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COMPUTERS AND KNOWLEDGE SHARING

Knowledge has always been associated with power. In the information age, knowledge is turning into the principal currency, making efficient access to data sources, services, and to expertise vital for survival.

TOWARD GLOBAL KNOWLEDGE REPOSITORIES

The ancient Bibliotheca Alexandria, created at the beginning of the third century BCE, was the first universal library in history. By the middle of the first century BCE, it provided access to close to half a million manuscripts classified and organized by highly sophisticated methods. The library also served as a meeting place, research institute, center of learning, and museum. It was an essential source of information and expertise for many generations of world-famous scholars and scientists until its disappearance in the third and fourth centuries CE.

In 1938, H. G. Wells described his conception of the future information center in his book *World Brain,* inspiring numerous efforts to create a global repository of knowledge. Vannevar Bush, in his seminal work "As We May Think," developed a new methodology called memex for the automatic storage and efficient access of books, records, and individual communications. Influenced by Bush's ideas, Douglas Engelbart's "A Conceptual Framework for the Augmentation of Man's Intellect" describes one of the first hypertext systems. Also in 1963, Theodor H. Nelson coined the words *hypertext* and *hypermedia* to describe his vision of worldwide hypertext—a universe of interactive literary and artistic works and personal writings "deeply intertwingled" via hyperlinks. Joseph Licklider, imagining the library of the future in 1960, invented the term "man-computer symbiosis" to refer to the close, mutually beneficial interaction that we strive for in the design of today's human-computer interfaces.

TOWARD SOCIOTECHNICAL KNOWLEDGE NETWORKS

The emerging global, sociotechnical communication network allows people to be connected not only to different data sources and services but also to one another. Digital libraries play an increasingly important role as they aim to provide site-neutral, open access to a great variety and granularity of information presented in multiple (multimedia) ways.

Visual interfaces to digital libraries apply powerful data analysis and information visualization techniques to transform data and information that are not inherently spatial into a visual form. They engage a human's visual and proprioceptive system to make judgments about data more reflexive and to ease cognitive load, and are intended to help humans mentally organize, electronically interact with, and manage large, complex information spaces. Frequently, visual interfaces exploit human beings' powerful spatial cognition and the method of loci (a mnemonic technique that originated with the ancient Greeks) to associate and attach any digital information, tool, or service to a spatial location or, using an identification tag, to other people.

The expansion of the worldwide electronic network leads to a continuous convergence of digital libraries with archives, museums, and diverse services into an integrated digital information space. Digital availability of multimedia documents and artifacts makes real artifacts and their physical locations in libraries, muse-

ums, and archives less important. The roles of contributors, librarians, archivists, visitors, users, and researchers blur.

Moreover, exchange of information needs to be understood as a social interaction rather than as a mere instance of goal-oriented information retrieval or interaction with an information system. As Caroline Haythornthwaite, Barry Wellman, and colleagues suggest, a person's "information neighborhood" is made up not only of documents, but also—and perhaps more importantly—of people, including family, friends, neighbors, coworkers, and a continuously changing network of acquaintances. Correspondingly, there is an increasing commercial interest in the design and utilization of information sharing and collaboration tools. For instance, "groupware" systems use computer technologies to facilitate informal flows of information, capture and replay of interaction experiences, storage and reuse of expertise, and discovery of expertise locations. In these systems, information is exchanged through social networks that facilitate local and distributed group collaboration in environments ranging from ad hoc meetings to virtual organizations. As an example, Robert Mack, Yael Ravin, and Roy J. Byrd (2001) describe community knowledge portals developed to help participants capture, access, and manage knowledge and expertise created during their work process; to link community members to each other and to relevant content; and to offer personalized services tailored to the individuals and communities based on collaborative filtering. Peter R. Monge and Noshir Contractor promote tools like I-KNOW that assist in the study, creation, and growth of knowledge networks.

Online "virtual communities," a term coined by Howard Rheingold, also function for their members as "information neighborhoods," contexts within which they can engage in ongoing information-sharing activities and information exchange.

Awareness tools convey information to users, ranging from cognizance of documents, projects, and tasks to knowledge of the location and activities of other community members.

Computer-mediated communication (CMC), according to Susan Herring, studies human communication and interaction via computer networks and in online environments—from the dynamics of group communication in Usenet news articles to how people use hypertext to shape meaning. Social network analysis is focused on uncovering the patterning of people's interaction.

A major shortcoming of today's digital online spaces is the scarcity of social navigation cues (e.g., who is online, what resources are accessed frequently), making it difficult to find relevant resources and expertise or to collaborate. Research on social visualizations aims to show data about a person, illuminate relationships among people, or visualize group activity to facilitate information access, collaboration, and decision-making (Donath et al. 1999).

OPPORTUNITIES AND CHALLENGES

The World Wide Web places humankind's knowledge, ideas, and achievements at one's fingertips. Recent advances in networking, computing, storage, and display technologies make possible the design of efficient communication facilities that connect us to any individual, group, or organization.

Research challenges concern the extension of physical information and workspaces via electronic means. Potential investigative areas include network technologies, electronic data storage, highly usable and sociable interfaces, and techniques for automatic reaction and adaptation to the information and social networking needs of temporary, dynamically evolving, professional networks and online communities.

Technological challenges comprise the sustainability, robustness, and support of heterogeneous hardware. The full implementation of the Semantic Web, described by Tim Berners-Lee, James Hendler, and colleagues, promises to bring structure to the meaningful content of Web pages and to provide the basis of interoperability between different data sources and Web services.

Social challenges relate to data protection, privacy concerns, social organization of work practices, trust, legitimacy via content contribution and evaluation by distributed subject and professional teams, and sustainable resource models. According to Amy Jo Kim, community building needs to be supported via private profiles and collaborative working practices.

The scale-free topology of the Web poses its own serious challenges with regard to multilingualism, preservation of diverse cultural heritages, traditions, views, and approaches, as only a minority of sources and experts is highly visible and accessible while the vast majority is too weakly connected to be seen. The exponential growth of the Web, caused by globalization, economic interdependencies, and technological development, leads to a global system of interconnected

human beings and computer technology of unheard-of complexity. Consequently, according to R. Kling, research on efficient knowledge and expertise access will need to study, analyze, and support this emerging sociotechnical system as opposed to its individual parts.

—Katy Börner

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