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# Towards Digital Libraries of Virtual Hyperbooks

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## ABSTRACT
This paper describes a technique for integrating several (many) virtual hyperbooks in a digital library. We consider a virtual hyperbook model that comprises a domain ontology. By interconnecting the hyperbook's ontologies, we can create a multi-point of view ontology that describes a set of hyperbooks. A hypertext interface specification language can use this ontology to construct new semantically and narratively coherent hyperdocuments based on the content of several hyperbooks.

## Categories and Subject Descriptors
H.5.4 [**Hypertext/Hypermedia**]: Architectures

## General Terms
Design, Human Factors

## Keywords
virtual document, digital library, ontology, link inference

## 1. INTRODUCTION
A virtual document is a set of information fragments associated with filtering, organization and assembling mechanisms. Depending on a user profile or user intentions, these mechanisms will produce different documents adapted to the user's needs. The idea of virtual document can be found in "pre-Web" hypertext systems, such as MacWeb [5] and, more recently, in adaptive and personalized hypertext systems [4][6].

Given the rapid development of theoretical and practical tools in this domain, it is reasonable to think that digital libraries will incorporate virtual documents in addition to traditional electronic documents. It is interesting to explore the new accessing and reading possibilities that a library of virtual documents can provide. The main distinction between a traditional digital library and a virtual document library is the disappearance of the monolithic character of a book or an article. The ability to select and assemble informational fragments originating from different virtual documents opens new perspectives on the reading task, but it also raises important questions.

In a digital library of virtual documents, a document reading system should be able to compose new documents from all the available informational fragments of the library, according to the readers' objectives. We can also consider that a virtual book, once inserted into a library, will automatically enrich itself by connecting to fragments of other books (new examples and exercises, new comments about several concepts, etc.)

In these two cases it is obviously necessary to check the semantic compatibility of the fragments before re-using them. The objective is to deliver to the reader new documents that are semantically coherent. For this, we propose an approach based on ontology integration and on reusability of virtual document interface specifications.


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## 2. VIRTUAL HYPERBOOK MODEL
The hyperbook model we consider is comprised of a fragment repository, a domain ontology and an interface specification. The domain ontology is a network of concepts related through semantic links such as "is a", "part of", "entails", etc.

The domain ontology plays two roles: On the one hand it describes the concepts of the domain; on the other hand, it serves as a reference to describe the information content of the fragments. By establishing typed links from fragments to concepts, one can qualify not only what the fragment is about but also what relationship it has with the domain concepts. Typical link types are: example, property, exercise, historical note.

The interface specification is a set of parameterized node schemas, expressed in a declarative language [3]. Each schema is composed of a selection expressions and a content structure (how to assemble the selected fragments) The actual nodes of the interface are instances of the node schemas. The hypertext links of the interface are also specified in node schemas. Links can be either navigation links or structural links (inclusions) that enable the interface designer to create complex contents that show several fragment contents together in a single hypertext node.

## 3. LINK INFERENCE
The idea is to replace direct linking between fragments (often called horizontal linking) by inferred links that correspond to paths starting from a fragment, traversing one or several ontology concepts, and ending on another fragment [1][2]. We have observed that these inferences provide semantically relevant links because users (authors) are generally able to establish correctly typed links from their fragments to the relevant concepts. In addition, the set of inferred links is always up to date and complete, which is not the case with used-defined horizontal links.

Since the ontology has a graph structure, link inferences can be expressed in the form of path expressions. For instance, an expression of the form

`Fragment` *f* -*example*- `Concept` *c* -example- `Fragment` *g*

produces a link between fragments *f* and *g* if they are both linked to a concepts *c* through a link of type *example* (as shown in Figure 1, right).

# 4. HYPERBOOK INTEGRATION

In order to integrate the hyperbooks that make up a library, we propose to interconnect their ontologies. We consider that each hyperbook represents the point of view of an author on a (sub-)domain, hence the interconnected ontologies should not form a single monolithic ontology be a multi-point of view ontology. Interconnecting ontologies amounts to establishing similarity links between their concepts. These links can be set either manually or automatically, through some similarity computation algorithm.

An interesting characteristic of the virtual hyperbook model and of the integration model is the possibility to simply re-use the interface specifications of the hyperbooks to create global reading interfaces.

A first technique for building a global reading interface consists in re-using the specification of a hyperbook interface, but to apply it to the whole information space of the library, i.e. to the fragments and ontologies of all the hyperbooks and their interconnections through similarity links. A new, extended, version of each node schema of the interface is derived by extending all its link inference expressions. Whenever an element of the form `Concept` *c* appears in a path expression, it is replaced by `Concept` *c* `-`*sim*`-` `Concept` *d*.

Thus every path through *c* can now "jump out" to another hyperbook, as shown on the following figure.

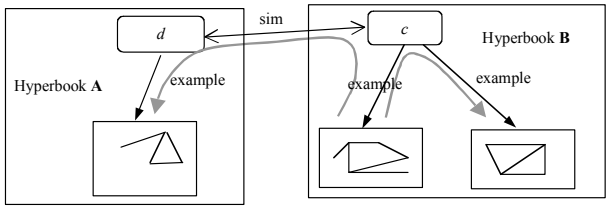


**Figure 1. Selection path to another hyperbook**

The initial book is thus enriched with other points of view of the subject. Figure 2 shows another example of hyperbook enrichment: the presented node contains the definition of a concept (*Finite state automaton*) together with links to example fragments. It also contains (bottom left) links to examples of similar concepts (*Deterministic FSA* and *State machine*) found in other hyperbooks.

By adjusting a threshold value, the user can define the type of extension he or she desires. A very high threshold corresponds to an extension with very close points of view while a lower threshold accepts dissimilar points of view.

A second way to re-use an interface specification consists of applying the interface specification of a hyperbook to another one. In this case, we will see the informational content of one hyperbook with the interface of another. If we consider that the interface of a hyperbook represents its narrative style, we obtain a vision of the content of a hyperbook in the style of another one. This kind of re-use does not require any rewriting of node schemas, but it implies that the hyperbook ontologies use the same types of relations.

It is also possible to define a completely new reading interface on the whole library. In this case, we suppose that an author wants to create a new book starting from information already existing in the library. This is a second level author, who will not create information, but invent new narrations and presentations. This task can be achieved either by creating new node schemas, or by re-using schemas of different hyperbooks.

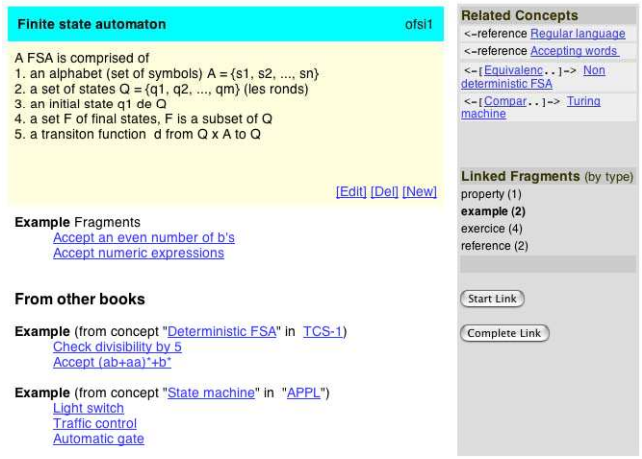


**Figure 2. Extension of a hyperbook**

As we have already seen, each node schema can be applied to any hyperbook. As a consequence, a second level author can create new schemas that include or refer to existing schemas, without having to modify the latter.

# 5. CONCLUSION

We have proposed an ontology based model and an integration technique for digital libraries of virtual hyperbooks.

We have implemented these ideas in a virtual hyperbook library management system. The domain ontology and the hyperbook fragments are stored in a relational database. Interface hyperdocuments and links are specified with the Lazy hypertext view definition language [3]. The system is currently used by teachers and students of different courses to collaboratively write hyperbooks. Thanks to the interconnection of the ontologies, the users can view extended versions of their hyperbooks (as show in Figure 2). Thus they can benefit from the information of other hyperbooks without leaving the context of the hyperbook they are currently reading or writing.

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