A Methodology for Hypertext Design: a Case Study

Oreste Signore - Giuseppe Fresta [1]

CNUCE - Institute of CNR - via S. Maria, 36 - 56126 Pisa (Italy)
Phone: +39 (50) 593201 - FAX: +39 (50) 589354
E.mail: oreste@ivm.cnuce.cnr.it

Keywords: Hypertext - Hypermedia - User interface

Abstract - The links between the nodes constitute one of the most significant aspects of the hypertext, and very much contribute to the support of their dynamic interaction paradigm, so relevant to the implementation of effective applications.
In this paper we firstly recall the characteristics of the hypertext, pointing out some of the main problems the hypertext applications' designer must face. Afterwards, we outline a hypertext design methodology that leads to a consistent design of the nodes' structure, and allows modelling the different kind of links that can exist among the nodes. In particular, introducing the "concept space" allows an effective modelling of the intensional links. Finally, we discuss some general implementation aspects, and point out the need of offering to the user multiple and interchangeable interaction paradigms.

Introduction

During the last years, we assisted to an explosion of the hypertext applications, and, perhaps, to the tendency of considering it a "magic" solution to some old and known problems. Two major areas of application are education and documentation.
In the following, we will discuss some design issues that can lead to the implementation of effective hypertext applications and present a hypertext design methodology with the support of examples taken from a case study developed for the Orto Botanico of the University of Pisa.

1 - Hypertext/Hypermedia: General issues

Hypertext was originally conceived essentially as a tool for the management of the personal information, that is, the information needed by the single researcher for his/her own purposes. As a consequence, the user of a hypertext was thought as having a complete awareness of the content and the organisation of the information. He/she is supposed to have a complete knowledge of the semantic domain the hypertext is concerned with, and therefore to be able to find quite evident and natural all the links, either they represent a "structural" organisation, either they just accomplish the task of representing some association among different information nodes.

---

[1] Giuseppe Fresta was in charge of engineering the first prototype version of the application, and helped in many clarifying discussions to define the methodology.

However, we must note that even a user with a thorough knowledge of the possible associations among the different information nodes can meet many difficulties in finding the relevant chunk on information.

As it is well known, hypertext is constituted by nodes and links, which are of greatest importance: in a certain sense, they are the ‘essence’ of the hypertext.
Really, the links are the basic component that contributes to the *enrichment of the knowledge*, as they have a fundamental role in *stimulating the user’s interest*, implementing *various types of connections* among the nodes.
According to some proposals in the literature (De Rose 1989) we can classify the links in two main classes: extensional and intensional. Each class is subdivided in more subclasses, and so on. Without going in more detail, we simply remind that the author must explicitly store the extensional links in the hypertext, while the intensional links shall be deduced from the context.
We have also to remember that each node can be linked to many other nodes due to many reasons, and this is especially true for the intensional links, that can be seen as the “added value” to the hypertext.
It is customary that the author analyses the content of the nodes and identifies the “*anchor point*” (Nielsen 1990a, Nielsen 1990b), that constitute the smallest element in a node that can give rise to a link towards other nodes. The physical implementation of a link makes use of buttons, icons, hot-words, and similar.
This is the phase where a great number of links can arise. As a matter of fact, many designers realise that the links are the power of the hypertext, and try to emphasise this concept introducing as many links as possible.

Hypertext presents some points of strength: the first one is the possibility of accessing immediately to the nodes containing the relevant information. Secondly, it is possible to have a non-linear organisation of the data, that very much resembles that of the human mind. Finally, it is possible to reduce the amount of information stored in each node, as it is sufficient to suggest possible items that can give supplementary or deeper information. The user will activate the links at his/her will, so enriching his/her knowledge according the specific needs or interests
There are several ways for accessing the information: *navigation* from one node to another, *browsing*, i.e. visualisation of a set of nodes and choise of the most relevant or “promising”, *querying*, i.e. the selection of a set of nodes that fulfill the information requirements contained in a single query. Quite obviously, we must expect that the user will intend to use these access modalities as many times as he/she wants, and in arbitrary order.

However, we must mention at least two “structural” problems, that constitute a real challenge, and are common to all implementations: the *disorientation* and the *cognitive overhead* (Utting 1989, Nielsen 1990b).

In respect to a linear text (e.g. a book) the hypertext offers a much higher degree of freedom, as we have more than one dimension. This can cause disorientation, therefore the possibility of being “lost in the hyperspace” is much higher. Carefully designed, functionally rich browsers can offer some help.

The second problem arising in the usage of the hypertext is related to the difficulty of being adapted to the *cognitive overhead*. This difficulty comes up in the design phase as well as in the navigation phase. In the first case, the author must decide about the structure to give to the texts, which links, and how many links to create, where anchor the links, etc. During the navigation, the user must operate a choise in front of a wide number of possible links.

Independently of the difficulties due to the peculiar tool adopted for the implementation of the hypertext, some considerations have a more general relevance, and can heavily impact on the design phase.

The first aspect is related to the *extensional* or *explicit links*: as they are defined by the author, they necessarily are dictated by his/her knowledge on the specific domain and mental organisation, that therefore are “hard coded” in the hypertext. Roughly speaking, we can have two extreme cases: the links are too many or too few. As a consequence, we will either cause a high cognitive overhead, or implement a “flat” non stimulating hypertext. In both cases, the user will be disappointed.

The second problem arises from the need of representing the *intensional* or *implicit links*, implementing interaction mechanisms that will emulate as far as possible the human mind’s associative mechanism.

The third problem, concerning the user’s interface, is well known in the context of the cognitive psychology, and in some way has some overlap with the others. In fact, the system’s interface accomplishes the task of communicating to the user the designer’s mental model (Norman 1988). As a consequence, the user will build his/her mental model according to the “messages” communicated by the interface. In practice, the two models only rarely are consistent, in many cases they can be totally different.

2 - A methodology for Hypertext Design

2.1 - Generalities

Too often the designers consider the hypertext design to be simply a “creative” task, and implement the hypertext/hypermedia (HT/HM) just following their “inspiration”, without a careful thinking to the organisation of the information. This leads to poorly consistent design, in spite of some brilliant solutions taken step by step, where mere technical effects (sound, colour, animation, etc.) mask obscure design choices, if any.

As a consequence, a relevant issue in the implementation of hypertext applications is the modelling of the knowledge and the structuring of information nodes and related links.

To our understanding, hypertext is related to other areas, either of computer science as well as pertinent to other disciplines: some of them are “mature” and can give a valuable help in the definition of a design methodology.

Table 1 shows the items the various disciplines can help to design.

Database Technology	*Data Modelling: i.e. definition of the nodes and their structure*
Information Retrieval	*Indexing of the free text information*
Artificial Intelligence	*Linking data items: i.e. capturing the connections that can be established among the nodes on the basis of the choices taken by the user*
Cognitive Psychology	*Implementing an effective User Interface*

Table 1 - Contribution of other disciplines to hypertext design

In addition we must stress that the purely sequential visit constitutes a too simple and poor interaction paradigm, while we must give to the user the possibility of associating the concepts that can be tied to the information nodes, so that he/she will be able to exploit the navigation capabilities at the highest level. Therefore, the user should have the possibility of choosing *several interaction paradigms*, as the association among the nodes can be dictated by several reasons (contiguity in space or time, relationship among the associated concepts, etc.). In addition the user must have the possibility of *switching* from one paradigm to another, so emulating the way the human mind works. Finally, the type of links must be clear to every user. Even more important is to *visualise* the links, so that the user can have a clear idea of how much a link is “promising” in terms of the number of nodes he/she can access. Finally, the *weight* of the links (i.e. the importance given to the specific association) should vary accordingly to the user’s interests.

2.2 - The nodes

A prerequisite to the implementation of an effective hypertext is the accurate analysis of the information to be managed. Making an analogy with other application environments, especially the database environment, the definition of a conceptual schema, that is a semi-formal description of the world of interest, takes a fundamental importance.

The architecture of a hypertext design methodology (Signore 1994) could be that reported in fig. 1.

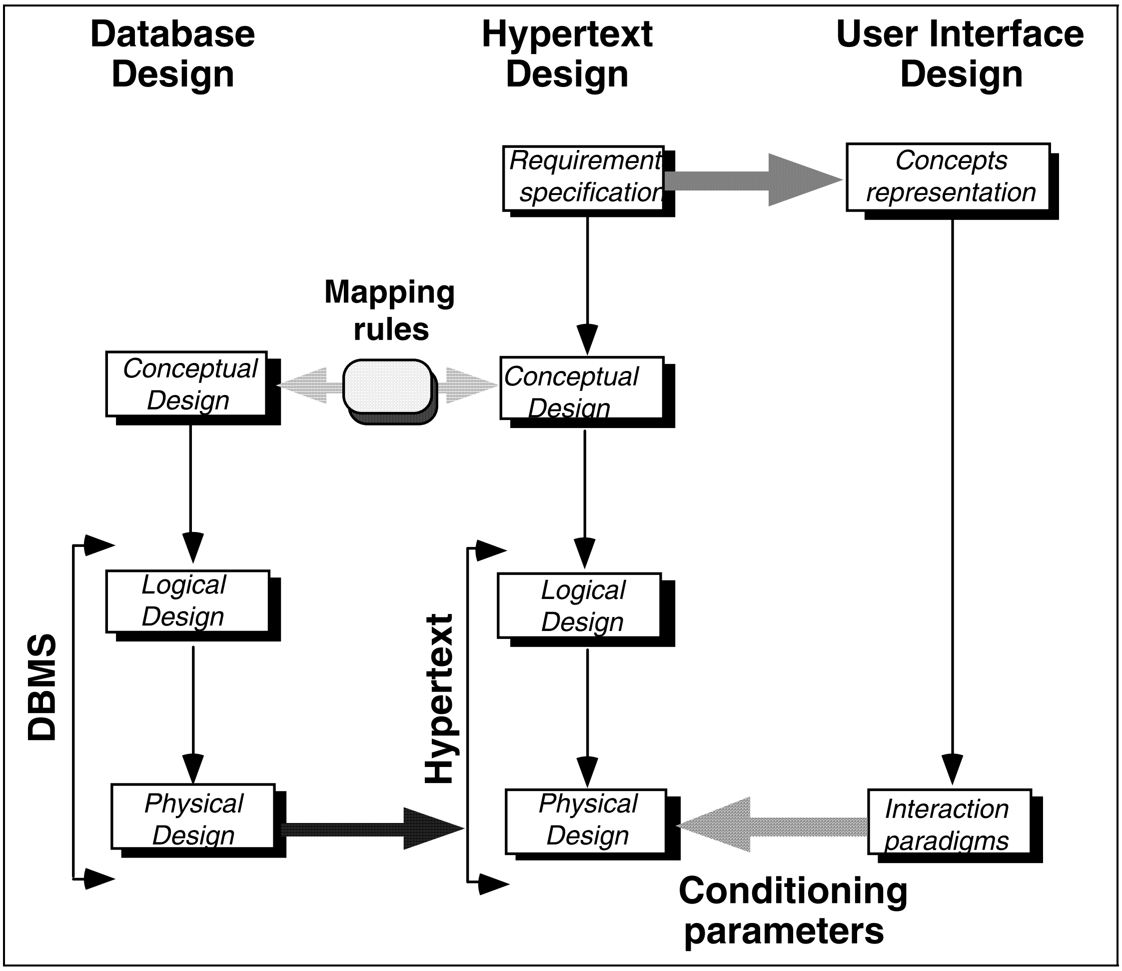

Fig. 1 - Schema of a hypertext/hypermedia design methodology

Once the conceptual schema has been designed, it is possible to proceed to the definition of the hypertext's structure by a straightforward process.

Going down to the physical level, the identification of nodes' and links' types allows the definition of nodes' structure that make them clearly distinguishable, while maintaining a "family feeling". By this, the structure of the node can automatically transfer information about the kind of information it contains.

In defining the nodes' structure, we may introduce the additional concepts of *components* and *perspectives*. This means that every node is made by several components, that can be seen as an enrichment of the concept of "field" of the card or the "attribute" of an entity. In fact, the components of a node can be of several types, e.g. sound, animation, image. This assumption leads to the extendibility of the proposed methodology to the design of hypermedia as well as hypertext applications, by means of a unified approach.

In addition, if we consider that every component can be seen from different perspectives, we can easily manage, at the design level, many problems, like the different resolutions of the monitors, user preferences, multilingual support, etc.

Finally, every node will contain several links towards other nodes, dictated by the associations modelled during the conceptual design phase.

2.3 - Associations among the Nodes

As we have pointed before, the links are the hypertext component in charge of representing the associative aspect, extensional as well intensional.

In fact, the extensional links are essentially structural links. However, the intensional links constitute a very different case, as they are modelled on the associative process typical of the human mind.

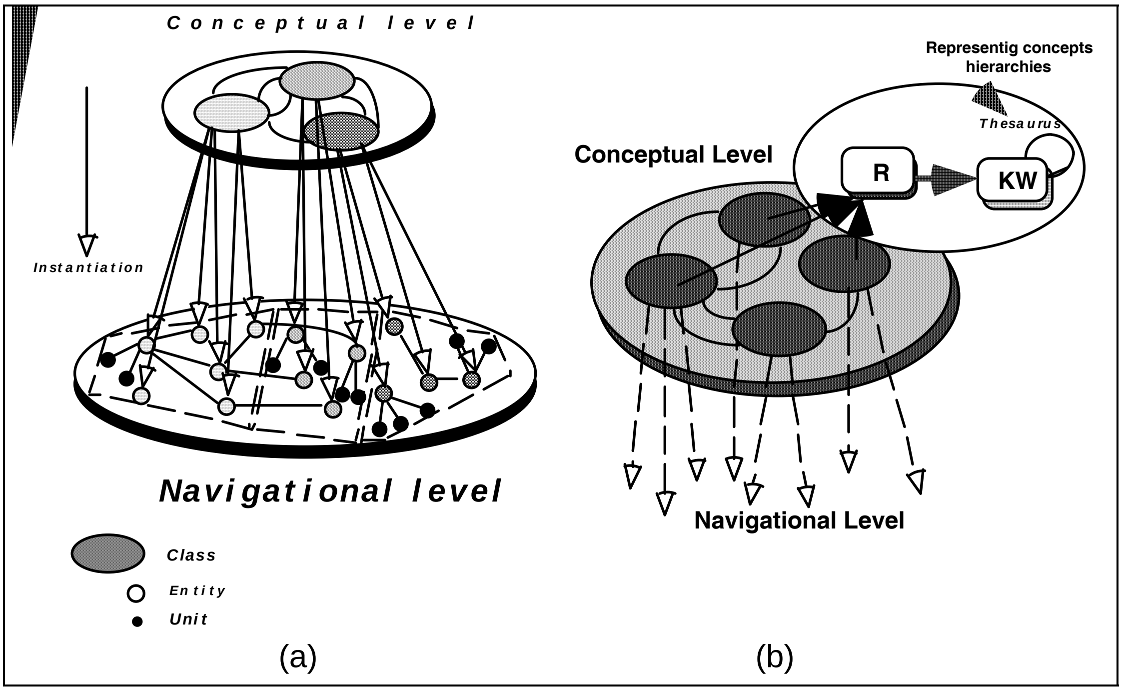

Fig. 2 - The two abstraction levels in the proposed hypertext model

We can emulate this process implementing a "*concept space*", that makes explicit the relationships existing among the concept that can be attached to the single information node (fig. 2). By this approach, we can implement a representation of the knowledge on the specific domain, and therefore we are no more forced to make explicit all the possible links existing among the various nodes. As a consequence, we can reduce the cognitive overhead given by the presence of an excessive number of links on the single node.

Such a mechanism makes the implicit assumption that the user has the ability of abstracting the significant concepts from a single node, and subsequently associate them in producing a personalised cognitive path. The navigation through the concept space enables the user to operate an abstraction process, then following the associations among the concepts, finally descending again to the information space. This process appears much more similar to the natural cognitive one. It is evident, however, that this solution will be effective only for really "active" users.

2.4 - Implementing the Links

We must pay much attention to the links' implementation as well as to the way they are made explicit to the user.

In the literature, the authors assume contrasting positions about the opportunity of having "typed" or "non-typed" links. Without going into technical details, we must stress that the user must be made well aware of the semantic meaning of the links, and therefore of its destination node type.

Another difficulty comes from the necessity of making evident these differences to the user, especially when a single "*anchor point*" is the starting point towards many other nodes belonging to different classes (fig. 3).

We can reduce the difficulties originated by the cognitive overhead and disorientation by making evident the links that exist among the various nodes, so that the user could immediately realise how much the activation of a link can be "promising". To emphasise this concept, it is worthwhile to introduce the concept of the link's weight, that will measure the affinity degree between two nodes. This concept allows to distinguish among the links representing a strong interrelation among two nodes from the loosely connected nodes. It is quite obvious to give a "spatial" representation of the affinity degree, where the distances among the nodes decrease when the affinity increases (fig. 4).

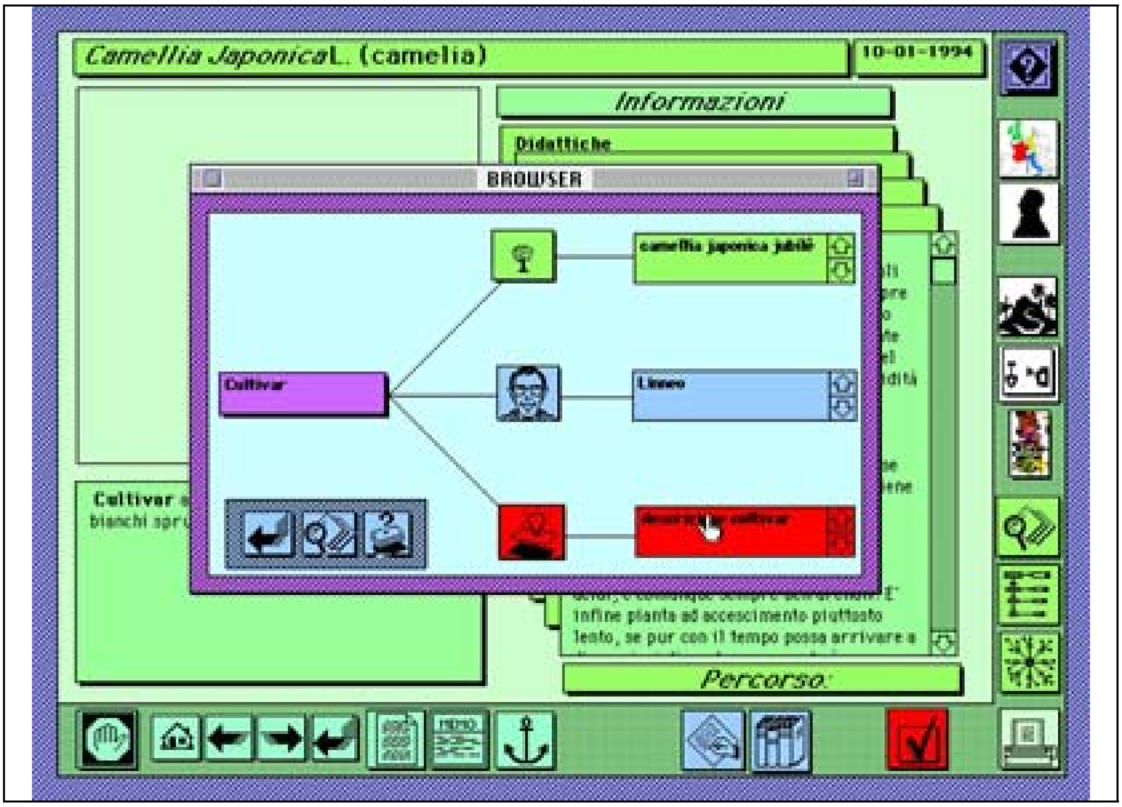

Fig. 3- An example of visualisation of a “multiple link”

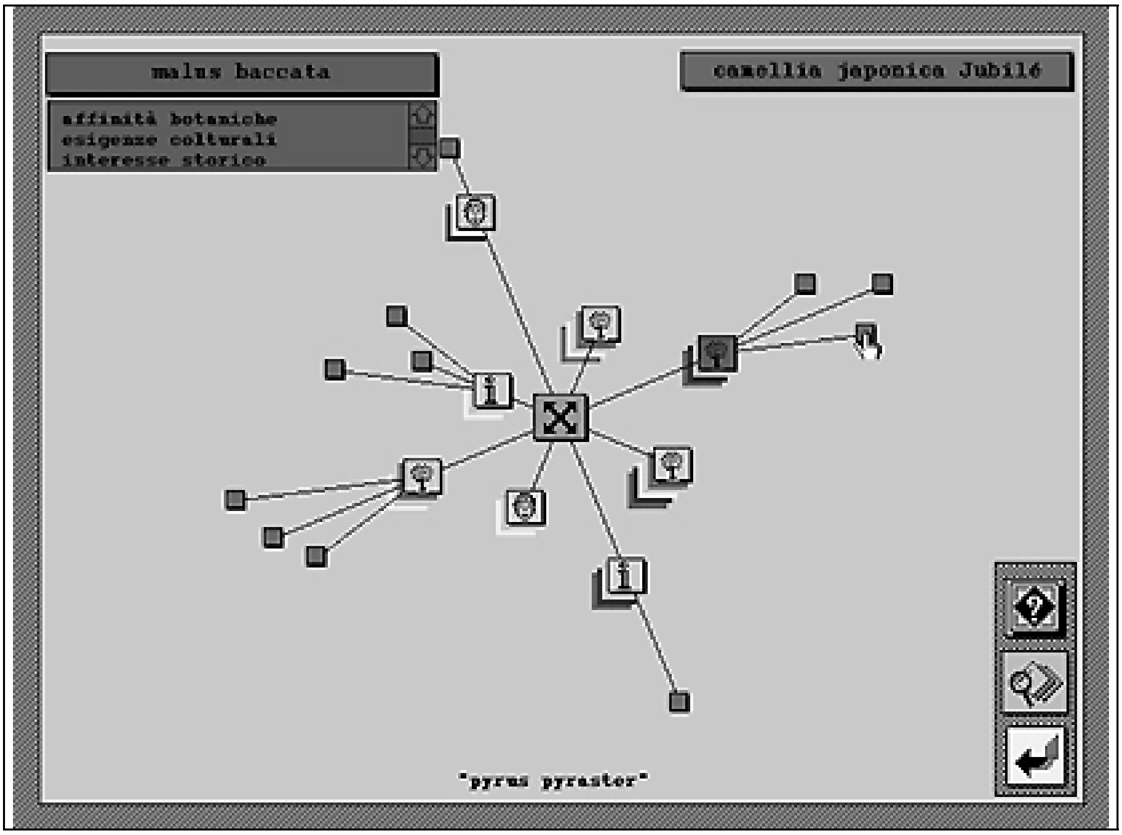

Fig. 4 - An example of the visualisation of the map of the available links to navigate.

Looking to this problem at a higher detail level, we can realise that the weight of the link between two nodes is affected by the specific user's interests and the peculiar aim the user has in his/her mind when navigating the hypertext. In particular, some of these links could be of null importance, and the user would be happy do not have them showed. As a consequence, we must consider the usefulness of defining a "user profile" so that the user should be able to modify at his/her will the importance given to the different links.

2.5 - The Interaction Paradigms

Traditionally, the author's knowledge is "hard coded" in the hypertext, so forcing the user to follow undesirable cognitive paths. We can reduce this disturbing effect by implementing many and interchangeable interaction paradigms, so that the user will be able to follow the mental paths that he/she will find the most natural and significant time to time.

The most obvious paradigm is based on the physical contiguity of the nodes. In this case, we will navigate the hypertext in the same way we would browse the pages of a book. Unfortunately, in many cases this is really the only available interaction paradigm. In fact, links towards other nodes, or the possibility of tracing back the followed path, do not substantially modify the characteristics of this kind of interaction, which very little stimulates the user, and do not much differ from the conventional cascade of menus. In addition, some undesirable effects can arise, like the navigation to a totally out of context node, reached simply because of its physical contiguity with the previous one. In conclusion, this kind of interaction paradigm forces the user to follow the cognitive paths defined by the hypertext's designer. Only predetermined and foreseen associations, explicitly implemented by extensional links, can be followed.

It appears much more relevant to implement more flexible and stimulating interaction paradigms, that will allow the user to follow intensional links (Signore 1993a, Signore 1993b).

On the basis of previous experiences, it seems that we can reconduce the most useful paradigms could to three basic types: classification, map, time.

The *classification paradigm* allows the navigation through the concept space: from a single node the user will raise up to one of the concepts associated to it. Afterwards, moving across the relationships that map the domain knowledge, he/she can identify other concepts. From these, it is possible to go down again the nodes' space. Figure 5 shows an example where from a botanical classification it is possible to directly access the related plants.

Widely used and useful is the *map paradigm*. In this case, the user can interact with a topographic or geographical map, selecting the interesting zones and choosing the nodes to be reached on the basis of their physical location (fig. 6).
In many application it can be very useful the implementation of a *temporal paradigm*, or the availability of the map and time paradigms at the same time. This allows to put the information in the right space-time context, according to a mental model widely used in many areas, especially in the management of the cultural heritage (Signore 1990).

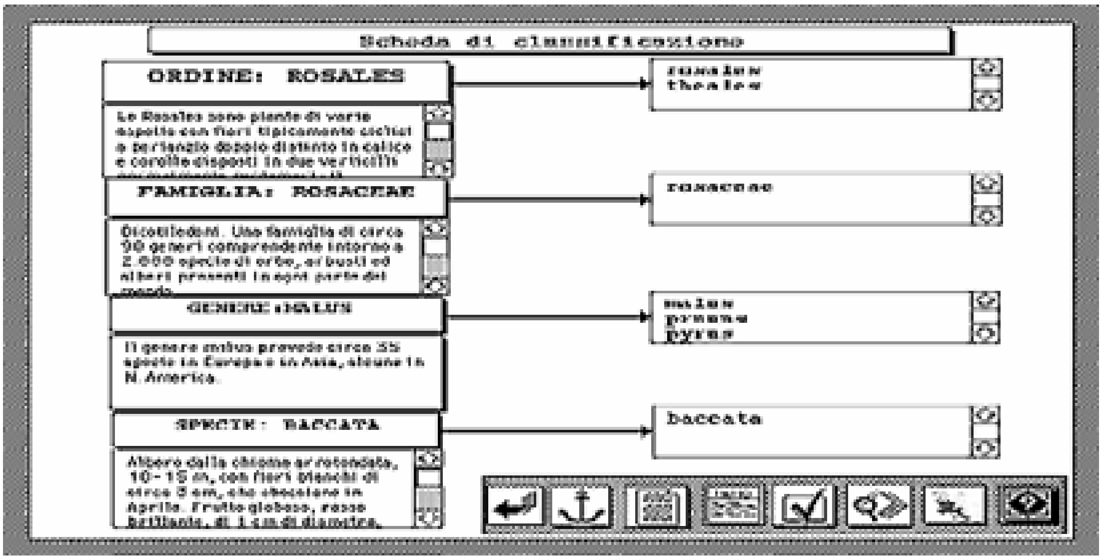

Fig.5 - An example of interaction paradigm based on a classification scheme.

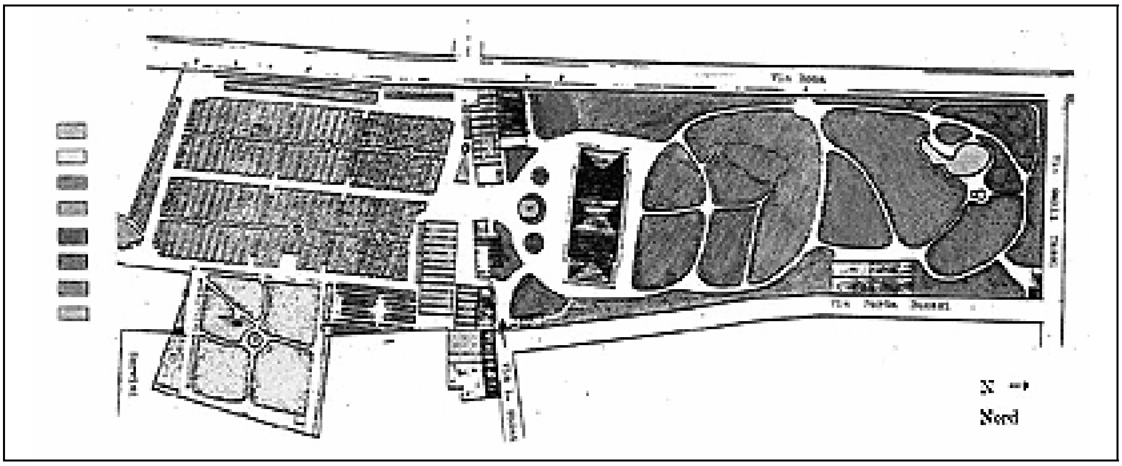

Fig. 6 - An example of map/classification paradigm

2.6 - Other aspects

When implementing a hypertext, we must consider that the target user is supposed to be particularly "active" and "curious". As a consequence, we must foresee the implementation of *annotational links*, that will allow to capture the user's knowledge, that can be added to the hypertext. In a subsequent phase, the annotations can be made accessible to the whole users' community, and will become part of the common patrimony of knowledge.

In many cases, especially in implementing educational applications, we must provide for, and implement, *vocative implicit links*, that will reference dictionary entries.

Finally, the author must provide guided tours, that will satisfy some peculiar needs. However, the user must be free of leaving the tour at his/her will, would he/she desire to perform a deeper investigation of some aspects, or follow associations dictated by his/her experience in the specific field. It is worthwhile to note that guided tours can be useful to the user to become familiar with the hypertext's structure and content.

Conclusion

Many hypertext applications pay much attention to mere technological aspects, while disregarding other important issues, like a consistent and expressive user interface, or the usefulness of an accurate data analysis.

In this paper we showed that distinguishing between extensional and intensional links leads to the definition of a hypertext design methodology that makes use of consolidated approaches in the database and information retrieval areas.

We also outlined the essential steps of the proposed hypertext design methodology, whose effectiveness has been tested in a case study developed for the Botanical garden of the University of Pisa. The implemented hypertext is characterised by the availability of multiple interaction paradigms, that the user will select at his/her will, switching from one to the other according to the associative mechanism that will appear to be the most adequate.

Acknowledgements

Our warm thanks go to Alessandra Cimbalo and Stefano Di Lecce, who implemented the first prototype version of the hypertext.

We have also to tank Prof. Fabio Garbari and Dr. Gianni Bedini from the "Dipartimento di Scienze Botaniche" of the University of Pisa, who helped in the organisation of the content of the hypertext. Their contribution has been of essential importance in defining the need of the potential users.

References

De Rose S. J. (1989), 'Expanding the Notion of Links', Hypertext '89 Proceedings, (November 1989), 249 - 257.

Nielsen J. (1990a), 'The Art of navigating through Hypertext', Communications of the ACM, Vol. 33, N. 3 (March 1990)

Nielsen J. (1990b), 'Hypertext and Hypermedia', (USA 1990), Academic Press inc., Harcourt Brace Jovanovich Publishers.

Norman D. A. (1988), 'The psychology of everyday things’, (New York 1988), Basic Books, Inc., Publishers.

Signore O., Bartoli R. (1990), 'Implementation of a historical/geographical database with support of imprecise dates’, DEXA’90: 'Database and Expert Systems Application, Proceedings of the International Conference in Vienna, Austria, 1990, (Tjoa A.M., Wagner R., Eds.) Springer Verlag Wien New York, ISBN 3-211-82234-8, pp. 271-274.

Signore O., Malasoma S., Tarchi R., Tunno L., Fresta G. (1993a), 'A Hypertext with Multiple, Interchangeable Paradigms of Interaction and Dynamic Links’, The Art of Communication, VIII International AHC-Conference, Graz, Austria, August 24-27, 1993, Abstracts, pp. 75-77.

Signore O., Malasoma S., Tarchi R., Tunno L., Fresta G. (1993b), 'A hypertext for an interactive visit to a science and technology museum’, Proceedings of the Sixth International Conference of the MDA and the 2nd International Conference on Hypermedia and Interactivity in Museums (ICHIM’93) Cambridge, England, 20-24 September 1993, ISBN 0-905963-89-X, pp. 204-209.

Signore O., Fresta G., Bertini F., Guazzini M.P. (1994), 'I Collegamenti Associativi negli Ipertesti/Ipermedia’, proceedings of: “Sistemi Multimediali Intelligenti. Multimedia e Beni Culturali. Multimedia e Formazione”, Centro Universitario Europeo per i Beni Culturali - Dipartimento di Informatica Università di Salerno, Ravello, Villa Rufolo, 14-17 settembre 1994 , in “MULTIMEDIA. Beni Culturali e Formazione”, ELEA Press, Salerno - ISBN 88-85269-41-9 (1994), pp. 298-314.

Utting K., Yankelovich N. (1989), 'Context and orientation in Hypermedia networks’, ACM Transactions in Information Systems, Vol. 7, No. 1, January 1989, Pages 58 - 84.