining global information to correctly interpret data. Possible criteria for efficient data representation (and therefore evaluation) are data compression, end-user usability, summarization, ranking etc.

9) **Best practices**: An important aspect of contextual modeling is a set of best practices developed on the top of particular settings. This influences the economy of different application scenarios which influence decisions on how to select individual options in the above dimensions.

4. CONTEXT AND PROCESS

There has been some recent research about context-aware processes. The major focus is on making business processes more flexible and adaptable [6, 7] .Therefore the challenge is to identify requirements for flexibility. As described in [8] the combination of all situational circumstances that impact the process design and execution can be termed the context in which a process is embedded.

In ACTIVE we are investigating how knowledge workers use their knowledge to reach a certain goal. The steps, called actions, define an informal knowledge process. Therefore, an informal knowledge process is a loosely defined and structurally ramified collection of actions. The structure of such a process and the order of actions are not fully defined at the start of a knowledge process. Many actions require a decision by an actor about the follow-up action. At such a decision point the actor uses his knowledge, including his tacit knowledge, and the context to decide about a successor action. In this way the actor drives and carries out the knowledge process. The context defines the boundaries and the environment in which the process is carried out and influences the actor with his decisions. Those decisions have to been taken during execution time over the process development path and lead to emerging structural ramifications constituted by admissible alternatives.

Compared to business processes and their demand for context-awareness to become more flexible and adaptable, informal knowledge processes are already flexible and adaptable by their nature. The context of such a process is defined by the environment the process is executed in. We can distinguish between four contexts which are relevant for informal knowledge processes (Fig. 2):

(1) **Work Context**: An informal process is executed because it is part of specific work, like writing a proposal for a project.

(2) **Business Context**: The knowledge process is triggered by an activity of a business process on the enterprise level. In this case the business process activity is providing the context in which the informal process is executed.

(3) **Task Context:** The knowledge process is triggered by another knowledge process (maybe of a different worker). The task or action triggering the process is providing the context for the triggered process

(4) **Environmental Context**: The knowledge process is triggered by an event from the outside and is not work related, like stock prices are dropping which forces the knowledge worker to sell his stocks.

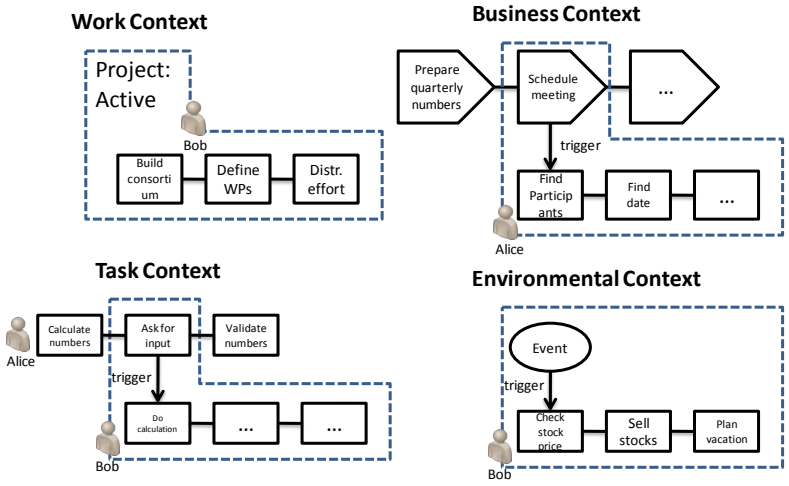

Fig. 2: Relevant contexts for informal knowledge processes

These relevant contexts for informal knowledge processes can be combined so as to build a hierarchy of contexts (Fig. 3). The knowledge worker will use the entire context hierarchy when he decides about a follow-up action. Storing the entire context data is useful for later reasoning about optimizing those processes and pro-actively supporting knowledge workers with recurrent executions.

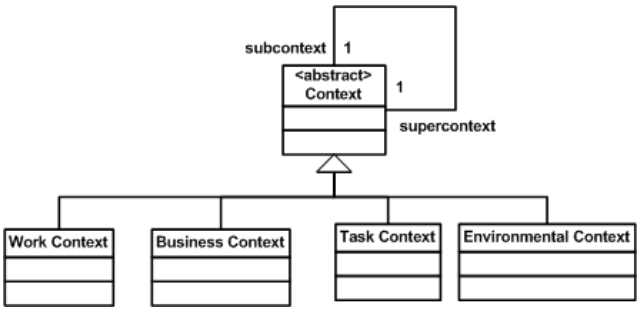

Fig 3: Context model for informal processes

5. CONCLUSIONS AND FUTURE WORK

We have presented a view of context, and how context can be used to guide the delivery of information to users. We have also defined the concept of informal process and discussed the relationship between context and process.

This raises some research questions, in particular:

- How can we best learn automatically the association between information objects and context.
- How can we deduce the existence of individual contexts without the user specifying them explicitly?
- How can we learn the relationship between informal processes and context, i.e. learn how the current context influences the steps taken in a process.

During the remainder of the project, these questions will be the focus of our technical work in ACTIVE related to context.

Besides these technical questions there are also research questions relating to how a context and process-aware system should best interact with the user. The fundamental question here is to what extent do users need or wish to be aware of the concepts of context and process; i.e. to what extent should these concepts be made use of by the system without the user's awareness? This question, and other questions relating to the user interface, will be examined in field trials. The results will be fed back to guide the development of the technology.

6. ACKNOWLEDGMENT

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