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A Group Has No Head
—
Conceptual Frameworks and Systems for Supporting Social Interaction

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Abstract

Based on the fact that the individual human mind is limited, conceptual frameworks and innovative systems in support of social interaction are a necessity rather than a luxury for our future information society. The conceptual frameworks need to be grounded in distributed cognition. Because "a group has no head", collaboratively constructed and evolved information repositories are of critical importance to support shared understanding, negotiation, critiquing, and organizational learning. Derived from this conceptual framework, requirements for computational environments supporting social interaction are described. Specific environments (e.g., domain-oriented design environments, organizational memories) illustrate the challenges of creating open, evolvable systems and of contextualizing information. The implications for social interaction (such as the need to allow users to be designers and active contributors , the critical importance of understanding social and motivational issues, and new conceptualizations of the World Wide Web) are derived from the conceptual framework and the systems.

Keywords: distributed cognition, symmetry of ignorance, communities of practice, open systems, organizational memory, organizational learning, consumers and designers, decentralized information repositories

Beyond Individual Human Minds

The Limitation of the Unaided, Individual Human Mind. The power of the unaided, individual mind is highly overrated — without external aids, memory, thought, and reasoning are all constrained [Norman, 1993]. As illustrated in Figure 1, the basic capabilities of the unaided, individual human mind have changed little over time. For the design of cognitive artifacts, it is important to know these basic capabilities; some of them, such as memories (working memory , long-term memory) and processors (perceptual processors, cognitive processor, and motor processor) and their basic characteristics are described [Card et al., 1983].

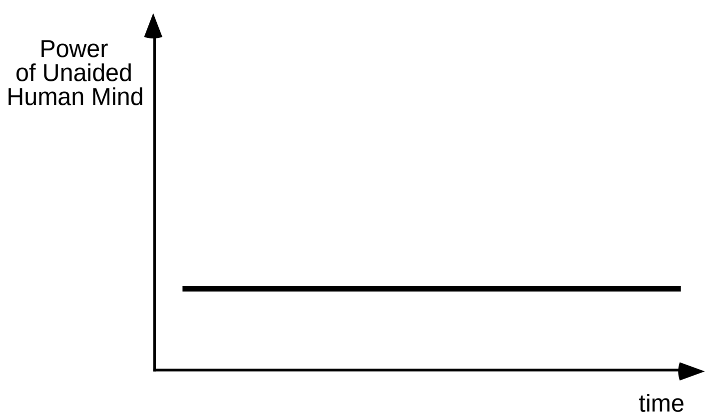

Figure 1: The power of the unaided individual human

The Tension between Human and Computational Power. In sharp contrast to the negligible change of the basic capabilities of the unaided, individual human mind, computational and communication technologies have changed dramatically. Moore's law (illustrated qualitatively in Figure 2) is the principle that computer capacity doubles every eighteen months. The principle, operative since the dawn of the computer age, shows no sign of abating and its implications have provided unique possibilities to create new cognitive artifacts. One of the basic misunderstandings has been that while these technologies are necessary, they are not sufficient to allow humans to think previously unthinkable thoughts, to let them work more creatively and efficiently, to learn and understand more, and to collaborate more [Landauer, 1995].

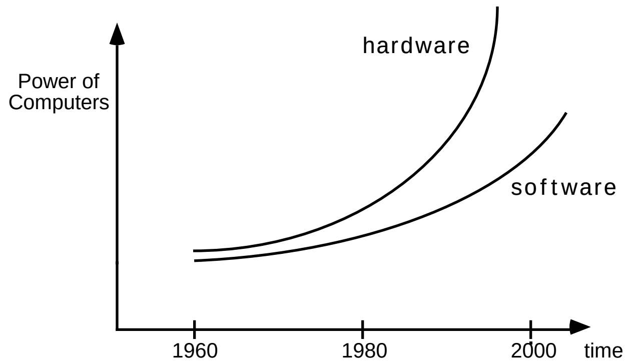

Figure 2: Computing power increases at an exponential rate

The Collective Human Mind — Exploiting Social Interaction. The Renaissance scholar does not exist anymore. Human beings have a bounded rationality—making satisfycing instead of optimizing a necessity. There is only so much we can remember and there is only so much we can learn. Talented people require approximately a decade to reach top professional proficiency. When a domain reaches a point where the knowledge for skillful professional practice cannot be acquired in a decade, specialization will increase, collaboration will become a necessity, and practitioners will make increasing use of reference aids, such as printed and computational media supporting external cognition.

Much of our intelligence and creativity results from the collective memory of *communities of practice* and of the artifacts and technology surrounding them. Though creative individuals are often thought of working in isolation, the role of interaction and collaboration with other individuals is critical. Creative activity grows out of the relationship between an individual and the world of his or her work, and out of the ties between an individual and other human beings. The basic capacities (see Figure 1) are then differentially organized and elaborated into complex systems of higher psychological functions, depending on the actual activities in which people engage. These activities depend crucially on the historical and cultural circumstances in which people live [Resnick et al., 1991].

Figure 3 illustrates the major fundamental human inventions and creations which have increased the power of the unaided, individual human mind. The big questions to be asked today are: (1) will computational and communication media have an equally important impact on humans as reading and writing and the printing press had in the past; and (2) will we be able to achieve another qualitative increase (indicated by the dashed line in Figure 3) by the development of new media and new technologies which exploit the possibilities of the *collective* human mind through social interaction?

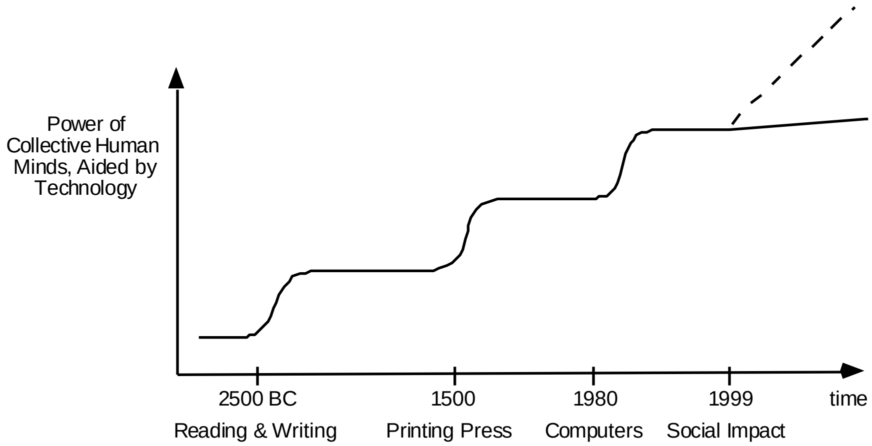

Figure 3: The Power of the Collective, Aided Human Mind

A Motivating Example for Social Interaction. One of our collaborating companies employs 700 help desk people. These employees help customers all day and every day to solve their problems. This setting appears to be an ideal environment to take advantage of social interaction, where the group at large benefits from the creative acts of the individuals in the group.

In our example, help desk person N expends considerable effort to solve a difficult customer problem. How should this creative act be documented and shared with the other help desk people? Should person N *broadcast* (using some kind of "push-technology") this problem and its solution to the 699 other help desk people, as illustrated by Figure 4?

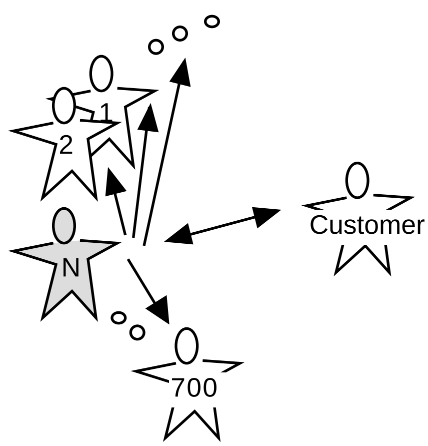

Figure 4: Information Overflow of Decontextualized Information Caused by Broadcasting

We claim the answer is no, because in general this information will not be relevant to the other help desk people. All of these people (like most knowledge workers) do not suffer from a scarcity of information, but from an information overload problem; and this problem is worsened by receiving more decontextualized information whose relevance is not recognized by the receiver at this point of time.

The more promising strategy is captured in Figure 5: the information should be captured in an information repository (such as an organizational memory) and it should be made available (either upon request or volunteered by the system) when other help desk people encounter a problem in the future to which the solution created and documented by person N is relevant.

The example is illustrative of the kinds of experiences that are important social interaction. One of the core challenge for social interaction is to collect creative solutions by individuals and make them available to colleagues who encounter similar problems. This core challenge raises difficult technical issues such as: (1) computationally tractable representations of experience; (2) retrieval technologies that notice deep as well as surface similarities; (3) capturing a significant portion of the knowledge that practitioners generate in their work; (4) the effort required to contribute to organizational memory must be minimal so it will not interfere with getting the real work done; and (5) developing a culture in which individuals are motivated to work for the good of the group or organization[Grudin, 1994].

A Conceptual Framework for Social Interaction

The basic foundation for social interaction is that people think, work, and learn in conjunction or partnership with others and with the help of culturally provided tools and artifacts. For a conceptual framework (or theory) of social interaction to be interesting, to inspire, to guide and to inform the development of new media supporting social interaction, it should contain some specifications how social interaction can be improved or altered in some significant way. A focus on social interaction has shifted our *internalist* view (seeing the mind as information processor by assuming that the mind's operation are characterizable independent of their relationship to the external world) to a *distributed* cognition view .

A Group has No Head. Distributed cognition [Norman, 1993] emphasizes that the heart of intelligent human performance is not the individual human mind but groups of minds in interaction with each other and minds in interactions with tools and artifacts. It is important to understand the fundamental difference of distributed cognition as it operates for the aided individual human mind. Distributed cognition between the individual human mind and artifacts (such as memory systems) often function well, because the required knowledge which an individual needs is distributed between her/his head and the world (for example: an address book, a folder system of e-mail messages, a file system). But a group has no head — therefore externalization are critically more important for social interaction. Externalizations (1) create a record of our mental efforts, one that is "outside us" rather than vaguely in memory, and (2) they represent situations which can talk back to us, critiqued, and negotiated.

Symmetry of Ignorance. As argued above when a domain reaches a point where the knowledge for skillful professional practice cannot be acquired in a decade, specialization will increase, collaboration will become a necessity, and practitioners will make increasing use of reference aids, such as printed and computational media supporting external cognition. Design [Simon, 1996] is one such domain par excellence. Complexity in design arises from the need to synthesize different perspectives of a problem, the management of large amounts of information relevant to a design task, and understanding the design decisions that have determined the long-term

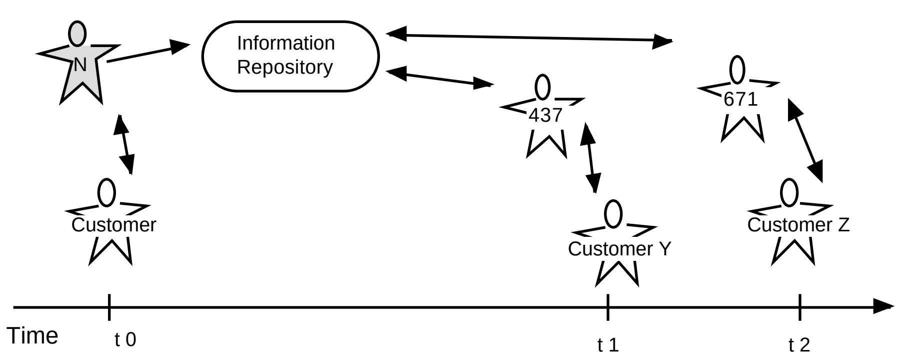

Figure 5: Contextualizing Information to the Task at Hand and Supporting Learning on Demand

evolution of a designed artifact. The social interaction among stakeholders in design can be characterized by a "symmetry of ignorance" [Rittel, 1984] or an "asymmetry of knowledge". In designing artifacts, designers rely on the expertise of others [Galegher et al., 1990; Resnick et al., 1991] by referring to textbooks, standards, legal constraints, and especially previous design efforts. Project complexity forces large and heterogeneous groups to work together on projects over long periods of time. Knowledge bases should include not only knowledge about the design process but also knowledge about artifacts of that process—parts used in designing artifacts, subassemblies previously created by other design efforts, and rationale for previous design decisions. Designers generally have a limited awareness and understanding of how the work of other designers within the project—or in similar projects—is relevant to their own part of the design task. The large and growing discrepancy between the amount of such relevant knowledge and the amount any one designer can possibly remember imposes a limit on progress in design. Overcoming this limit is a central challenge for developers of systems that support social interaction[Nakakoji, 1998].

Organizational Learning and Organizational Memories. *Organizational learning* focuses on recording knowledge gained through experience (in the short term), and actively making that knowledge available to others when it is relevant to their particular task (in the long term) [Fischer et al., 1996]. A central component of organizational learning is a repository for storing knowledge_ an organizational memory. However, the mere presence of an organizational memory system does not ensure that an organization will learn. Today, information is not a scarce commodity; the problem is not just to accumulate information, but to deliver the *right* knowledge at the right time to the right person in the right way. Organizational learning happens only when the contents of organizational memory are utilized effectively in the service of doing work. Efficient support for organizational learning raises many unresolved issues: how can we create a working and learning culture, in which individuals are willing and encouraged to share; how do we effectively collect individual knowledge and make it easily accessible to the entire organization?

For sustained organizational learning, three seemingly disparate goals must be served simultaneously. Organizational memory must (1) be extended and updated as it is used to support work practices; (2) be continually reorganized to integrate new information and new concerns; and (3) serve work by making stored information relevant to the new task at hand. Organizational learning is a continuous cycle in which organizational memories play a pivotal role:

- Individual projects serve organizational memory by adding new knowledge that is produced in the course of doing work, such as artifacts, practices, rationale, and communication.
- Organizational memories are sustained in a useful condition through a combination of computational processes providing information and people actively contributing.
- Organizational memory serves work by providing relevant knowledge when it is needed, such as solutions to similar problems, design principles, or advice.

The intimate relationship between organizational memory and work practices implies that the contents of organizational memory must be easily accessible *within the context of work*. Computational support for organizational learning, therefore, must tightly integrate tools for doing work with tools for accessing the contents of organizational memory. Processes of information capturing, structuring, and delivery must be computationally supported as much as possible or they simply will not get done.

Organizational memories are information systems that are used to record knowledge for the purpose of making this knowledge useful to individuals and projects throughout the community of practice and into the future. Ideally, an organizational memory allows individuals within the community to benefit from the experiences and insights of others, by *actively* informing work practices at the point when the information is actually needed. That is, an organizational memory should not be simply a passive repository of information, but an interactive medium within which collaborative work can actually be conducted and through which communication about the work can take place and be situated. Systems that support *organizational learning* and *organizational memories* [Fischer et al., 1996] will be useful for professionals working on complex tasks in large team environments. An example of an organizational memory is GIMMe, the Group Interactive Memory Manager [Fischer et al., 1996] which captures group email, automatically categorizes it, and then provides context-sensitive search capabilities. These systems will have to be enhanced to capture richer types of information and provide more powerful categorization and search techniques.

Examples of Systems in Support of Social Interaction

Domain-Oriented Design Environments. In our own past research efforts we have developed conceptual frameworks to empower individuals by developing domain-oriented design environments [Fischer, 1994] in a variety of different domains. By being domain-oriented, they support *human problem-domain communication*, making the computer invisible and bringing tasks to the forefront. Domain-oriented design environments (created over time as a joint effort among clients, domain designers, and environment developers) empower individuals by (Figure 6 provides a example of a domain-oriented design environment in the area of computer network design)

1. letting them articulate a partial description of their tasks with the help of a specification component (see pane 4),
2. supporting the creation of an artifact with a construction component (see pane 2 and 3),
3. using a catalog of previous designs supporting design by modification (see pane 5),
4. signaling potential breakdowns with a critiquing component,
5. supporting the exploration of argumentation and design rationale (see pane 1), and
6. providing additional feedback with a simulation component (see pane 3).

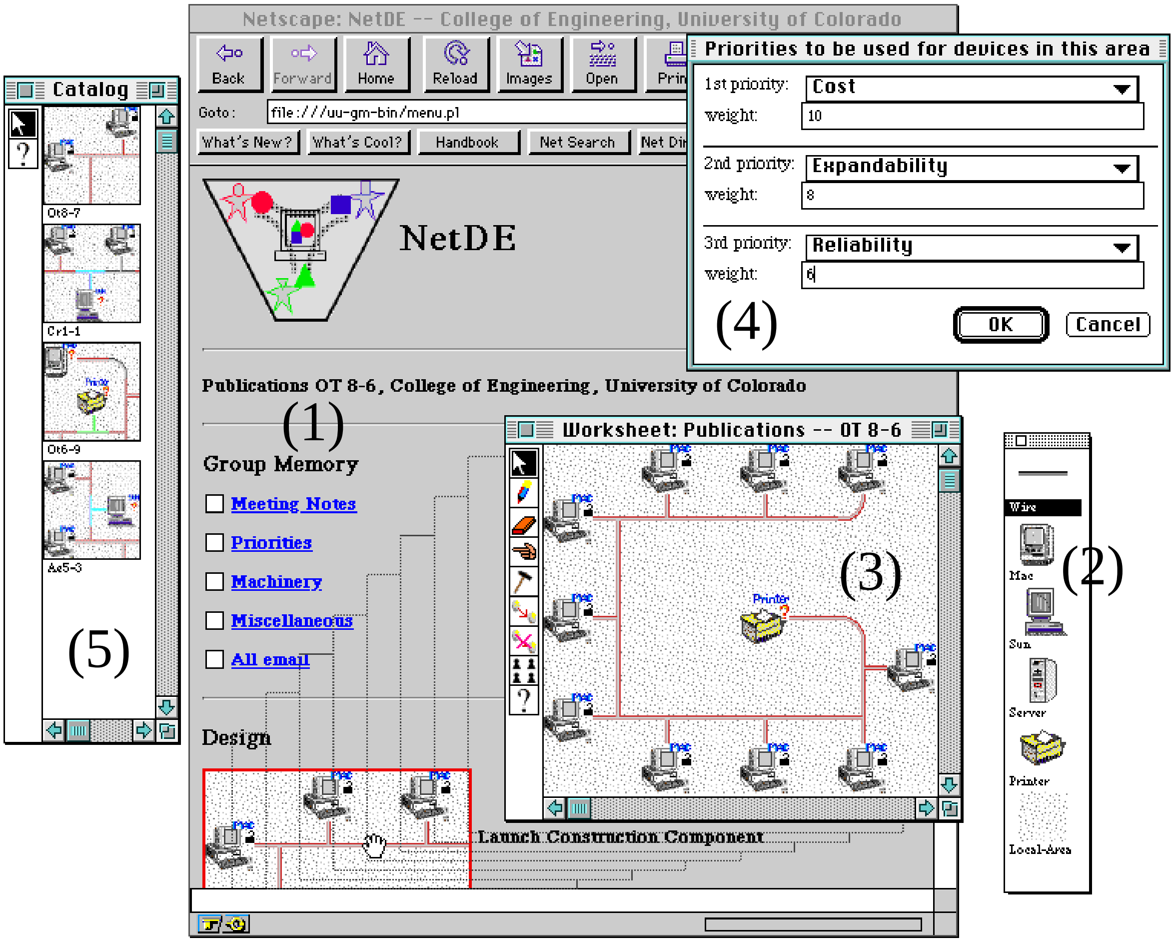

Figure 6: A Domain-Oriented Design Environment for Computer Network Design

The Envisionment and Discovery Collaboratory. The Envisionment and Discovery Collaboratory (EDC) (http://www.cs.colorado.edu/~l3d/systems/EDC/) [Arias et al., 1997] is a domain-oriented design environment under development to support social interaction by creating shared understanding among various stakeholders, contextualizing information to the task at hand, and creating objects-to-think-with in collaborative design activities. The EDC framework is applicable to different domains, but our initial effort has focused on the domains of urban planning and decision making, specifically in transportation planning and community development. Creating shared understanding requires a culture in which stakeholders see themselves as reflective practitioners rather than all-knowing experts [Schön, 1983]. The "symmetry of ignorance" is a defining characteristic of such collaborative design activities: stakeholders are aware that while they each possess relevant knowledge, none of them has all the relevant knowledge.

Figure 7: The Envisionment and Discovery Collaboratory (EDC)

Figure 7 shows the current realization of the EDC environment. Individuals using the EDC convene around a computationally enhanced table, shown in the center of the figure. This table serves as the Action Space for the EDC. Currently realized as a touch sensitive surface the Action Space allows users to manipulate the computational simulation projected on the surface by interacting with the physical objects placed on the table. The table is flanked by a second computer driving another touch-sensitive (vertical) surface shown in the center of Figure 7. This computational whiteboard serves as the EDC's Reflection Space. In the figure, neighbors are filling out a Web-based transportation survey that is associated with the model being constructed. The Reflection and Action spaces are connected by communication between the two computers using the Web as a medium. The entire physical space, through the immersion of people *within* the representations of the problem-solving task, creates an integrated human/computer system grounded in the physical world [Arias et al., 1997].

Much development of technology for learning and design builds on or is constrained by the "single user/single computer" interaction model. The EDC emphasizes the creation of shared interactionand the cultural embedding for learning and design within the context of communities of learners. Crucial processes relevant for social interaction which are supported by the EDC are:

- dealing with a set of possible worlds effectively (i.e., exploring design alternatives) to account for the design is an argumentative process, where we do not prove a point but we create an environment for a design dialog;
- using the symmetry of ignorance (i.e., that all involved stakeholders can contribute actively) as a source of power for mutual learning by providing all stakeholders with means to express their ideas and their concerns;

- incorporating an emerging design in a set of external memory structures, and recording the design process and the design rationale;
- creating modifiable models, which help us to create shared understanding, have a “conversation” with the artifacts created, and replace anticipation (of the consequences of our assumptions) by analysis;
- using the domain-orientation to bring tasks to the forefront and supporting human problem-domain communication ;
- increasing the “back-talk” of the artifacts with critics;
- using simulations to engage in “what-if” games.

The EDC is a contribution to create a new generation of collaborative domain-oriented design environments. It shifts the emphasis away from the computer screen as the focal point and creates an *immersive* environment in which stakeholders can incrementally create a shared understanding through collaborative design. It is an environment that is not restricted to the delivery of predigested information to individuals, but it provides opportunities and resources for design activities embedded in social debates and discussions in which *all* stakeholders can actively contribute rather than being confined to passive consumer roles.

Implications

From Consumers to Designers. Social interaction is impossible in communities in which most of their members regard themselves as consumers. Consumers must evolve into power-users and co-developers who use artifacts and at the same time modify and extend them. A strict separation between these two groups is undesirable and unproductive. One of the biggest potentials of information technology (which provides the potential to lead to another qualitative level of support for the collective, aided human mind; see Figure 3) is giving people the option to become designers by changing and enhancing a software system. Software, after all, as already indicated in its name, should be “soft.” One of the major contributions that information technology can lend to the world is to deeply understand and exploit the potential of the malleable nature of software.

Individuals acting as designers must acquire a *new mindset*—they are no longer passive receivers of knowledge, but instead are active researchers, constructors, and communicators of knowledge. Knowledge is no longer handed down from above, but instead is constructed collaboratively in the contexts of work. Empowering individuals with convivial tools is grounded in the fundamental belief that humans (albeit not all of them, not at all times, not in all contexts) want to be and act as designers [Fischer, 1998].

New Conceptualizations of the World Wide Web (WWW). Many people will argue that the most important new technology in support of social interaction is the WWW. The scope of this article does not allow to review all the new interesting developments (such as social filtering, recommender systems [Terveen et al., 1997], chat rooms, etc.). But in analogy to the argument made with the exponential growth of computational power (see Figure 2) the WWW is a necessary medium for new forms of social interaction, but not a sufficient one. For example, the WWW in its current form does not support evolutionary design.

Figure 8 describes three different models of the WWW. Most WWW-based use engages the WWW as a broadcast medium (Model M1) in which content is predetermined at design time and placed on static WWW pages. Most popular general-purpose WWW tools provide support for the easy generation of this static content. As a broadcast medium, the WWW serves as a distribution channel and provides few opportunities for designers to interact with the information because the content was not originally designed to be interactive. Responding to the need for feedback from consumers, many WWW sites are evolving into forms that augment content with some communication channels. *Broadcast with feedback* (Model M2) provides links from consumer to producer such as allowing learners to provide feedback and ask questions by filling out forms. Although users can react to information provided by the author, this presentation model provides little support for evolution.

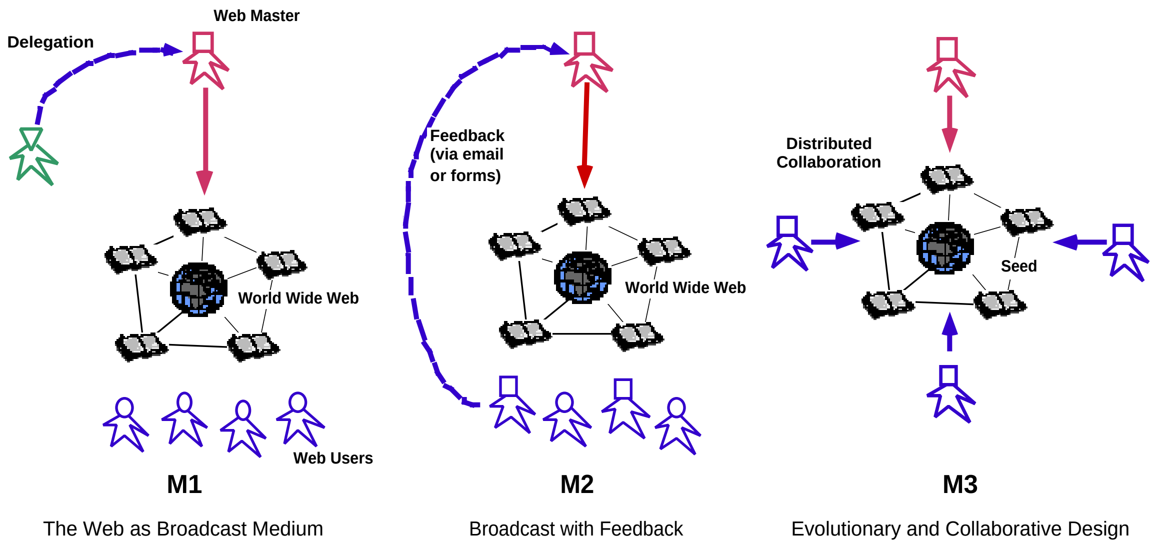

Figure 8: Making the World Wide Web a Medium for Collaborative, Evolutionary Design

To support social interaction, users need to be able to use the WWW to collaborate on projects by *actively* contributing and by learning from all contributors (Model M3). The evolution of content and ideas is now the responsibility of the participating community of practice, focusing on the distributed generation of content and the reflection upon it. When a wide variety of individuals collaborate in a cooperative forum, the unique skills of the members all become valuable resources in making the WWW resources useful in the current context. This model of the WWW poses a number of technical challenges, including the ability (1) to add to an information space without going through an intermediary, and (2) to modify the structure of the information space.

Decentralized Constructed Information Repositories. The M3 model is a useful framework for understanding the processes inherent in the development of *open systems* [Fischer & Scharff, 1998]. For example, the development of open-source software systems such as the Linux operation system [Raymond, 1998] provides an interesting example that reliable, useful, and usable complex systems can be built in a decentralized “Bazaar style” by many rather than in a centralized, “Cathedral style” by a few. The Linux development model treats users simultaneously as co-developers and designers [Fischer, 1998].

Open systems are examples of first steps illustrating the power of social interaction based on community participation. In addition to Linux there are other interesting examples:

- **Gamelan** (http://www.gamelan.com) is one of the first community repositories of Java-related information. The primary users of Gamelan are Java developers looking for information about what other people are doing with Java. Gamelan is a forum to facilitate the self-directed learning of members of the emerging Java community. The software developers who use the content are also the primary contributors, continuously adding new resources to the Gamelan repository. Gamelan was originally designed to be the official clearinghouse for all third-party uses of Java, and the site attempts to support any work that uses Java.
- The **Educational Object Economy** (http://www.eoe.org/) provides a more focused system than Gamelan. Currently realized as a collection of Java objects (mostly completed applets) designed specifically for education, the target users of the Educational Object Economy are

teachers (presumably acting as consumers of completed applets) wishing to use new interactive technology and instructional designers interested in producing educational software. The Educational Object Economy's primary goal is to provide educators with a collection of useful resources ready to be used to help students learn.

- The **Netscape Communicator** (http://www. mozilla.org/) allows the decentralized development of source code and supports the centralized integration.
- The **Agentsheets Behavior Exchange** (http://www.cs.colorado.edu/~l3d/systems/agentsheets/) is an initial prototype of a domain-specific system for sharing computational artifacts.

One important common feature of these systems is their support for evolution. As new knowledge becomes available, members of the community may share new developments with each other. In all four systems, the repository administrators set up an initial *seed* that structures how information is added, presented, and searched by users. The goal is to create useful information repositories in a decentralized fashion. Because all systems are envisioned as tools that evolve at the hands of a community of users, all four are prime candidates to study the challenges, strengths, and weaknesses of open systems and social interaction.

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Conclusions

Until recently, computational environments focused on the needs of individual users. As computers are being used for more complex tasks by more people, it becomes apparent that environments supporting social interaction among communities of practice, groups, and organizations are needed. However, this perspective does not necessitate the development of environments in which the interests of the group inevitably supersede those of the individual. Individuality makes a difference, and organizations get their strength to a large extent from the creativity and engagement of their individuals. One of the important challenges for the future is to gain a better understanding of the relationship between the individual and the social.

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Masanori: the terms below (and maybe a few more) could be put into a box/sidebar and the URL for Dynagloss should be given.

Cognitive Artifact: Cognitive artifacts are objects and environment that aid the human mind by complementing its abilities and by strengthening its mental powers. Domain-oriented design environments are part of a research agenda to identify and create unique possibilities for computational media as a cognitive artifact. Examples of cognitive artifacts are books, calculators, spelling correctors, and other computational tools.

Collaboratory: A Collaboratory is a new concept denoting the merging of "collaboration" and "laboratory".

Community of Practice: Communities of practice are groups of practitioners who work as a community in a certain domain. One objective of domain-oriented design environments is to support communities of practice through its domain-orientation which supports interaction at the level of the problem domain of the community of practice and not only on a compuational level. Virtual communities of practice are supported with web-based domain-oriented design environments and with systems such as the Behavior Exchange and Dynasites.

Domain-Oriented Design Environments : Domain-oriented design environments are computational media that allow people to be engaged in more authentic tasks in their work practices by allowing them to deal with domains, not to fight with tools. Domain-oriented design environments make computers invisible and enable users to communicate with the problem domain rather than with computer tools. They extend construction kits by supporting not just the design of an artifact, but the design of a "good" artifact by increasing the back-talk of an artifact using critics. They support reflection-in-action as a design methods. They are based on a multi-faceted architecture and they are designed and involved using the seeding, evolutionary growth, reseeding process model.

Evolutionary Design of (Complex) Systems: Based on empirical findings that successful systems (software systems, buildings, cities) evolve, a paradigm shift is needed which is based on the following requirements: software systems must evolve; they cannot be completely designed prior to use; they must evolve at the hands of the users and they must be designed for evolution. domain-oriented design environments , being based on the seeding, evolutionary growth, reseeding model, support evolutionary process at the architecture level, the domain, and the artifact level.