Collaborating through Real-Time VoIP and Visual Search

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Abstract
This paper describes the importance of allowing human-human collaboration in the information-seeking task by modeling the task using Charnov's Marginal Gain Theorem. Highlighting areas of potential gain, the paper then describes an application that exploits those areas. The application described takes an existing information seeking tool – SolonEvo – and integrates it with a free point-2-point (P2P) Voice-over-IP (VoIP) tool by defining a set of protocols for message passing and providing an interface between the two applications that implement those protocols. The protocol and application are described.

Introduction

Digitally-supported human-to-human collaboration occurs regularly in all types of information seeking, including support of long-term information interests; each time you forward a link, document, video clip or some other information artefact to someone you think might be interested, an informal serendipitous collaboration occurs. Indeed, this process, in a more formal context, is often used as a means of information sharing in groups conducting seeking in support of synthesis type tasks. Digitally supported collaboration allows improved workflow within groups diminishing the relevance of geographic separation between members of a group. It also simplifies sharing of some resources and has peripheral advantages such as the ability to record ones interactions during a collaborative session. The interactions may be peer-to-peer or teacher-student; peer-to-peer would occur where a group moves from a position of ignorance to one of clarity on a topic by working together, perhaps by distributing segments of an information space to individuals or subgroups for exploration and analysis. Teacher-student type interactions occur when an expert educates an individual or group about an information space. Using Information Foraging Theory (IFT) three types of collaboration that support these interactions can be identified.

Information Foraging, first described by Pirolli and Card (Pirolli 1999), is an innovative model that allows Information Retrieval (IR) practitioners and user-interface designers to describe and evaluate information retrieval interface techniques. Based on the analogy of animals in an ecosystem, it describes information as a source of nutrition and information seekers – info-vores in information foraging parlance – as consumers of that information. Information has scent, cues that help info-vores to locate it. That scent can be enhanced or diminished by the surrounding environment, e.g., if there were a lot of confusing scents, it would increase the difficulty of locating an interesting item of information. Certain information may have greater nutritional content, or value, than others; information diet has a significant influence on gain. For instance, in the field of text-based information retrieval, a summary document might be of greater value to a researcher than would a document focusing on only one detail of interest. Relevant artifact density within a patch is also significant. If the relevant artifacts within a patch are hidden by the noise of other irrelevant artifacts, the rate of gain will decrease. Pirolli and Card examined the application of Charnov's Marginal Gain

Theorem to the foraging task. By doing this, they created a model that allows comparison of information retrieval interfaces. Figure 1(A) shows the model that calculates a cost function based on the ratio of the knowledge gained over the cost of locating that knowledge. Cost is the sum of the time spent in an information patch and the time spend locating that patch.

Charnov's Theorem describes two nutrition rich environments, those with *prevalence* and those with *profitability* – these are not mutually exclusive descriptors. An environment may be richer in information because a large number of relevant artefacts are distributed across that environment; this condition generally approximates high recall (of relevant items) in information retrieval – the time spent finding relevant patches (between patch time) decreases resulting in an increase in gain. The nutritional quality of those items need not necessarily be high. Profitability describes the condition where items of high nutritional value are distributed within the environment – these items will yield greater gain. This concept approximates precision in an information retrieval. However profitable items are not necessarily evenly distributed and seeking them may result in an increase in between-patch time. The concepts of prevalence and profitability are shown in Figure 1 below.

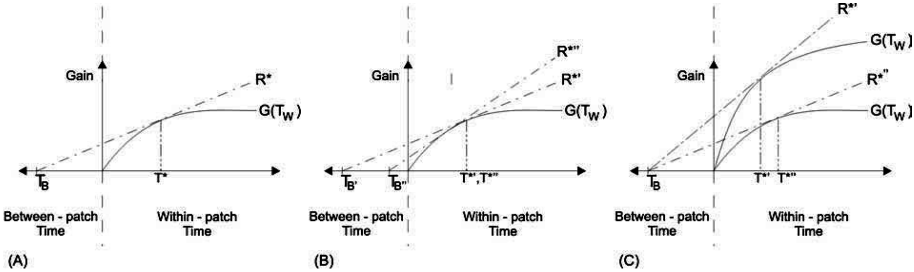

Figure 1: (A) Standard Case (B) Prevalence (C) Profitability.

How Collaboration increases Prevalence and Profitability

Figure 1(B) demonstrates how between patch time can be reduced, in effect filtering an information space to increase recall of relevant documents. This occurs when patches of potential interest are identified by suggesting sources and areas within those sources that might be of interest. This situation occurs in digital reference type applications or when collaborators create an information map of a landscape from their individual explorations of that space.

Figure 1(C) shows how indicating which documents within that patch should or should not be read can reduce within-patch time. This might involve identifying documents of interest or indicating syndicated sources for multiple documents that might indicate duplicate information.

Figure 1(C) also shows how gain can be increased to improve an information seekers diet. Interactions of this kind might occur when a mentor suggests a summary document to a student in order to give them a good starting point for their exploration. This would improve the students understanding of the topic as a whole as a more complete picture is likely to be communicated with a summary document than exploration of a document that specialises on describing part of a topic.

While the author has modelled each type of interaction as an individual occurrence, they are all likely to occur within a collaborative session.

Technologies and Approaches that seek to achieve collaborative goals

Human-to-human collaboration can be supported by numerous technologies; for instance, digital reference desks were often supported by simple webforms and email before the advent of Voice-over-IP (VoIP) and Instance Messaging (IM) applications. These real-time commutations media allow live interaction between collaborating parties and are a mechanism for routing artefacts of interest between those parties before supporting a discussion about those shared resources. Both VoIP and IM have been enhanced through the application of screen-sharing and digital whiteboard services. Mails, VoIP and IM are recordable media allowing archiving of collaborative interactions.

Most research into collaborative information seeking applications has occurred in the domain of digital libraries, concentrating on mentor-student type interactions rather than providing support for peer-peer interactions in the library. Many services such as Horizonlive[1] use these technologies and have adopted teaching and instructional software to the digital library domain. Several digital libraries have been quite imaginative in using these types of tool, some forming collaborations to unify the expertise and collections available (Kresh and Arret, 2000) and extending opening-hours for those resources in some cases (Kasowitz, 2000). Some libraries have chosen to emulate these services with ad-hoc combinations of software (Kasowitz, 2000).

Collaboration and Synthesis

While most research on human-human collaboration in support of synthesis has concentrated on mentor-student type interactions, some work has been conducted on peer-peer collaborations. This type of collaboration often occurs in support of synthesis type tasks.

Information synthesis is a type of information seeking is conducted in pursuit of long-term information needs. This seeking, perhaps in pursuit of business or educational goals, is characterised by a query or interest that extends over a pro-longed period of time where the information sources and concepts expressed by the query evolve. Numerous strategies have been evolved by information seekers to fulfil this requirement – examples of these techniques have been described in Bates (1989), Blake and Pratt (2006) and Marchionini (1995). When generalised, the conclusions of their work identifies note taking, the ability to explore data from numerous perspectives and the ability to explore data from several evolving sources as key attributes of a long-term or synthesis style information seeking strategy. Blake notes that collaboration often plays a role in all of these activities. She notes how a group of medical researchers, synthesising a report, collaborate, sharing queries and strategies at query formulation while group analysis of returned documents and the information space as a whole also occurs.

Twidale and Nichols (1996; 2000) have created several interfaces for collaboration in the digital library; these interfaces have integrated real-time conferencing, though that feature is not emphasised, rather, they concentrate on presenting the query and query result as a single object that can be shared. Collaborators can then edit, annotate, replay or re-execute the query. The result of these interactions is sharing of discovered knowledge, sharing of search strategies and the ability to use part or the entire query as the basis for satisfying one's own

[1] http://www.horizonlive.com.

information need. It should be noted that the application could be used by several collaborators who are co-located or geographically separate users. Twidale and Nichols also emphasise the need for annotations as a means of information sharing within the query. Interestingly, and at odds with much work on digital reference desks, they found that many users would prefer see all features required for collaboration integrated into a single application.

Application Specification

The application described herein was created to fulfill the following specification; an existing document foraging tool that interfaces through a search engine with a knowledge repository – to be a digital library or some other collection of knowledge – was modified to support interaction with a Voice-over-IP service. The application sought to allow a group of users to independently search, browse, annotate and record information discovered in a repository of information. The application also allowed users to create ad-hoc discussion groups where either telephony calls or instant messaging sessions allowed users to converse on information located during their searches. Further, the application sought to allow users to intuitively swap documents, result set views and metadata in real-time while those conversations are underway. We are particularly interested in assisting users whose collaboration revolves around discussion of a common visual resource (documents and collections of documents in the case under discussion). By providing a single tool for information seeking and multi-user collaboration, we believe that the amount of preparation required for an online meeting is reduced, while the flexibility allowed to parties to conduct informal examinations of a collection is increased.

The Foraging Interface

SolonEvo (shown in Figure 2) was originally created to explore the use of proximity based information maps in a digital library environment. The application was used as a test bed to explore different layout and visualisation techniques. The application is implemented using client/server architecture. The server component consists of a repository manager that interfaces with the document collection, queries of that collection and generated visualisations of the results of those queries. The server also manages user sessions, recording user browsing habits and annotations that the user may create for a document in the repository.

The application retrieves a result set, the result of a query to a central repository accessed through the server, from which the application calculates and presents an interactive 2-dimensional proximity based visualisation to the searcher. The position of each artifact is calculated by applying a clustering algorithm to inter-artifact similarity measurements and then submitting those clusters to a force-directed layout algorithm to determine the position of nodes within the visualisation. Encoding information about each artifact in its representation further enhances the functionality provided by the visualisation; this includes whether or not a node has been visited. Ranking of documents is accomplished through scaling the intensity of the nodes colour. A ranked list is also provided to create a link with the traditional approach of representing results. The visualisation is enhanced by the provision of several tools. The threshold controls manipulation of the visualisation allowing a searcher to vary the density of information patches. The proximity tool allows users to focus on particular artifacts within segments of the visualisation by changing affected nodes colour. This allows users to maintain focus on particular parts of a visualisation without loosing the context of those nodes within the overall result set. The application also allows users to annotate documents with their own notes.

Voice-over-Internet Protocol (VoIP)

Voice-over-IP (VoIP) describes a set of technologies that allow voice and multimedia calls to be set up across an IP network. VoIP as a concept has been demonstrated by numerous ventures since the mid-1990s but has only become a viable commercial option due to the convergence of several enabling technologies – including increased broadband availability, commercial drivers for cheap telecommunications, improved QoS and the popularising of 'extra' features – such as file sharing and instant messaging – made available through VoIP technologies. Users benefit from cheap reliable high quality communications while service providers can develop new lines of business along with decreasing costs on existing services. At this point, the technology is recognised as a disruptive technology – one that might cause a shift in the communications industry – as its users move from being occasional opportunistic users to mainstream users of a service.

Two dominant architectures have emerged; a central server approach where clients attach to a central call server and a P2P architecture where clients are distributed and communicate with one another across a distributed environment. Voice-over-IP offers numerous advantages over traditional PSTN communications media. The technology allows for easy management of conference calls and other asymmetrical call types that have traditionally been difficult to support. In addition, data transmission through APIs is much easier to facilitate programmatically. VoIP has some disadvantages – integration with PSTN call-in/out is made more complicated, though it is increasingly supported by commercial offerings. In addition, explicit configuration steps may be required to overcome firewalls and other security issues.

Integrating VoIP and Foraging

Communications are facilitated through the Skype API. To use the API, a valid Skype user profile must have been created and the Skype client must be installed on the application's host machine to support interaction with the service. Skype allows applications to establish a communications stream between individual remote applications using the Skype client as a background service. An XML based protocol was developed to allow exchanges of information between remote instances of SolonEvo. Two exchanges are currently enabled; the first allows for exchange of single documents. Formally, each document is described as a set of values in the form of A = v where A is an attribute and V is a text value. Documents are atomic entities that are used to describe resultsets. A document is described thus:

```
< Document id = [uid] rl = [resource-locator] >
  < Sysnote id = [uid] text = [text note] />
  < Note id = [uid] text = [text note] />
< /Document >
```

Each document is described through a unique identifier and a resource locator. Each document can have a SysNote associated with it – metadata available to all of the documents viewers and Notes – metadata created by a user and available to all those users that are given permission by the notes generator. Resultsets are described by a set of document entities; each document entity is wrapped in a result descriptor that places each document in context within the resultset. The XML is defined as follows:

```
<Resultset>
  <Result rank = [doc-rank] >
    <Pos xvalue = [x-pos] yvalue = [y-pos]>
    <Document id = [uid] rl = [resource-loc]>
```

```
      ...
    </Document>
  </Result>
</Resultset>
```

Each result is described by a rank identifying the documents within the resultset. The value also allows reformulation of a ranked list to describe the resultset. The result also posses attributes to describe the X and Y co-ordinates of a document in a 2-D visualisation. This definition is easily extended to use other visualisation techniques.

User Interface Modifications

The SolonEvo information seeking application was extended to support enrichment of the foraging environment through the provision of real-time collaboration. The interface itself had two new controls added – one to manage telephony and one to manage instant message (IM) communications. Both modes of communications are supported; while telephony provides a convenient and traditional form of telecommunications, IM has the advantages of both being a silent medium (appropriate in some environments) and self-documenting. The application supports drag-and-drop from one view to another; this allows individual documents and query result sets to be dragged from either the ranked list view or the visualisation to either the communications controls; this transmits that document/view representation to all other participants in the conversation. In the next iteration of the application, users will have an option of sharing a common view allowing propagation of user interactions across all participants' views. When a document or view is received, it is displayed in a list on the communications panel. The user can view the item by double clicking on it; documents are displayed in an appropriate reader while views are opened as a new tabbed visualisation. The visualisation is shown in Figure 2.

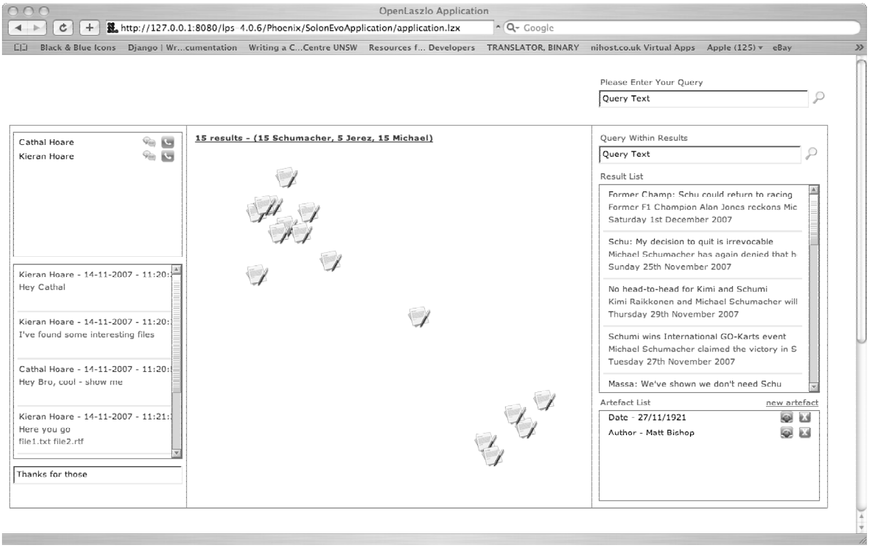

Figure 2: The SolonEvo Collaborative Environment.

Conclusions

This paper has described an application that takes an existing information seeking tool – SolonEvo – and integrates it with a free point-2-point (P2P) Voice-over-IP (VoIP) tool by defining a set of protocols for message passing and providing an interface between the two applications that implement those protocols. Future work will explore whether the application described can be used to support collaborative feedback in an information seeking context.

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