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.

Email: {kgronbak,preben}@daimi.aau.dk

In Proceedings of the Participatory Design Conference (PDC '94), Chapel Hill, North Carolina, USA, October 27-28, 1994.

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 quite good prospects in applying cooperative analysis and design techniques in *specific* use settings to inform development of *general* products. We describe and discuss the application of cooperative – i.e. participatory – analysis and design techniques in a project developing a general hypermedia framework as well as specific cooperative hypermedia applications for the engineering domain. In our project, a single engineering company (Great Belt Link ltd.) managing one of the largest bridge/tunnel construction projects in the world was chosen as the user organization. The paper summarises what happened in observational studies, a future workshop, and cooperative prototyping activities. We demonstrate how these 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. Prototypes, scenarios, and concise bullet list summaries are used as the mediating artifacts in this interaction rather than comprehensive requirement and design specifications.

KEYWORDS
Cooperative Analysis, Cooperative Design, Cooperative Prototyping, Hypermedia.

1. 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

[13]

, and a quantitative survey of some 50 German companies. The general CSCW development was split into four: 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

[10, 11, 15]. For a general introduction to the concepts of hypertext and hypermedia, see [3].

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 [8, 27]. Moreover, the general hypermedia development, cf. Figure 1, continues in a successor ESPRIT III project called EuroCODE: CSCW Open Development Environment.

1.1. Cooperative analysis and design

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

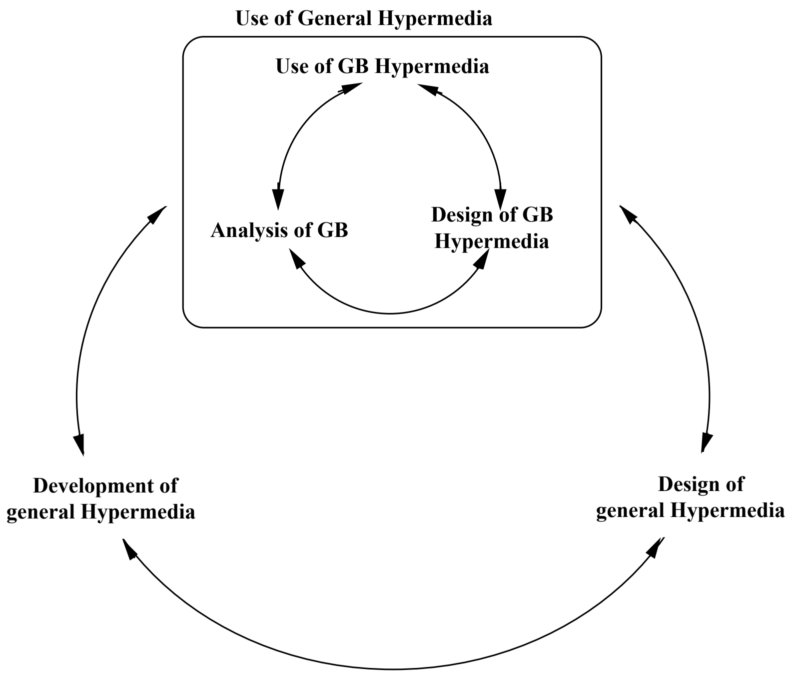


Figure 1: Interplay between specific cooperative analysis and design activities at GB and general hypermedia product development.

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 [27] and cooperative design [8].

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 both be used to trigger new insights concerning current praxis as well as future possibilities

[28]

.

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 a general hypermedia design. 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.

1.2. Structure of the paper

Section 2 gives an overview of the entire cooperative analysis and design process at Great Belt. Findings during the initial analysis and the future workshop are briefly described. Section 3 gives a detailed description of the cooperative prototyping activities following these. Section 4 summarises and discusses implications for the general hypermedia design and development. Section 5 discusses experiences with respect to integrating *specific* cooperative analysis and design in *general* hypermedia product development. Section 6 briefly outline how a highly compressed version of the cooperative analysis and design activities can be applied to start specific hypermedia development in other organizations.

2. INITIAL ACTIVITIES AT THE GREAT BELT

Figure 2 gives an outline of the cooperative activities focusing on hypermedia, it thus gives an impression of the flow of activities depicted in the cycle of Figure 1. These activities are discussed in [13] at a general level, including discussions of activity coordination.

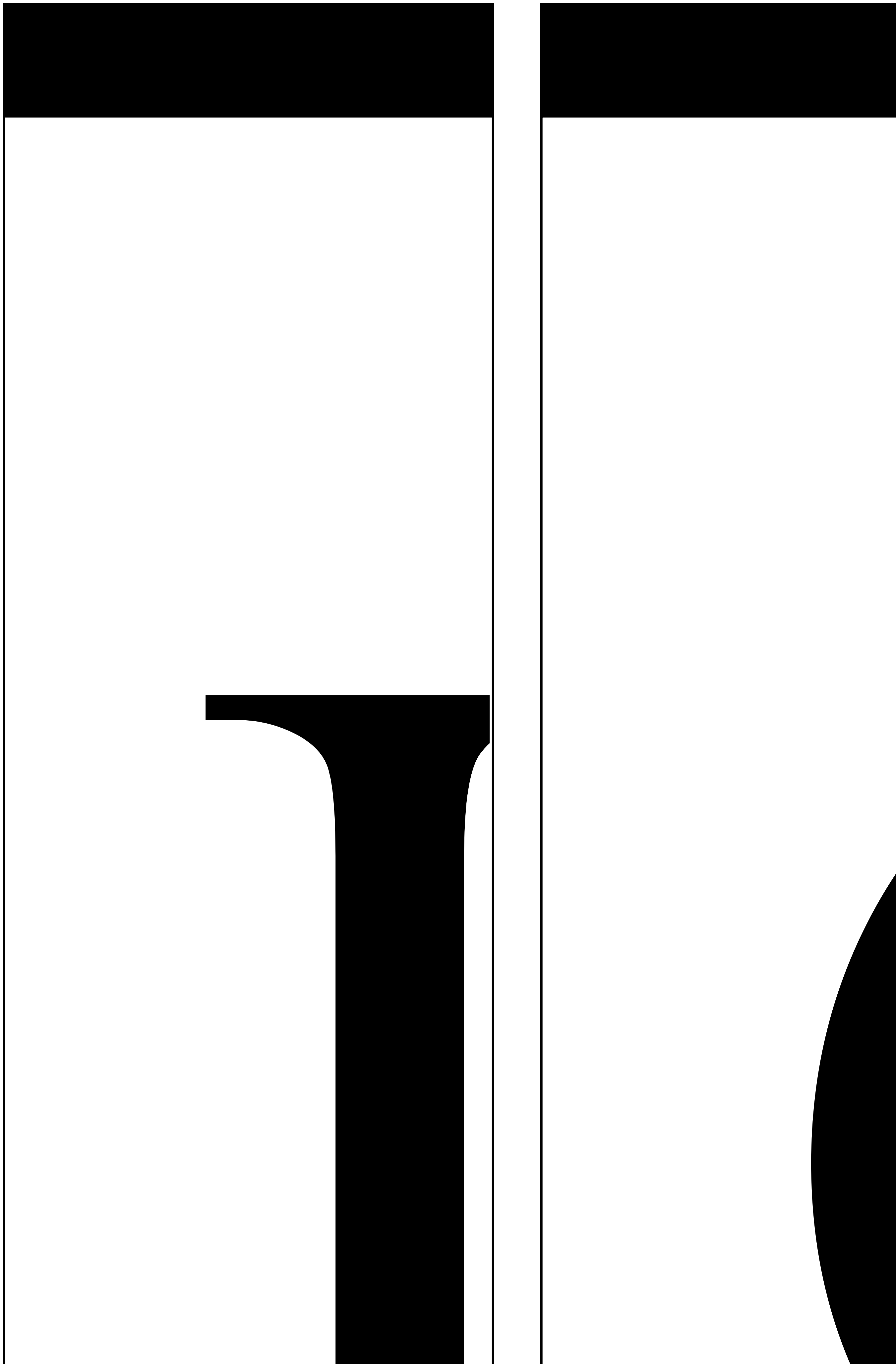


Figure 2: Overview of the cooperative analysis and design activities involving GB during the hypermedia development in EuroCoOp

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.

2.1. 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: Task 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

[12]

.

2.2. Future Workshop

As an intermediate step between observations and the more intervening analysis and design, we arranged a variant of a Future Workshop [19, 20]. 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* of differs from future workshops in the following ways: 1) The people at GB could hardly be said to be resource weak (as presumed in [19]

); most of them are engineers and have used (and programmed) 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.

Our main attempt to be more active concerned the organizing of materials: 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

[21]

. The future workshop provided the primary rationale for exploring possibilities for hypermedia support in supervision. See section 3 for a discussion of these activities.

2.3. 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.

Supervisors work with many different types of materials, cf. Figure 3 for an overview.

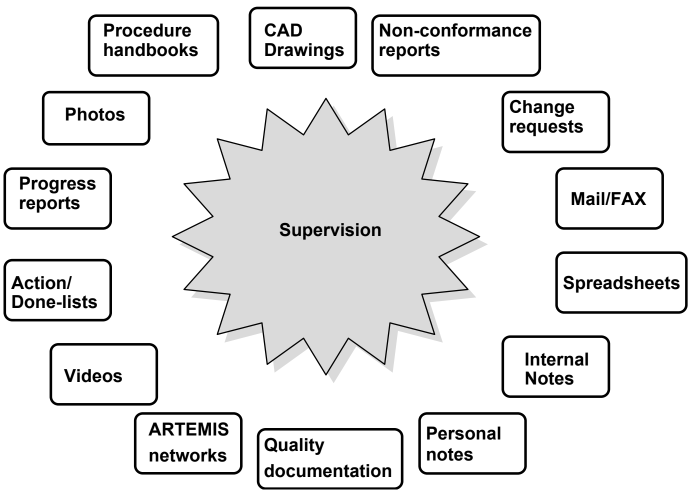


Figure 3: Examples of different materials in use for supervision at GB.

NON-INTEGRATED ACCESS TO HETEROGENEOUS MATERIALS

The materials outlined above cannot be accessed in any uniform manner: some material is in a central paper archive, some on the supervisors' shelves, some on a mainframe, some on a UNIX server, 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 QC-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 [13]. The identified problems at GB led to a change of focus with respect to the 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 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 idea was further explored in the cooperative prototyping activities described in the following section.

3. COOPERATIVE PROTOTYPING ACTIVITIES

This section discuss the three cooperative prototyping [2, 9] activities outlined in Figure 2.

3.1. 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.

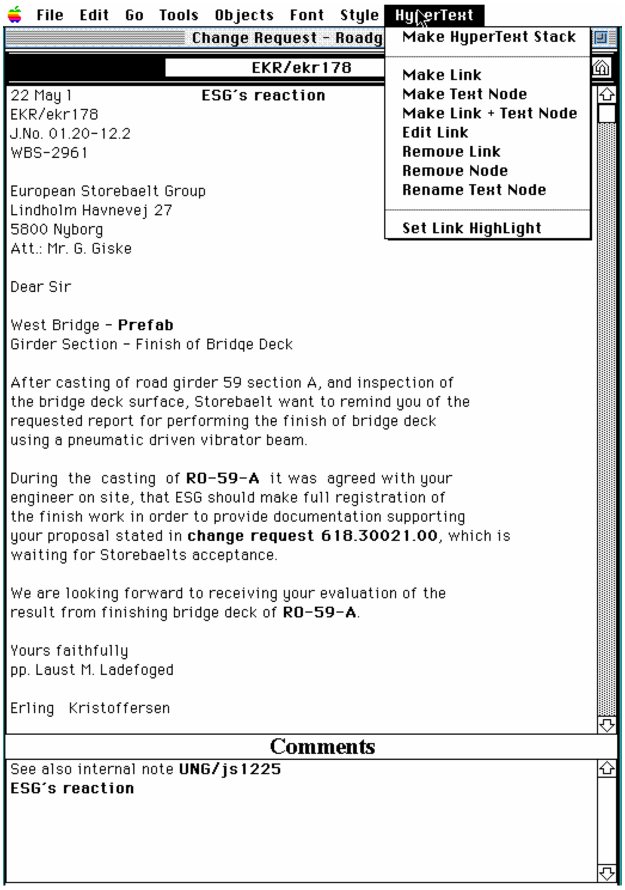


Figure 4: Snapshot of a text node and the 'Hypertext' menu from the first prototype.

For this purpose we (the authors) spent approximately 2 weeks to develop a prototype with basic hypertext features on top of HyperCard, see 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 Keywords 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, we collected example data to help GB supervisors relate the hypermedia idea to their own work in the cooperative prototyping workshop [9].

We contacted supervisors to get a small collection of interconnected materials to enter into the prototype. Several documents from supervision work in the Prefab department were thus scanned (with OCR) and entered as nodes in the prototype. All in all we entered approximately 1 MB of material (mostly text) into the prototype.

3.1.1. 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.

3.1.2. 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 in journalisation.

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

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. by 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 [6].

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.

3.1.3. Synchronising specific and general cycles

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 also conducting a parallel activity developing a so-called "Distributed hypermedia design tool". One of the authors (KG) played a main role in this other activity. At this stage the specific analysis/design activities at GB were "synchronised" with the parallel development activity (i.e. a direct interaction between the specific and the general cycles in Figure 1). It was decided to pursue the idea of developing a *general* hypermedia framework that, among other things, could provide the kind of integrating service to support supervision. The general development group designed the DHM framework based on the concepts from the Dexter Hypertext Reference Model

[17]

. This 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

[18]

, Intermedia

[29]

, and KMS

[1].

We managed to extend the Dexter concepts to make the DHM framework into an open architecture suited for developing hypermedia systems providing the possibilities for integrating third party applications. The next section describes how a hypermedia system built with an early version of our general hypermedia framework was used for continued cooperative prototyping activities at GB.

3.2. 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 supervision materials in a hypermedia structure.
- Who should establish an initial set of links, how, and when.

Both issues were addressed through a cooperative prototyping session leading up to the second workshop.

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. The discussion centered around four issues:

- How to organize the collected material.
- Possibilities in supporting access to relevant material not currently accessible.
- Alternative ways of accessing the huge amount of data (the prototype only supported the case handling view, i.e. accessing material via tasks to be performed).
- Strategies for achieving an initial set of links in a supervision hypermedia making it worthwhile for people to enter and expand a possible hypermedia at GB.

We continued the work on the prototype and made scenarios [22] for the use of hypermedia at GB including suggestions for some of the initial links to be provided already in the journalisation (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 transparent 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. Much supervision work consists in negotiating satisfactory solutions with supervisors from the contractor. 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.

3.3. 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 one was aimed as an industrial prototype. Hence much of the 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/manipulated and augmented with anchors. Various atomic types of nodes (“chunks” of material) were supported in the hypermedia system: 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. a simple integration of third party applications.

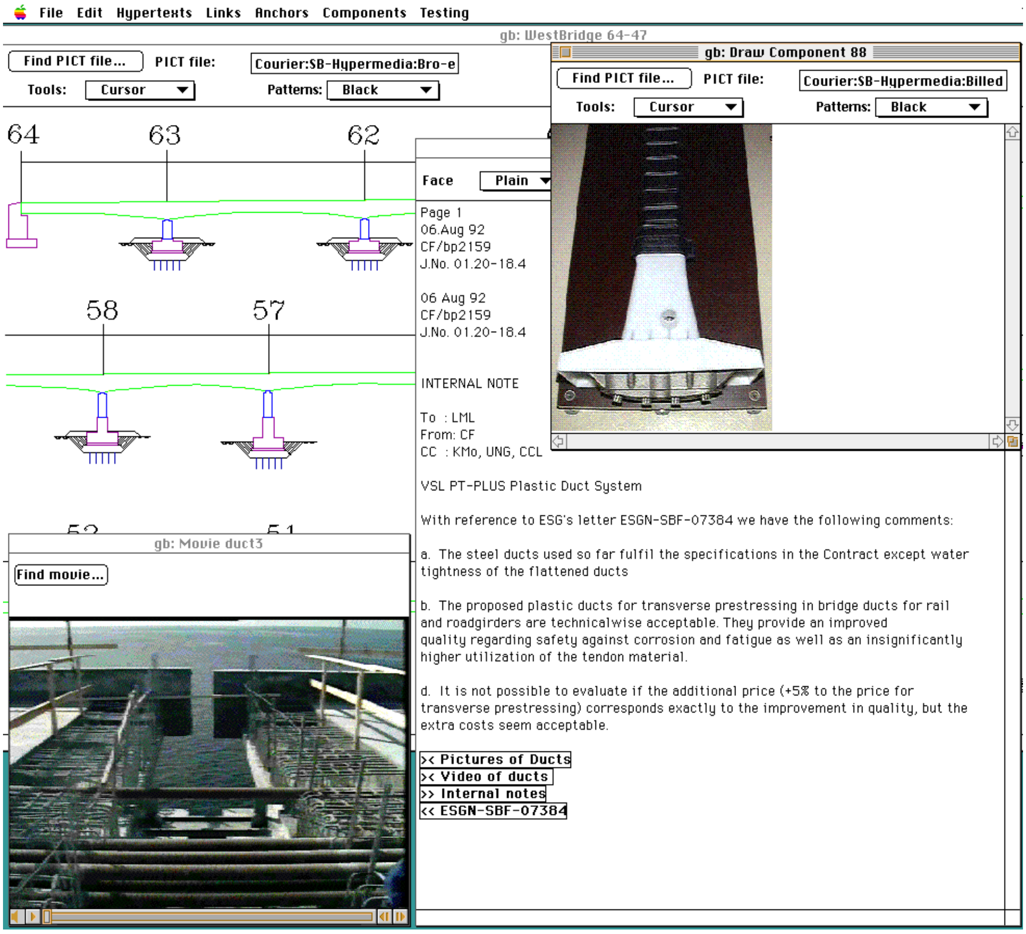


Figure 5: Example on nodes in the prototype: Graphical interface, picture, video, and text node

The prototype 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

[15]

.

3.3.1. 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 initially demonstrated by one of the supervisors and later also 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.

3.3.2. 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.

In order for the hypermedia to be used in supervision it was seen as important that the supervisors received 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.).

The same issue arose concerning the monthly reporting, where progress monitoring send out the contractor’s assessment of the progress made for the supervisors to comment on. Here the progress report could be a hypermedia document in which the supervisors could respond by attaching their comments to it.

As mentioned before, it was also crucial that the journalisation established the obvious initial links.

In conclusion, the use of a hypermedia system in supervision is heavily dependent on the use of hypermedia in other departments as well. As a consequence a set of seven different strategies for introducing a hypermedia in an organization like GB was developed [23] .

DESIGN

One of the outcomes was a suggestion for semi-automatic support in the creation of standard links. More specifically, the registration of and link creation in incoming letters could be supported: 1) by automatically creating links to letters to which the present is a respond (assuming that the letters are somehow properly identifiable, e.g. by systematic naming); 2) establishing a place holder (an anchor) for an answer to come; 3) establishing links to the action lists; etc.

Another 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 link types (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 node type resembling Post-its and one resembling 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 of this, 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 strategy 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 service as a necessary overhead constraining their own work (the supervisors provided much information to project service). 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.

4. 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

[17]

. This section discuss examples of impacts from the specific GB activities on the general development.

USE OF COMPONENT ATTRIBUTES

There were several requirements from the GB users that could be handled via elaborated link attribute mechanisms: 1) It should be possible to inspect who has established a certain link. 2) It should be possible to make different categories of links.

The DHM framework is designed with a general attributes mechanisms on all components according to the Dexter model, for instance, ownership and update information (Figure 6). A link type mechanism is also built through attributes assigned to link components.

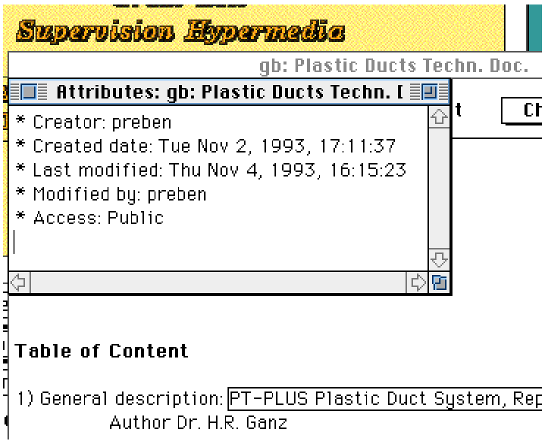


Figure 6: An example of ownership and update information on a text node.

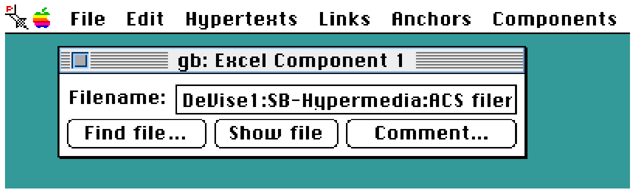
INTEGRATION OF THIRD PARTY APPLICATIONS

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 [4, 25], but the requirements were pushed quite hard by the specific analysis at GB.

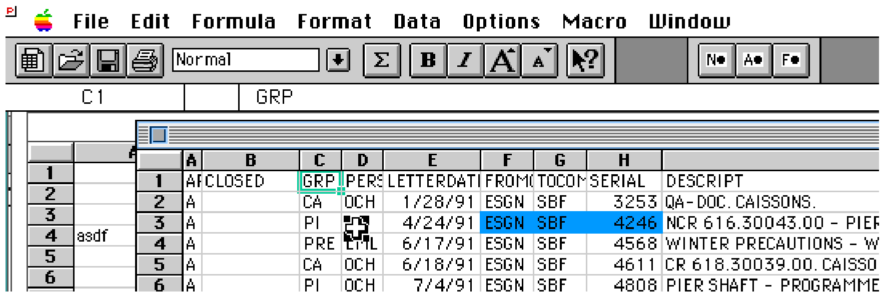
Consequently, we designed for different levels of integration depending on the degree of openness provided by the third-party applications, e.g. by communication protocols, APIs or the like, hence we are able to provide:

- 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 ([7], Chap. 5), to the degree they are open. It is for instance possible to provide a 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, see Figure 7. Similar integration can be provided with other applications having an API accessible from the outside.



(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.

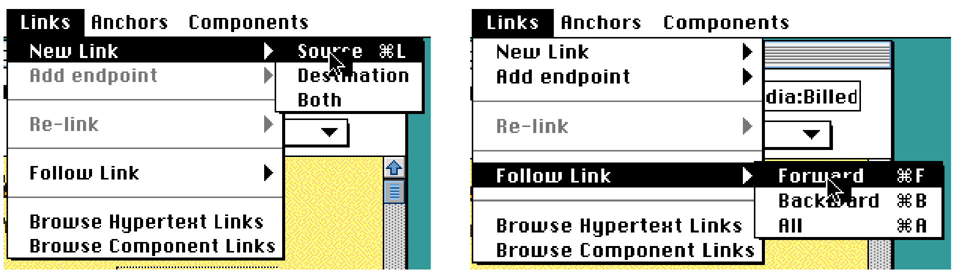


Figure 8: Support for direction on links

FILTERING AND STRUCTURING

The 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 the target components in composites were developed, e.g. a title search. More advanced (structural) queries can be implemented by specialising the general query facility

[15]

. Similarly, basic facilities for structuring a hypermedia network into a tree structure like a file system directory tree has been developed in terms of so-called container composites

[10]

.

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

[5]

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.

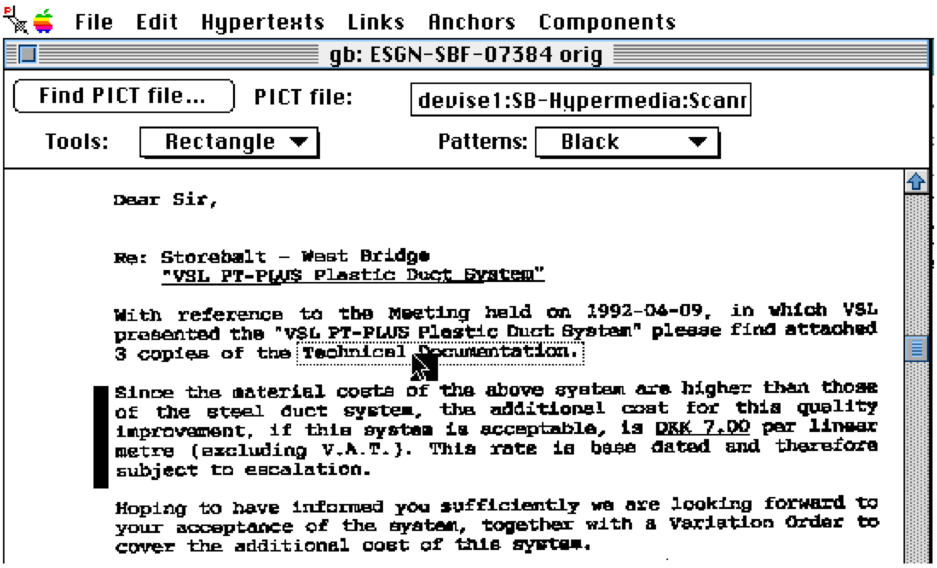


Figure 9: Annotating scanned images. The black change bar to the left and the transparent rectangle around "Technical Documentation" are anchored as endpoints for links.

COOPERATION SUPPORT

Another important impact came from the requirements on better support for sharing of working 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 users were, however, either implicitly or explicitly concerned with multi-user and cooperation issues. For instance, it was important for the GB users to maintain access rights and to know who is responsible for certain documents and annotations. It is also important for the supervisors to have support for monitoring of updates to materials involved in handling cases, 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.

The above hypermedia facilities are illustrated by examples from a specific prototype, but the important general result is that we have developed the general DHM hypermedia development framework to support development of hypermedia systems to other specific domains and organizations. We claim that the DHM framework addresses a wide range of problems also identified by other researchers studying, e.g. engineering

[24]

and auditing

[5]

.

5. Interaction between the 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). The specific and general cycles took place in parallel. In the plan, only the deliverables from the specific cycle were considered as "crucial input" to the general cycle.

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, on the one hand, the characteristics of such interaction concerning specific and general development and, on the other hand, the mediating artifacts.

5.1 Challenging interaction

Cooperative design as conceptualised in *Design at Work* [8] bases itself in current practice and is directed towards envisioning future possibilities. Cooperative analysis [27] is directed towards understanding and changing constraints and potentials within 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 they elaborate each other's resources in a dialectical interaction. The interaction between the 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 "provoke" and challenge

[26]

the general cycle by confronting it with concrete constraints and potentials.

The specific cycle is not “authoritative”, i.e. it is not so that the general design must follow the guidelines from the specific one. Rather, the specific cycle might serve as a testbed for general development.

In the case of hypermedia development at GB the two cycles, to a large extent, were represented by each of us (PM concentrating on the specific and KG on the general cycle). The interaction between the specific and the general cycle to a large extent 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 via PM, they were always considered with relation to resources and the wider applicability of the proposals. The suggestions that seemed to have wider applicability ‘survived’ while others were postponed.

The specific cycle benefited from the general by continuously being provided with new possibilities. It was the general 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 more than rapid prototypes.

The general cycle benefited from the specific by continuously being challenged by the specific constraints and potentials, which in turn challenged current design, some taken-for-granted assumptions, and triggered new design ideas. The general development was challenged in that it was used to develop a large hypermedia prototype, which revealed a number of bugs, inconveniences, and alternatives. The general design, as illustrated above, learned from the:

- specific use of GM hypermedia (cooperative prototyping sessions),
- specific analysis (constraints and potentials in introducing hypermedia technology),
- specific design (the construction of the GB hypermedia).

Finally, 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.

5.2 Mediating artifacts

With respect to mediating artifacts, 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 the interaction between the cycles. Instead, scenarios, prototypes, and bullet list kind of summaries, were used to support the direct communication among members of the groups responsible for each of the cycles.

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 [2, 9]. For the first cooperative prototyping activity we produced scenarios representing both current work situations and a possible future work situations supported with hypermedia

[22]

. 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

[11]

.

Finally, the prototypes were quite important artifacts 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 summaries and direct communication. As mentioned above 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 [7, 14] for the general DHM framework and applications was not produced until after the cooperative prototyping activities described in this paper.

In short, the interaction between cooperative analysis and design activities and general more technical development activities can be efficiently facilitated with artifacts such as scenarios, prototypes, and concise bullet list summaries. 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.

6. CONCLUSION

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 invaluable 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 quite concentrated specific project in a large Danish company, Grundfos ltd., producing pump systems. This new specific project 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 [16]. 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 quite good prospects in applying cooperative analysis and design techniques in specific use settings to inform development of general products.

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. 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.
3. Conklin, J., *Hypertext: An introduction and survey.* IEEE Computer, 1987. 20(9): p. 17-41.
4. 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.
5. DeYoung, L., *Hypertext Challenges in the Auditing Domain,* in *ACM Hypertext'89 Proceedings*. 1989, p. 169-180.
6. Ehn, P. and Kyng, M., *The Collective Resource Approach to Systems Design,* in *Computers and Democracy*. 1987, Avebury: Aldershot. p. 17-57.
7. EuroCODE-WG2, *D2.5: Design of the Toolkit Layer of the CSCW shell*. 1993, Aarhus University, Computer Science Department:
8. Greenbaum, J. and Kyng, M., *Design at Work: Cooperative Design of Computer Systems*. 1991, Hillsdale, NJ: Lawrence Erlbaum Associates.
9. Grønbæk, K., *Prototyping and Active User Involvement in System Development: Towards a Cooperative Prototyping Approach*. 1991, Computer Science Dept., University of Aarhus:
10. Grønbæk, K., *Composites in a Dexter-Based Hypermedia Framework*. 1994, Computer Science Department, Aarhus University:
11. 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).

12. Grønbæk, K., Kyng, M., and Mogensen, P., *Workpackage WP1 Task T1.1 report: On cooperation, computers and the organization of work at A/S Storebæltsforbindelsen (Great Belt Link Ltd.),* in *Report from ESPRIT Project 5303 EuroCoOp: IT Support for Distributed Cooperative Work*. 1991, Aarhus University:

13. Grønbæk, K., Kyng, M., and Mogensen, P., *CSCW Challenges: Cooperative Design in Engineering Projects.* CACM, 1993. 36(4).

14. 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:

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

16. 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.

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

18. 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.

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

20. 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.

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

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

23. 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:

24. 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.

25. 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.

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

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

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

29. 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.