# Shared Readings in Spatial Hypermedia

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## ABSTRACT
Spatial hypermedia research is revising and integrating ideas previously explored in navigational hypermedia, such as adaptation, distribution, integration of new media, etc. A result of one such investigation is the support personal readings of distributed spatial hypertexts via transclusion links. WARP provides the required platform for a first exploration of the issues associated with reading distributed spatial hypertexts. However there is limited research on the exploration of shared readings of spatial hypermedia. This paper presents a forward-looking perspective on the possible issues associated with reading and interacting with spatial hypertexts.

## Categories and Subject Descriptors
H.5.4 [**Information Interfaces and Presentation**]: Hypertext/Hypermedia – *architectures, navigation, user issues.*

I.7.2 [**Document Preparation**]: document Preparation – *Hypertext/hypermedia*, *Multi/mixed media.*

## General Terms
Documentation, Design, Experimentation, Human Factors.

## Keywords
Information delivery, spatial hypertext, adaptation, shared readings.

## 1. INTRODUCTION
Spatial hypermedia evolved out navigational hypermedia in response to the need to augment the expressiveness of the medium. In contrast to navigational hypermedia, where links are either present or not, spatial hypermedia can represent *possible* relationships and implicit links. This provides a medium where authors can delegate to the readers the proper interpretation of the association between objects.

Faithful to its initial motivation of increasing the representational power of the medium, research in spatial hypermedia has also revised and incorporated approaches first explored in navigational hypermedia including adaptation and distribution among others.

Reading is a complex activity that involves many strategies and actions. The activity itself is associated with the affordances and constraints of the medium. As spatial hypermedia enhances the expressiveness and representation capabilities of the medium, it also affects the reading activity.

Spatial hypermedia supports direct manipulation of the objects and relationships present in the document. When reading a spatial hypertext, readers must interact with the document moving and changing objects and relationships, actively cooperating in the process of attaining a proper presentation of the information. Thus, in the context of spatial hypermedia, the terms *reading* and *interacting* become interchangeable [3].

This is particularly significant when considering distributed spatial hypermedia, because the interaction with the hypertexts raises possible issues with access rights, ownership of documents, and collaborative environments. These issues and their possible solutions are the focus of this paper. It commences the discussion by briefly presenting relevant work previously conducted in the areas of distributed systems and spatial hypermedia. It then proceeds to discuss some spatial hypermedia features and emerging reading strategies that present interesting challenges. Next, the paper discusses how support of private readings of distributed hypermedia has been supported. This provides a starting point for the discussion of how shared readings might be best supported. Finally the paper concludes by summarizing the main concepts.

## 2. RELATED WORK
Prior work on spatial hypertext heavily influenced the development of the present work. A brief overview of each is presented here to provide grounding for the discussion of personal and shared readings of spatial hypertexts.

### 2.1 Distributed Systems
There is extensive previous work in the area of distributed systems and distributed hypertext. Conferences such WWW, CSCW, Hypertext, and CHI and journals such as TOIS are just a few of the places that publish research papers regarding distributed and collaborative access to documents. As for systems, many have been implemented, with the Web being the most obvious one. A complete review of this work is out of the scope of the present document. However, mention of the area is important as the work in this field informs about the basic approaches and techniques, such as synchronization and notification mechanisms, which can be transferred to spatial hypermedia in order to facilitate the shared reading of documents.

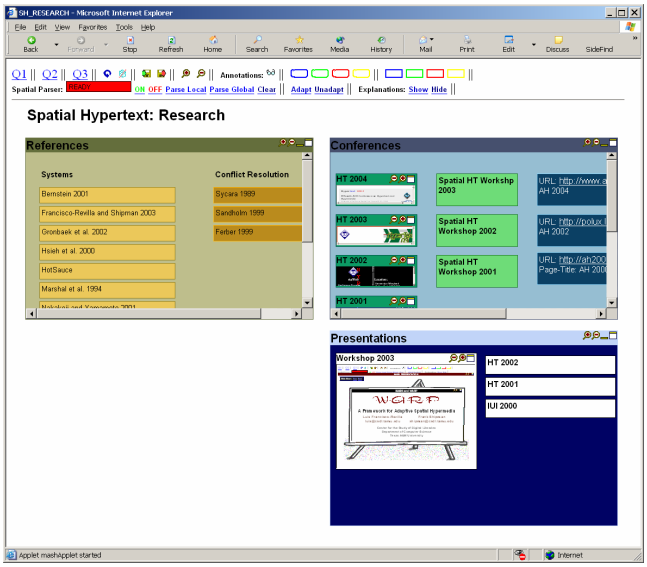


**Figure 1. Transclusion links in WARP**

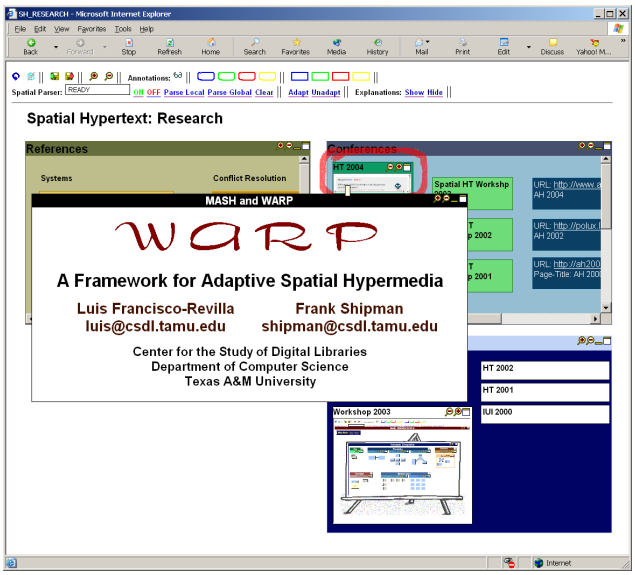


**Figure 2. Import/export of objects in WARP**

## 2.2 Spatial Hypermedia

In order to envision how the reading activity would be affected by providing shared access and interaction with spatial hypertexts it is necessary to first understand the medium itself. Since 1992, spatial hypermedia researchers have explored the affordances and constraints of the medium. This research has covered many topics such as: how the relative spatial position between objects is used to imply relationships between objects [7, 8, 11], what kinds of spaces can be used [6, 5, 3], how to represent explicit and implicit links with varying degrees of formality [8, 12], how to augment the medium with adaptive behaviors [3, 4], how different hyperlinks are used in spatial hypermedia, including semantic and navigational [11], and transclusion links [4].

There has been previous work in spatial hypermedia in regard to creating collaborative spatial hypermedia. Shipman et al. studied the emergence and evolution of visual languages as a result of synchronous and asynchronous collaboration in spatial hypermedia [10]. Cox and Greenberg [1] investigated the support of collaborative interpretation by small distributed groups. Employing a metaphor of Post-its and index cards, they created a system called PReSS. PReSS allowed users to move and locate text objects on a 2-D space and supported the creation of text annotations and freehand annotations. Additionally, Grønbæck et al. [5] investigated the creation of collaborative virtual environments in the domain of architecture, where architects and customers interacted with a 3-D spatial hypermedia system. In their approach they implemented a collaboration server that managed the synchronization of a set of distributed copies of a given spatial hypertext. While their system, TOPOS 3-D, supported referential hyperlinks to other spatial hypertexts, it did not supported transclusion hyperlinks.

This paper elaborates on a recent study about the reading activities of people interacting with instructional information [2]. By observing how people read instructional information in spatial hypermedia, the study discovered emergent navigation and orientation strategies performed spontaneously by people reading spatial hypertext documents.

Users often moved and modified the information objects as part of their reading process. Readers used changes in object appearance or location to group or compare objects, to keep track of what had been read, to bookmark sections, and to assign personal semantics such as the degree of relevancy. The readers' interactions with the document are highly relevant when considering shared readings of a spatial hypertext, as the actions of one reader can affect the reading process of another reader.

# 3. SYSTEM

Our research into shared readings of spatial hypertexts is conducted using WARP [4]. WARP is a multi-model adaptive spatial hypermedia system [3] implemented in Javascript and Java applets to execute inside IE or Netscape. WARP's functionality is primarily as a spatial hypertext reader, providing for interactive, dynamic and adaptive spatial hypermedia. Authoring of the spatial hypertexts is accomplished in VKB [11], which are then exported to WARP format. The WARP format allows the spatial hypertext to be read and interacted with as just another web-based resource in the browser.

In addition, WARP supports the personal reading of composite spatial hypertexts that incorporate a distributed set of documents using transclusion links. This ability of WARP raises interesting issues that need to be understood before extending the approach to shared readings. Thus the next two sections present a more detailed discussion of transclusion links and WARP's support for personal readings. WARP's ability to support distributed spatial hypertexts motivated us to consider extending the approach from personal readings to shared readings.

## 3.1 Transclusion Links

Transclusion links [9] in WARP allow external hypertexts (spatial and navigational) to be presented as subcomponents of the spatial hypertext. In the spatial hypertext shown in Figure 1, the user organized objects representing references, conferences and earlier presentations. The "Conferences" collection has different kinds of objects that represent some of the conferences and workshops attended by the user. Notice that the ACM HT conference objects display a zoomed out view of the actual conference Web pages.

These are transclusion links to navigational hypertexts. In contrast, the document object for the "Workshop 2003" presentation inside the "Presentations" collection exemplifies a transclusion link to a spatial hypertext. In this case the user can interact with the sub-document as if it were part of the parent document.

In addition, WARP supports import/export operations across spatial hypermedia documents linked by transclusion, as illustrated in Figure 2. After interacting with the 2003 Spatial Hypertext Workshop spatial document, the user imported a collection and all its contents into the present space/document (and thus exported it out of the Workshop 2003 space).

WARP's import-export operation is identical to dragging an object out of a collection. This results in a transparent interaction that blends different spaces into a seamless one. From the user's perspective, it is a unified space. However, spaces are more than distributed collections. Each space can have particular behaviors, explicit relationships, transformations and spatial characteristics.

The support of import/export operations across transclusion links greatly enhances the interaction with the hypertexts but, given the implications of the interactions used when reading spatial hypertexts, it also creates challenges for the support of shared reading in spatial hypermedia systems.

## 3.2 Personal Readings

WARP, by virtue of being a Web-based application that runs in a Web browser, circumvents some of the distribution issues typically associated with proprietary spatial hypermedia systems. However, it also requires dealing with issues about how to publish and access the documents. As mentioned before, reading a spatial hypermedia document often requires interacting with it. This can be considered a modification of the document. These possible "modifications" can have repercussions that raise issues about ownership of the document and collaborative access to the document. WARP supports a personal access to the document, as opposed to shared access. This has a dual effect of preventing the reading activity of a user for interfering with the reading of any other users, and limiting shared readings.

In WARP, the first time that a user accesses a document, s/he gets a copy of the original spatial hypertext. The document author is allowed to specify if the user can or cannot modify properties of the objects such as their position or other metadata. In addition WARP supports the creation of user annotations on the document by creating new objects. These are personal annotations. An example of a user annotation is shown in Figure 2, which shows a red circle that the user has created around the "HT 2004" conference. The purpose and meaning of the annotations depend completely on the user. Annotations in WARP are private and cannot be shared.

Reading spatial hypertexts is an active process that often extends through time. In recognition of this, WARP can save the state of the spatial hypertext as a cookie in the local machine, making it possible for the readers to return to their own personal version of the document the next time they access it.

# 4. Shared Readings

In order to continue and enhance the system ability to support human activities, we are in the phase of extending WARP's functionality to support shared readings of distributed spatial hypertexts. Simultaneously, we are working on the enhancement of interesting features such as transclusion links, behaviors, adaptation and other dynamic features currently present in WARP. This investigation is in its early stages, iterating between the general conceptualization and design phases. This section presents the current choices under consideration.

## 4.1 Architecture:

Supporting synchronous access of multiple readers to documents often requires coordination mechanisms. As mentioned before Grønbæck et al. [5] opted for implementing a collaboration server. It provides independent collaboration services without needing to modify the document server. This is a feasible design alternative for the augmentation fo WARP. However, it requires the addition of a collaboration server in parallel to the Web server, and for the users (both authors and readers) to know about their existence and location. This is a centralized approach, even if collaboration servers can also contact other collaboration servers. While it is possible to mount the collaboration server on the Web server and even to modify the Web server to proivde an integrated point of service, this requires system adminitrators to provide support for new applications. As an alternative we are leaning for a peer-to-peer approach, were all messaging is coordinated between the readers. This circumvents issues typically associated with centralized approaches (e.g. scalability).

## 4.2 Annotations

Given the ease provided in spatial hypermedia to modify and personalize a spatial hypertext, we foresee, perhaps optimistically, a greater desire to create and share annotations. This kind of asynchronous collaboration can also enable different post-publishing schemas were readers can create an authoring layer, clearly differentiated from the original, that augments, criticizes, comments, combines, compares, or elaborates about the original documents in different ways.

## 4.3 Sharing and Access Control

An important design decision regards the kind of control that readers have over the access and sharing of their readings. Based on previous work and experiences, we decided to create a reading environment where the readers can specify what (objects, relationships, behaviors), where (areas in the spatial hypertext), and to which degree can be accessed and/or shared by other readers. In this regard we are designing the system such that authors and readers can specify, with a fine-granularity degree, the access rights, sharing rights, and even legal copyrights for all components of a spatial hypertext.

## 4.4 Augmentation of Transclusion and Dynamic Features

By augmenting transclusion links and the import/export operations capable of operating through them, the system can allow readers to share and transfer objects, behaviors and adaptations to one another in order to apply to spatial hypertexts that originally did not had them.

In addition, new behaviors can be created in order to support synchronous collaboration. In particular we see behaviors that help enforce interaction policies and protocols, by controlling the interactions of the participants with the spatial hypertext.

## 5. Conclusions

Reading is a complex activity inherently related to the medium being read. Given the nature of spatial hypermedia, reading spatial hypertexts requires people to interact with the document by moving and modifying the objects, relationships, and behaviors. This interaction is of particular importance when considering shared readings since the actions of multiple readers can interfere with each other.

We believe that collaborative spatial hypermedia can support shared readings of distributed hypertexts while providing authors and readers the ability to specify, in a fine-grained manner, how and to what degree access and sharing are enacted.

We are in the process of designing and implementing a peer-to-peer architecture that enhances the existing implementation of WARP to support synchronous and asynchronous collaboration.

WARP's enhancements go beyond the implementation of notification mechanisms. These enhancements require the revision and augmentation of features such as behaviors, annotation mechanisms, and transclusion links.

## 6. ACKNOWLEDGMENTS

This work is partially funded by NSF grants. IIS-9734167, DUE-0121527 and DUE-0226321.

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