Workspaces enhance efficiency – theories, concepts and a case study

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Abstract Traditional process-oriented system development methods often result in fragmentary user interfaces with information presented in various windows without considerations of requirements for simultaneous viewing. Opening, closing, moving and resizing these windows attracts the users' attention away from the actual work. User interface design according to the workspace metaphor could provide skilled professional users with an efficient, customised user interface to administrative information systems. This can improve work performance and facilitate efficient navigation between workspaces. A case study in co-operation with the Swedish National Tax Board (RSV) describes practical use of the workspace metaphor.

1. Introduction
In the recommendations by the International Standardisation Organisation (ISO 9241-11, 1998), usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. A general problem in the design of usable interfaces concerns how a large and complex information structure can be efficiently visualised on a relatively small computer screen. A common solution to the limited screen space problem is to divide an application into a large number of different windows, often hierarchically structured. A hierarchical application structure causes navigational difficulties; the user easily becomes lost in the information space (Woods and Watts, 1997). Interfaces where the users have to spend a lot of time rearranging windows instead of doing their actual work are unfortunately common (Gulliksen and Sandblad, 1995). To be able to design a usable interface it is essential to understand that the users' main interest is to perform their work, not to operate a computer. The computer system must support the user with appropriate sets of information that can be reached fast and with minimal cognitive effort.

The design of the user interface is especially important when developing information systems for skilled professionals (Nygren et al., 1992). Skilled users are often forced to use one particular support system and the efficiency of their work is strongly related to the usability of that system. Badly designed computer systems can cause mental stress, which in turn may contribute to musculoskeletal

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problems (Smith and Carayon, 1993). Our research aims at identifying such
cognitive work environment problems, and to find solutions to them. These
problems are often specific to certain work domains. The design must therefore be
based on extensive domain knowledge and the user interface should be tailored to
support each category of users (Gulliksen and Sandblad, 1995).

In this paper, two main approaches to design will be discussed, a process-
oriented and a workspace-oriented approach. We mean that user interfaces
based on workspaces can support the skilled user more efficiently, especially in
administrative work domains.

2. Process-oriented versus workspace-oriented design
2.1. A process-oriented approach
Traditional systems development is usually performed with a process-oriented
approach. The users’ work is typically specified with a data model and a
definition of the processes, e.g. through a data flow diagram (DeMarco, 1978).
Usually a process corresponds to one function of the planned application. In
such methods there is seldom any suitable aid provided for developing
dialogue interfaces (Floyd, 1986), i.e. how to use the resulting models in the
design of the user interface. Recent object-oriented methodologies, such as
UML (Booch et al., 1997), do not give enough support for this process either.
Instead, the process-oriented approach invites the designer to create an
interface where each specified function corresponds to one or more windows.
Typical modelling and design work consist of the following steps:

- Specify the functions that involve interaction with a user.
- Define a structure for how the different functions can be accessed from
  each other during the work process.
- Give each function its own, unique user interface (i.e. a window).
- Create a menu on the top level from which the user can access the
different functions.

With a process-oriented approach the application is the sum of all its functions
(Figure 1). The user interface contains all functions that all different users can
access in all different work situations. A user works with the application by
selecting among the desired functions in a menu or by navigating through the
structure of functions. Each function will have the same look and behaviour no
matter who accesses it, for what purpose it is accessed, or in which context it is
accessed.

There are some major problems associated with this approach:

- the design is not adapted to the users’ actual work tasks;
- the user has to spend time on opening, closing, moving and rearranging
  windows while performing the work task; and
- the user often has to consult several different functions in order to
  complete a certain work task.
In order to reach the desired functions, the user must understand and navigate a rather complex structure of windows and menus. The described way of working is inappropriate because it will cause unnecessary cognitive load. Parallel presentation of information is more efficient than sequential presentation (Lind, 1991).

It is easy to proceed from the process-oriented analysis to a multiple window design and the result will most likely be a fragmentary interface split into a large number of windows. Furthermore, to deal with an assignment, a user typically has to use more than one application, where each application has its own main window with accompanying secondary windows. In a large corporation where the applications have been developed in-house each application might in addition have its own unique look and feel. In order to overcome these problems a more appropriate metaphor has to be chosen.

2.2. A workspace-oriented approach
With a workspace-oriented approach the interface is designed to support categories of users in their different work situations (Lif, 1997). The main idea here is to support each category with a tailor-made interface that is complete with respect to information contents and tools for each of the different work situations in which the users can become involved.

Modelling and design according to the workspace-oriented approach means specifying, among other things, the following:
The workspace-oriented approach results in a design that is specifically tailored according to how the professionals actually perform their work. Each work situation corresponds to a workspace on the screen. A workspace is the user interface to a complete work situation. The relevant workspaces are made available for each category of users via a task panel. When a user has selected a workspace, the screen is "ready to use", without the need for further design actions, with respect to information and tool contents (Figure 2). The number of different workspaces (work situations) for a specific user is often relatively small; less than five or six should be sufficient for a user in the domains we have studied.

Administrative work, such as case handling (Gulliksen, 1996), often requires an overview of an extensive amount of information. The interface design must be as complete as possible in order to satisfy demands on simultaneous presentation of information. When all required information and all operations are gathered in one workspace it is easier for the user, frequent as well as novice, to immediately become oriented in the information space and get support for further actions. In addition each workspace must have a distinct layout well separated from others. This will help the user to recognise the workspace immediately, its contents and the included operations, when switching to another task. The workspace concept, as described here, would

Figure 2.
Each category of users can potentially perform work in one or more work situations. Each work situation corresponds to a workspace, i.e. an interface to the part of the information system that supports the work situation.
not only support the user while performing each work task, but also provide an overview and facilitate task switching.

We mean that using a workspace-oriented approach to design offers better possibilities to create an interface that supports the users in their work. We will now, in more detail, describe the workspace metaphor as an alternative to the desktop metaphor.

3. The workspace metaphor
The workspace metaphor is based on a framework for a multiple virtual workspace called the rooms design (Henderson and Card, 1986; Card and Henderson, 1987). The idea behind the rooms design is to provide the user with a number of screen-sized workspaces called rooms. Each room has a set of small icons ("doors"), used for navigation between rooms. Each room contains a number of windows that support the task to be performed in that room. A modified version of the rooms design is suggested here to replace the prevalent desktop metaphor for administrative information systems.

3.1. Work task and actor
An important concept related to the workspace metaphor is the work task. A work task in this context is defined as a continuous moment of work performed in order to reach a specific goal. Each work task includes a judgement process and is terminated by a decision. The interface must be structured according to the actual work tasks and how the users perform them. The analysis of the users work must not only cover all different aspects of the work tasks, but also identify the different actors and specify which tasks they perform. For a more thorough analysis of the concepts concerning work tasks and actors, see Gulliksen et al. (1997).

3.2. Workspace
Each workspace has to completely support one or more work tasks in order to relieve the user from having to switch to another workspace during a judgement process. A workspace can be thought of as a container enclosing the interface elements that hold the information needed while performing a work task. One specific interface element can appear in different workspaces since the same information, possibly viewed in different ways, may be required in many tasks. An element can for instance be presented in one workspace where the information is read-only and in another workspace the same information may be editable. The logical relations and the connections in time between the tasks define whether they should be performed in the same workspace or not.

An administrative work task can, for example, consist of the following actions:

- taking care of a newly arrived document;
- finding out that this document concerns a request for delay of the current case;
• analysing the arguments for the delay, checking current status and previous history;

• making a decision about the request, accepting it, rejecting it or requesting more information from the concerned part; and

• documenting the decision.

This work task has then been completed and the next task can be handled. Depending on the nature of other assignments connected to the same kind of case, additional tasks could be performed in the same workspace as well. The work is seldom performed in a perfect sequence from start to finish. Therefore, the user must always be able to interrupt and leave an ongoing work task in one workspace, and return later to complete the task.

3.3. Actor-workspace

The concept of actor (Jacobson et al., 1992) is used to describe different categories of users. Each workspace is especially designed to fulfill the requirements of a certain actor and has consequently a specific authority level. The contents and the layout will depend on the requirements of the intended actor. This implies that a workspace may admit or deny access to (show or hide) information depending on the authority of the current actor. A specific user can play the role of one or more actors. An actor will typically have access to a number of workspaces and use a few of them frequently.

The relations between the defined concepts are many-to-many, i.e. one actor can be engaged in several work situations, one work situation can consist of several work tasks. One work task can as well be a part of different work situations.

4. Designing a workspace

A basic idea with the workspace metaphor is that a professional user should be able to perform an entire work task in one workspace. The completion of a single task should not require switching between different workspaces. Each workspace must therefore be carefully designed to support the users in their work. We will here introduce some design heuristics to support the design of the workspace interface. The heuristics are especially important when designing according to the workspace metaphor, but most of them are also valid when designing for skilled users according to other metaphors.

4.1. Simultaneous presentation of information

During decision making, humans tend to omit information that is not immediately available (Tversky and Kahneman, 1974). To be able to make a proper judgement, the information must be simultaneously visible on the screen. However, a skilled user can easily overview a large set of familiar data (Nygren and Henriksson, 1992). According to our experience it is possible to present more information on the screen by using information coding and a careful spatial layout. Window-based information systems almost always occur as subwindows or windows within windows. This means that important information has to be presented as a sequence of frames in the hierarchy, i.e. three frames in the level hierarchy are presented simultaneously.

4.2. Operating environment

Each of these frames contains information on a specific kind of user. The environment is designed to support different kinds of work situations in different kinds of workspaces.

5. Conclusions

In conclusion, we have presented a metaphor for designing work systems. This is a rather general research area and the design heuristics are not meant to be applicable in all cases. However, we believe that the heuristics are applicable in situations where the design of the workspace is important.

This is especially true for those situations where the user is involved in work situations that are difficult for the user to handle (reduction of information overload).
occupy the screen with information irrelevant for the skilled professional, such as window frames. Windows tend to cover important information in other windows. Information presented on screens that can only be viewed in sequence has proved to be more cognitively demanding than information presented in parallel (Lind, 1991). The process of keeping decision-relevant information in the short-term memory is often disturbed when manoeuvring through the information space. Due to the advantages of simultaneously presented information, hierarchies should be avoided.

4.2. Support pattern recognition
Experienced users decode frequently occurring, meaningful patterns, quickly (Nygren et al., in press). If a set of variables always has the same properties (such as colour or shape and spatial location on the screen) global patterns may emerge over time that can be used to guide the users in the reading process. The decoding of patterns can be performed on an automatic cognitive level without interfering with processes performed on a conscious level.

4.3. Workspace contents
Each workspace must be especially equipped to supply the user with all information and every tool needed to perform all parts of the work task. This will render each workspace an obvious character that immediately reveals the kind of tasks that can be performed there, which facilitates recognition of the different workspaces. Some generic tools have to be available from any workspace (such as electronic mail, calculators, note pads), depending on the kind of activities performed in the current environment.

5. A case study
In our co-operation with the Swedish National Tax Board (RSV) the workspace metaphor has been implemented to facilitate case handling. Characteristic for case handling is that a lot of information from different sources has to be gathered and verified to enable a correct decision. Traditionally, the users have performed their work by interacting with several different applications. In this case study the purpose was to create one application in which each user has access to different workspaces tailored for each work situation, as defined by the workspace metaphor.

The work situations to be supported by the future system were specified in the analysis of the users’ work. Each such work situation corresponds to a workspace in the user interface. The users of the system have various authorities, therefore the individual number of required workspaces differ.

The different workspaces were designed and implemented by different groups of software engineers. The choice of development tool differed between the groups. The application was designed for a PC with a 17-inch screen (resolution = 1024 x 768).

Figure 3 shows a typical workspace included in the system. All information and every tool needed for the judgement and decision-making process are
available in the workspace. Every interface element included in the workspace has its fixed position on the screen. The left side of the display shows a ledger that contains information about all previous events and decisions concerning a case. This ledger provides a direct index to previous decisions. An overview is shown for the case as well as facilities for making a decision on how to handle the current matter.

Switching between workspaces is enabled through a task panel (to the upper right), either permanently visible, or hidden and occurring upon demand. The contents in the task panel depend on the users' authorities. Each workspace can be selected directly via the task panel. A workspace is represented with an icon and a short explanation (tool tip).

5.1. Method
The first version of the system was evaluated with a heuristic approach (Nielsen and Molich, 1990). Three HCI researchers, with limited domain knowledge, and five work activity professionals, evaluated the user interface. Each evaluation was performed individually. The heuristics used in the evaluation were specified by the authors in co-operation with the person responsible for usability issues at the Swedish National Tax Board.

![Figure 3.](image)
The display shows a workspace from the application. It has been selected from the task panel to the right.

5.2. Results
Some people identified errors.
Task: and interaction calls are possible.
Main window: the graph can sometimes be canceled.
Work: could not be performed.

5.3. Conclusion
Some problems in mixing tasks in a sequence may be detected.
Other problems may be very difficult to identify. Immediate feedback is needed to analyze the decisions between workspaces.

The display could implement them, and they are difficult to interpret in work. The use of a visual interface detected and enhanced the effectiveness.

6. Discussion
The interface is a representation.
5.2. Results
Some problems related to the implementation of the workspace metaphor were identified in the evaluation. The most important findings are listed below:

Task switching. Sometimes it is necessary to interrupt an ongoing work task and initiate a new task before a decision has been made, e.g. when a customer calls and needs immediate service. In this version of the system this was not possible unless the current task was either completed or postponed.

Mainframe systems. To get access to and change information stored in older mainframe systems the user had to start a new application in a separate window on top of the current workspace. The content of this window was not graphical and it was handled differently from that in the ordinary workspace.

Lack of information. Sometimes important information was hidden and sometimes it was not even possible to view the required information without cancelling the current work task.

Workspace character. It was difficult to recognise which kind of work tasks could be performed in a workspace. Furthermore, the layout of many of the workspaces was too similar, which made them difficult to distinguish.

5.3. Comments on the Results
Some of the problems described above can be explained by the difficulties in mixing old systems with new ones. Placing information from the older system in a separate window, on top of the current workspace, will most likely lead to problems since the user is then unable to view all information needed for a decision simultaneously.

Other problems concern the analysis of the users' work. The analysis has to be very thorough in order to avoid usability problems later on (indeed this should be the case independent of the choice of system metaphor). This puts immense demands on the analysis team in order to reach a level where all needed information, for certain, is supplied within a workspace. An incomplete analysis could for instance cause a situation where the user has to switch between workspaces in order to perform a task, which makes the produced workspaces just as inadequate as an application using multiple windows.

The problems detected in the evaluation point out potential pitfalls in the implementation of the workspace metaphor in a computer system. Most of them occurred because of technical limitations, insufficient task analysis and difficulties in understanding the users' needs. They did not depend on the workspace metaphor itself. In this case study we have only been able to analyse the use of the workspace metaphor in a first version of the system. Some of the detected problems will be dealt with in later versions. In the future we will see the effects of long time use.

6. Discussion
The limited screen space is one of the major obstacles when designing information systems for administrative work. The workspace metaphor represents an interesting approach to solve some of the basic design problems,
such as task switching and visualisation of large and complex information structures onto the limited screen space. Based on basic principles of the room metaphor as presented in Card and Henderson (1987) and Henderson and Card (1986) we have developed a structure for a workspace oriented design methodology. Our ambition has been to create a framework for design that easily can be implemented using most commercial development tools.

Implementing the workspace metaphor puts new demands on the software engineers. It is difficult for developers familiar with the ordinary desktop with multiple windows to immediately adapt to the workspace metaphor. Nielsen et al. (1992) have discussed similar problems in a survey where software engineers were taught object-oriented design. They conclude that experience is needed and advice from specialists is useful. We believe that the workspace metaphor could be adopted more readily if the developers were supported by methods for analysis that capture aspects directly applicable in the design of the user interface. In order to utilise fully the advantages of the metaphor, the design work should be based on an object oriented system development method. The workspace metaphor is well suited to work in conjunction with the use-case approach (Jacobson et al., 1992) and user interface modelling (Lif, 1997).

The design of a workspace must be elaborate. It is not sufficient to make sure everything needed is there and leave the final layout to the user. This kind of design almost always ends up with a work situation where the user constantly has to rearrange the contents of the workspace in order to display the information needed for the moment. Frequently needed information must be structured in a way that facilitates retrieval. The design requirements stated here might seem contradictory compared to a changing work situation. Even though a perfected design is desired, it must at the same time be possible to let the application evolve in time and grow with the work task that inevitably will change over the coming years. A modular way of thinking is required, otherwise the application will soon be outdated. Consequently the objects in a workspace must be easy to replace and it must be possible to append new elements. New methods or services must be possible to add without disturbing the previous structure of a workspace.

An information system designed according to the workspace metaphor can work more efficiently if all of the users' applications are workspace oriented. Achieving this is a matter of supervisory status, a strategic issue. One way of accomplishing this is by including the workspace metaphor in a corporate style guide. This can be done according to the theories of domain specific design, that is with the use of a domain specific style guide as a basis for making the design decisions (Gulliksen and Sandblad, 1995; Borålv et al., 1994).

The workspace metaphor has been applied in several research projects (e.g. Borålv et al., 1994; Borålv and Göransson, 1997). It has been used to a wider extent at the Swedish National Tax Board where descriptions on its application and functionality have been specified in the organisation's domain specific style guide.

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The full implementation of the workspace metaphor in a large organisation, with requirements on high performance and compatibility with other systems, can be problematic. However, it has the potential of solving many of the basic problems encountered when designing complex computer support systems.

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