Specific Cooperative Analysis and Design in General Hypermedia Development

Kaj Grønbæk & Preben Mogensen
Computer Science Department
Aarhus University
Ny Munkegade 116, Bldg. 540
DK-8000 Århus C, Denmark.
Tel: +44-89-42-31-88
Email: {kgronbak,preben}@daimi.aau.dk

ABSTRACT

Cooperative analysis and design is often considered only to be applicable in settings where a system is being developed solely for the 'user' participants in the process. This paper, however, argues that there are good prospects in applying cooperative analysis and design techniques in specific use settings to inform development of general products. We discuss the application of cooperative – i.e. participatory – analysis and design in development of a general hypermedia framework, the DEVISE Hypermedia (DHM). A single engineering company managing one of the largest bridge/tunnel construction projects in the world was chosen as the user organization. We demonstrate how specific activities informed the general hypermedia framework and application design. Use scenarios and prototypes with example data from the users' daily work were used as sources both to trigger design ideas and new insights regarding work practice. Mutual challenging characterised the interaction between specific cooperative analysis and design activities and general development activities. People working across boundaries facilitated this interaction, and prototypes, scenarios, and concise bullet list notes were used as mediating artefacts rather than comprehensive requirement and design specifications.

Keywords: Cooperative analysis, cooperative design, cooperative prototyping, hypermedia.

INTRODUCTION

The work described in this paper was part of a multinational, EEC Esprit II project, EuroCoOp, developing systems supporting distributed collaborative work. This project had two main goals: analysis of CSCW needs in organizations, and development of general CSCW systems. The analysis was divided into a qualitative analysis at the Danish Great Belt Link Ltd. (GB), see [14], and a quantitative survey of some 50 German companies. The general CSCW development was split into four subprojects: hypermedia, desktop conferencing, task coordination, and enterprise information service. This paper describes and discusses the interplay between the specific GB analysis and the general hypermedia development. The hypermedia design discussed, is the DEVISE Hypermedia (DHM) framework which is described from a technical point of view in several papers [12, 13, 16]. For a general introduction to the concepts of hypertext and hypermedia, see [6].

In the project we served two 'roles'. We served as facilitators for the general system development by providing a specific analysis of GB as well as we ourselves conducted general hypermedia development. The primary goal of the GB analysis was to provide feedback to the general system development in EuroCoOp, both on specific functionality and as long term visions for CSCW in such settings. A secondary goal was to facilitate the ongoing development at GB. To achieve these goals, we applied cooperative analysis and design techniques throughout the project [10, 29]. Moreover, some of the general developments, including the general hypermedia, cf. Figure 1, continue in a successor ESPRIT III project called EuroCODE: CSCW Open Development Environment.

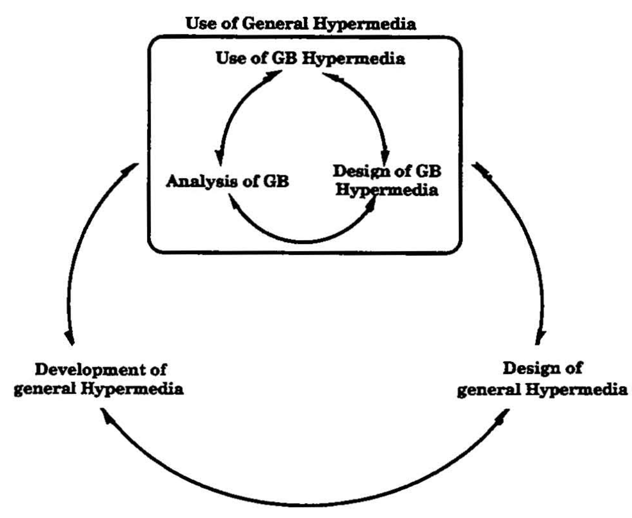


Figure 1: Interaction between specific cooperative analysis and design activities at GB and general hypermedia product development.

In *PDC'94: Proceedings of the Participatory Design Conference.* R. Trigg, S.I. Anderson, and E.A. Dykstra-Erickson (Eds.). Chapel Hill NC USA, 27-28 October 1994. Computer Professionals for Social Responsibility, P.O. Box 717, Palo Alto CA 94302-0717 USA, cpsr@cpsr.org.

Cooperative analysis and design

One way to conceptualise the relationship between specific and general development in the project is given in Figure 1.

The figure depicts two development cycles:

- specific cycle: development of a GB hypermedia (the smaller cycle in the rounded box)
- general cycle: the development of a general hypermedia (the larger cycle).

The terms analysis and design in the figure mean cooperative analysis [29] and cooperative design [10]. Cooperative analysis is primarily directed towards current constraints and potentials in a praxis with respect to certain possibilities for change. Thus cooperative analysis complements more traditional approaches focusing on describing praxis as is. Cooperative design is focused on constructing these future possibilities (new computer systems) given current constraints and potentials.

Cooperative analysis and design are both conducted through cooperation between people from the 'use'-praxis and analysts/designers. Furthermore, the approaches are characterised by experimentation and intervention; they both analyse and design by experimenting with alternatives to the existing, and both do it by experiments within the praxis, i.e. by intervention. For example, prototypes of future possibilities can be used to trigger new insights concerning current praxis as well as future possibilities [30].

The general cycle indicates how a specific development process, here the development of a specific GB hypermedia, may both gain from and contribute to the development of general applications, here hypermedia. In this case the development cycles for the specific domain may function for the general design in the same manner as use-sessions at GB do for the specific design. That is, as instances of concrete uses that may trigger new insights concerning obstacles to as well as possibilities for the general design.

The double arrows in Figure 1 indicates, as will be elaborated below, a reciprocal affecting and informing among the different activities.

INITIAL ACTIVITIES AT THE GREAT BELT

Figure 2 gives an outline of the EuroCoOp activities involving GB, focusing on cooperative analysis and design concerning the hypermedia development. It provides an impression of the activities depicted in Figure 1 over time. These activities are discussed in [14] at a general level, and in [24] focusing on the initial analysis and its relation to activity coordination.

In between the cooperative activities outlined in Figure 2, analysts, designers and programmers were working on technical development, and documentation. Informal contacts with the supervisors at GB were established when needed during these intermediate activities.

Initial Analysis

The objective of the initial analysis was to get an overall picture of the GB organization, its objectives, practices, objects of work (bridge construction), etc. It was carried out through a number of visits at the headquarters in Copenhagen, a site office, and a construction site. To a large degree, the focus in the initial analysis was determined by GB - they told, showed, and demonstrated what they considered to be of relevance for us. Our understanding of the GB work practice and the overall project goal led to more specific analyses, focusing on three aspects of cooperation at GB: activity coordination, synchronous communication, and (asynchronous) sharing of materials. In this paper we focus on the issue of sharing materials.

One of the primary findings in the initial analysis was that current information technology *only* supported vertical reporting in the organization whereas support for horizontal cooperation among different people and departments in GB was lacking. Daily work procedures were instead supported by maintaining small databases and calculations using word processors, spreadsheets, or special purpose applications. We discovered several bottlenecks and problems in the daily performance of supervision work in this setting [14].

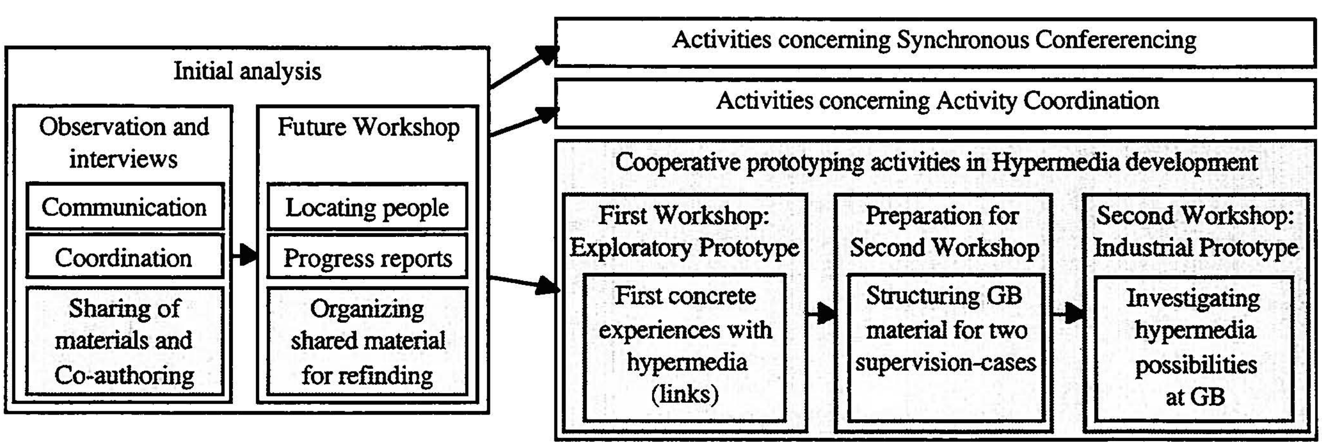


Figure 2: Overview of the EuroCoOp activities involving GB, highlighting the cooperative analysis and design concerning the hypermedia development.

Future Workshop

As an intermediate step between observations and the more intervening analysis and design, we arranged a variant of a Future Workshop [20, 21]. The goal was to encourage GB people to express views on problems and bottlenecks in GB and to generate ideas concerning how to overcome them.

Our *variant* differs from future workshops in the following respects: 1) The people at GB could hardly be said to be resource weak (as presumed in [20]); most of them are engineers and have used computers for years. 2) As conductors we took on a more active role in the workshop. We used our previous analysis and technical knowledge to challenge current practices as well as to suggest possible solutions. Instead of being facilitators only, we were also 'co-players'. 3) Finally, we conceived the implementation phase to be the succeeding prototyping activity.

Issues concerning recurrent tasks, exceptions in the bridge construction, locating people, and sharing of materials were raised. Our main attempt to be more active concerned the organizing of materials, which was one of the elaborated possibilities: It was a fundamental part of existing practice at the GB that retrieving of materials (letters, drawings, notes, change requests, non conformances, pictures, etc.) was accomplished via key-words. As a consequence it was almost impossible for the people at GB to imagine solutions beyond better assignment of key words. We tried to explain alternative visions such as hypermedia structures, but this was really hard for people to grasp in the abstract [22]. The future workshop provided the primary rationale for exploring possibilities for hypermedia support in supervision. See section 3 for a discussion of these activities.

Findings with respect to management of supervision materials

This subsection presents some of the key findings from the initial analysis and the future workshop, focusing on areas where hypermedia has a potential.

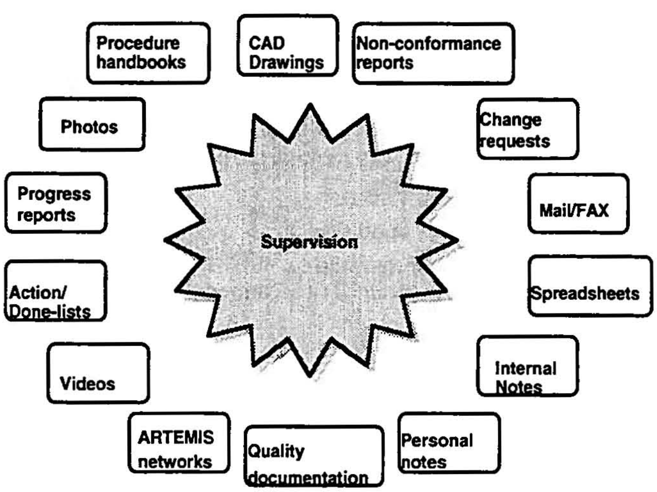


Figure 3: Examples on the multitude of materials used by supervisors at GB.

Non-integrated access to heterogeneous materials

The materials outlined in Figure 3 cannot be accessed in a uniform manner: some material is in central paper archives, some on the supervisors' shelves, some on a mainframe, some on UNIX servers, some on local PC's, etc. Many special purpose systems have been introduced to handle specific kinds of material, but the various systems, although they are quite new, mostly introduce their own monolithic storage and access paradigm. The heterogeneity of materials and systems imply a disintegratedness among the systems and it is typical that a few persons who are experts in using one of the systems become a bottleneck for accessing important information residing in a specific system.

Re-finding of materials is difficult

In general, retrieval is accomplished through "keys": filenames, key-words, dates, etc. Provided one has (parts of) the key, re-finding is easy, however, this is often not the case. A typical task for a Supervisor is handling so-called "actions". Examples of such actions are: assessment of a Quality Control-form, handling a non-conformance report, handling a change-request, etc. The information needed is typically hidden in material such as: similar cases from the past, previous correspondence concerning this issue, pictures of this or similar parts of the bridge, notes concerning this issue, videos concerning the applied procedure, drawings of the part of the bridge in question, etc. Retrieving such relevant materials is difficult and cumbersome. First, the proper "key" to search in the proper archive is seldom present. Second, if the keys are present, it is rather cumbersome to collect material from (many) different archives in different locations.

Supplementary descriptions of identified problems or challenges can be found in [14]. The identified problems at GB led to a change of focus concerning development of computer support for sharing of materials. Due to the overall plan of the project we should develop better support mainly for asynchronous collaborative *editing* of design diagrams and reports. However, the primary problems for GB supervision appeared to be management of huge amounts of heterogeneous supervision materials. Hence, we turned the primary focus more towards the construction of an integrating hypermedia service for *managing* heterogeneous materials, and support for collaborative editing became a secondary goal. This was further explored in the cooperative prototyping activities described in the following section.

COOPERATIVE PROTOTYPING ACTIVITIES

This section discuss the three cooperative prototyping [5, 11] activities outlined in Figure 2.

First Workshop: Exploratory prototype

As described above, the future workshop identified problems concerning management of diverse materials in supervision and pointed at a hypermedia structure as a possible solution. Subsequently, we explored this idea through cooperative prototyping. An important goal was to let supervisors experience link creation and following as an alternative to keyword search.

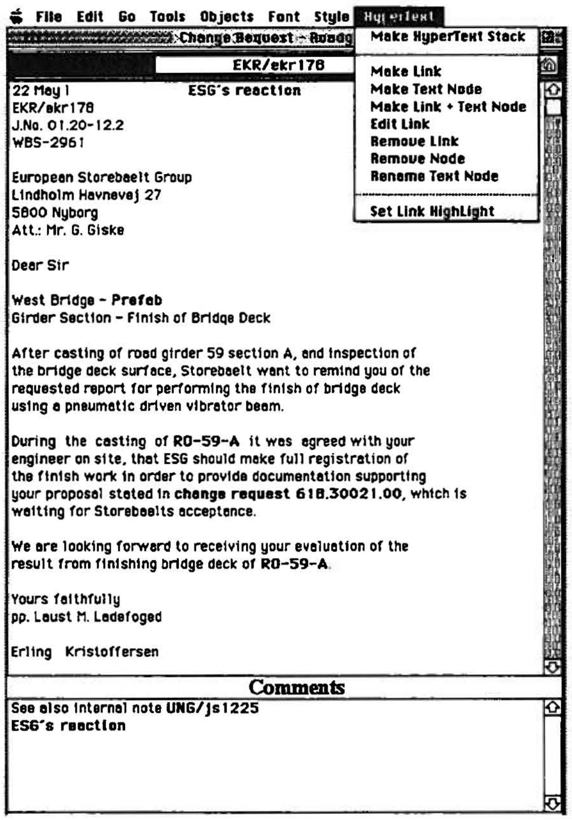


Figure 4: Snapshot of a text node and the 'Hypertext' menu from the first prototype.

For this purpose we (the authors) spent approximately 2 weeks developing a prototype with basic hypertext features on top of HyperCard (Figure 4). The bold parts of the text node represent anchors with attached links to be followed by clicking the mouse while pressing a command key. The Comments field is used to add keywords as in the current Journal system. In addition, keywords can also be anchors for linking. The menu shows the basic hypertext functions.

Having built the hypertext prototype, GB supervisors provided example data to help them relate the hypermedia idea to their own work in the cooperative prototyping workshop [11]. Several documents from supervision work in the Prefab department were thus scanned (with OCR) and entered as nodes in the prototype. All in all approximately 1 MB of material (mostly text) was entered into the prototype.

The first cooperative prototyping session

Having prepared the prototype with example data, we conducted a series of sessions where supervisors and secretaries from GB got the opportunity to experience hypertexts in relation to their work. We organized a workshop where 10-15 people from GB participated. A brief general introduction to hypertext was given. Then they were split into groups for the actual prototyping sessions. We had two machines with the running prototype, and each group in turn got a short demo, and the opportunity to follow and create links in the prototype. For each group one from the design team took notes, while one facilitated the session. Several aspects of the prototype were challenged by the supervisors. Both link structures and appearance of the prototype were modified during the sessions.

Outcome of the first prototyping activity

ANALYSIS

During the prototyping session a number of issues were raised that contributed to our understanding of constraints and potentials for applying hypermedia technology.

First, many of the supervisors were highly concerned with the effort needed to enter all existing materials into hypermedia networks. They mainly needed to interlink recent materials for ongoing cases, but they would definitely also need to establish links to old material. Entry of recent material and initial links potentially belonged to journalization.

Second, a critical mass of supervisors, secretaries, and area managers should commit themselves to establish links when they discover relations between parts of materials to enable effective retrieval.

Third, most of the participants in the session expressed that a company wide system with hypermedia linking capabilities would help overcome many of the serious bottlenecks in managing the huge amounts of heterogeneous materials, especially by integrating the different information sources.

DESIGN

The first prototyping session also raised a number of issues for design of hypermedia support at GB.

Our initial prototype supported span-to-node links, i.e. links from a selection in one text node to the entire destination node. The engineers, however, often have to make links to parts of larger documents, e.g. handbooks and letters. Thus it was required that the hypermedia should support also span-to-span or point-to-point links.

Second, the engineers pointed out that they often experienced one-to-many, or many-to-many relations between materials. For instance, a letter often had several addenda listed at the end. Thus it was required to have links supporting many-to-many relations.

Third, incoming letters should be made available in the hypermedia, e.g. through scanning, such that it becomes possible to annotate on top of scanned letters without changing the content.

Fourth, it was hard for the supervisors to assess whether a particular link was important to them. They proposed distinctions between link markings. Moreover, they wanted to be able to see who established a link and when.

Fifth, the engineers' typical reactions were: "Can't we use WordPerfect for editing instead?", "We don't want to throw out our existing applications!" These reactions turned out to be a strong request for a "link service" to be integrated with the existing kinds of applications in the organization. Such applications include word processors, spreadsheets, CAD systems, etc.

Finally, it was pointed out that support for queries were also needed. For example, it should be possible to extract, say, all change-requests for a certain road-girder.

GB

The prototyping session also affected the GB personnel and organization. The trivial result was that it increased the participants' knowledge about technological possibilities for enhanced computer support for their work. But it also initiated several discussions on the information infrastructure of the organization.

People started questioning the disintegratedness of the existing archives. GB had one archive for letters, one for drawings, one for quality documentation, one for plans, etc. But there was no common access to these archives even though the supervisors often needed to access materials from most of these archives every day. As a concrete spin-off of the process so far, the GB personnel organized a series of internal seminars, where they discussed problems and visions about solutions. Among the visions discussed were various means to make the existing computer systems more broadly accessible and more integrated.

Revisiting goals of the general cycle

The general conclusion was that developing hypermedia technology to support management of supervision materials would increase both efficiency and quality of the supervision work in GB. Due to the overall plan for the EuroCoOp project and our research interests we were conducting a parallel activity, the general cycle, designing a so-called "Distributed hypermedia design tool". One of the authors (KG) played a main role in this other activity and was giving input from the GB activities. At this stage after the first GB prototyping activity, the general development activity adjusted its goals according to the results of the specific analysis and design activities at GB. The original idea in the general development group was to take a set of graphical and textual editors as the outset and extend them with linking capabilities. Instead it was now decided to focus on development of a *general* hypermedia framework that could provide an application independent linking service to support supervision based on common tools typically available in the engineering domain.

The general development group considered the Dexter Hypertext Reference Model [18] as a technical source of inspiration for their development. The model was quite powerful with respect to the range of hypermedia concepts supported, but at the same time it was highly inspired from earlier monolithic hypermedia systems such as NoteCards [19], Intermedia [32], and KMS [1]. Nevertheless, we took the basic concepts from Dexter as the outset for developing the DHM framework. To meet the initial requirements from the specific cycle, we managed to extend the Dexter concepts making the DHM framework into an open architecture suited for developing hypermedia systems providing the possibilities for integrating third party applications.

The group responsible for the specific GB activities also committed to use a hypermedia prototype built with a first version of the DHM framework for the continued cooperative prototyping activities at GB.

Preparing for second workshop

Due to the challenges disclosed in the workshop evaluating the first prototype, we primarily addressed the following two issues in preparing for the second workshop:

- How to organize materials in a hypermedia structure.
- Who should establish initial links, how, and when.

Both issues were addressed through a cooperative prototyping session leading up to the second workshop. Although the purpose was to enter and organize GB material the work, of course, also triggered a considerable amount of design issues.

About a month before the workshop one of us (PM) went down to GB to collect a range of material primarily belonging to two supervision-cases. All the paper based material (mostly letters from the contractor) were scanned and all the electronic material was converted into suitable formats. Subsequently we made a first prototype of a GB supervision hypermedia by interlinking the collected documents in a preliminary structure.

Three weeks before the workshop, four people from GB came to Aarhus in order to discuss the prototype. We presented what we had achieved so far concerning the prototype. A prolonged discussion about how to organize the material from the two cases followed.

We continued the work on the prototype and made scenarios [23] for the use of hypermedia at GB including suggestions for some of the initial links to be provided already in the journalization (where scanning of incoming documents were already considered a possibility for the future).

The week after, the people from GB came back. This time we worked mainly on two issues. The one was a session in which we and the GB people went through the prototype and discussed alternative structures and implemented some of them. The second was the introduction of new material (e.g. a masterfile that is a folder containing copies of all materials pertaining to a specific part of the bridge). From this work, three major proposals for changes emerged:

- The need to provide a sort of overlay (like a transparency on top of a node) to primarily graphical nodes and third party application. This enabled creation of link markers without altering the material (e.g. for legal reasons) or without knowing its internal representation.
- Visual representation of markers indicating what following them would yield (e.g. forward, backward, to a video, to a picture, or to a referenced drawing).

- Graphical interfaces to access data. For example, the master file would appropriately be accessed through a graphical interface consisting of a drawing of the bridge with links from the bridge elements to the appropriate master files.

Consequently, we continued the work on the prototype, simulating 'types' on the link markers with, for example <<, >>, ><, representing 'backward', 'forward', and 'see also' respectively. Furthermore, we designed a graphical interface (simulating the overlay) and finished the work on the two cases.

Besides providing valuable input to the design of the prototype the two sessions also highlighted two rather profound constraints to possible use of a hypermedia at GB - input to the analysis. Much supervision work consists in negotiating satisfactory solutions with supervisors from the contractor organization. For security reasons, it was not a possibility to interlink materials pertaining to the two organizations respectively. Furthermore, the work of gathering all the materials from GB as well as converting it into suitable formats had highlighted the inherent constraints in GB's monolithic systems with their own storage and access paradigms.

Just before the workshop, one of the supervisors joined us once again, primarily to get acquainted with the structure of the two cases and the hypermedia as such. He was the one to demonstrate the prototype at the workshop rather than one of us. The idea was (and is) that the demonstration should take as points of its departure the use of a possible hypermedia in the daily work at GB. No matter how much we had analysed at GB, we were still not supervisors.

Second workshop

As mentioned above, at the second workshop we introduced a comprehensive hypermedia prototype addressing some of the issues from the first workshop while others were still being developed. The first prototype was solely meant to show possible uses of a hypermedia. The second, (DHM) was aimed as an industrial prototype. Hence much effort had been put into developing a full-fledged hypermedia using an object-oriented database.

Contrary to the first prototype, we now supported a range of different node types. Each node type provided a viewer or an editor where the material could be displayed and manipulated and augmented with anchors. Various atomic types of nodes ("chunks" of material) were supported in the hypermedia: Text, Draw, Movie and File. Text, Draw, and Movie nodes supported editing and viewing of their respective data. File nodes supported linking to arbitrary files in the file system, and following a link to a File node implied launching the attached file with the proper application, i.e. simple integration of third party applications.

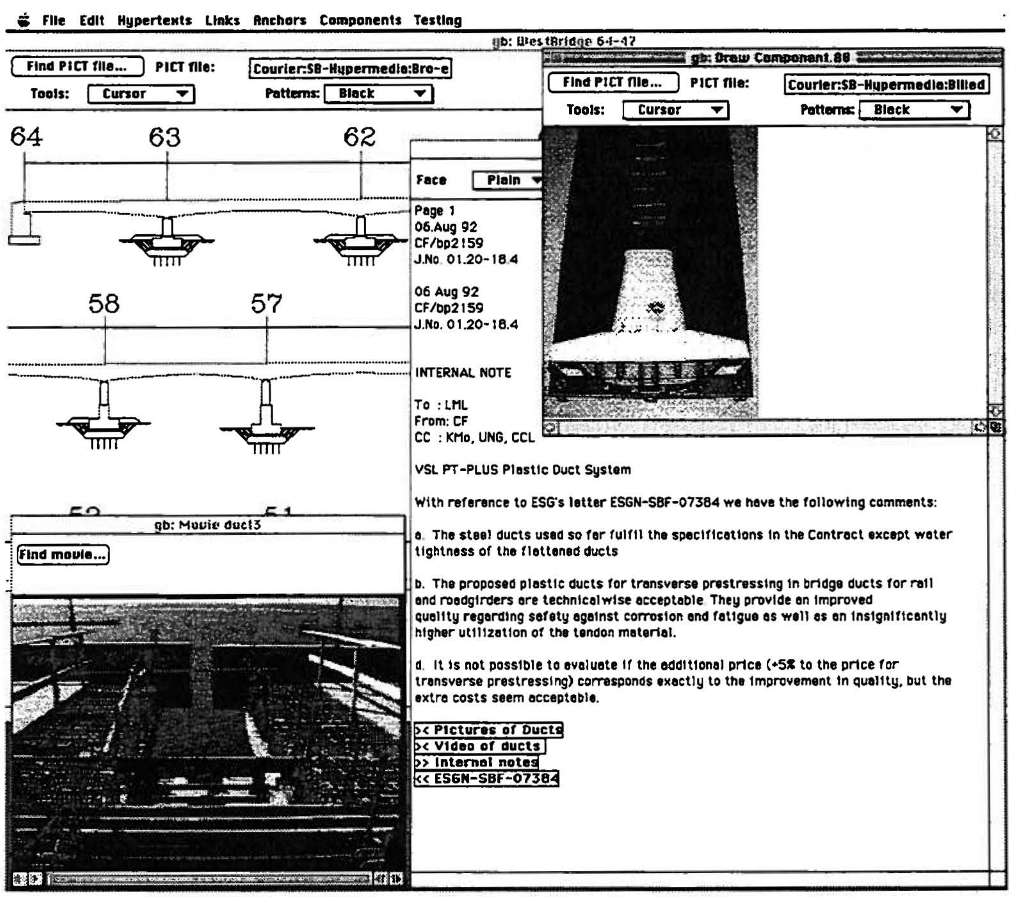


Figure 5: Example on nodes in the prototype: graphical interface, picture, video, and text node

DHM supports various composite node types: nodes that contain or reference other nodes and links, e.g. browser nodes. Browser nodes can be used to support non-link based navigation in the network. The prototype supports bi-directional links with multiple endpoints. The sources and destinations of links can be entire nodes or anchored parts of the node contents. In Text nodes span-to-span links are supported. Detailed descriptions can be found in [16].

Cooperative prototyping at the second workshop

The second workshop was held at GB October 1992. First, about 20 people were introduced to the general idea of hypermedia, how it might support work tasks, and what it would require for it to do so.

Secondly, in smaller groups, the hypermedia was demonstrated by one of the supervisors and used in work-like settings by people from management, project monitoring, journalising, reception and supervision secretaries.

In effect, the prototype developed primarily to support supervision, was now confronted with the work tasks of many other 'functions' in the organization. This led to new input to the design process as well as it highlighted constraints and potentials regarding a possible hypermedia at GB.

Outcome of the second workshop

Analysis

Besides the design suggestions, new constraints for successful introduction of a hypermedia at GB were disclosed as well. The issue of critical mass arose already in the first workshop concerning how to establish a minimal set of links making it worthwhile to enter the hypermedia in the first place. This issue got another twist at this workshop. It became increasingly clear that for the hypermedia to be used, it required the collaboration of more 'functions' than just supervisors:

- the supervisors should receive their work tasks (e.g. assessment of a change request from the contractor) as hypermedia documents, i.e. the current action list should be modified to hypermedia notes with relevant material linked to it (drawings, references to handbooks, pictures, etc.).
- progress monitoring, regarding monthly reporting should send out the contractor's assessment for the supervisors to comment on. Progress reports could be hypermedia documents in which the supervisors could respond by attaching comments to it.
- initial links should be established in journalization.

In conclusion, use of a hypermedia system in supervision heavily depends on the use of hypermedia in other departments as well. Strategies for introducing hypermedia in organizations like GB are discussed in a project report [25].

Design

One outcome was the issue of awareness notifications. In the prototype we could link to, for example, the SAB (a 400 page document describing work procedures) that was heavily referenced by other documents. Changes to this document often occurred. At that time, people were notified about changes in the SAB by getting the changed pages and pasting them into their paper based original. If we assumed the SAB to be a hypertext, we should also provide notification about changes.

The hypermedia tool supported different node types, and as mentioned above, the supervision hypermedia simulated different types of link-marks (e.g. '>>', '<<', '><'). On the one hand, these were seen as offering good possibilities. On the other, it became clear that the set of types was not sufficient, and most likely never would be no matter how many could be designed. In effect, what we had to provide was a facility to let people create their own link types. Likewise, suggestions for new node types arose, for example, a kind of sticky notes and a kind of folders/directories to reflect hierarchical structures of documents.

Finally, it was seen as a major issue that the hypermedia was capable of inter-linking documents pertaining to different applications, allowing one to use 'the best' applications for text processing, drawings, calculations, pictures, etc. and the hypermedia as the 'glue' between them. Taking the consequence, the hypermedia should provide browsers, queries, hierarchies, links, node types, and the ability to link to third party applications. Editors (such as the current draw and text nodes) should be left to whatever applications people preferred for accomplishing that kind of work.

GB

The work with the prototype also challenged current strategies for organising material at GB. People began to reconceptualise current work in light of the new possibilities. Because it was now technically possible to interrelate material from formerly isolated databases, people began to "discover" these connections. For example, supervisors formerly saw project monitoring as a necessary overhead constraining their own work (the supervisors provided much information to project monitoring). The interlinking of materials provided the supervisors with information also from project service. Consequently, these services were seen much more as a resource. Instead of being conceived as a constraining factor, they were seen as potentials in daily supervision work.

IMPACTS ON GENERAL HYPERMEDIA PRODUCT

Throughout the general hypermedia development process we improved the general design based on the specific cooperative activities at GB. The general hypermedia products being developed in course of the project are an object oriented hypermedia development framework, DHM, as well as several hypermedia systems built with the framework. The DHM framework and systems are designed to be compliant with the Dexter model [18]. This section discuss examples of impacts from the specific GB activities on the general development.

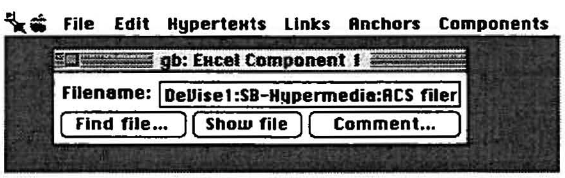
Integration of third party applications

One of the most important impacts was the strong requirement that the hypermedia should be able to integrate existing types of applications, rather than just provide new special hypermedia editors. This led to the design of an architecture with protocols that allow integration with third party applications. The design in this respect takes a radical step beyond the Dexter Model used for the general design. Ideas about integration and open system design are not entirely new [7, 27], but the requirements were pushed quite hard by the specific analysis at GB.

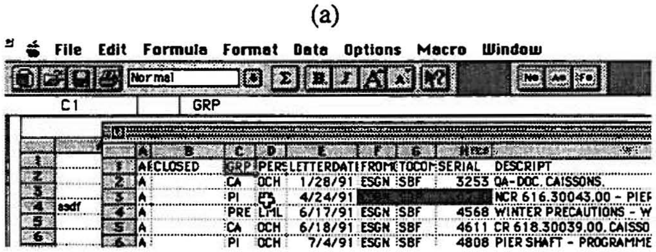
Consequently, we designed for different levels of integration depending on the degree of openness provided by the third-party applications, e.g. by communication protocols, APIs or the like, hence we are able to provide:

- a full-fledged linking interface from within fully open applications
- links into semi-open applications
- whole node links only, for closed applications

Our support for integration of closed applications is the File Node. More open applications are integrated through a general protocol for integrating third party applications ([9], Chap. 5), to the degree they are open. It is for instance possible to provide simple local anchoring in Microsoft Excel spreadsheets by writing small plug-in modules for Excel to call our protocol. This allows us to provide links to and from Excel via AppleEvents without having access to the source code of Excel (Figure 7). Similar integration can be provided with other applications having an API accessible through inter-application communication.



(a)



(b)

Figure 7: Integration with Microsoft Excel. (a) shows an Excel node in the prototype. (b) shows how Excel has been extended with three buttons in the standard toolbar to perform New Link (N•), Add Endpoint (A•), and Follow Link (F•) on given selections. Cells being anchored as link endpoints are marked with blue background colour.

Link directionality

The version of the hypermedia being evaluated at GB supported general bi-directional links, where a follow operation always presented all other endpoints of links. It was noted by the supervisors that it was confusing that links had no directions. Directed creation and following of links was implemented in the DHM framework, and it may appear in the user interface of a specific system as shown in Figure 8.

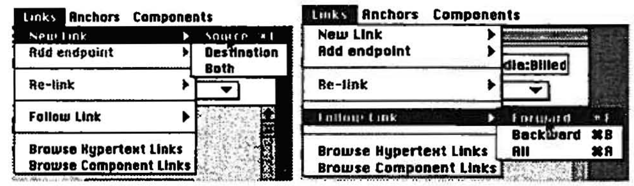


Figure 8: Support for direction on links

Filtering and structuring

GB supervisors required support both for query mechanisms and hierarchical structures within hypermedia networks. This kind of support was provided by specialising the general notion of composites in the DHM framework. Basic capabilities for treating queries and collecting target notes in composites were developed, e.g. a title search. More advanced (structural) queries can be implemented by specialising the general query facility [16]. Similarly, basic facilities for structuring a hypermedia network into a tree structure like a file system directory tree has been developed in terms of container composites [12].

Annotating scanned letters and pictures

Among the requirements from GB was support for annotating scanned materials with links in an overlay on top of the scanned image. A requirement which is quite similar to those raised in the studies by DeYoung [8] of the auditing domain. Such support has been implemented in a specialised draw node. It has been extended to have images in the background, such that annotations can be made by means of linking to graphical objects on top of the image, See Figure 9.

Cooperation support

Another important impact came from the requirements on better support for sharing materials for the supervision activities. The need to support distributed cooperation during the supervision activities directed the general design of cooperation aware navigation and annotation facilities.

The first two prototypes evaluated at GB had no cooperation support, they were focused on the issue of evaluating the concept of hypermedia within a large scale engineering setting. A large body of requirements from the specific cycle were, however, either implicitly or explicitly concerned with multi-user and cooperation issues. For instance, it was important for GB to maintain access rights and to know who is responsible for certain documents and annotations. It was also important to support for monitoring updates to materials involved in case-handling, e.g. the SAB. Cooperation support has been developed at the database level and has been used to extend the DHM framework to support development of cooperative hypermedia.

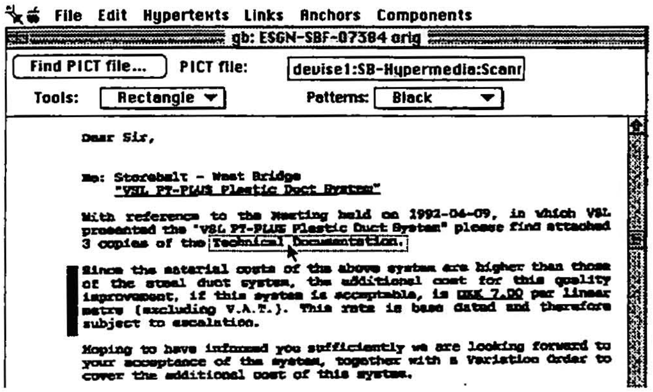


Figure 9: Annotating scanned images. The black change bar to the left and the transparent rectangle around "Technical Documentation" are anchored as endpoints for links.

The above hypermedia facilities are illustrated by examples from a specific *application*, but the important general result is that we have developed the general DHM hypermedia application *framework* to support development of hypermedia applications to other specific domains and organizations. Both the underlying framework classes and the applications built with the framework can appear with a general interface not being tied to GB concepts. The influence from the specific GB activities is mainly on the selection of facilities supported and how they are designed. Of course GB specific component types mirroring specific forms and document types could be integrated in a hypermedia application to be used at GB. However, a GB hypermedia application may also be a completely general DHM application integrating GB's general CAD, word processing, and spreadsheet applications. We claim that the DHM framework influenced by the GB activities have been designed to address a wide range of problems also identified by other researchers studying, e.g. engineering [26] and auditing [8].

INTERACTION BETWEEN SPECIFIC AND GENERAL PROCESSES

The project as a whole was from the outset framed by a document specifying the division of work in terms of a number of subtasks. Each subtask was specified with an abstract goal formulation, a deliverable (document or software) specification, a dependency specification, a deadline and resource allocation in person months. The specific cycle was in EuroCoOp specified by three consecutive subtasks (Pilot Requirements Elicitation, Evaluation Plan, and Evaluation). Similarly, the general cycle was specified by four consecutive subtasks (Hypermedia design tool, Object oriented database interface, Distributed hypermedia design tool, and Distributed Object oriented database interface). In the plan, only the deliverables from the specific cycle were considered as "crucial input" to the general cycle. Actually, the specific and general cycles took place in parallel.

This paper has largely been discussing how the relation, in contrast to what was specified, developed into a fruitful two way relation. In this section we discuss characteristics of such interaction concerning specific and general development, people accomplishing it, and mediating artefacts.

Challenging interaction

Cooperative design as conceptualised in *Design at Work* [10] bases itself in current practice and is directed towards envisioning future possibilities. Cooperative analysis [29] is directed towards understanding and changing constraints and potentials in current practice, and its point of departure is possible changes to the given practice. Seen this way, cooperative analysis and design continuously challenge one another as well as elaborate each other's resources in a dialectical interaction. The interaction between specific and general cycles, cf. Figure 1, can be seen in the same manner. The role of the general cycle is to provide alternative possibilities to the specific cycle. The role of the specific cycle is to challenge (provoke) [28] the general cycle by confronting it with concrete constraints and potentials.

The general cycle provided the specific cycle with new possibilities to challenge current state of affairs. It was the general notion of hypermedia that challenged current ways of organizing material at GB in the future workshop, later the general DHM framework informed the specific analysis as well as the specific design of the GB hypermedia. Similarly, the development of a general hypermedia served as a primary means in the specific cycle: it represented alternatives to challenge the existing in the analysis and it enabled the specific hypermedia design to provide much more than horizontal prototypes.

The specific cycle provided the general cycle with specific constraints and potentials to challenge ongoing design. The general development was challenged in that it was used to develop a hypermedia interlinking a large corpus of material. This use revealed a number of bugs, inconveniences, as well as it triggered a range of new design ideas

In both cases it was *future possibilities* that facilitated the challenging. It was the future possibilities of reorganizing work and technology that challenged current state of affairs in GB, and it was the future possibility that the DHM would encounter constraints and potentials similar to GB's that challenged the DHM design and development.

What enabled these possibilities to challenge was that *they mattered*. A discrepancy between peoples' current reality and alternative possibilities can only provoke or challenge if the possibilities are of importance (positive or negative).

For possibilities to matter it is important that they *are realistic* in both senses of the word: the sense of being likely or obtainable; and the sense of being close to real.

For people focusing on the specific cycle the closeness to reality was obtained through concrete use of the GB hypermedia prototype in extended use scenarios with data from daily work at GB. The obtainability of a hypermedia at GB became visible through product as well as process: productwise through the evolving features of the DHM (ported to several platforms, integration to third party software, supporting cooperative work, etc.), and processwise through the cooperative nature of the endeavour (current work was taken seriously, alternative ways of organising were analysed, current work had impact on the specific as well as the general hypermedia, etc.).

For people focusing on the general cycle the closeness to reality was mainly obtained through participation in the specific analysis at GB in contrast to reading abstract descriptions of GB work and/or requirements. The participation also made it likely that the analysis could contribute to general hypermedia design, both because the actual findings showed promising and because the general cycle via participation could influence the analysis.

In short, concrete experiences with proposed artefacts and current work at GB as well as the fact that people worked across traditional boundaries (use, analysis, design, implementation, etc.) seem to be main facilitators in the mutual challenging between specific and the general development.

People crossing boundaries

Development cycles do not provide challenging interaction, people do. Figure 1 depicts some objectives involved in the two cycles (specific use, analysis and design, and general use, design and development). These objectives were not directly assigned to specific people. On the contrary, the same people typically contributed to many objectives (often at the same time).

The people from GB contributed to use, analysis and design in the specific cycle: they used the GB hypermedia, they gained and contributed to new insight regarding work at GB, and they promoted new ideas for the specific design.

PM contributed primarily to analysis and design in the specific cycle as well as use of the general hypermedia, and KG contributed to development and design in the general cycle as well as analysis in the specific cycle. [1]

In the case of hypermedia development at GB we (KG and PM), to a large extent, represented a cycle each (PM concentrating on the specific and KG on the general cycle). The interaction between the specific and the general cycle was characterised by being a sort of negotiation process between these cycles, constantly balancing between, on the one hand, the wish to provide prototypes that fulfilled the requirements from GB and, on the other, to maintain a general design and to manage within limited resources. Whenever requirements were put forward, for example mediated by PM, they were always considered in relation to resources and the wider applicability of the proposals. The suggestions that seemed to have wider applicability 'survived' while others were postponed.

Furthermore, the main designer (PM) in the specific cycle was himself a primary user of the hypermedia prototype developed in the general cycle. This in fact, lead to several requirements which were raised by the specific designer rather than GB. An example of such requirements, was the need to be able to convert example data smoothly from one version of the general prototype to another.

It is beneficial to break down the barriers between technical centered and user centered work in product development projects. In typical product development organizations, there is a strict division of work between people who are responsible for technical development, software engineering departments, and people who take users into account e.g., human factors and marketing departments [17]. In the hypermedia project we deliberately avoided such strict division of work, and as described we achieved a more direct interaction between user centered analysis/design and technically focused development. We found that it was possible to avoid most of the dangers used as the rationale for dividing work, e.g. developing a general product that is too closely tied to the users from a specific cycle, or having the technical people distract the users with technical details, different cultures, etc.

Cooperative design sessions including people with competencies from: a use organization, specific analysis, as well as technical design, opens up the design space. On the one hand visionary ideas from the user side can immediately be assessed and further developed by the people with the technical qualifications. On the other hand technical based ideas and visions can immediately be challenged by users and people who undertake specific analysis. We also found that our experiences from joint sessions argues strongly against introducing a third party representing or substituting the users in the interaction with the technical development people as proposed in new literature on ethnographically-informed design [3]. From our own experience in EuroCoOp, we acted as facilitators between GB and development of activity coordination, cf. Figure 2. This turned out to be inefficient cooperation and a source of misunderstandings as noted in [24], e.g. regarding interpretation of example data.

Mediating artefacts

With respect to mediating artefacts, the relation also developed to be much more complex than just delivering reports in one task to be read by participants in another task. In fact, comprehensive requirements specifications and general product design specifications did not play any significant role in supporting interaction between the cycles.

---

[1] The authors were of course not the only designers in the project. Many people contributed, but Morten Kyng, should be mentioned here. He participated in activities both in the genral and the specifc cycle. He was mainly as a process facilitator, who also organized some of the activities with the parallel activity coordination development [24].

The interaction between specific cooperative analysis and design activities and general, more technical, development activities can be efficiently facilitated with artefacts such as scenarios, prototypes, and concise bullet list notes.

For example, the results from the initial analysis activities were formulated as commented lists of problems and bottlenecks to be attacked.

Another example is scenarios. To focus the cooperative prototyping sessions we used scenario descriptions to identify what is called frame tasks in [5, 11]. For the first cooperative prototyping activity we produced scenarios representing both current work situations and a possible future work situations supported with hypermedia [23], as well as scenarios regarding activity coordination and organizational browsing [24]. The scenarios we had in mind from the beginning of the general development cycle were collaborative writing and design scenarios. As a result of the specific cycle different scenarios about integrating access to supervision materials were developed. We also generalised some of the scenarios on cooperation to act as domain independent general scenarios for cooperative hypermedia support [13]

Finally, the prototypes were quite important artefacts in mediating the interaction between the general and the specific cycles. First, the user's reactions to the first prototype were collected as bullet lists, and together with the first prototype they provided important input to the design of general hypermedia support. Second, an early hypermedia prototype based on the DHM framework was given as input to the specific GB design for development of an experimental supervision hypermedia structure. GB reactions to this prototype and the prototype with example data were again propagated back to the general development group in terms of bullet list notes and direct communication. The fact that one of the designers (KG) participated in both the specific and the general development group enabled an efficient communication without large volumes of written specifications.

Extensive written design documentation [9, 15] for the general DHM framework and applications was not produced until after the cooperative prototyping activities described in this paper. More technical specifications of system architecture and object oriented design were only applied internally in the general development activity and quite late in the process.

RELATED WORK

This section briefly compares our work to a selection of projects that has similar characteristics i.e., specific analysis of a small group of potential users has been used as input for the development of general products for a wide range of users and organizations.

The legendary UTOPIA project [4] was also aimed at developing a general product, a text and image processing system for graphical workers. The UTOPIA design process was highly cooperative and it was also based on specific analysis, in this case of work in newspaper production. Compared to the hypermedia project described here, there are significant differences in the interaction between the general and specific cycles. UTOPIA had several specific analysis and design cycles at different newspapers in Scandinavia. But the general cycle was not initiated until half way through the four year project. At this point, the Swedish printing and computer company Liber was associated with the project; they in advance had a development project called TIPS. A formal agreement on the interaction between UTOPIA and TIPS was made. The goal was that UTOPIA should provide a written requirements specification for Liber, such that they could take the requirements into account when developing TIPS. But there were no obligation for Liber to follow the UTOPIA requirements, and vice versa no obligations for UTOPIA to promote TIPS. Compared to our experiences, the UTOPIA kind of interaction looses much of the benefits of cooperation when it comes to the technical development: First, the cycles had been initiated and run independently for a long period before interaction began. Second, there were no people in common in the general and specific cycles, thus there were no people at Liber to whom the UTOPIA experience really *mattered*. Third, a lot of the knowledge achieved in the cooperative analysis and design process were lost when they had to be communicated to TIPS as a written specification. Due to our background, our work learned from UTOPIA regarding cooperative techniques. However, we moved them further towards the technical implementation of a product based on specific cooperative analysis and design.

The Case-handling project described by Pape and Thoresen [31], is aimed at developing a system for Town Planning Departments in Norwegian municipalities. The project was not aimed at developing a general product in the same sense as our project, it was aimed at developing a core system for Norwegian TPDs which could be tailored to meet the needs of specific municipalities through a compressed cooperative design process. In the Case-handling project, there were three parties involved, a system manufacturer, process consultants, and people from three TPDs. There were one main specific cycle going on in close interaction with the general development; and two other specific cycles were undertaken to study variations in requirements for the system. In this project it was mainly the process consultants who facilitated the interaction between the specific and general cycles. A similarity to our project which is emphasized is the observation that the cooperative analysis and design activities themselves lead to reconsideration and change of the current work organization in the use organization.

The Class project described by Anderson and Crocca [2], aimed at developing a system for preservation of library books through digital reproduction. The project was accomplished through what is called a codevelopment approach, where Xerox Engineers and Librarians at Cornell University cooperate on the analysis, design and implementation of the Class system. Here a specific analysis and design cycle is going on at the Cornell Library, where the engineers at some point installs a running prototype for the librarians. The general development cycle takes place at a Xerox engineering lab located 90 miles from Cornell. The approach in this project is much like the approach taken in our project. The developing engineers are themselves responsible for the specific analysis and design at the library. A sociologist was involved in the project to study the process, not to contribute to the development. The key observations here are in line with our observations: personal relationships between the specific and general cycles are important and individuals should be able to participate in many different types of tasks some of which are on the edge of a priori qualifications. A difference to our project concerning the interaction is that, the Class project seems to use phone conversations and a traditional meeting kind of interaction rather than direct involvement in terms of workshops and joint prototyping sessions.

CONCLUDING REMARKS

This paper discussed an extensive case of applying *specific* cooperative analysis and design activities in the context of *general* hypermedia system development. It has been demonstrated how observational studies, a Future Workshop, and a series of Cooperative Prototyping activities in a specific organization has provided important input for general product development. Subsequently, it has been described how the specific organization has benefited from the cooperative analysis and design activities before getting any software product as result.

The general development activity continues within the context of the ESPRIT successor project EuroCODE. In this project the DHM framework will be used as an integrated part of several demonstrator systems to be evaluated at GB. Moreover, the DHM framework is currently being used for a new and concentrated specific cycle in a large Danish company, Grundfos ltd., producing pump systems. This specific cycle has already provided feedback to the general development activity in that it raised critical requirements on how to organize screen layout of hypermedia material.

Finally, cooperative – participatory – analysis and design approaches are often considered difficult to pursue within general product development settings [17]. The approaches are typically seen as applicable solely in 'in-house' settings where a system is being developed for the participating user organization, only. However, given the experiences described in this paper, we also see good prospects in applying cooperative analysis and design techniques in specific use settings to inform development of general products. However, boundaries of work and use of mediating artefacts may need to be revisited in light of mutually challenging development cycles.

ACKNOWLEDGEMENTS

We thank Morten Kyng for his contributions to the cooperative analysis and design work at GB, and we thank Randy Trigg for his contributions to the DHM Framework design. We thank the people at GB who participated in the work. Finally, we thank our colleagues in the DEVISE project, in particular Søren Brandt, Jens A. Hem, Ole L. Madsen, Henry Michael Lassen, Elmer S. Sandvad, and Lennert Sloth for their contributions to the DHM development. The work is supported by the Danish Research Programme for Informatics, grant number 5.26.18.19, and the Esprit projects EuroCoOp and EuroCODE.

REFERENCES

1. Akscyn, R.M., McCracken, D.L., and Yoder, E.A., *KMS: A Distributed Hypermedia System for Managing Knowledge in Organizations.* Communications of the ACM, 1988. 31(7): p. 820-835.

2. Anderson, W. and Crocca, W., *Engineering Practice and Codevelopment of Product Prototypes.* Communications of the ACM, 1993. 36(6): p. 49-56.

3. Bentley, R., *et al.*, *Ethnographically-Informed Systems Design for Air Traffic Control,* in *Proceedings of ACM CSCW'92 Conference on Computer-Supported Cooperative Work.* 1992, p. 123-129.

4. Bødker, S., Ehn, P., Kammersgaard, J., Kyng, M., and Sundblad, Y., *A UTOPIAN Experience: On Design of Powerful Computer-Based Tools for Skilled Graphic Workers,* in *Computers and Democracy,* G. Bjerknes, P. Ehn, andM. Kyng, Editor. 1987, Avebury: Aldershot. p. 251-278.

5. Bødker, S. and Grønbæk, K., *Cooperative Prototyping: Users and Designers in Mutual Activity.* International Journal of Man-Machine Studies, 1991. 34(3): p. 453-478.

6. Conklin, J., *Hypertext: An introduction and survey.* IEEE Computer, 1987. 20(9): p. 17-41.

7. Davis, H., Hall, W., Heath, I., Hill, G., and Wilkins, R. *Towards an Integrated Information Environment with Open Hypermedia Systems.* in *European Conference on Hypertext (ECHT '92).* ed., 1992. Milano, Italy: ACM.

8. DeYoung, L., *Hypertext Challenges in the Auditing Domain,* in *ACM Hypertext'89 Proceedings.* 1989, p. 169-180.

9. EuroCODE-WG2, *D2.5: Design of the Toolkit Layer of the CSCW shell.* 1993, Aarhus University, Computer Science Department:

10. Greenbaum, J. and Kyng, M., *Design at Work: Cooperative Design of Computer Systems.* 1991, Hillsdale, NJ: Lawrence Erlbaum Associates.

11. Grønbæk, K., *Prototyping and Active User Involvement in System Development: Towards a Cooperative Prototyping Approach.* 1991, Computer Science Dept., University of Aarhus:

12. Grønbæk, K., *Composites in a Dexter-Based Hypermedia Framework.* 1994, Computer Science Department, Aarhus University:

13. Grønbæk, K., Hem, J.A., Madsen, O.L., and Sloth, L., *Cooperative Hypermedia Systems: A Dexter-Based Architecture.* Communications of the ACM, 1994. 37(2): p. 64-75.

14. Grønbæk, K., Kyng, M., and Mogensen, P., *CSCW Challenges: Cooperative Design in Engineering Projects.* Communications of the ACM, 1993. 36(6): p. 67-77.

15. Grønbæk, K., Madsen, O.L., Møller, K.J., Nørgaard, J., and Sandvad, E., *EuroCoOp Workpackage WP5 Task T5.3 Distributed Hypermedia Design Tool.* 1992, Aarhus University:

16. Grønbæk, K. and Trigg, R.H., *Design issues for a Dexter-based hypermedia system.* Communications of teh ACM, 1994. 37(2): p. 40-49.

17. Grudin, J., *Obstacles to User Involvement in Software Product Development, with Implications for CSCW.* International Journal of Man-Machine Studies, 1991. 34(3): p. 435-452.

18. Halasz, F. and Schwartz, M., *The Dexter Hypertext Reference Model.* Communications of the ACM, 1994. 37(2): p. 30-39.

19. Halasz, F.G., Moran, T.P., and Trigg, R.H., *NoteCards in a Nutshell,* in *Proceedings of ACM CHI+GI'87 Conference on Human Factors in Computing Systems and Graphics Interface.* 1987, p. 45-52.

20. Jungk, R. and Müllert, N., *Future Workshops: How to create desirable futures.* 1987, London: Institute for Social Inventions.

21. Kensing, F. and Madsen, K.H., *Generating Visions: Future Workshops and Metaphorical Design,* in *Design at Work -- Cooperative Design of Computer Systems.* 1991, Lawrence Erlbaum: Hillsdale, New Jersey. p. 153-168.

22. Kyng, M., *Designing for a Dollar a Day.* Office, Technology and People, 1988. 4: p. 157-170.

23. Kyng, M. *Making Representations Work.* in *Representations of Work, HICSS Monograph, Hawaii International Conference on System Sciences - 27.* L. Suchman, ed., 1994. Honolulu, Hawaii:

24. Kyng, M. *Scandinavian Design: Users in Product Development.* in *CHI '94.* B. Adelson, S. Dumais, andJ. Olson, ed., 1994. Boston, MA: Association for Computing Machinery.

25. Kyng, M. and Mogensen, P., *Workpackage WP1 Task T1.3: Evaluation of EuroCoOp prototypes re work at A/S Storebæltsforbindelsen (Great Belt Link Ltd.),* in *Report from ESPRIT Project 5303 EuroCoOp: IT Support for Distributed Cooperative Work.* 1992, Aarhus University:

26. Malcolm, K.C., Poltrock, S.E., and Schuler, D., *Industrial Strength Hypermedia: Requirements for a Large Engineering Enterprise,* in *Proceedings of ACM Hypertext'91.* 1991, p. 13-24.

27. Meyrowitz, N., *The Missing Link: Why We're All Doing Hypertext Wrong,* in *The Society of Text,* E. Barrett, Editor. 1989, MIT Press: Cambridge, Mass. p. 107-114.

28. Mogensen, P., *Towards a Provotyping Approach in Systems Development.* Scandinavian Journal of Information Systems, 1992. 4: p. 31-53.

29. Mogensen, P., *Challenging Practice: an Approach to Cooperative Analysis.* 1994, Aarhus University, Daimi PB-465: Aarhus, Denmark.

30. Mogensen, P. and Trigg, R. *Artifacts as triggers for participatory analysis.* in *Participatory Design Conference (PDC).* Kuhn, Muller, andMeskill, ed., 1992. Boston, MA:

31. Pape, T.C. and Thoresen, K., *Evolutionary prototyping in a change perspective: A tale of three municipalities.* Information Technology & People, 1990. 6(2-3): p. 145-170.

32. Yankelovich, N., Haan, B.J., Meyrowitz, N.K., and Drucker, S.M., *Intermedia: The Concept and Construction of a Seamless Information Environment.* IEEE Computer, 1988. 21(1): p. 81-96.