# A Design Framework for Collaborative Browsing

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## Abstract

*Collaborative Browsing has experienced an increasing popularity as a topic for both, academic research and commercial software development, due mainly to the promise that it represents as an enabling technology for distant collaboration. Several areas are adequate for the application of this paradigm.*

*In this paper, we present the results of an overview analysis of different proposals found in the literature, and show their main differences from the point of view of the conceptual models they use, and the practical solutions they provide. Based on this overview, we propose a framework for the design of Collaborative Browsing Systems. Finally, we focus on the framework instantiation for the conceptual model and architecture we started to develop.*

*Keywords: Communication, Cooperation, Collaborative Browsing, Virtual Teams, Tele-Activities.*

## 1. Introduction

Browsing, as defined by G. Marchionini in [1], consists in "*information search that is opportunistic, reactive and unplanned, and for which the goal may be fuzzy and dynamic*".

As stated in [2], the real-world's browsing activity is usually quite rich in interaction among actors. In a library, for example, people searching for bibliographical references sometimes do this activity in groups, ask for information to other people doing similar activities, as well as to the library's employees, look how other people do things, etc., improving in this way their search capabilities, and increasing their possibilities for success. This activity represents a form of *Collaborative Browsing*.

Contrasting with the real world, when working in electronic environments, the browsing activity becomes a solitary, and even isolating, task: the user works alone using a computer and its Internet connection, looking for information through various means. In this case, if a user gets a successful result during his/her search process, he/she cannot share it in a direct natural way with any other user. Sharing this information may be by sending the web page's URL through e-mail or an independent chat system, or, in the worst case, by calling and spelling, letter by letter, the web page's URL, which may sometimes be a pretty complicated task.

Despite this situation, there is no reason to keep working that way since computing and telecommunications have become complementary and integrated technologies resulting in the definition of new paradigms.

Eventually, virtual teams, as defined in [8], could evolve and become virtual communities. In such a case, the social factor should be considered, leading to the existence of complex hierarchies and rules that govern the interactions of team members, as it happens with real-world communities.

The paper is organized into five main sections: Section 2 gives some definitions of the concept. Section 3 defines a framework for the design of *Collaborative Browsing* systems, on which our proposed architectural model is based, which is presented in section 4. Finally, the last section draws some concluding remarks.

## 2. *Collaborative Browsing* concept

### 2.1. Definition

In a first approach, the *Collaborative Browsing* activity can be seen as an extension of Web browsing, firstly dedicated to isolated distributed users with low interactions between them, to group of users with a mutual and more important consciousness of the group presence and interaction. The *Collaborative Browsing* concept aims therefore to extend the multimedia interactive document access and vizualization to group of users where a subset can communicate through synchronous communication

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tools, in a distributed co-presence. The different elements (users and documents) involved will respectively influence the *Collaborative Browsing* process, according to their structure, organization and their joint evolution in time. This new-emerging concept benefits both from the contribution of Web technologies and the multimedia synchronous groupware environments, whose advance has been very important over the last years.

### 2.2. Application domains

There have been several projects attempting to develop *Collaborative Browsing* systems. The first ones are designed in the domain of virtual libraries, for group document researches and indexing [2]. The common edition, access and modification of a document are other tasks related to browsing in collaboration [21].

Simple collaborative systems, as found in [3, 4, 5 & 31], consist in the realization of Web Tours; in such a case, a presentation is made by a presenter, and all the attendees follow that presentation in a synchronous fashion.

Another important area particularly adequate for the application of *Collaborative Browsing* is *Tele-Learning*. This kind of environments can be used to implement the metaphor of a class, including accessing sets of available resources, attending class sessions, and collaborating through the use of communication tools.

The authors of [5] propose a set of requirements for *WWW* based educational design: *(a).* Presentation material through a range of sensory experiences as interactivity and multimedia, *(b).* Providing the students with the opportunity to experiment (possibly through simulations), *(c).* Testing and checkpoints are important from the point of view of repetition and student retention (evaluate and assess the students progress), *(d).* Intrinsic (challenge, fantasy, etc.) and extrinsic (examination, set goals, etc.) motivation, *(e).* Supporting the cognitive structures of the student (periodic review of material, responses to questions of the student, annotation, note taking and bookmark facilities), *(f).* Facilities for synchronous communication and collaboration should be supported where possible, *(g).* The development of a complete solution for a Tele-Educational course requires the support and cooperation of both, faculty and administration and *(h).* WWW based educational courses must be integrated within a well understood and explicitly specified curriculum with clear objectives, content description, method of teaching, student learning, student assessment and course evaluation.

In general a well-designed interface will enable the student to interact with the material and will aid in the understanding of the knowledge domain and structure.

In the analyzed literature on this topic we have found several interesting proposals which can help to fulfill at least a part of the above requirements. For example, in [12] we have found a system for the design of intelligent tutoring systems that use adaptive techniques to orient both, presentations and navigation. Through the use of these techniques the system adapts itself to the learning abilities of each individual student, presenting the material in a flexible way, optimizing as a consequence, the students benefit. The mechanism proposed to control the advance of each individual student is called a "Universe of Logical Learning Units", and each unit consists of three parts: *(a).* Pre-requisites, preconditions and constraints to be satisfied to have the right to access the contents, *(b).* Contents described through several parameters: identifier, type, referenced items, filename, title, number of pages, etc and *(c).* Post-actions describe the changes to be carried out in the student's model when the unit is finished.

Complementing the previous component there exist the Physical Learning Units, which are provided by the teacher and consist in the didactic material itself. It can have different forms: presentations, animations, exercises, etc.

Other adaptive techniques, some of them implemented through the use of multiple software agents, can be found in references [11, 13 & 14].

Another interesting concept, the virtual portfolio, is proposed in [13]; it consists of the storage of all the successfully applied or learned material for each student, and it is used to keep track of his/her advance when attending a course.

## 3. Framework analysis and definition for *Collaborative Browsing* systems

In this section, we present a descriptive analysis of some features we have found in existing systems, and which appear, from our point of view, as the most important characteristics having a direct impact on the design of *Collaborative Browsing* systems.

The authors of [16] proposed another classification more focused on real-time interactions on top of heterogeneous environments.

The main features of our framework, discussed in the next paragraphs, is composed of the following points:

- Place and group modeling
- Communication and sharing
- Access control
- Awareness
- Technological platform

### 3.1. Place and group modeling

Collaboration can be made online or offline. If online, it is needed that all the members of the collaboration group have a meeting point in space and time. If offline, the

members of the group require at least of a common work place or communication media. In this sense we can find that one interesting conceptual proposal is the introduction of the concept of a "place" [6, 9 & 28] where people with potentially common interest or work meet together. According to [6 & 28], places can be private (personal) or public (common). The main interest behind this concept is that everything existing in the public place is, by definition, shared among all the users present in that place, whereas everything existing in a private place belongs to the owner of that place.

In addition, there is the concept of persistence, which can be useful when working offline. The authors of [24] define the meeting place as a room, common to all the participants, and state, as it happens with real-world rooms, that it is persistent. Objects left in a room persist over time in the same spatial location, unless they are borrowed or moved by someone else.

### 3.2. Communication and sharing

Users collaborating in a virtual environment need to communicate among them and possibly share information.

In terms of communication, most approaches propose similar capabilities: chat, voice chat, avatars, multipoint video conferencing, blackboard, annotations, etc. However, depending on the implementation techniques and algorithms used, there may be major variations in terms of the performance of the developed programs to support each of these communication media.

On the other hand, sharing can consist in document, presentation or application sharing. One interesting proposal is that found in [26], where everything inside a computer is susceptible of being shared, even the desktop; in that case, the user to whom sharing of the desktop has been granted gets a complete remote control over the resources that computer.

One variant of information sharing is found in [4], where a system can "split" the presentations among different electronic devices that are used to present different types of data (audio, video, images, etc.). This splitting can be made according to specific user's interests or technical restrictions. For example, if a user is following a presentation with a PDA, given the limited capacities of this device, then the only data that are presented are the one admissible by such a device.

### 3.3. Access control

Access control is a very important component of any system dealing with multi-user environments, as it is the case of *Collaborative Browsing* systems. The simplest and best-known access control systems is that used for the *Unix* operating system.

Access control for the users can be attached to the concept of user's roles, which is useful when the users within a group have different hierarchical levels. On this topic, we have found in [5 & 6] the use of roles, although they are predefined and their use remains rigid.

With respect to this point, two main interesting proposals have been made. One of them [20], is related to the use of a scheme called *RBAC* (*Role-Based Access Control*). It is proposed that access control can address two central issues: *(a).* To restrict access to information and functionality in a shared environment to trusted users and *(b).* To help coordination by providing the users only the data and functionalities that are strictly necessary for their work.

In *RBAC*, roles are created as needed, and users are assigned roles based on the capabilities that they should have, and permissions are assigned to roles rather than to individual users. The context-dependent access control is represented by matrixes that combine teams and state of tasks in "Protection State". Components (node and link objects) and composites (structures) of the system can also be classified according to their semantic type. Access authorization of roles can be assigned based either on object types or specific objects, which inherit the set of permissions of the group to which they belong, unless exceptions are specified.

Although oriented to collaborative editing, proposal [21] coincides in some aspects with [20], and introduces some other interesting concepts: *(a).* Generic and fine-grained set of collaboration rights (weak and strong, positive and negative ones), *(b).* Multiple, dynamic user roles, *(c).* A set of inheritance rules in the subject, object and access right dimensions and *(d).* A set of conflict resolution rules.

The use of this kind of collaboration rights, and the inheritance rules and their associated rules for conflict resolution provides the system with a great flexibility for specifying the access control.

Both proposals are very interesting; however, from our point of view, they lack some degree of flexibility in terms of the access right control; indeed, once the roles and permissions have been defined, they remain essentially static in time.

### 3.4. Awareness

Awareness is an indispensable feature since it is not possible to propose neither communication nor collaboration facilities if the members of a team do not have any notion of who else is present at a given moment, and what they are actually doing.

Awareness information can have several forms. The authors of [16] propose a five types classification: *(a). Activity*: What a given user is actually doing, *(b).*

*Availability*: Notion of the presence of a certain user at a given moment, *(c). Process*: It's an element often used in workflow that provides information about each one's work with respect to the overall process, *(d). Perspective*: This allows, in some way, to anticipate the others actions according to the knowledge of their background, beliefs, etc. and *(e). Environment*: Information about environmental events that can affect the collaborative work.

The awareness information delivery is important too. The authors of [16] propose that information delivering can be: *(a). Active or passive*: If active, the system informs automatically users about events, otherwise the system does not provide any information unless required, *(b). Differentiated or undifferentiated*: Different types of awareness information can be made available to different users depending on their level in the group hierarchy, *(c). Customized or fixed*: Implies how configurable is the awareness data delivery, *(d). Focal or peripheral*: When focal, awareness information is presented in such a way that it calls immediately the attention of the user, while peripheral does not produce immediate distraction, *(e). Within a single application or among applications*: It defines whether it is necessary that all the participants access the same system/program to be able to receive awareness information or not and *(f). Accessible anywhere or from a particular place*: Allows the users of the system to access this information independently of the place (computer) from where they are accessing the system.

With respect to activity awareness during search information processes we have found in [2] the proposal of being aware of two types of information: the final product of the search process (the hits), and the search process itself (the strategy and tactics used). This can be used to improve the browsing performance of users by simply observing how the others work.

### 3.5. Technological platform

The selection of a good technology to be used as the base platform for the implementation of *Collaborative Browsing* tools is fundamental for success. In our study, we have found that two general approaches may be used. The first approach consists in implementing solutions that do not modify neither existing browsers nor existing web servers, but try instead to implement the required facilities as external programs, as for example Proxy servers at the server side, and Plug-In's or Java Applets at the client side. Systems like [3, 4 & 5] are implemented using this approach.

The second approach is based on the deployment of fully proprietary platforms either for the server side, for the client side, or for both; like, for example, the one proposed in [27].

Selecting the approach to be used depends on the particular needs of the application to be deployed. The first approach is convenient for deploying applications that are desired to be widely available for use, without imposing the users to use neither a particular hardware/OS platform nor specialized programs.

As far as *Collaborative Browsing* is concerned, the main orientation consists in allowing groups of users to browse Web pages; it is therefore mandatory to design and implement caching mechanisms for reducing the time required for loading web pages [3]. Caching can be done at the level of one main proxy server to which all the clients are connected. However in the case of the existence of several work groups during one session, this caching can have a group or thematic orientation too, having different cache servers for the users belonging to different groups or browsing on different topics.

### 3.6. The resulting framework

The analysis of our bibliographical survey has led to a five-dimension framework for classifying the design of *Collaborative Browsing* systems. This framework is based on the points addressed before and it is summarized in Table 1.

| Dimension | Observations |
|---|---|
| *Place and group modeling* | Places, virtual rooms |
| *Communication and sharing* | Chat, Blackboard, Voice chat, Annotations, Videoconferencing, Application, Presentation and Document sharing, File transfer, etc. |
| *Access control* | Role based, User based, On type of object, On specific object, etc. |
| *Awareness* | *Type*: (Activity, Availability, Process, Perspective & Environment). *Delivering*: (Active/Passive, Customized/Fixed, (Un)Differentiated, Focal/Peripheral, Within/Among application & (Un) Accessible anywhere). |
| *Technology* | *Open*: Proxy servers & Java Applets. *Closed*: Proprietary implementations |

Table 1: A *Collaborative Browsing* classification framework

From our point of view, the five dimensions presented above represent the main axes to be taken into account when designing or classifying *Collaborative Browsing* systems. This functional analysis isolates the basic elements required for the design of our *Collaborative Browsing* environment presented in the sequel.

## 4. Architectural model proposition

According to the previous functional analysis, we can see that all the analyzed models and implementations propose different solutions, that can be regrouped in a unified canvas. In fact they have been taken into account as a basis of our initial proposal. The aspect that seems to us the most sensible is *Access Control*. We consider that those systems that include it lack of some degree of flexibility with respect to the design of these mechanisms. In particular, the studied schemes are quite rigid, and do not consider in their design the fact that actions performed by the members of a group, as well as the occurrence of predefined events, might modify the access control definition itself. In other words, they consider only partially that collaboration could evolve and dynamically influence the group policy.

Based on this consideration, we introduce first the specification of the elements that will be developed for the *Collaborative Browsing* of Web documents.

The main active elements involved in *Collaborative Browsing*, i.e. the initial group of users and accessed documents, will be statically defined and modeled to match to a unified access control and awareness basis required to ensure the starting of the *Collaborative Browsing* activity.

During the progress of a *Collaborative Browsing* session, users realize actions through the communication layer, sharing tools and documents. All these actions have a dynamic influence on the current on-session access control and awareness state maintained for the members of the group. Moreover, we suppose that access control and awareness modifications have an indirect influence on the current group structure, the communication part and sharing tool access. These, so called, *retroactions* are supported by the technological layer.

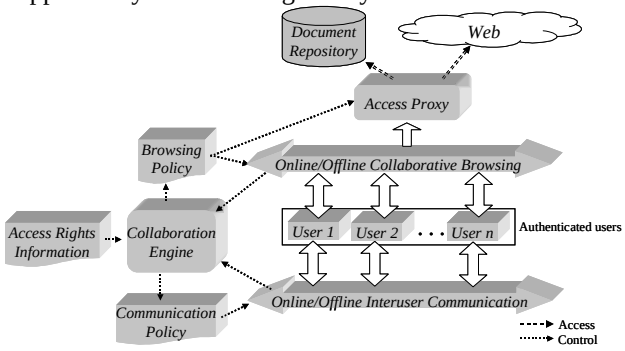


Figure 1: Architectural model of a *Collaborative Browsing* Environment

The instantiation of the *Collaborative Browsing* framework in system architecture is presented in Figure 1. The main innovative part being introduced by our architectural model is related to the design and implementation of a *Collaboration Engine*, which will take in charge all the activities, related to the access control and its evolution in time. Access control influence documents, communication means and awareness of users.

The *Collaboration Engine* will be fed by the specifications contained in the, so called, *Access Control File*, which will contain the initial specification of access rights for all the users of the system (possibly grouped by roles), as well as the specification of events that should be considered in the evolution of the access control, and that could possibly change the access status for certain users. These events could be triggered by temporal conditions, but also by specific actions performed by the users.

The *Access Control Policy* generated by the *Collaboration Engine* if formed by the *Browsing Policy* and the *Communication Policy*. This will be the information generated by the *Collaboration Engine*, and it will control the whole operation of the system, allowing or denying the access to the information of the *Document Repository* (internal) or the *Internet* (external) or to the communication capabilities provided by the system.

Finally, the *Collaboration Engine* will take a feedback from the collaboration itself, in such a way that actions performed by the group of users while browsing, according to the specifications of the original *Access Control File*, and the actual *Access Control Policy*, could change the *Access Control Policy* irself, generating the retroaction behavior.

The system awareness will be formed by the state of the group of users with the tools they can use, those of the currently accessed documents and the on-line access control policy of the system. The current awareness for each user will be part of this global system awareness, of course in accordance with it.

The system platform being currently designed is planned to be based on a Proxy Server/Java Applets suite, in order to allow its wide use.

## 5. Conclusions

*Collaborative Browsing* is a rather new concept, although some first generation tools have become available in the past few years, and it is easy to see that it is an area that will be under strong development in the next coming years. In the bibliographical survey presented in this paper we defined criteria to assess different proposals and better understand some key issues which are behind their design. These criteria have been used as a framework for the collaborative model and architecture we plan to implement, which will be enriched by the implementation of the architectural model that we propose, and which will be the basis of a very flexible system.

In order to provide as much support as possible, and taking into account their importance, we plan to define different scenarios for *Collaborative Browsing* in the Tele-

Learning domain to test the adaptability of the concept and the supported platform.

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