Contextualized Visualization at the Workplace

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Abstract—The problem of the information society today is that knowledge workers are overwhelmed by the amount of information they get. This creates the need of a filter: the possibility to find relevant information in an easy and systematic way. In fact, working at a knowledge intensive workplace and retrieving information is a kind of learning—informal learning—which takes place at daily work. This type of learning includes reading documents and digital snippets, asking questions and searching for the help of other colleagues.

This paper investigates how people at knowledge intensive workplaces can be supported through a graphical integration of existing information in a contextualized way to fulfill their given work task. We present research on software that visualizes the information of knowledge workers, tasks, digital resources, people and the relations between them. In addition context information is taken to enrich the output to provide an intuitive and appropriate tool for knowledge workers. As the visualization tool we used the TopicMap Viewer to visualize the data and context information together. We will show all the necessary steps to offer these contextualized information in a supporting visualization.

To verify the usefulness of our approach, we did a quantitative and qualitative user study to see if contextualized information visualization is helpful to knowledge workers for a specific scenario. Therefore we analyzed how beginners or new employees benefit from such a tool. The results clearly show the advantages of our solution. Contextualized visualization substantially boosts efficiency and effectiveness of knowledge workers, because of time savings and avoidance of failures.

Index Terms—Context Awareness, Electronic Workplace, Informal E-Learning, Knowledge-intensive Work.

I. INTRODUCTION

The main problem for knowledge workers today is to get the right information and data at the right time in a usable form. If information is delivered according to the current context (situation) of the knowledge worker, the content can be learned, assimilated and used in an effective manner.

Different surveys show the valid demand and high requirements from knowledge workers [1]. Especially the searching of information and collaboration partners are important key activities for informal learning [2]. In combination with task and process based learning and working, this is the main focus of the European project called APOSDLE [3].

Our hypothesis is that taking context information into account for knowledge or information visualization can boost the support of this kind of tools considerably, especially for beginners in a specific topic or new employees to get involved into well-established standard procedures and processes.

The paper is structured as follows. After discussing the related work, we introduce our approach with a definition of context and a theoretically introduction of our framework. The prototypic implementation and evaluation is explained and presented afterwards. We conclude with ideas for future work and a summary.

II. RELATED WORK

This work is related to three research areas. It is located in the intersection of the areas of informal learning at the workplace, knowledge visualization and contextualized systems. The importance of informal learning at knowledge intensive workplaces and especially for beginners in a new job surrounding is discussed in detail in [2]. But there is little scientific work in the socio-technical intersection area with knowledge visualization and contextualized systems. So we will discuss two major related contributions.

The first one tries to adapt cooperate work spaces to the current work context of a distributed collaborating group of knowledge workers [4]. To accomplish this task, they define adaptation rules based on context information of the group to automatically adapt the user interface of the collaborative work space to the needs of the teams. But this approach only focuses on the user interface and not on relation context, the contextualization of information, which leads to new relations and associations.

The other interesting work can be found in [5]. The authors visualize relation context (information which could be derived from data sources, which is discussed below in more detail). Based on work context they try to choose the right content, with right detail, resolution, format, delivery time and data granularity.

But this work only introduced a conceptual framework without implementation and evaluation. In addition this approach is not modular, i.e., the visualization component is a fixed piece of the system. So it is not easily possible to add or change the kind of visualization or the visualization algorithm. It is rather a system, with a fixed mapping of raw data to the visualization. Furthermore it is unclear if there is one or more external data sources and if contextualization can take part across data source boundaries. Another important point of this approach is the definition and understanding of the notion of “context”. It is more related to cognitive processes and models, and it is unclear how this is technically perceived and realized.

We can conclude that there is still a lack of systems which enable contextualized information, based on desktop information and data relations to visually/graphically support knowledge workers at their workplace for informal learning processes.
III. APPROACH

To accomplish the demand of knowledge workers we propose the following solution. We developed a framework for contextualized visualization, which uses existing context information sensors, different knowledge visualizations and various data sources.

Our framework integrates different sources of information and data to enhance existing visualizations at the knowledge intensive workplace to support the knowledge workers.

A. Context

We have to define how we understand context. In general we follow the definition of Hartmann and Austaller [6]:

"Context characterizes the actual situation in which the application is used. This situation is determined by information which distinguishes the actual usage from others, in particular characteristics of the user (her location, task at hand, etc) and interfering physical or virtual objects (noise level, nearby resources etc). Thereby, we only refer to information as context that can actually be processed by an application (relevant information), but that is not mandatory for its normal functionality (auxiliary information)."

This means context can give us information about the current situation and the current work task of the knowledge worker. For further discussion we sub classify the term “context” into “relation context” and “state context”. The former means relations in or between data sources and the latter information about the status of the user.

Definition Relation context: “Relation context is the part of context information, which characterizes the environment respectively the relations of information or virtual objects among each other.”

Relation context usually can be computed by analysis of the data (data mining). This is especially useful, if several data sources are combined [7]. Techniques to accomplish this task range from simple “pattern matching” over mechanisms from artificial intelligence to probabilistic approaches [8].

A concrete example could be the cross linking of authors of documents, which can be obtained from the metadata of the documents itself, and contact information from the mail tool of the user.

In contrast and complement we define state context as follows:

Definition State context: “State context is the part of context information, which describes the characteristics and properties of the user itself and his/her environment and cannot be extracted from static data or information.”

Examples of state context information are location of the user, her current task or level of noise. All this information can help to adapt the workplace and especially the visualization for the better.

A central and significant source of this state context information is the operation system [9]. This provides mechanisms to get any kind of events and user interactions, like mouse movements and mouse clicks, but also keyboard events, clipboard content and information about open applications, windows, files and content of files.

Some of this low level context information can be aggregated to high level information, e.g., desktop topics or keywords based on file’s content or the content of the current Internet page in the Internet browser of the user. Another example is the elicitation of the current work task. Machine learning methods are one possible medium to compute this information based on keyboard input, window titles and file content [9].

Other examples of context information are (physical) sensors like noise level and brightness. All this can be applied and integrated to optimize and adapt the visualization for the knowledge worker.

B. Framework

Figure 1 gives a general overview of the system for contextualized visualization we propose. At the bottom there are three external elements we reuse for our framework:

- Context sensors (source of information about work context or the current work situation of the knowledge worker)
- Visualizations (existing adaptable knowledge or information visualizations of any kind)
- Data sources (at knowledge intensive workplaces this could be tasks and processes, competency information and ontologies for concept definitions)

These three types of external elements are taken and combined in a new way, to support the knowledge worker’s daily work.

Context sensor information can be of interest at launch time of the visualization, but also at runtime, if important context information changes. To fulfill this, we use a push/pull mechanism to ask all context sensors at the beginning about all information (pull). If context information changes during actual work, e.g., specific keyboard input or a new window appear, this information is forwarded to the visualization automatically (push).

On the data side, many data sources of any kind can be integrated, if an adapter is provided alongside. Usual kinds of data at knowledge intensive workplaces are: pre-modeled, implicit or ad-hoc processes, explicitly modeled domain information (by domain experts) or content management systems.

In the center of the external elements at the bottom of Figure 1, is the “Visualization Selection” component. Based on context information and data analysis, a fitting
visualization is chosen. The System supports a wide range of visualization types. By implementing a simple API, additional visualizations may be added later in an easy way. This is true for any of the external components. Data sources as well as Context Sensors can be added at any time in a simple manner.

At the final step the “Contextualization” is done. Context information is taken to adapt the visualization. Some examples of context-based adaptable visualization parameters are:

- highlight important or helpful information, based on desktop keywords, e.g., typed by the users or extracted from open documents (the importance of keywords may be estimated, e.g., by matching with explicitly defined user models [9])
- automatic starting point of visualization, e.g., current work context or task
- size and scaling of whole visualization or single elements according to available space or screen resolution
- adjustment of single visual elements, e.g., status of tasks or persons, or size of icons to show importance
- adjust level of detail for a given work context

The result of this process is a visualization of important data, with the right amount of information, with the right level of detail, which best fits to the current work context or work situation of the knowledge worker.

IV. PROTOTYPIC IMPLEMENTATION

The prototypic implementation of the above framework was done in Java, to allow easy extension of the system with new context sensors, data sources and visualizations.

The main data source for this prototype is from EUDISMES, a project for CTM – collaborative task management. This tool integrates into MS Outlook to enable the users to define ad-hoc processes just by defining new tasks, sub-divide and delegate them [10].

Every task has a corresponding person, the owner of the task. In addition to this relation from task to the corresponding person (responsible person), there can also be relations to helpful or necessary documents of any kind. These documents are associated by the user while creating or working on the given task. If such an ad-hoc process seems to be valuable, it can used as a template for new processes, with all the persons and documents involved.

Figure 2 show a screenshot of the resulting application. On the left side is the information visualization of a net of different kinds of data. In separate sectors, hierarchies of tasks (ad-hoc processes), a network of people, related to these tasks, and associated documents of any type are shown together with its relationship. The most interesting part of this visualization besides the relationships is the adaptation and contextualization of the elements.

In addition to the graphical visualization of the data the application has a textual information space showing more and deeper data on the right side. It shows extra information regarding the selected item, like due date and status of tasks, workload in number of tasks for any of the visualized people. This is information which is not easily embeddable in the graphical visualization. The sidebar also allows another way of navigation through the data by offering drop down lists for all elements.

At the end this tool allows the knowledge worker to navigate through the displayed information and explore the relationship of responsive people to task, importance of tasks, availability and workload of people and associated documents for tasks.

A. Context information

This tool is analyzing the information from the CTM, to find all the inter relationship between tasks, persons and documents. Also context information are computed based on heuristics, which allows emphasizing tasks regarding their due time and complexity (number of sub-tasks and delegations) and persons regarding their workload (number of associated tasks). These possibilities are shown in figure 3. Supplementary status context data is taken from desktop sensors or other external tools (see above).

![Figure 3. Contextualized Elements](image)

The context information is partly embedded into the visualization and partly into the sidebar, depending on type of context and importance. The following list gives an overview about all supported context information together with its visual position realized in this instantiation of our framework:

- complexity of task: size of icon in visualization
- due date of task: colored bar and number of days as text below task icon in sidebar
- availability of person: color of icon in visualization
- workload of person: colored bar beneath the person and as number of tasks as text in sidebar

This context information and especially its visualization or parameterization of the visualization allows an easy overview and perception of information by the knowledge worker at her desk.

For state context information a context sensor based on information of the operating system or special tools are needed. For example availability of other persons may be obtained out of an instant messaging tool.

B. Chosen visualization

As the visualization we choose the TopicMap Viewer [11]. This visualization was chosen due to the following
facts and advantages. One major point is that the visual-
ization is explicitly developed with tree structured or
hierarchical data in mind.

It also offers a great flexibility, like adaptable graphical
icons and dynamic configuration and is adjustable in re-
gards to many (graphical) options.

Another important issue is the usability. The TopicMap
Viewer is highly usable and allows the user to navigate
through the data very fast and easy. To prevent cognitive
overload, it only shows part of the data based on the
selected information to reduce the amount of visible in-
formation.

To support the user and while browsing through huge
data sources, a history option is provided and figure con-
istency gives orientation to the user. This consistency is
achieved by minimize shifting of items and sectors. So
usually, if the user comes back to a topic already visited,
the graphical appearance should be the very same.

In summary the main advantage of TMV is, that it
displays a large quantity of information with specific
features like zooming the required activity, hiding the
inactive data without losing the track of links with other
topics which are currently not required and differentiates
the topics according to types by using sectors and levels.

V. EVALUATION

To verify the usefulness and relevance of our approach,
we did a quantitative and qualitative user study. The eval-
uation was done in two dimensions: quality (feeling and
opinion of the user) and efficiency (time the user needs to
fulfill the given task and number of failures). To measure
results in both dimensions we used a questionnaire for
the evaluation system (scenario B). This way we could
find a document. The experimental setup was probably
too unusual for a knowledge intensive workplace. The
prototype was already running on the computer and MS
Excel was used to semi-automatically measure the times.
For the second scenario (without the contextualized visu-
ization system) a telephone was also simulated. The
attendant could ask questions to the supervisor of the
experiment, by telling the name of the person to contact
and a question. To adjust this a little bit, we add a penalty
of 10 seconds for the “telephone call” to simulate real
calling or walking the next office. 10 seconds is a small
assumption, especially when concerning small talk, which
usually is taking place in such situations, or finding a
person in a slightly farther office or department.

B. Time Measures

In Table 1 the average times of the three tasks are
shown, separately for the two user groups. Scenario A
means with support of the contextualized visualization
system and Scenario B is without this kind of support.

<table>
<thead>
<tr>
<th>TASK AND SCENARIO</th>
<th>Task 1</th>
<th>Task 2</th>
<th>Task 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A</td>
<td>57 sec.</td>
<td>33 sec.</td>
<td>51 sec.</td>
</tr>
<tr>
<td>Scenario B</td>
<td>87 sec.</td>
<td>97 sec.</td>
<td>39 sec.</td>
</tr>
<tr>
<td>t-Test Value</td>
<td>4.0403</td>
<td>8.2402</td>
<td>-2.0715</td>
</tr>
</tbody>
</table>

For task 1 and 2 the average duration is clearly shorter
when using the supporting graphical system. But also
after deeper analysis of all 30 users for the six tasks, the
result clearly shows the benefit of the system.

For the deeper analysis we choose a t-Test, which is
designed to compare different sets of samples with each
other. Table 1 also shows the t-Test values for the three
tasks (4.0403 and 8.2402 for tasks 1 and 2). This indi-
cates that the results are highly significant (for the signi-
ficance level α of 0.05% and 58 degrees of freedom the
threshold would be between 3.496 and 3.460). As both
numbers obviously exceed this threshold, it shows the
high validity and high significance of our results.

Our observations regarding task 3 are different. Here
the results are opposite (indicated by us as a negative t-
Test value). A potential explanation for this result is the
following one. As already outlined above, task 3 was to
find a document. The experimental setup was probably
too unusual for a knowledge intensive workplace. The
prepared file hierarchy was pretty easy to follow and the
requested document was the only one in the target folder.
Perhaps this does not reflect a real workplace, where
hundreds or thousands of documents reside in a some-
times unclear hierarchy. So the last task may not be re-
presentative for a real knowledge worker’s environment.
C. Quality Results

In addition to the quantitative analysis based on time measures, a quality evaluation complements this user study based on a questionnaire.

This analysis and interpretation of the questionnaire is about the user satisfaction. The questionnaire itself is based on ISO (German national standardization committee) standard for user interface and usability evaluations. It contains 13 questions, while 11 are multiple choice and two free text questions to get annotations and comments from the users.

To enumerate each and every question together with all answers would break the size of this paper. Instead we are going to present the main and key facts and results from the questionnaire.

First and foremost, all users found the system at least helpful if not, as most users did (63%), very helpful. Most attendants said that the system is self explanatory and almost all attest unobtrusiveness to the contextualized visualization. Contextualized information is explicitly judged as supportive for the given tasks.

The question about which task was best and which task was least supported by the system, the answers where as estimated. As the numbers above already indicated, most users found it least helpful for task 3 (discussed in detail above), but very helpful for task 1 and especially task 2.

All in all, the evaluation strongly confirms the importance and potential of our approach.

VI. Future Work

There are a number of interesting context sensors which could be integrated into our framework to further extend the usefulness of this approach for knowledge intensive workplaces. For example application based tracking of low level user interactions or the very promising above explained desktop keyword utilization. The latter is the context monitor daemon, for topic detection based on currently open documents and user typing, and is directly related to the presented scenario.

We also think of combining this prototype with other experiments and additional visualizations to broaden the field of application. To clarify the evaluation results regarding task 3, we will enhance our measurements by a systematic comparison with more realistic file hierarchies.

VII. Summary

In this paper we presented the design, prototypic implementation and evaluation of a framework for contextualized visualization at knowledge intensive workplaces. By using a combination of (already existing) context sensors, visualizations and data sources, we built a prototype that offers great visual support to knowledge workers.

The evaluation showed a significant improvement by our approach to knowledge intensive work. This holds especially for informal learning, which among other things, means information finding and task/cooperation based activities. In particular, our system helps knowledge workers to get familiar with tasks and processes in a new environment or working area. We showed that at least some tasks at knowledge intensive workplace clearly benefit from our approach.

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