Chapter 3
Collaborative Information Seeking (CIS) in Context

Abstract The field of collaborative information seeking (CIS) has been going through a fundamental shift, so much that it is almost emerging as a new field altogether. One of the challenges that such an invigorating process brings to a field is how to define its key elements, and CIS is no exception. Researchers have brought forth their works in this domain under the labels of collaborative information retrieval, collaborative information behavior, co-browsing, and collaborative or collective search, among others. Often a subset of these terms are used interchangeably, but one could also see them as subdomains in their own right. This chapter introduces the reader to several of the most commonly used terms and definitions. Corresponding works for these terms are summarized to provide a comprehensive overview of recent developments in this field. In addition to the literature, the chapter also uses discussions and derived lessons from half a dozen recent workshops and other events on CIS and related topics. The landscape of CIS is constantly evolving, but the present chapter should provide a firm ground for one to observe and participate in the development of this emerging field.

3.1 Introduction

It is often difficult for researchers and practitioners in this field to agree on a definition for CIS. Even if they do come to a common understanding of this term, there is still the question of how it relates to many other seemingly similar terms. The literature is filled with usages such as collaborative search [52], collaborative information retrieval [8, 16, 29], social searching [12, 14], concurrent search [4], collaborative exploratory search [44, 45], co-browsing [13, 20, 23], collaborative navigation [36, 37], collaborative information behavior [47], collaborative information synthesis [9], and of course collaborative information seeking [17, 24, 51]. Many definitions and conceptual understandings exist in the literature. I have referred to CIS as a process of information seeking "that is defined explicitly among the participants, interactive, and mutually beneficial".

Here we will attempt to classify various related works into categories with the labels such as CIR, co-browsing, and social search. We will also briefly explore a relevant topic of collaborative filtering. Figure 3.1 is a depiction of various concepts

C. Shah, *Collaborative Information Seeking*, The Information Retrieval Series 34,
DOI 10.1007/978-3-642-28813-5_3,

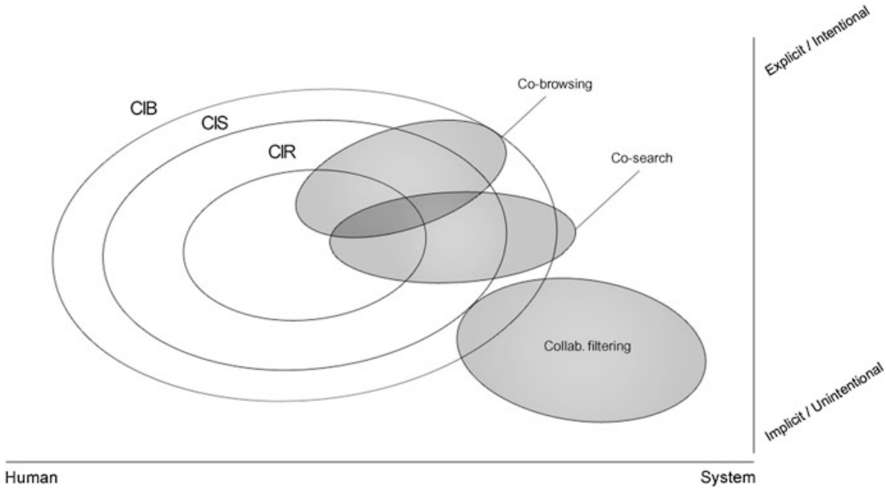

Fig. 3.1 Depiction of CIS and related topics using the dimensions of human–system and explicit–implicit collaboration

around CIS. As seen, these concepts are placed on dimensions of human–system and explicit–implicit collaboration.

3.2 Collaborative Information Retrieval (CIR) and Co-search

The discussion will now be narrowed down to those scenarios in collaborative setup where the goal is to seek information together for a common information need. As discussed earlier, if/when the problem of IR is difficult to solve, a carefully executed collaboration can help. Smyth et al. [52] argued that one way of making it possible to connect users to the information that is difficult to find is to incorporate collaboration in the search phase of an information seeking process. They showed how collaborative search could act as a front-end for existing search engines and re-rank results based on the learned preferences of a community of users. They attempted to demonstrate this concept by implementing the I-Spy system [18]. I-Spy captures the queries and the related results for a given workgroup and uses that information to provide filtered, and presumably more relevant, information to the user. Thus, I-Spy acts more as a collaborative filtering process than as synchronous collaborative searching.

While I-Spy attempts to extend content-based filtering techniques by incorporating communities, several collaborative IR systems have been developed by extending a traditional IR model to incorporate multiple users. However, such extension is often ineffective or non-trivial. For instance, Hyldegard [28], with her studies of information seeking and retrieval in a group-based education setting, found that even though people in a collaborative group to some extent demonstrated similar cognitive experiences as the individuals in Kuhlthau's Information Search Process (ISP) model [35], these experiences did not only result from information seeking activities, but also from work-task activities and intragroup interactions. Her further work also indicated [29] that group based problem solving is a dynamic process that shifts between a group perspective and an individual perspective. Such a finding calls for a thorough investigation into collaborative information seeking that is not simply an extension of a traditional IR system for multiple users. As Olson et al. ([43], p. 347) suggested, "The development of schemes to support group work, whether behavioral methods or new technologies like groupware, should be based on detailed knowledge about how groups work, what they do well, and what they have trouble with."

Unlike co-browsing, where the applications are aimed toward web browsing, works on collaborative IR are often focused on specialized domains for searching. For instance, Twidale and Nichols [53] presented the Ariadne system, which allowed a user to collaborate with an information expert remotely and synchronously over a library catalogue. The idea behind Ariadne was to allow the patron (naive user) to collaborate with a reference librarian (search expert) for an information need in a library situation. The authors identified the importance of supporting social aspects of searching for information and showed how it can be addressed using their system. However, Ariadne did not have support for asynchronous collaboration.

Morris and Horvitz [42] presented the SearchTogether system that allowed a group of remote users to collaborate synchronously or asynchronously. This system was based on supporting awareness, division of labor, and persistence for collaboration. Their rationale for facilitating awareness was that it could enable lightweight collaboration by reducing overhead involved in explicitly asking other group members to provide that information. Awareness was provided using per-user query histories, page-specific metadata, and annotations. Division of labor was implemented using integrated IM as well as a recommendation mechanism, by which a participant can recommend a page to another participant. SearchTogether also provided "Split Search" and "Multi-Engine Search" options for automatic division of labor. Finally, persistence was implemented by storing not only all session states, but also automatically creating a shared artifact that summarizes the findings of a collaborative search.

MUSE [34] supports synchronous, remote collaboration between two people searching a medical database. MUSE lets its users perform standard single-user searches, with a provision of chat and the ability to share metadata about the current database results with the other user. S^3 [42] is not so much of a CIS system, but it has an important component of being able to share the retrieved results asynchronously among a set of users.

A stream of research came out of the CIR group at University of Washington, studying the situations where members of a work-team are seeking, searching, and using information collaboratively and showing how such a process can be realized in a multi-team setting. This started with Fidel et al.'s work [15], where the authors defined collaborative IR (CIR) "as any activity that collectively resolves an information problem taken by members of a work-team regardless of the nature of the actual retrieval of information." They employed a cognitive work analysis framework to guide a field study examining social, organizational, cognitive, and individual characteristics of information seekers, and then focusing to address collaborative situations [16]). From their studies involving two design teams working in collaboration, they found [10] that (1) the nature of the task and the structure and the culture of the organization in which tasks are performed are important factors that determine CIR behavior, and (2) not all information behavior takes place collaboratively even in teams that carry out CIR. In their further work on this line, the authors found [46] that (1) any information retrieval activity (identifying information needs, formulating queries, retrieving information, evaluating it, and applying it to address the need) may be performed by an individual on behalf of the team, by an ad-hoc group, or by the team working together in a meeting, and (2) technologies intended to support teamwork could be more effective by recognizing and supporting collaboration in the activities that comprise information retrieval and their coordination. This suggests that a successful CIR/CIS system should not try to lock the users down in a certain kind of framework imposed by that system; it should rather let the participants choose their own way of collaborating, and provide enough support for carrying out that collaboration.

The efforts of connecting multiple users for information seeking (retrieval or browsing) continue to produce systems either by reinventing the wheel of traditional IR, or by extending existing IR systems to accommodate more than one user. None of these systems have been adopted widely in practice. Several reasons can be found for the lack of wider visibility of collaborative systems, among which are the cognitive load involved in using these systems, the learning curve to start using these environments, and the lack of proper integration of information seeking to other parts of the collaboration.

3.3 Co-browsing or Collaborative Navigation

Co-browsing or social navigation is the process of allowing a set of participants navigate or browse, and share information with a possible intermediate interface. Root [50] introduced the idea of social browsing to support distributed cooperative work with unplanned and informal social interaction. He described a "social interface", which provided direct, low-cost access to other people through the use of multimedia communications channels. The design of his conceptual system, called CRUISER,[1] incorporated three basic concepts: social browsing, a virtual workspace, and interaction protocols. His premise was that by integrating all of our digital media into a richly interconnected workspace, we could significantly extend and enrich the available context of our workgroup activities.

[1] "Cruising" was the stereotypical teenage activity of the 50s and early 60s. The term refers to the practice of piling into somebody's car and visiting the chain of gathering places frequented by other peer group members, or simply driving around in search of almost any sort of social encounter [39].

Root's idea of facilitating informal and effortless interaction among a group of people was carried over later by Donath and Robertson [12] with *The Social Web* that allowed a user to know that others were currently viewing the same webpage and communicate with those people. They believed that users accessing the same page are likely to be in search of the same type of information and share similar interests. Providing them with the ability to communicate with each other can facilitate information searches and help foster community.

Cabri et al. [11] presented a system for synchronous cooperative browsing that permitted users within a workgroup to share information and cooperate toward a common goal. This was done using a proxy without changing the browsers on user ends. Gerosa et al. [20] presented a similar idea of proxy-based co-browsing with the application of e-learning. They called this *Symmetric Synchronous Collaborative Navigation*, a form of social navigation, where users virtually share a web browser. They presented a symmetric, proxy-based architecture implemented without the need for a special browser or other software. Once again, the motivation behind such lightweight interfaces was to allow the users to emerge into a collaborative environment with as little effort as possible. Esenther [13] emphasized having a lightweight real-time collaborative web browsing service and providing an instant co-browsing facility. Their system was targeted to casual (non-technical) users and allowed remote participants to easily synchronize pointing, scrolling and browsing of uploaded content in their web browsers.

Another example of collaborative browsing application is *AntWorld* [40], a tool developed to make it easier for the members of a common-interest user group to collaborate in searching the web. *AntWorld* harnesses the expertise of the members of a common interest group as displayed by their evaluation of documents encountered while searching. It stores users judgments about the documents they find and uses this information to guide other users to pages they may find useful.

Sometimes it is not just the webpages that people want to browse and share, but other objects such as bookmarks. Keller et al. [32] presented *WebTagger*, a social bookmarking service similar to del.icio.us (http://delicious.com), which allowed a group of users to tag and share webpages. *WebTagger* enables users to supply feedback on the utility of the resources that they bookmarked relative to their information needs, and provides dynamically-updated ranking of resources based on incremental user feedback.

Several other systems used their own interfaces rather than relying on a web browser. For instance, *GroupWeb* [22] is a browser that allows group members to visually share and navigate World Wide webpages in real time. Its groupware features include document and view slaving for synchronizing information sharing, telepointers for enacting gestures, and "what you see is what I see" views to handle display differences. *GroupWeb* also incorporated a groupware text editor that lets groups create and attach annotations to pages. Similarly, *GroupScape* [21] was a multiuser HTML browser to support synchronous groupware applications and browsing of HTML documents on the web.

Yet another architecture to support multiuser browsing is *CoVitesse* [37], a groupware interface that enables collaborative navigation on the web based on a collaborative task model. This system represented users navigating collaboratively in an information space made of results of a query submitted to a search engine. In contrast to these systems, which are primarily designed for remotely located participants, *CoSearch* [2] is implemented to provide multi-device support for collaborative browsing among co-located participants.

Some of the applications allow the users of that system to play different roles during their social or collaborative browsing for information. For instance, Pickens et al. [45] proposed the roles of *Prospector* and *Miner* in a collaborative video search environment, the former one responsible for seeking out various areas where relevant information could be found, and the latter one responsible for digging deeper in a given sub-domain with high likelihood or useful information. A collaborative navigation system proposed by Gerosa et al. [20] had the provision where each user could take the lead and guide others in visiting websites. However, Aneiros and Estivill-Castro [3] advocated against controlled co-browsing where one user guides the browsing process for the others (what they referred as the *master/slave model*) and proposed to use a model with unconstrained collaborative web browsing. They argued that such unconstrained collaborative web navigation is essential to allow natural information flow among multiple users.

3.4 Social Search

In case of interactions relating to searching for information, Evans and Chi [14], discussed how social interactions could help in searching together. They called this *social search*. Such social ties leading to social search can be extended to stronger ties leading to collaborative search.

Let us talk about how ties in information seeking environments such as transferring weaker ties to stronger ones to encourage possible collaboration has been used several other places too. For instance, there are co-browsing applications that let visitors of the same webpage be aware of each other, hoping they may want to collaborate as they have the same information need [12].

Sometimes the stronger ties are formed not to do collaboration, but for a possible filtering of information. Most of the collaborative filtering systems depend on converting weaker ties (e.g., being the users of the same system and interested in similar objects) to stronger ties (e.g., connecting the users based on their behavior, and having them influenced by each other). For instance, a Netflix user can have social (weaker) ties with his friends on Netflix network, but when Netflix's collaborative filtering system starts making recommendations based on one's social network, and when the users in the network start using those recommendations and/or start interacting with their peers based on their similar interests, the weaker ties of social network become stronger and more specific.

In summary, a social network typically exhibits weaker ties among the participants, based on their interactions, intentions, and objectives. A collaborative network, on the other hand, shows stronger ties. A social tie can be useful and converted to a collaborative tie. The reverse can happen too. Often participants without social ties are put in a collaborative project. While working on such a project, the participants may develop a social tie as well. Based on this, it can be seen that one tie (social or collaborative) does not subsume the other; they both can be complementary to each other.

While a social network differs from a collaborative group based on the strength of the ties (which was proposed to be measured by objectives, intentions, and interactions), it can be useful for creating and understanding the other. There have been several works on social networks, and since a social tie can be converted to a collaborative tie, we can learn a lot about collaborative groups by looking at those works done on social network analysis.

As we saw, several of the early works on social network analysis explored the notion of homophily. One of their key findings was that the people tend to create social ties with those who match their interests. While this may not be a surprise, it tells us that in order to have a tie, the participants need to have something in common, and the more the commonalities, the stronger a tie can be. For instance, two users of Twitter may not have any tie at all, but when one discovers the other to be interesting or relevant in some way, he/she can decide to follow that person's Tweets. This creates a stronger tie. Such a tie can eventually be useful for creating possible collaborations. In our personal experience, we have seen several collaborations happened through blogs and feeds subscriptions (stronger ties).

Another line of research in social network analysis looked at the influence of the peers on a network. Works, such as Berelson et al. [6], showed that people are easily and frequently influenced by their peers on the same social network. Such behavior was more predominant in younger generations. Today, online social networking services, such as MySpace and Facebook, make such influences even easier and more frequent.

Considering that a weak form of tie in a social network can be transferred to a stronger tie creating collaboration among the participants, and the participants can be influenced by that weak tie, we can study the motivations (why) and scenarios (what, when) of collaboration by looking at the influences in social networks.

It is also important to note here that one of the interesting factors to study in collaboration is the social aspect of it. Social interactions happening due to the collaboration can be engaging, enriching, and entertaining.

Moving our attention to the technologies that facilitate social or collaborative ties, it should be noted that with the advent of technology involving social networking, people are increasingly becoming familiar and encouraged to share information about themselves, as well as explore other people's information. Such information exchange is used not only for connecting people or providing recommendations, but also for accomplishing a variety of tasks as we saw earlier. The analysis of social networks, on the other hand, has been a well-studied domain for nearly a century and is being adapted to the newly emerged online social networking sites.

What is of interest here is the realization that some of the aspects of CIS, particularly communication, are analyzed extensively in social networking research. In addition to this, research in CIS can also benefit from the understanding developed from social network analysis about how and why people work with each other, the costs and benefits of such collaborations, and user behavior in these ties or networks.

Collaboration can also be considered a stronger form of social tie that, according to the definition presented here, involves a group of people working together for a common goal. Often the seeds for such collaboration are planted at the level of social interactions. As Karamuftuoglu [30] argued, knowledge production, as a part of IR, is fundamentally a collaborative labor, which is facilitated by community interactions. This argument allows us to look at the analysis of social network from a different perspective in which social searching, which is a weaker form of searching together [14], can lead to collaborative searching, which is a tighter and more specialized form of searching together.

3.5 Collaborative Filtering

Information filtering refers to a variety of processes involving the delivery of information to people who need it [5]. In other words, information filtering is a process through which information is derived based on relevance to a user as well as his preferences or past behavior. The manifestation of relevance, preferences, or the past behavior can be limited to the given user or can be extended to map to the same attributes about other users.

To clarify this point, let us plot various scenarios of information seeking. Figure 3.2 shows a typical information seeking scene for a single user. The need for information is expressed and executed, and the found results are returned to the user. The user then evaluates the results and keeps the ones that are relevant to him.

Now, if we had a "smart" system, it will monitor this user's behavior over time and use it in new information seeking processes (Fig. 3.3). The behavior refers to the kind of queries that the user submits, the results that he views, and the information that he saves. In other words, this smart system learns the user's information seeking model and uses it to aid in future information seeking processes. An example is online movie renting services such as Blockbuster and Netflix. Based on the kind of movies a user has rented in the past, as well as the ratings that he assigned, the system recommends new movies to him. In recommender systems literature, such an approach is referred to as the content-based recommendations [1]. In such systems, the utility $u(c, s)$ of item s for user c is estimated based on the utilities $u(c, s_i)$ assigned by user c to items $s_i \in S$ that are "similar" to item s. In our example of online movie renting, in order to recommend movies to user c, the system tries to understand the commonalities among the movies user c has rated highly in the past (specific actors, directors, genres, subject matter, etc.).

In conjunction with the system learning the user behavior, the user himself can also provide his preferences by setting up his profile. The system can then filter the information based on the user profile.

Now let us extend the above scenario to incorporate multiple users. Such a scenario is depicted in Fig. 3.4. As we can see, now the system uses the information

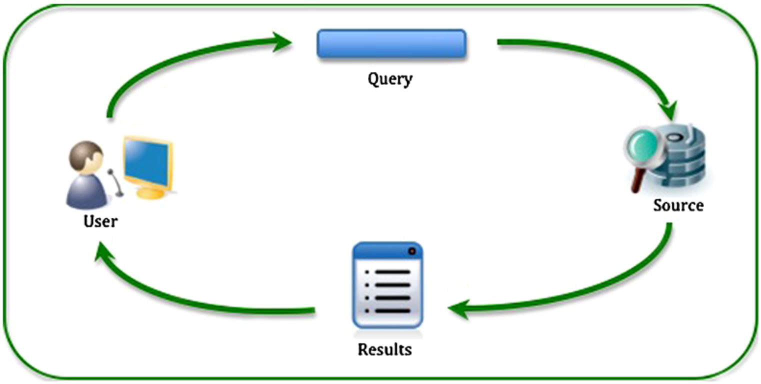

Fig. 3.2 A typical scenario of information seeking in an IR environment

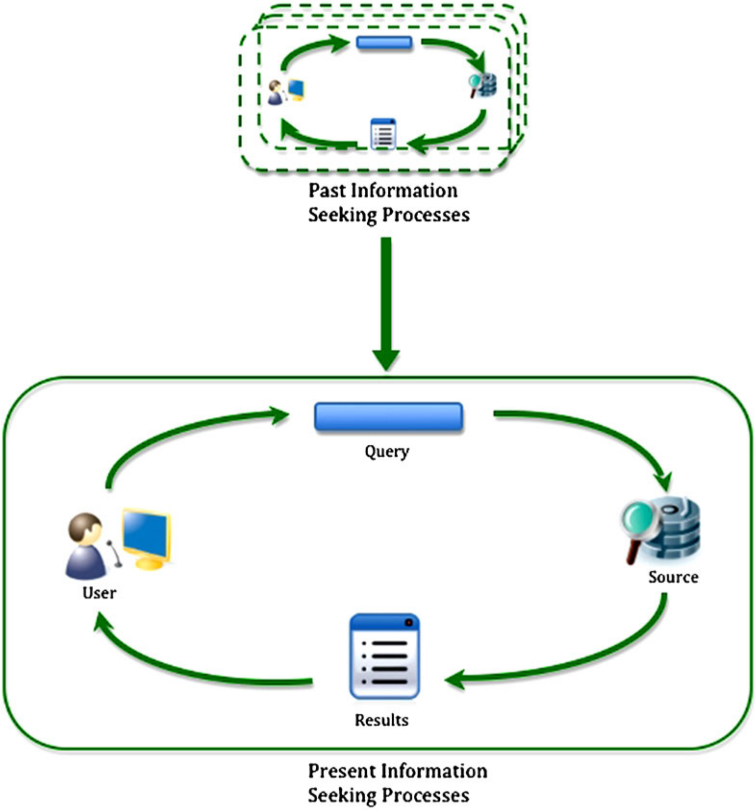

Fig. 3.3 Content-based information filtering

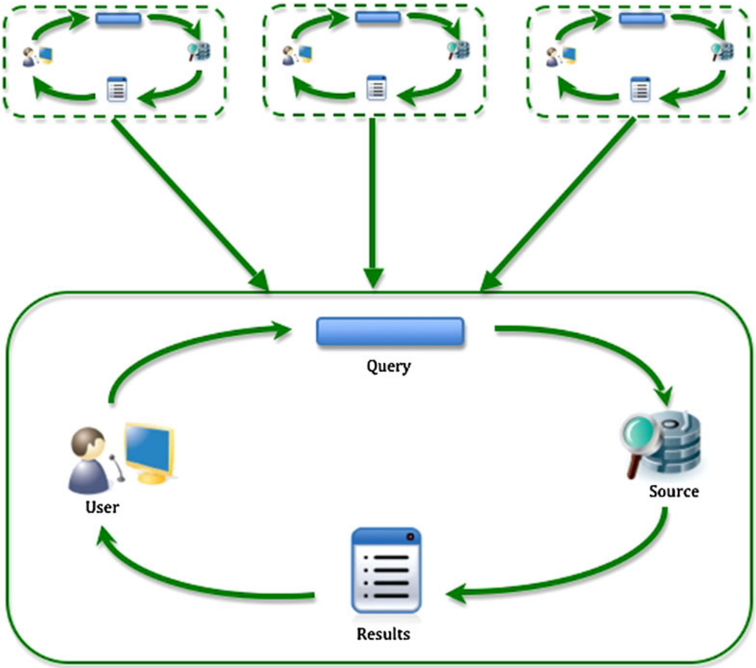

Fig. 3.4 Collaborative information filtering

seeking behavior of other users to aid the given user in his process of information seeking. Typically, these mappings are done based on like-interests among the users. For instance, if users A and B both liked x, and if A liked y, there are good chances that B will also like y. Thus, the system will recommend y to B. In the literature, such kinds of recommendation are called collaborative recommendation [1].

It is also possible to combine the two kinds of approaches described above combined to create a hybrid approach.

As we saw earlier, collaboration among users based on common information need and asynchronous communication flow results in collaborative filtering. In other words, collaborative filtering refers to a process in which a user benefits from other users' past actions on the same/similar information seeking tasks. In practice, this concept is realized as recommender systems. Examples of such applications include Amazon.com [38], movies recommendations by MovieLens [41], and news filtering by VERSIFI Technologies [7].

Often the systems that are built for supporting collaborative filtering are promoted as CIS systems. A typical characteristic of such systems is a way to combine information requests and/or results in some way. However, due to asynchronous and unidirectional interactive nature of these systems, they do not fulfill the requirements for CIS that is of interest here. An example of this can be found in the work by Klink [33], where a method for improving the original query by an automatic reformulation method is proposed. This method uses the term-concept correspondence learned from the documents given by the feedback of the actual or of the other users. Here, there is no direct interaction among the users of the system to carry out a common goal. Thus, even though the users are benefiting from their own or other users' past behavior (content-based or collaborative filtering), they are not collaborating in a strict sense.

Furnas [19] demonstrated the power of community knowledge and collaborative filtering with his adaptive indexing scheme, which helps re-weight indexing terms by the past usage of more experienced users. Along the line of reformulating the queries, Hust et al. [27] showed how to use previously learned queries and their relevant documents for improving overall retrieval quality of an issued query. They do so by expanding the new query by extracting terms from documents which have been judged as relevant to previously learned queries. This approach is further formalized in Hust et al. [26], and [25]. Once again, we see that objects and actions from the past are used to improve retrieval effectiveness, but the "interactions" among the users were asynchronous and unidirectional.

Similarly, Romano Jr. et al. [49] presented *Collaborative Information Retrieval Environment* (CIRE), a system architecture constructed using the user experiences with IR and Group Support Systems (GSS). Their prototype system employed a client-server architecture, where the server was responsible for connecting the client requests to the AltaVista search engine and recording all the interactions as well as annotations by the participants. The executed queries, stored search results, annotations, and relevance judgments are shared among the group members to facilitate collaborative IR. This is similar to Smyth's I-Spy system,[2] in which the participants of a workgroup can benefit from others' searches on the same/similar topics. Once again, such systems or environments facilitate collaborative filtering rather than an active and interactive collaboration among the information seeking participants.

How Information Filtering Relates to CIS It is important to note here that in many of these applications, a user receiving the recommendations may not know the other users in the network personally. Thus, a user is not *intentionally* and *interactively engaged* in a true collaboration with other users; he is merely getting filtered content based on other users' actions on the similar information. There have been some applications that go beyond such a constraint and exploit more tightly connected social networks of a user instead of the entire network to filter and recommend information. For instance, Kautz et al. [31] presented *ReferralWeb*, which was based on providing recommendations via chains of named entities instead of anonymous users in the network.

In addition to this difference, the goal of collaborative filtering systems is to use the opinions of a community of users to help individuals identify content of interest with ease from a potentially overwhelming set of choices [48]. Looking carefully, we can see that the flow of information and the direction of filtering at a given time is only one way (shown in Fig. 3.4). Collaboratively seeking information, on the

[2]This has been transposed to HeyStaks (http://www.heystaks.com/).

other hand, involves both the agents actively engaging in an information sharing situation; thus making the flow of information and filtering in both the directions at any given moment.

Another characteristic of a typical information filtering system is the asynchronous nature of user interaction. A user of an information filtering system is provided with the filtered information based on the actions that other users took in the past. In contrast, the focus of the work related to CIS is on active user interaction among the users of a system who are working in the *same time frame*.[3]

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[3]It is not implied here that the interactions should be strictly synchronous; they simply need to be in the *same time frame*, letting the users work synchronously or asynchronously as needed.

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Collaborative Information Seeking
The Art and Science of Making the Whole Greater than the Sum of All
Shah, C.
2012, XXI, 185 p. 43 illus., 5 illus. in color., Hardcover
ISBN: 978-3-642-28812-8