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Mark Maybury

Director, Bedford Articial Intelligence Center
The MITRE Corporation
202 Burlington Road
Bedford, MA 01730
Telephone:617-271-7230
FAX:617-271-2352
Internet:maybury@mitre.org

The Future of Interaction on the Internet

The federated collection of heterogeneous computers we collectively term the Internet has been the force behind revolutionary change, both in terms of actual practice and imagination of what might be. The raw numbers are staggering: IP registrations are now ten-times that of only five years ago (3000 in January, 1989, 36000 in March 1993); between 1992 and 1993 the amount of information being transferred tripled (from approximately 2.2 to 6 terabytes per month). Industry is dreaming visions of the future such as Apple Computer's Knowledge Navigator (with the infamous knowledge butler, Phil) and the Computer Systems Policy Project's projection of the National Information Infrastructure. In this brief talk I will describe and forecast changes in three key areas: knowledge discovery, intelligent information access, and collaboration on the Internet. A visionary video demonstration developed by MITRE's advanced human computer interaction group will illustrate some of these forecasts (equipment permitting).

Knowledge Discovery

Increasingly organizations are establishing information infrastructures to facilitate information sharing (e.g., servers, e-mail, directory services, video teleconferencing), however, many still do not have effective means for finding, accessing, and using electronic information and expert personnel within and outside their organizations. The more flexible structures fostered by virtual organizations and ad-hoc tasking within existing organizations has increased the requirement for enhanced communications, information sharing, and rapid team formation. The proliferation on the Internet of common information sharing tools (e.g., Wide Area Information Servers (WAIS), World Wide Web (WWW), Gopher) together with information browsers such as Mosaic which bring these together in one common viewer, has established an effective means of referencing and retrieving information. With the advent of Uniform Resource Locators (and the forthcoming Uniform Resource Naming, which will provide logical naming of sources), users can now reference Internet information repositories and exchange information with as much ease as they exchange e-mail. While tools like Mosaic and standard protocols such as WAIS and Hyper Text Transfer Protocol (HTTP) are important infrastructural advances, they primarily provide an ability to browse the vast Internet information space or navigate to a well-known destination. A further requirement is an effective organization of this heterogeneous information space to enable users to efficiently find and extract valuable information.

One notion is a straightforward Electronic Yellow Pages in which offering organizations post or offer information and services to a centralized or distributed directory, possibly based on directory standards such as X.500. Another idea is a Source Recommendation Agent (SRA), a knowbot (knowledge robot) that would automatically search the information space based on user information needs (explicitly stated or learned by observing user interactions) and source characteristics (e.g. type, cost, quality of information). We are already beginning to see initial capabilities in this area in the guise of web-crawlers, which fan-out over World Wide Web links to discover potentially relevant information. A more general Intelligent Information Agent (IIA) might not only identify sources, but it might also assist the user in organizing, summarizing, and evaluating them. These agents could not only act upon information in repositories, but help filter incoming "pushed" information (e.g., e-mail), adapting over time to user's reactions to previous information (e.g., printing it, deleting it, storing it in an electronic folder, forwarding it to relevant parties, warning the user of a new topic) (Burger 1994). One vehicle for information delivery might be a personalized electronic newspaper, a popular notion for a number of years.

Intelligent Mosaic

An important element of future interaction are intelligent and intuitive interfaces to complex information spaces. For example, consider a visionary demonstration of interaction on the internet prototyped for ARPA by MITRE, whose architecture is illustrated in Figure 1 (Smotroff, Hirschman, and Bayer 1994). The prototype addressed some limitations of Mosaic: disorientation in a web of hypertext, poor indexing of document collections, and untailored information presentation. The MITRE team augmented the existing X-Mosaic infrastructure with an event queue to manage interactions. More significantly, they adapted and integrated natural language processing and distributed document visualization capabilities to support the process of information exploration and retrieval from a database of joint venture documents representing different sources on joint ventures (e.g., Mead, Prompt, Wall Street Journal). First, a natural language understanding system for full-text understanding was applied to the document collection to generate database templates representing the joint venture objects and relationships represented in the content of the documents[1]. MITRE further integrated CMU's Phoenix natural language parser to provide a natural language front-end to the document collection. Successful hits against a user query were then displayed in a visualization tool, essentially a matrix, with columns representing different information sources and rows representing a rank-ordered set of the most relevant documents. Color and size were used to emphasize individual document relevance. This adaptation of University of Maryland's TREEMAP visualization software further enabled the user to interatively refine their query, resulting in an updated color and size encoded visualization of the distributed document space. The user could either retrieve the full text of the document or request a summary the document, generated automatically from the underlying database templates by MITRE's TEXPLAN system for natural language generation. A user model adapted output to user characteristics (e.g., their age, preferred language) and a discourse model interpreted queries in the context of their use (e.g., anaphoric expressions such as "the ones that are from Japan" are resolved automatically). Custom collections of documents could be generated on the fly based on a user query along with custom views (e.g., a table of contents page resulting from an ad-hoc collection of documents). A visionary facility for converting sources from one media to another (e.g., from a full-text article to a multimedia presentation) was also simulated.

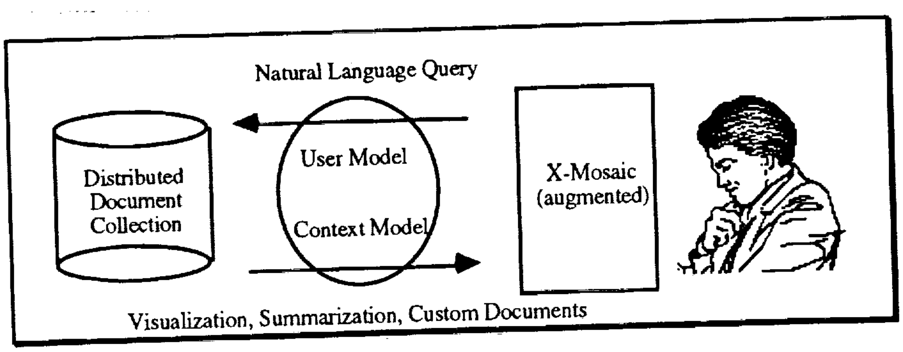

Figure 1: Intelligent Mosaic

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[1]As current information extraction techniques have low precision and recall, this was simulated in the prototype by using the templates manually generated by domain experts to be used as answer keys in the Message Understanding Conference evaluation.

An important aspect of the above demonstration was the ability to search on the content of the information, that is on the people, places, organizations, relationships, events and so on, mentioned in the document. Because automating this remains difficult, it was actually simulated by searching on the object-oriented answer keys developed for the Message Understanding Conference, which is focused on automated information extraction technology. Both automated extraction and machine translation of foreign documents remain important needs. Also important is the ability to perform content-based search on multimedia sources (e.g. text, video, audio). In the demonstration, the user was able to retrieve video by simple keyword search of associated closed-captions. While this interface was primarily passive, other researchers are investigating more active, agent-based systems that engage the user in a mixed-initiative dialogue.

Collaboration on the Internet

While tools such as Mosaic support knowledge sharing, they (currently) do not support direct user-to-user or group-oriented interaction. Computer-mediated collaboration has been an area of great interest for a number of years, resulting in such areas as telemedicine, distance learning, and virtual manufacturing. While there are a number of commercial tools that support collaboration for document sharing, screen-sharing, and work flow, there has been a rapid growth in the use and interest of collaborative work environments in the Internet community, so called Multi-User Dimensions (MUDs). Historically having roots in the computer games termed Multi-User Dungeons, MUDs currently provide a shared workspace via persistent, primarily text-based meeting facilities with object sharing capabilities, hence the term Multi-User Dimensions Object Oriented (MOO). Today these facilities are heavily text-based, supporting ("chatter") interaction between multiple distributed participants along with a shared white board and facilities for saving dialogues (persistence) and leaving a proxy object (virtual agent) in the environment even when the real user is not present. These environments, which often include data, tools, and analyses, are currently being used for virtual work teams to support distributed education (EcoMOO, MediaMOO) and scientific research (BioMOO, AstroVR) (Anderson, 1994). Applications to group decision support may soon follow. While primarily text-based today, researchers are currently integrating real-time audio and video into these virtual workspaces as well as facilities to support workflow and other applications.

Conclusion: Cultural Barriers to Success

The potential for the Internet to support knowledge sharing, virtual groups, and indeed virtual corporations is only beginning to realized. The infrastructure is in place to support offerings of services such as document conversion, document translation, and information summarization. To be sure, several technical challenges remain such as the need to provide security and privacy, to protect intellectual property, to support electronic commerce, and to better organize, index, and standardize existing and future information and services. However, the cultural challenges are perhaps greater, such as the individual and organizational pressures that promote information hoarding. We must circumvent these dangers by providing incentives for the dissemination of knowledge, value-added services, and collaborative efforts. Only then will we realize the promise of the electronic information infrastructure to help draw upon our creative capacity to cooperatively solve the complex industrial, government, medical, and educational problems we together face.

Acknowledgments

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About the Speaker

Mark T. Maybury received his BA in Mathematics from the College of the Holy Cross in 1986 where he was Valedictorian. As a Rotary Scholar at Cambridge University, England he received his M.Phil. in computer Speech and Language Processing 1987 and his Ph.D. in Artificial Intelligence in 1991 for his dissertation, "Generating Multisentential Text using Communicative Acts". Mark was awarded an MBA from RPI in 1989. Mark currently is Director of the Bedford Artificial Intelligence Center at the MITRE Corporation, where he directs and conducts research in human computer interaction, collaborative computing, intelligent training, speech and natural language processing, knowledge based software tools, and intelligent databases. Mark's interests include technologies for Open Source Processing, document mark up standards, and tools to help increase analyst and research productivity.

Mark has published over fifty technical survey articles in the area of language generation and multimedia presentation. He chaired the AAAI-91 Workshop on Intelligent Multimedia Interfaces and recently edited the international collection, Intelligent Multimedia Interfaces (AAAI/MIT Press, 1993). He has served on several national and international workshop and conference committees. Mark has taught both undergraduate and graduate courses in Artificial Intelligence, Health Management Information Systems, and Database Management Systems