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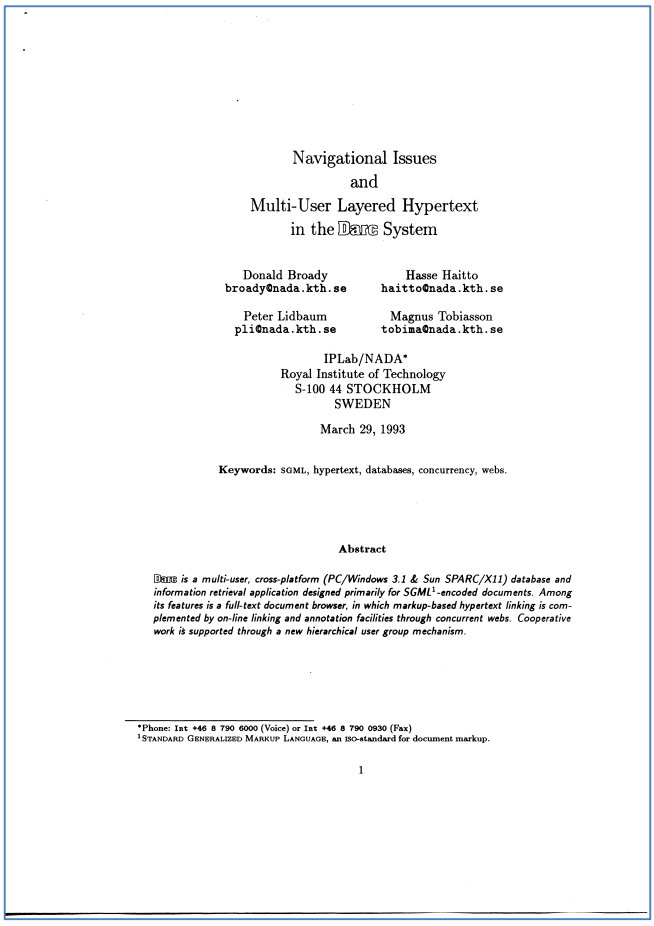
Donald Broady, Hasse Haitto, Peter Lidbaum & Magnus Tobiasson,
Navigational Issues and Multi-User Layered Hypertext in the Darc System,
Institutionen för numerisk analys och datalogi, KTH, Stockholm,
29 March 1993, 10 p.



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Donald Broady
broady@nada.kth.se

Hasse Haitto
haitto@nada.kth.se

Peter Lidbaum
pli@nada.kth.se

Magnus Tobiasson
tobima@nada.kth.se

IPLab/NADA*
Royal Institute of Technology
S-100 44 STOCKHOLM
SWEDEN

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Keywords: SGML, hypertext, databases, concurrency, webs.

Abstract

Darc is a multi-user, cross-platform (PC/Windows 3.1 & Sun SPARC/X11) database and information retrieval application designed primarily for SGML[1]-encoded documents. Among its features is a full-text document browser, in which markup-based hypertext linking is complemented by on-line linking and annotation facilities through concurrent webs. Cooperative work is supported through a new hierarchical user group mechanism.

*Phone: Int +46 8 790 6000 (Voice) or Int +46 8 790 0930 (Fax)
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Darc is a multi-user, cross-platform (PC/Windows 3.1 & Sun SPARC/X11) database and information retrieval application designed primarily for SGML[1]-encoded documents. Among its features is a full-text document browser, in which markup-based hypertext linking is complemented by on-line linking and annotation facilities through concurrent webs. Cooperative work is supported through a new hierarchical user group mechanism.

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1 A User Scenario

Consider the following scenario: A user is querying a document database at a workstation, and finds a set of documents matching some criteria, e.g. keywords. The user begins perusing the document on-line, follows cross-references displayed as hypertext links, and perhaps makes a few electronic annotations to the documents. Every now and then, the user finds some interesting connection between documents and inserts links between corresponding passages. Satisfied of these findings, he or she then organizes the documents hierarchically in folder-like fashion for fast retrieval next time around. Finally, the user selects the newly created 'folder' for export, perhaps to continue work on the PC at home, or to publish it electronically e.g. as courseware.

This is a typical example of work with Dare. It is a multi-user document database system designed primarily for SGML-encoded documents that runs on the PC/Windows 3.1 and Sun SPARC/X11 platforms.

2 Introduction

Dare uses three techniques for organizing document collections:

- Information Retrieval (IR) methods to access large collections of documents, where e.g. full-text and structure-sensitive indexing is performed by user-tailorable criterias on the SGML markup.
- A virtual, hierarchical file system to access database contents in much the same way as window-based file managers. This interface is personal, so that a user can construct any number of such *views* of the database.
- Hypertext services. Links are either based on the SGML markup or interactively created by the user.

Also, Dare has access control of database objects and a novel, hierarchical user group concept.[2]

[2] [Broady 1993] is an overview of the system. A preliminary version was shown at ECHT'92 [Lucarella 1992].

3 Navigational Issues

Douglas Engelbart's pioneering work with *Augment* convincingly demonstrated the benefits of organizing files into hierarchical structures, with outline-style access, that can be arbitrarily referenced and linked on-line in a collaborative work group environment [Engelbart 1968]. The use of descriptive markup, especially the international standard SGML [SGML 1986], has since paved the way for on-line viewers to build on this rich heritage of ideas, see e.g. [EBT 1991, Raymond 1992]. In the same vein, Dare has an interactive browser to view SGML-encoded documents and network-based support for cooperative work through its notion of groups (see section 6). Within Dare, SGML-encoded documents can be navigated, annotated, and arbitrarily linked with any other document in its database.

3.1 Structured Documents

SGML documents are by nature structured, and can be represented as trees (reflecting the structure of the hierarchical markup). The Dare on-line delivery tool creates an interactive, outline-style, table of contents from the SGML markup. The table of contents is then used for rapid access to the corresponding full-text window contents. A feature of Dare is that documents can be browsed directly without a pre-compilation step.

The SGML tree structure[3] is displayed on demand as an alternative way of accessing the contents. Both mechanisms are illustrated in figure 1.

Brown explores the problem of providing *hierarchical* and *cross-referencing* links (or equivalently, *structural* and *unstructured* links) with respect to the *Guide* system [Brown 1988].

In *Guide*, hierarchical links are used to encapsulate document sections that are expanded at will. In contrast, Dare uses the document structure inherent in the markup, allowing the user to manipulate this structure by interacting with the table of contents or the graphical SGML tree. The cross-referencing links are covered in the next three sections.

[3] Much as the Tree Mode of WE [Smith 1987].

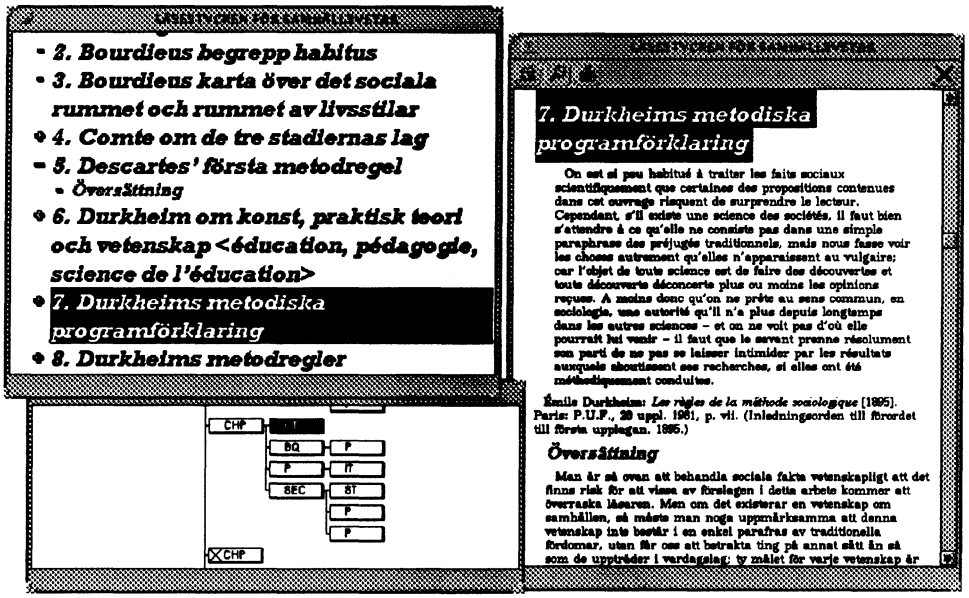

Figure 1: Going from the top to bottom and left to right, this figure illustrates a table of contents, a tree representation, and a corresponding full-text view. The user has clicked in the table of contents to rapidly move to the seventh chapter. (The items prefixed with a plus-sign in the table of contents can be expanded to show contained elements such as sections, subsections, etc). The user can interact with any of the three windows to navigate through the documents.

3.2 Markup-based Linking

The Dare presentation tool resolves cross-references[4] in the SGML mark-up into live hypertext links. The targets of mark-up based links are indicated, so that a referred element is also linked to the elements that refer to it, making the links bidirectional (see figure 2 on page 5).

Because the SGML documents in the database are not editable, the underlying link data is *static*. Furthermore, these markup-based links cannot, due to the nature of SGML markup, span other documents[5] Additional linking facilities are covered in section 3.4.

[4] Encoded with the ID, IDREF and IDREFS attribute mechanism; these are used for references to elements such as footnotes, tables etc.

[5] Thus, markup-based links have a narrower span than implied by Brown in using the term 'cross-referencing.'

3.3 Navigation by Search

Navigation as a result of string searches is also a form of unstructured linking. Dare uses a pick list as the starting point for such navigation. The result of string searches are displayed in a pick list, as illustrated in figure 3. When one clicks in the pick list, the full-text view will scroll the corresponding line to the top of the browser window. All matching occurrences are shown highlighted. The pick list remains available when one follows such a link, and previous search strings are kept during the session.

3.4 Web-based Linking

In addition to the links automatically derived from the mark-up, or created while searching, documents can be linked by hypertext links, and annotated, in *webs* stored externally. This is the most powerful (and potentially most disorienting) of Dare's link mechanisms, as it allows un-

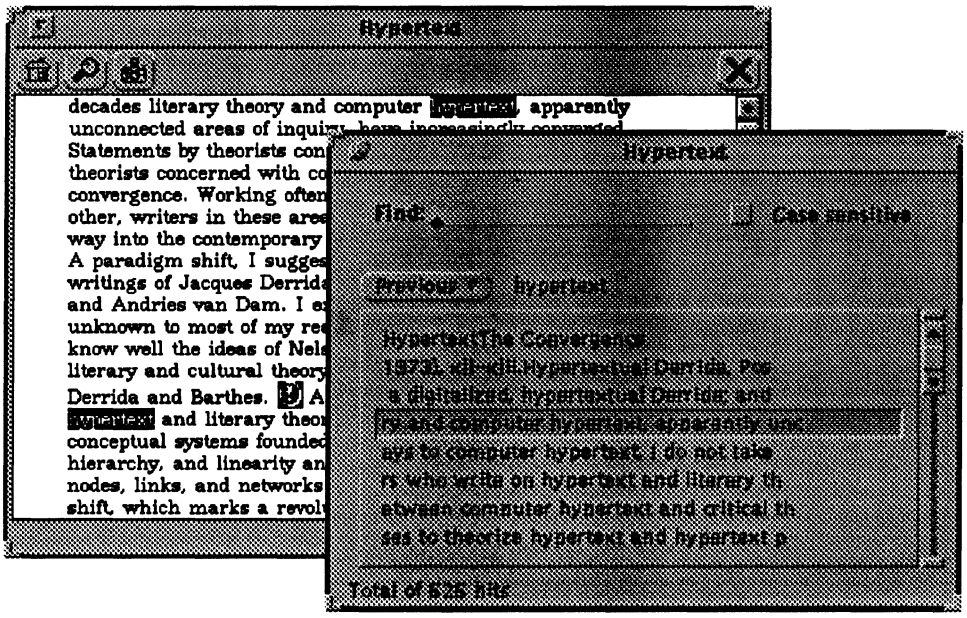

Figure 3: String searches result in a pick list, where the matched string is displayed concordance-style with its surrounding words (here the word 'hypertext' has been sought). The button marked `Previous` *is a list of search strings that have been entered during the session. Notice also the highlighted ● icon in the full text browser window; this is a footnote icon, and it has been highlighted because the string being sought occurs in the footnote contents (as can be deduced from the pick list).*

restricted linking among all available documents. Just as links derived from markup, the dynamically created links can be followed from either direction.

Such linking functionality was pioneered by Brown University's Institute for Research in Information and Scholarship (IRIS) in the *Intermedia* system [IRIS 1990]. We have expanded this functionality in several ways, the most important addition being the capability of having multiple webs open simultaneously, achieving *concurrent, layered hypertext* support:

- **Concurrent webs**: Several webs, i.e. collections of annotations and/or links, can be open at the same time. A useful metaphor is to think of each open web as a transparency layer upon which the links and annotations are attached; the document is displayed as if it were seen through these layers of transparencies. The anchors to which annotations and links are connected can reside in different webs.

  The mechanism of concurrent webs can be used e.g. for gradual disclosure of course materials. An example would be different educational uses of one and same document base: The freshmen are offered a web covering a small number of documents and a restricted set of links, more advanced students use a more extensive document collection and a wider variety of links, while the teacher develops even more complex webs for personal use.

- **Unmodal webs**: The externally stored webs can be opened or closed at any time while reading a document. The on-line display will adapt itself accordingly.

- **Enhanced user feedback**: The user is informed of which documents are contained in

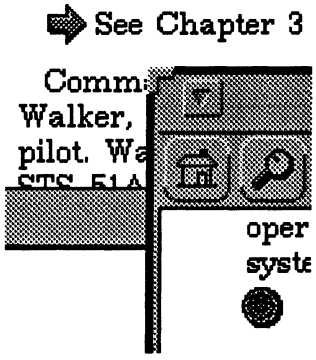

Figure 2: The arrow at the top left is a markup-based cross-reference displayed as a hypertext link. The referred element will have a 'target' icon, such as the one shown at the lower right. Links can be navigated bidirectionally.

a web, as well as the reverse (*"Which webs have links to this particular document?"*).

3.5 Anchors

As in *Intermedia*, Dare *anchors* are blocks of contiguous selections. Anchors are central to web-related data and are used in three contexts:

- **Highlighting**. An anchor can be *highlighted* so that the corresponding text is shown as if it were highlighted by a marker pen. (Figure 4).
- **Annotations**. Annotations are connected to an anchor, so that it is always clear *what* is annotated. (Figure 4).
- **Linking**. Finally, anchors are the endpoints of web-based links. Several links can point to the same anchor. (Figure 5).

3.5.1 Link Anchor Previewing

The *Web Manager* is the user interface to the web-based links: All links[6] are accessible in a list, and any link endpoint anchor contents can be previewed without effectuating the jump.

[6] As well as annotations, optionally filtered e.g., so that only annotations or links of one's own are displayed.

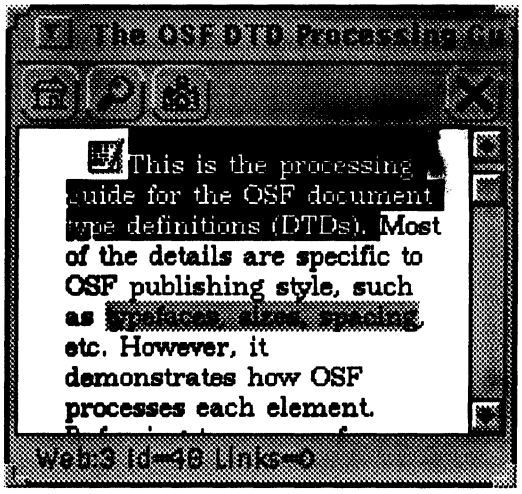

Figure 4: At the top of the figure is an annotation connected to an anchor. Below is a highlighted passage. When one clicks on an annotation icon, the corresponding anchor will be displayed as shown here. Database objects such as webs—used for annotations and links—can be shared with other users, group members or kept private.

3.5.2 Taxonomic Links

Finally, a link can fork to a multi-way branch, leading to a choice of several destination anchors, i.e. Dare supports what DeRose calls *taxonomic* links [DeRose 1989].

3.6 Document-level Navigation

Dare files documents according to user-tailorable criterias on the SGML markup, with indexing contextually dependent for any element. A nice feature is that the document browser is aware of the database indices of any given document, so that a selection can be looked up in any of the indices. E.g., one can select a name from a bibliographic reference in the full-text browser, and immediately look it up in an index of author names. In this manner, one can reach other database documents by following *implicit* or *associative* links.

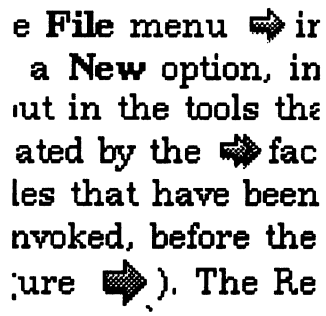

Figure 5: Web-based links are shown with a somewhat smaller icon than their mark-up based counterparts, see the link at the top of the figure vs. the one at the bottom. In the middle of the figure is a taxonomic link (indicated by double arrows).

3.7 Multi-Document Hypertexts

Gluschko characterizes four classes of links to consider in the design of multi-document hypertexts [Glushko 1989]. We notice that Dare has support for all four types.

3.7.1 Explicit Intra-Document Links

This kind of link connects two (or more, in our case) parts of a document together. Such linking can be performed by either inserting appropriate SGML markup, or by creating web-based links online.

3.7.2 Implicit Intra-Document Links

This class of link is implied by the foregoing, e.g. every *"See also"*-type of cross-reference should have a matching *"Cited by"* link. Dare inserts a 'target' icon for such links, as mentioned in section 3.2.

3.7.3 Explicit Inter-Document Links

Glushko points out that explicit inter-document links "pose more challenges for the hypertext designer...because it is harder to predict the...usefulness of the information at the end of the link" (a work may be cited for many different reasons).

Assuming the documents exist in the database, concurrent webs work nicely for this kind of linking. It is not only possible to have several sets of explicit inter-document links but, thanks to anchors, one designates precisely what part of the document is being referred to.

3.7.4 Implicit Inter-Document Links

These kind of links become apparent from "careful and creative analysis of...the texts". The possibility of accessing indices from within the browser (section 3.6) gives some support for such activities, but it is perhaps, as Glushko concludes, better "to provide functions that make it easy for readers to create private links and notes."

4 Views

Views are based on the metaphor of how one organizes the *hierarchical* file structure of a hard disk, but are more flexible. In effect, they allow users to create a personalized interface to database contents, and reduce the need to hunt for documents using traditional index-based searches. A view (as shown in figure 6) is a set of labeled boxes, or *nodes*. Each node may contain documents as well as other nodes, commonly called subnodes or children. One can construct any number of views, that can be shared with other users or kept private.

5 User Disorientation

A reader of a hyperdocument encounters two classical problems leading to user disorientation [Conklin 1987]. The first of these is the problem of navigation ("lost in hyperspace"), usually addressed by solutions in the form of maps [Envos 1989], sometimes in conjunction with a history list or *path* [IRIS 1990, Utting 1989].

In Dare, user disorientation is countered by consistently bidirectional links which permit easy backtracking, the use of unmodal lists (see e.g. section 3.3) in connection with anchor previewing and, finally, conveying a sense of the underlying

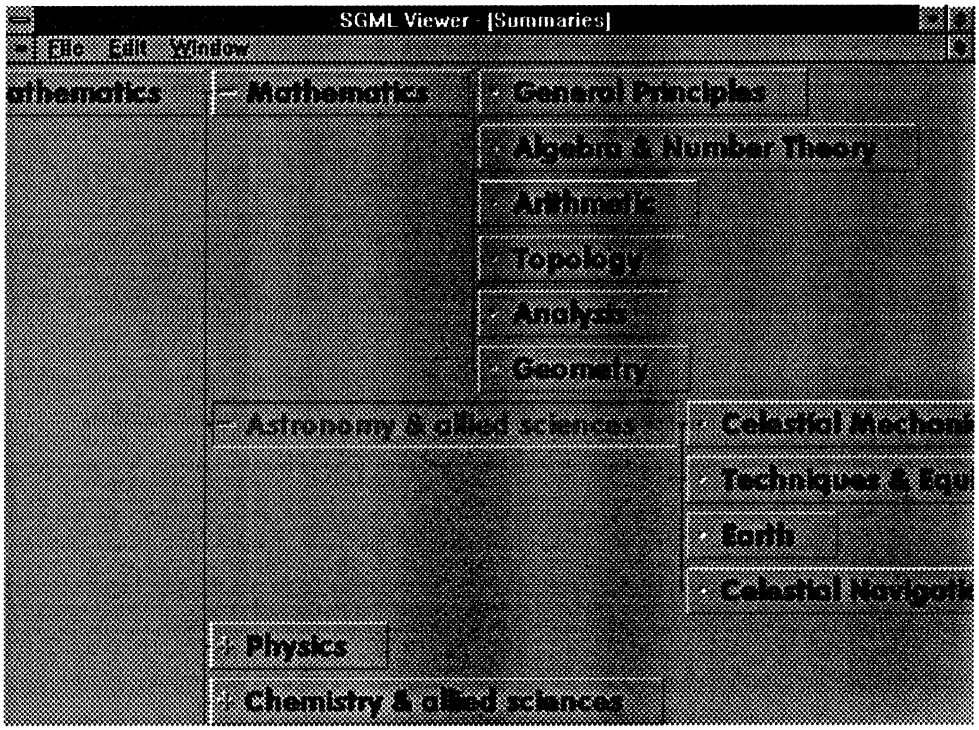

Figure 6: Views allow users to organize documents in hierarchical relations. Unlike the other figures in this paper, this screen snapshot is from the PC/Windows version of Dare. Both versions are functionally equivalent and the document databases are binary compatible across platforms.

document structure through the interactive table of contents and SGML tree representation.

The second problem is of cognitive nature: For comprehension, the reader must create a coherent mental representation of a hyperdocument. It is thus essential to grasp the boundaries of a hypertext corpus [Utting 1989].

This problem is tackled in several ways: By informative feedback which allows the user to determine what documents are linked (or annotated) in any particular web and, also, to see if a document is connected to some web. The selective filtering options available from within the Web Manager—as mentioned in section 3.5.1)—refine this process: a user can choose to work only with material he or she has created, or material created by a particular group.

Finally, *views* make it possible to encapsulate sets of documents in hierarchical relations. One can e.g. collect all documents pertaining to a web and place them in one or more views to create a corpus. Thus, Dare has a document-level knowledge structuring mechanism.

6 The User Environment

The Dare database manager is designed for collaborative work groups and provides access control for all database objects across the network. Every object belongs to one owner and is attached to one group. What is novel is the way groups are formed. To begin with, all users belong to a common group. Other groups are descendants of this group, which in turn can have subgroups, so that a hierarchy of groups is established. Group administration is performed from within the system and is not related to e.g. UNIX groups. Dare supports multiple inheritance, meaning that a group can be formed trough the

union of other existing groups.

A group has access to all documents belonging to the group or to its ancestors[7].

6.1 User Privileges

Hierarchical ordering is used in many contexts of the system. It appears once again in the privileges users are accorded within their group. We have, in ascending order of privileges, the following user roles:

- **Guest**. A guest can only access objects (views, webs, documents, etc.) accessible to every other user.
- **Reader**. A reader is allowed to create views and webs.
- **Author**. An author can also add new documents to the database.
- **Editor**. An editor is granted all of the above, and can also create new groups and admit new Dare users[8].

The privileges map well to the ways work groups tend to function, while the group construct models organizational structures.

7 Conclusions

The Dare system is an attempt to manage several current topics in the field of hypertext:

- Hypertext and structured documents [Quint 1992].
- Hypertext and document databases [Stotts 1991].
- Collaborative knowledge-structuring tools [Streitz 1992, Marshall 1991].
- Integration of hypertext systems with SGML [Quint 1992, Streitz 1992].

[7] The groups inherit previous access rights but deny access from their parent groups.

[8] There is also a *system administrator*, who is the inital user who assigns accounts to the editors.

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