Web Technologies For Technology Transfer and Organizational Learning in a Production Environment

by
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Abstract

A study was carried out on the design and management of web tools for technology transfer and organizational learning in a high-tech production facility. Two large-scale web projects were carried out, and other web projects within the facility were benchmarked. The performance of these projects is analyzed and specific recommendations made for business groups attempting to build and manage large-scale, business-critical web sites. Further observations are made about the future implications of web technology for knowledge management and organizational learnings.

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TABLE OF CONTENTS

1. INTRODUCTION

Use of the World Wide Web as a business tool has expanded dramatically in recent years. The widespread availability of desktop PCs in business settings, linked via intranets and the Internet, has made possible a degree of business communication and information sharing which was unheard of just a few years ago. The technology of the web, furthermore, has made this sea of possibility manageable by regular business users. Users of web-based systems benefit from ease of use and short pathways to the information they need. Minimally trained workers can now make their information accessible company using web pages, and sophisticated designers can build productivity-enhancing tools rapidly and make them widely accessible to the rest of the company immediately.

But the transfer of information management to business groups and individuals presents new challenges. How can non-IT-professionals manage information effectively to serve themselves and other groups? How can individuals be encouraged to document learnings and knowledge in a way that is useful to groups which are disconnected from them in space or time? How can web-based tools help to grow business-relevant conversations?

This paper opens in Section 2 with a discussion of the economics and benefits of web-based technologies over previous generations of information technology. It describes the types of business situations which are especially ripe for web systems, and the array of technologies available to web designers today.

Section 3 turns to practical research carried out using web technology in a semiconductor manufacturing company. Two projects in which the author participated are described in detail, along with overviews of a variety of other web projects at the firm. Research here

and elsewhere suggests that many web-based systems fail to become effective business tools not because of technical or design flaws, but because their designers fail to allocate proper resources and to understand the organizational cultures in which the systems will be used. These failures, in turn, occur because the low cost of web tools suddenly shifts the burden of information system management to part-time information workers who lack experience in information management and customer service.

Section 4 attempts to analyze success and failure modes of a number of web projects at SemiCo and then to suggest a clear methodology for designing, resourcing, and growing a web-based information system in a business environment. Since numerous resources exist elsewhere on principles of layout, design, and programming of web systems, this work will confine itself to the key managerial and organizational issues which are less well understood but even more critical to project success. Section IV is targeted towards business groups (rather than IT professionals) looking to design and manage their own web sites.

Finally, Section 5 contemplates broader issues of information sharing and management which the web makes possible, and how the role of the business manager will change as a result. This section gives suggestions to managers on how to cultivate an environment in which knowledge is valued and shared, how to work with new kinds of support organizations, and how to spot new opportunities to use knowledge to increase business productivity.

2. WHY THE WEB: POTENTIAL IN BUSINESS ENVIRONMENTS

2.1. OVERVIEW OF INTRANETS AND THE WEB

Intranets are simply the use of internet technology to connect computers within a business enterprise. All computers within a company can be linked to each other, and then the intranet as a whole can be linked to the internet, allowing access to computers and information worldwide.

The web is a set of technologies for serving and displaying multimedia content via the internet using a software application known as a browser. Web "pages" organize multimedia, and contain hyperlinks to other information. Pages can provide a critical layer of conceptual structure which overlays data organization; information held on many different computers in different locations can be accessed from a single web page.

2.2. THE BUSINESS BENEFITS OF WEB TECHNOLOGY

Web technologies can dramatically reduce the costs of information systems and transform strategies for information management. Web systems are generally cheaper and less time-consuming to design and build, require much less training and technical expertise for content providers, and require less training and technical support for users. These benefits allow for information systems which are much more flexible and responsive to user needs than traditional systems are.

From the user's perspective, the web reduces the costs of training and of searching for desired information. Most content is delivered through only one application, the web browser, reducing the need to learn how to install and operate many applications. The

intuitive organization of web pages and hyperlinks, combined with effective search engines, allows a user to find quickly the information she wants even in a network of thousand (or millions) of computers.

For web site designers and content providers, the web greatly simplifies site design and management. Design of a simple web site containing business documents can take just days, or even hours. Even more complex, database-driven web applications can be built in days or weeks rather than months under older technologies. Web design tools have progressed tremendously, and creating web pages can be as easy as using a word processor. Numerous off-the-shelf web applications exist, from group schedule managers to document libraries, and can be installed and debugged quickly.

Because web systems are so much easier to design, build, and change, webmasters enjoy great flexibility in growing their sites. Rather than being locked in to an initial design, webmasters can constantly add content and restructure information based on user needs. This permits a new, customer-focused relationship between the content provider and the content user.

2.3. HIGH-PRIORITY OPPORTUNITIES FOR THE WEB IN BUSINESS SETTINGS

Because of the web's benefits as described above, certain specific situations lend themselves particularly well to the use of the web. These include scenarios in which:

- *The business group has active discussion and decision-making driven by breaking news.* All relevant information (plus the discussion itself) can be pulled together in one place, permitting the continuous, organized flow of key information and

debate. Because updating information on the web is so quick and easy, content can be refreshed often.

- *Information must be extremely reliable.* The low cost of maintaining information on the web makes it possible for generators of business information to organize and post it themselves, guaranteeing that the information found on the web is the freshest and most reliable available anywhere.

- *Many types and sources of information (especially across sites) are relevant to the business issue.* Even though information is generated by many different people and systems, it can be pulled together as one-stop shopping for information consumers.

- *The information, learnings, and decisions to be included in the information system might be of value to a greater audience than the business group is aware of.* If other employees can benefit from the business group's experience, perhaps elsewhere in time and space, they will be able to do so easily at no additional cost to the business group.

- *The information system must be deployed rapidly and at low cost.* Few other information systems can be deployed as rapidly as a web site.

2.4. TYPES OF WEB APPLICATIONS

A variety of web-based applications exist. Most business web sites in place today involve one or more of these types of content.

- *Search engines.* Search engines index the content of hundreds or thousands of web servers, allowing rapid searches for content based on keywords and concepts.

- *Document libraries.* One of the most useful tools for business groups, these libraries store and organize key business documents, including meeting minutes, schedules, technical documents, policy statements, or reference materials. They

are designed to make posting and editing of documents as easy as possible for content providers.

- *Database-driven applications.* Encompassing a huge family of information-intensive applications, database-driven applications are often extremely high value-added and can change workflow or increase productivity. They may pull together information from numerous different systems, analyze it based on user specifications, and present reports to users via the web. Examples of such applications include customer support files, employee databases, manufacturing information systems, and sales support systems.

- *Collaborative tools.* These applications allow users in different groups or regions to collaborate on business tasks. These include online meeting systems, document workspaces, and distributed design and CAD tools.

- *Newsgroups and discussion boards.* Structured like bulletin boards, these tools help users communicate by posting messages to one another in a public or private forum.

2.5. THE WEB AS PARADIGM SHIFT FOR INFORMATION MANAGEMENT AND OWNERSHIP

The economics of the web promise to have far-reaching implications for the overall management of information in organizations.

- Business groups or individuals taking on a greater role in building and managing information systems.

- Information system management by part-time content providers rather than full-time IT staff.

- New types of relationships between content providers and users.

These ideas will be articulated more fully in Section 5.

3. RESEARCH AT SEMICO

3.1. DESCRIPTION OF BUSINESS ENVIRONMENT AND CULTURE

As one of the world's leading manufacturers of microprocessors, SemiCo's success depends on producing high-quality processors in extremely high volumes. Historically, the company has seen its ability to produce, rather than market demand, as the bottleneck for revenue growth. This belief has resulted in an extreme focus on managing production process and yields to maximum benefit.

To support this, the company is designed for constant innovation in both product and manufacturing process. At the same time, the company is very explicit about the need to manage risk in its production process. Every production experiment is an opportunity to learn, but comes at the cost of lost production time and revenue in the short term. Improvements are always at the margin; potential innovations must be backed up with credible research and justifiable on a return-on-investment basis. Most innovations must be approved by formal committees before being rolled out to factories.

Complementing this cautiously innovative attitude is a focus on effective management of large production ramps. The ramp schedule is carefully managed to balance the need to perfect the process against the need to generate saleable product quickly.

The company places an extremely high value on communication and cooperation. People are brought together as needed to guarantee effective problem-solving and accountability. Many engineers, managers, and technicians are trained by assisting in production ramps at other sites before running a production ramp in their own. Numerous committees, both

functional and cross-functional, exist and meet frequently to make sure that all issues of production ramp are tackled and worked through. The combination of regular work and committee work keeps most employees very busy and time-constrained.

3.2. DESCRIPTION OF INFORMATION TECHNOLOGY ENVIRONMENT AT SEMICO

SemiCo uses computer-based information technology extensively throughout engineering and manufacturing. Broadly, the bulk of information infrastructure is handled by two organizations, the Information Technology department (IT) and the Automation department.

Automation is responsible for all systems directly related to the manufacturing floor. They manage manufacturing control and information systems, materials handling systems, factory floor terminals, and integration of production tools into the information network. IT, on the other hand, handles most systems and infrastructure outside of manufacturing: the company intranet, office PCs, office applications and electronic mail, and management information systems.

Both Automation and IT consist of central corporate entities and site-specific groups. In both cases, corporate mainly sets company-wide standards and policies, as well as carrying out research and development of new tools. The site-specific organizations handle installation and ongoing management of systems, and usually have some flexibility to offer additional services based on local needs. Custom design and programming services are usually part of the local menu.

Both IT and Automation focus on maintaining the systems for which they are responsible to an extremely high standard of reliability. Automation's systems are critical to

manufacturing production, and IT's intranet, email, and office applications are essential to engineering and management productivity. Because of the importance of these central missions, each group is reluctant to take on additional responsibilities which are seen as less than mission-critical.

Numerous organizations exist to develop customized information applications for specific departments. IT and Automation have groups which sell services including custom system design and implementation, file server setup and hardware maintenance services. Special independent groups (*business technology groups*, as detailed in Sections 4 and 5) also design leading-edge systems for management, engineering, and manufacturing. Finally, departments can contract outside firms to build custom systems.

At the opposite end, some business groups develop their own systems. A few engineering and manufacturing departments keep their own IT staff, but more frequently a full-time engineer develops the necessary expertise and builds tools and systems for his own group. The web is accelerating this trend, as the barriers to learning the necessary skills for system design and maintenance come down over time.

3.3. WEB USAGE AT SEMICO AND EXTERNAL BENCHMARKING

According to most measures, use of the web is growing rapidly at SemiCo. Most web sites are built by members of engineering groups who happen to have web design skills and perceive an opportunity to set up sites for their own groups. Recently, however, basic training in web design (which is available from the IT organization) has encouraged many employees, particularly administrative staff, to boost their skills and set up web pages. Web sites at SemiCo have focused on the rapid dissemination of information and the storage of key documents. Use of the web for two-way communication is at a very early stage.

As part of this study, research was conducted into uses of the web in production and non-production environments at other firms. SemiCo leads most manufacturing firms in the extent of its deployment of the web throughout non-factory areas; extensive web technology and support services are available at almost every desk outside the factory. In the factory itself, however, SemiCo lags behind many firms who have incorporated the web more fully into their factory-floor IT strategy.

Notable innovative uses of the web in the factory observed during benchmarking included the following:

- *Delivery of just-in-time training and reference information to the factory floor.* At an aerospace manufacturing firm, complex engine manufacturing procedures are captured in a highly visual multimedia format and delivered to web terminals located in assembly cells. This reduces overall training costs and helps to ensure that complex engines are assembled correctly. SemiCo's training organizations are moving to offer similar resources to their employees.

- *Factory floor integration with suppliers.* At a computer manufacturing company, terminals on the factory floor are tied in to an Extranet linking the factory directly with parts suppliers. Workers on the floor can reorder parts from an online catalog, or get reference and troubleshooting information online from a supplier database. SemiCo engineers are interested in organizing similar resources to speed their troubleshooting process.

Some of the most cutting-edge uses of the web for productivity enhancement are occurring outside of the production environment. Some of the notable examples include:

- *Sharing of knowledge between field sales personnel.* One large telecommunications company organized an online bulletin board through with its field reps can exchange information to help each other close sales. A rep having a hard time closing a sale can turn to other reps in real time for advice. As a result,

a sales organization which was plagued by negative rivalry has become a mutually supportive, focused team which shares leads and pricing strategies to increase sales yields.

- *Systematic storage of situational learnings.* The Center for Army Lessons Learned is a long-term program dedicated to capturing learnings from the Army's engagements worldwide. Volunteers in each engagement attempt to understand the full context and consequences of each decision made, and then write it down for extensive post-engagement analysis. Learnings are condensed into reports which are made available to Army personnel on the Web for consultation in future engagements.

3.4. WEB PROJECTS AT SEMICO

The following sections describe in detail two large-scale web projects in which the author participated.

3.4.1. PROJECT 1: WEB FOR INTERSITE TECHNOLOGY TRANSFER

Background

The first project undertaken for this study was the design and construction of a set of websites (TransferWeb) designed to support the transfer of a new production process from another facility to Facility A.

When a new process technology is introduced at SemiCo, it is first introduced in a development manufacturing facility, and then it is introduced to high-volume production facilities on a staggered basis; another high-volume facility starts up on the new process every few months.

SemiCo's goal is to start up each new facility at the same quality and yield levels at which the predecessor facilities are currently operating. Close cooperation and communications between facilities is critical for this process; since the manufacturing process is constantly being refined and improved, these learnings must immediately be communicated to all facilities to keep the whole system in step. A complex system of committees, face-to-face meetings, and agreements about responsibilities help to guarantee this transfer of knowledge.

The startup of the new process in Facility A was managed by a group of temporary organizations. A set of startup steering committees, each responsible for one aspect of the startup (such as Automation, Build, Install, and Technology), was formed. Each steering committee consisted of members from each functional department connected with that aspect of startup. All committees reported to a high-level Program steering committee which included plant managers, and coordination of all activities was supervised by a small staff of program managers.

The startup program manager perceived an opportunity to use the web to enhance communications between and within factories during startup. The manager's initial views to possible content of the web included:

- Steering committee minutes
- Project schedules and milestones
- Up-to-date news and status information about the startup process
- Key technical information

A web project leader was designated to explore opportunities, develop relationships with the steering committees to decide upon appropriate uses, and to carry out construction and management.

Facility B, which was designated to transfer the process technology to Facility A, also undertook an internal web site to manage its own startup process. The Facility A and Facility B web projects had no formal relationship.

Special Concerns

Several major concerns existed which had to be addressed. These included:

- *Security issues.* Because the startup process is considered highly sensitive information, and the manufacturing process itself is a company secret, it was necessary to ensure that effective information security would be in place, and that access to the web site would be granted only to appropriate staff. A further debate ensued as to whether the site should be available on a need-to-know basis or a more open basis.
- *Limited period of focus.* The site would only be relevant to Facility A staff during the immediate pre- and post-startup period, totaling approximately nine months. After that period, several months would remain before the next fab to receive the technology would have need for the archived information. As a result, some consideration had to be given as to which organization would maintain the site after startup.
- *Lack of web expertise on the part of the site users.* While some of the startup staff were familiar with use of the web, many had little or no experience. As a result, a significant amount of effort would have to be devoted to training, support, and building ease-of-use into the site design.

System Design

The webmaster decided to take an iterative approach to site design. Since the informational needs of the startup staff would change dramatically over the life of the site, it was expected that the site would be grown based on user demand, with at least one full-fledged site redesign after a few months.

The site was designed to be managed by a single full-time webmaster who would receive and post all content, and then to be gradually transitioned to a part-time webmaster who would manage access, with content posted directly by content owners.

Phase 1. Initial Design and Operation

Content. After a series of interviews with the heads of each steering committee, it was decided that the site would be organized initially with a web page devoted to each steering committee. Starting content included committee schedules, meeting minutes, and weekly reports. All content was sent to the webmaster on a weekly basis.

Design and layout. The webmaster also spent time improving the graphic design and layout of the site. Startup staff wanted a site that was crisp and easy to navigate, and the webmaster needed a format which would require minimal alteration when new content was posted. Procedures were developed for the rapid production of web graphics, updating of content, and structuring of files and directories.

Marketing. The webmaster made presentations to each steering committee to advertise the site and collect input about how the site might be expanded. The webmaster also made a pledge to help staff members learn how to use the web on a one-on-one basis.

Security features. A great deal of time was spent during this phase setting up and debugging security features for the site. Facility A's Information Technology department had only set up security maintenance systems for sites serving a few dozen users; since the startup site had to be made open to thousands of employees, the webmaster had to work with IT to accelerate the completion and debugging of appropriate security systems. This process took over a month, but once complete, all websites in the facility were able to benefit from the new security systems.

Customer service. The webmaster pledged to handle all technical support requests immediately. Most problems were related to security access, and were caused by inconsistencies in the company's employee databases and security systems. The webmaster worked with IT, IT's Technical Assistance Center, and the UNAC information security team to develop clear and efficient protocols for handling these failures.

Data collection. A variety of information was collected taken during this phase.

- Number of times each page in the site was accessed
- Time spent weekly on design, maintenance, content posting, and customer support
- Number and type of requests for technical support
- Number of requests to post new kinds of information
- Interviews with users and non-users

These measurements proved helpful in carrying out the redesign for Phase 2.

Phase 2. Redesign and Rapid Growth

Approximately one month before the startup date, it became clear that a site redesign would be necessary. Traffic to the site had been low during Phase 1, with each steering committee page receiving less than 20 hits per week. At the same time, requests had been pouring in about posting content relating to the first few weeks of startup. Program staff agreed that the site should be expanded using the following principles:

- Shifting of effort to pages which had received high traffic
- New pages built around key events, rather than around groups
- Emphasis on most-recent news and information, rather than past meeting minutes
- Daily, rather than weekly, updating of content
- Inclusion of technical help directly on the web pages

Content. Based on new conversations with the steering committees, approximately 20 documents were deemed critical to startup and would have to be updated daily or hourly. The 12 "owners" of these documents decided that the web would be the most efficient and reliable way to disseminate them. To eliminate the bottleneck of requiring the webmaster to post all documents, and the webmaster gave content owners direct access to the web server and trained them on how to post and update the documents. After training, owners could update a document in just a few seconds. Furthermore, some of the owners designated the web as "sole-source" for their documents, to stem the tide of direct calls and email requests.

Customer service. Based on the technical support data collected and the customer service protocols developed in Phase 1, the webmaster was able to make a service pledge that all customer problems could be solved in five minutes or less. This

pledge was widely marketed to make potential users more willing to use the web. In fact, 97% of problems were solved within the pledged five minutes.

Traffic. Site traffic began to ramp up dramatically in the week prior to startup. By the startup week, the site was receiving over 150 hits per day. This high level of traffic lasted for approximately three weeks—the critical period of startup.

Key Learnings

All in all, the transfer site was a success. Startup staff praised the ease of finding information, the reliability of information, and the quality of customer service. In addition, staff from startup efforts in other fabs sought to emulate Facility A's site in their own web efforts.

Several lessons emerged from the transfer site project.

- *Web usage is driven by business need.* Despite all efforts to include fun and useful information, or links to other resources, the use of the web site was ultimately driven only by having business-critical information available more readily than by other means.
- *Proactive design is valuable.* Deciding up-front what content is business-critical greatly simplifies the task of building the site and growing it effectively. Creating graphics and a design template allows new pages to be rolled out more rapidly and consistently.
- *Customer service must be consistent and readily available.* Since users are often both time-constrained and technology-averse, having poor technical support can rapidly drive them away. Interviews indicated that most users would try for no more than 20-30 minutes to get to the information they need before abandoning

the effort. When asked how long they thought a typical technical support call to IT would take, users on average estimated 1-2 hours. Promising that service calls will be handled quickly thus can have a very large impact on user retention. Finally, heading off customer problems with clear instructions right on the website can have a huge impact on effectiveness.

- *Document and access management need to be improved.* For webmasters and content owners, document management and access management are the greatest time sink. Access management for this site of several hundred users took 10-20 person-hours per week; this time requirement drops as the security systems are debugged. Document management took 20-40 person-hours per week; since documents constitute 70-100% of the content of most business web sites, streamlining the process of posting and updating content will greatly reduce the time demands of the web. Many software packages make this possible.

3.4.2. PROJECT 2: WEB FOR INTRASITE MANUFACTURING COMMUNICATION

Background

The first project undertaken for this study was the design and construction of a set of websites (FabWeb) designed to support intrasite communications on the factory floor, primarily between different shifts in the same work area.

Historically, use of the web was prohibited on the factory floor in most SemiCo sites. Factory managers viewed the web as a distraction from real work, with no business value. A series of bad experiences with abuse of the web (including downloading of pornographic materials to office computers) had further soured managers on bringing the web to the floor without a compelling business need.

Despite these concerns, staff from manufacturing, training, Organizational Development, and Automation saw potential to use the web to improve cooperation between shifts and tighten communications between management and floor technicians. After months of lobbying, Facility A received permission to move forward with a pilot to explore uses of the web on the factory floor. A cross-functional team was formed to design and implement the three-month pilot, and then to return with recommendations to management.

The pilot also dovetailed with an earlier effort in the factory called Module Teams. In that project, groups of technicians in the same functional area underwent team-building activities and then built a web page for the team, where they could post meeting minutes and inspirational content. Module Teams had been suspended several months earlier due to lack of resources, but the factory pilot team leader sought to reintroduce Module Teams as a driving application for the web.

Special concerns

- *Unlimited time frame.* Unlike the transfer website, this site was designed potentially to last indefinitely, as an ongoing communications tool.
- *Uncertainty about user expertise with web.* While the level of expertise in the engineering ranks was fairly well-known, the expertise of the factory technicians was much more unclear. It was expected that more training and technical support would be necessary.
- *Less communicative environment in general.* Communication and collaboration between engineering groups tended to be very frequent, formalized, and friendly. In the factory, however, communication between shifts and functional areas was much less structured. Rivalries often existed between shifts. Manufacturing

managers had fairly free rein on how to manage operations on their shifts, and their learnings were not always shared.

- *Users extremely time-constrained.* Because moving product through the factory was perceived as the most critical bottleneck to generating revenue for the company, workers were under strong pressure not to lose production time. Any time for reflection and improvement was thus often relegated to off-shift time.

System design

Content. Content on the site was of several forms, each managed by a different party.

- *Main home pages.* These pages, designed by the pilot team, linked together all of the resources which might be of interest to technicians, including those below.
- *Department pages.* These were pages created by support departments such as safety and training, and which offered useful job-related information to all technicians. These pages were managed entirely by the departments themselves.
- *Newsfeeds.* These were designed to display daily or weekly announcements from manufacturing managers. Manufacturing managers could update these announcements through the web in seconds by filling out a simple onscreen form.
- *Module team pages.* As described above, these pages were created by teams of technicians in each functional area and contained area-specific information and announcements. These pages were managed entirely by the teams themselves.
- *Newsgroups.* These were intended to be the crux of the communications component of the site—a bulletin-board system where users on different shifts could post discussions, questions, and answers to one another.

Training. The pilot staff personally provided web training to the technicians involved in the pilot. Each technician took a two-hour training class on using the site;

technicians interested in learning web design were offered the opportunity for further training by the IT department.

Implementation problems

The pilot was plagued by problems from the beginning.

- *Access problems.* First, because of time constraints in the Automation group, the web was installed on factory terminals at a much slower rate than was originally planned. As a result, technicians sometimes had to spend 20 minutes just searching for a web-equipped terminal. Second, the web browsers performed very poorly on the terminals, and individual web pages often took several minutes to load. Automation had not budgeted enough time to solve these problems. These factors combined to make the time cost of using the web prohibitive to most technicians.

- *Lack of defined business objectives.* The pilot staff spread their efforts over a wide range of content, and never defined critical business objectives or key business tools which would be the "killer applications" for the pilot website.

- *Lack of adequate human resources.* All of the pilot staff were involved in the project on an informal, part-time basis; therefore, no one was completely accountable for the success of the project. Long-term resource needs were not estimated up front, and web design alone quickly ballooned beyond available staff time.

Ultimately, the pilot fell apart. When access problems began to make themselves felt, the team quickly dissolved because no one could put in the extra time to make it work. The Automation and Organizational Development departments, who had initially spearheaded the entire web effort (and who possessed all of the technical expertise on the project), grew frustrated and turned their attention towards other projects. The other members of the pilot team, now lacking their technical partners, had to drop the initiative.

Despite the dissolution of the project, there remained a strong demand from technicians to develop the web as a factory tool.

Key learnings

Two important learnings emerged from this pilot process:

- *The business goals of a web site must be well-defined up front.* Content providers and web managers need clarity of business goals in order to focus their development efforts. Web users must perceive a compelling business purpose to take the time to use the web. Without these business goals in mind, the effort will become diffuse and irrelevant.
- *Building conversation is done by people, not by technology.* The pilot team had a strong belief that if newsgroup technology was made available on the website, then a quality business conversation would grow spontaneously. Despite numerous examples to the contrary, the team failed to think about how to build communication and conversation at the human level.
- *Access must be guaranteed to users of the system.* The pilot team failed to provide realistic access to the users of the site. The scarcity and slowness of the designated terminals made it impossible for a critical mass of technicians to use the site.

3.4.3. OTHER NOTABLE WEB PROJECTS AT SEMICO

The following projects are examples of effective sites currently in use by business groups within SemiCo. These descriptions are based on extensive interviews with webmasters, designers, and users of each project.

INSTALL

Business description. SemiCo's Install/Qualification (INSTALL) is a business group which handles the installation and qualification of production equipment in SemiCo factories worldwide. With over 900 SemiCo employees, plus outside contractors, INSTALL is one of the company's largest global business groups.

Effective coordination of activities and adherence to strict time schedules is essential to the organization's performance. New best practices and approved procedures which are developed at one site must also be rapidly disseminated to all locations to be used in subsequent installations.

To aid in the management and dissemination of critical documents, and to prevent problems of delayed or conflicting information flows, INSTALL sought to create its own web site. The INSTALL website, also known as INSTALLWeb, which has become one of the most successful at SemiCo, is designed to be a central source for critical business documents for the INSTALL organization worldwide.

Development process. INSTALL took a proactive approach to designing its web system. A cross-functional team was formed which included representatives from all of INSTALL's departments and sites, as well as members from SemiCo's Manufacturing Strategic Support (MSS) group, a group dedicated to the design of innovative web tools for manufacturing organizations. This team worked for six months to develop a structured pilot and rollout plan for the following year.

Content. The INSTALL team laid out a list of critical documents which each department would be responsible for contributing to the web and maintaining on an ongoing basis.

After this initial determination, departments could add content as they saw fit provided that they pledged to keep it properly updated.

Management and staffing. INSTALLWeb was initially staffed fully by INSTALL engineers who volunteered to work on the web on a part-time basis. An engineer from each department managed a web page for that department.

As the site grew, duties were split between web design and content management. Designers were responsible for laying out web pages, posting documents, and performing redesigns as content demanded; each designer supported multiple web pages. Content owners, on the other hand, were responsible only for providing and updating documents for the single web page pertinent to their department. Content owners continued to be only part-time, but designers' roles gradually grew until they became full-time or near-full-time staff for INSTALLWeb.

Programming support was provided initially by MSS, but gradually full-time programming staff were added to the INSTALLWeb team so that routine web programming could be carried out in-house.

Special solutions. INSTALLWeb developed a number of solutions to their particular challenges.

- *Template generator.* To speed the process of designing new pages, INSTALLWeb and MSS designed a template generator. This tool could generate new pages in seconds which included all of the INSTALLWeb graphics, scripts, and directory structure and which adhered to the general INSTALLWeb standards.

Web designers simply had to include the custom text and document content to drop in to the page.

- *Private access system.* Since INSTALLWeb had to operate at all SemiCo site, and SemiCo's main IT organization used different security software for each site, INSTALLWeb decided to set up its own security software and standards to be used systemwide. New users who wanted access to INSTALLWeb materials had to submit an application to the central INSTALLWeb staff for approval.

- *Web developers group.* As the number of INSTALLWeb designers and content managers rapidly grew to several dozen part-time people, INSTALLWeb set up a web developer's group. This group met on a regular basis to share learnings, discuss problems, and propose improvements to the INSTALLWeb system.

Learnings. The INSTALLWeb manager described several important learnings which emerged during the course of their work.

- *Need for marketing.* Once the system was operating well, INSTALLWeb staff had to allocate time to demonstrate the new system personally to business group managers and potential users at each site. This marketing process helped to build enthusiasm and overcome management resistance. This process continued for over a year, and momentum built substantially over this time.

- *Need for sole-source designation.* Despite the presence of INSTALLWeb, many business group personnel persisted in using traditional channels to get the documents they needed, continuing the problem of document confusion and delay which INSTALLWeb was designed to solve. To stem this tide, INSTALLWeb gradually pushed for management to declare that the INSTALLWeb would be the sole official source for all business documents within its scope.

Thanks to these efforts, after 18 months INSTALLWeb became accepted as "the way business is done" in the INSTALL organization.

Facility C KSN

Business description. Facility C is one of SemiCo's manufacturing sites. Facility C faced the loss of a large percentage of its staff, who were being redeployed to a newer factory. Fab managers believed that the sudden loss of expertise could be detrimental to their productivity.

To prevent the sudden drain of expertise, Facility C sought to capture some of its staff knowledge in a Knowledge Sharing Network. Facility C worked with the Manufacturing Strategic Support group to construct a system in which process and operations knowledge could be captured in a rich, contextualized form. Remaining Facility C workers could then search this database to find answers to technical questions arising in the future.

PCCB

Business description. The Process Change Control Board is the committee responsible for approving any changes to the manufacturing process. One of the PCCB's critical documents is the white paper, a document detailing a process change along with the experimental research making the case for that change. PCCB sought to create a website for the storage and archival of all white papers.

Development process. PCCB staff worked with a local Automation group to develop a document library system. This system makes it easy to upload documents quickly without special training. A search engine also allows searches of white papers by keyword.

Management and staffing. The PCCB website was managed on a part-time basis by two engineers. These engineers handled both design and the uploading of documents into the library.

Sort

Business description. SemiCo Sort is a business group dedicated to managing the sort phase of the manufacturing process in all SemiCo fabs. Sort's success depends on the successful coordination of sort activities across all sites, including the dynamic allocation of product between sites for processing.

Content. The Sort family of sites includes a central document database containing critical documents relevant to all sites. In addition, a variety of local sites contain documents, schedules, and project status of local interest only.

Management and staffing. The Sort web site is actually a family of web sites, each built independently by a single sort engineer on a part-time basis. Each site was and continues to be managed separately, though eventually a central page was created to link all Sort sites worldwide.

Special solutions. To make document management much easier for content owners, a Sort engineer custom-programmed a set of file management tools. These tools allowed documents to be downloaded, edited, and uploaded via the web in seconds and with no training required for content owners.

Springboard

Business description. Numerous business groups participate in the production, sale, and delivery of SemiCo products. These groups include manufacturing, marketing, sales, and distribution. Managers of all of these groups need up-to-date status information in order to make sure that they coordinate efforts and manage the pipeline effectively.

Springboard was designed to pull together current status information from all parts of the enterprise to give managers the information they need to make decisions. Rather than having to track and integrate information from different parts of the company, managers could now look at a single web site to get an integrated picture of production and order fulfillment.

Content. Springboard contained information feeds from a variety of existing information systems in manufacturing, marketing, and sales. Springboard designers could create customized pages which integrated and analyzed this information and displayed charts and reports for decision support.

Management and staffing. Springboard was designed by a special arm of the IT department. A staff of full-time programmers and IT consultants managed the system, and worked closely with business groups to develop reports of interest to managers.

4. OPERATIONAL LEARNINGS AND STRATEGIES FOR DESIGN AND MANAGEMENT

Based on our internal case studies, interviews with web managers throughout SemiCo, and a review of the literature, we now attempt to present an integrated methodology for designing and managing a web-based information system. This section is targeted

towards business groups looking to design and manage their own web sites. This methodology is applicable to web systems of any scale, be it a few pages managed by a single person or a large-scale site involving dozens of content owners.

Our methodology focuses on the managerial and organizational aspects of web management; readers interested in web page layout and design principles are referred to the excellent literature on the subject. The methodology is organized as follows:

- Defining the business purpose
- Justifying the investment
- Building buy-in and creating the culture
- Resource estimation and allocation
- Staff management and development
- Design and redesign
- Supporting and growing the user community
- Investing in special technologies
- Interfacing with support organizations

4.1. DEFINING THE BUSINESS PURPOSE

Our research indicates that a frequent reason for the failure of web sites is a lack of a well-defined business purpose. The web site must solve at least one business problem significantly better than the existing information mechanisms. Developing a clear business purpose helps content owners prioritize their efforts, and give users a compelling reason to keep coming back to the site.

Several key questions should be answered as a result of this thought process:

- *What is the compelling customer need?* How, specifically, will this system help people do their jobs better? Will it result in significant savings of time or money? Will it reduce error or improve quality performance? Site planners should be able to point to quantifiable job benefits for users. INSTALLWeb tackled this evaluation very early in the process.

- *Why is a web-based solution better than the alternatives?* Many web sites are constructed to serve needs which are already served adequately by alternative means. If an issue is already easily handled by phone, email, face-to-face meetings, or other information systems, then the web may add unnecessary overhead.

- *Who is the target audience?* The choice of audience has strong implications for how the system will be designed, marketed, and resourced. What population is this site designed to serve initially? Who else might benefit from this information in the future?

- *What is the critical content that must be made available on the web site?* Research indicates that 80% of the usage of a website is driven by 20% of its content. Which documents, information, or applications are most critical to accomplishing our business purposes? How can we ensure that this critical content is always fresh and reliable? TransferWeb and INSTALLWeb both tackled these questions effectively, yielding sites that were effective from day one. FabWeb, in contrast, did not consider these issues from a business standpoint and the site consequently received little usage.

- *What organizations must participate in this project for it to be successful?* Any organizations which will be key content providers or users should be included in the planning process to guarantee the quality and effectiveness of the system.

This checklist of questions, while relatively straightforward, is often neglected in web system planning.

4.2. JUSTIFYING THE INVESTMENT

Since creating a web system is almost certainly a significant investment of someone's time, energy, and money, some sort of justification of return-on-investment (ROI) eventually is required.

A number of frameworks have been developed for evaluating the ROI of information systems. These have historically proven difficult to apply to many web-based information systems because of their often ad-hoc nature and the great deal of uncertainty in evaluating their impact. Managers of large web systems at SemiCo have reported that this is one of the most difficult parts of getting their projects off the ground, but groups that have gone to the trouble (such as INSTALLWeb) have found it to be very effective in building buy-in from management early.

A rough framework for describing the impact of information on the bottom line is described below. As can be seen from the framework, the value of information must be determined indirectly. A new information system can be evaluated relative to existing systems in terms of its direct impact on the following variables:

Benefits

- *Reduced information delay.* Using the web can reduce the delay of information flow from provider to user to minutes rather than hours or days through other mechanisms. Tying web pages directly in to other information systems can further reduce this time. This benefit, if it exists, is generally easy to quantify.

Information delay was a compelling value behind the creation of TransferWeb, where information delays had measurable impacts on startup production.

- *Reduced search costs.* A key advantage of a website is often that it reduces the time spent by users to locate critical pieces of information. This cost reduction can be particularly substantial when 1) the user does not know who the content provider is (as often happens in large or global organizations) or 2) when the critical piece of information is buried in a sea of information. Well-structured sites can reduce search times from hours to minutes. This benefit drove the creation of INSTALLWeb, enabling users to find procedural information across many sites.

- *Increased information reliability.* Web systems can often cut out middlemen in the flow of information from the source to the user. Whether the source is a person creating the content and posting it to the web, or an automated information system feeding information to a web page, the information follows a fast and direct path, reducing the chance of errors in translation. This benefit was another driver for TransferWeb, which wanted to avoid misinformation in the confusion of startup.

- *New types of information.* Web sites, like any other information system, can deliver previously unavailable information to users, improving decision-making. This is perhaps the most difficult type of benefit to quantify. Factory C KSN, for example, was designed to give engineers access to the knowledge of former employees.

Costs

The following costs are the most significant drivers of the lifetime cost of a site. A detailed process for estimating these costs is described in Section 4.4, "Resource Estimation and Allocation".

- *System development cost.* This is the most obvious cost in both money and time. It includes design, programming, and hardware and software purchases.
- *System management cost.* This is the time cost of non-content-related services, such as technical support, ongoing redesign and programming, marketing, and maintenance. This cost may be substantial, as web sites are generally run by the business groups themselves.
- *Content management costs.* This is the increased time cost to content managers of creating and updating content for the web site. In many cases, this can actually be a net benefit rather than a net cost; many web sites are built by individuals because the costs of serving user requests via other channels (such as phone, email or mail) becomes too high.

Even though a web system may offer a variety of potential benefits, many webmasters find it beneficial to focus on the one or two which are either most likely to occur or most quantifiable. In a high-pressure production environment like SemiCo, even a net savings of a few hundred person-hours per month or the demonstrable prevention of a few production errors can easily justify the cost of a web site.

4.3. BUILDING BUY-IN AND CREATING THE CULTURE

The distributed nature of web site management demands a new level of commitment from participating business groups. Under traditional IT models, business groups often contracted a third party to handle system design, implementation, and management. Using the web, many of these duties now come in-house. This means that organizations must commit themselves (and their employees) to providing adequate resources to maintain the system in the long-term.

Furthermore, because the web is a fairly young medium in business environments, the process of building buy-in often must also overcome employees' aversion to new

technologies and negative impressions about the web. Management must often be convinced that a web site is a true business tool, rather than a distracting toy. Finally, the success of the web as a communications tool is often intricately tied to the existing communications culture in the organization.

Important issues for building the necessary commitment to a web project include:

- *Understanding the existing communications culture.* What individuals or groups do we want to communicate or collaborate using the web? How do they do so already? Are they enthusiastic about communication, or are there reasons that they are resistant to it (competition, rivalry, antagonism)? What do we have to do *organizationally* to overcome these hurdles?

- *Securing management buy-in.* If management does not see the web site as important, it becomes difficult to convince employees that it is important. Furthermore, without management commitment, resources for a web project can be cut at any time. Cultivating management commitment is essential to the long-term health of the project, and can do a great deal to build the credibility (and in some cases, enforce usage of) the system. INSTALLWeb, for instance, devoted a great deal of time over a period of a year to introduce managers to the web personally, building strong commitment.

- *Early participation by involved parties to agree upon business purposes.* As described above, early participation by content providers and users helps to define effective business goals and make sure that the system reflects the needs and interests of all involved. FabWeb included many key parties, but did not include any of the technicians it was being designed to serve, and thus missed many of their needs.

- *Sharing responsibilities as well as benefits.* Because content providers often are posting information as a benefit to others rather than themselves, it is appropriate to expect content users as well to share in the costs and responsibilities of

supporting the site. This also serves to foster a sense of mutual aid between organizations. Issues around this sharing are described in detail in Section 5.

- *Setting sole-source expectations.* If the web is designed to supplant other means of obtaining information, it can be helpful to cut off those other means once the web is in place. Designating the web site as the sole-source for critical business content helps to build traffic rapidly and to accelerate the improvement of the web site as a tool. INSTALLWeb and TransferWeb used this strategy for much content, thereby accelerating the shift of users to the web.

4.4. RESOURCE ESTIMATION AND ALLOCATION

Perhaps the greatest threat to the long-term survival of web projects is the failure to estimate resource requirements and obtain firm commitments for those resources up-front. As usage of the site grows, site staff are unable to keep up with demands to update site content, to offer technical support, or to expand the site according to customer needs. Even when the site is not in a state of rapid growth, other job demands of part-time web staff end up cutting into site work, which almost always has lower priority. FabWeb quickly ran into difficulties because the workload had not been estimated well; but even INSTALLWeb, which invested a lot of time up front to estimate resource loads, found itself having to recalibrate its estimates after a few months of operation.

Like most projects, the resource requirements for web projects are usually underestimated by a wide margin. Resource estimation for web projects can be difficult for a variety of reasons, including:

- Rapid, often unpredictable growth in the user base
- Constantly changing content
- Rapid changes in web technology

During the growth of a site, the composition of work can change rather dramatically. As in the experience of TransferWeb, customer service requirements may surge early and then die down to a steady-state value. Time spent updating content may rise or fall over time depending on the nature of the site's content.

Fortunately, reliable estimates of required resources for a site can be made based on past experience and a small amount of empirical data. We will outline a growth model and some quick heuristics for resourcing a web site.

The key resource factors are divided here into those which vary with size of the user base, those which vary with volume of content, and those which are independent of both. Under each factor are the key driving variables. These variables should be estimated initially, and then the estimates should be revised based on experience during the first few weeks of the site's operation.

Factors which do not vary with size or content

Application development. This is based on the particular application being constructed. This estimate is best provided by knowledgeable programmers doing such work.

Hardware and software support. This includes time spent setting up equipment, installing software, backing up files, and troubleshooting overall systems failures. This can take several hours per week, and is best estimated by knowledgeable webmasters.

Factors which vary with amount of content

Page design. **Weekly page design time = number of new pages * time to design pages**

- *Number of new pages.* This number will generally surge during the initial growth of the site, and then level out over time. Small sites may include only 1-3 pages and never add new ones, while large ones may include several dozen pages and add pages on a regular basis.
- *Time to design pages.* This time varies with designer experience, page complexity, and design tools used. It can be as much as a few hours for an inexperienced designer, or as little as a half-hour for a moderately experienced designer working from a design template.

Content management. **Weekly content mgmt time = number of documents * frequency of updating * time required to update**

- *Number of documents.* Once again, this is generally fairly well defined by the initial site design, but can be expected to grow over time.
- *Frequency of updating.* This depends on the specific document, and may range from several times per day to once every few months.
- *Time required to update content.* This includes all time spent by the content manager to update and repost documents to the site. This can range from a few minutes to a few hours.

Factors which vary with size of user base

Access management. **Weekly access mgmt time = rate of user introduction * (time to setup access + initial training time)**

- *Rate of user introduction.* This can vary dramatically from week to week, but is typically loaded towards the early part of a site's life.
- *Time to setup access.* This includes the total time required by site staff per user to bring a user into the site. If the access process is complex, requiring extensive authentication and permission, this may take hours per user; simpler processes can take just a few minutes.
- *Initial training time.* This includes any personal training that must be provided to users. If users are taught in classes, this will be minimal; one-on-one training may take hours per user.

Technical support. **Weekly tech support time = total number of users * rate of tech support calls * avg time to solve problems**

- *Total number of users.* This will presumably grow over time, ramping up to a maximum number of potential users which can be estimated.
- *Rate of technical support calls.* This is very difficult to estimate up front, but is related to the complexity of the web site and the technical sophistication of the user base. Reliable estimates can be made after a short period of use, and the rate generally drops over time as users become more familiar with the system. TransferWeb, for example, found that approximately 20% users required technical support in the first two months of the site's operation, but this number quickly dwindled to 5%.

- *Average time to solve problems.* This is also difficult to estimate up front, but can be estimated over time. This typically drops quickly as procedures for solving common problems become established; TransferWeb's average service time dropped from 20 minutes to 5 minutes per call over a two-month period.

Discussion management. **Weekly discussion mgmt time = number of postings per week * filtering time per posting**

- *Number of postings per week.* This can grow rapidly and is related to the size of the user base.
- *Filtering time per posting.* This is generally 1-2 minutes per posting.

Interactions between amount of content and size of user base

Content growth and user base growth can be a reinforcing loop. As the quantity and quality of web content grows, new users are attracted to the site and existing users visit the site more frequently. As more users visit, they provide ideas (and often demands) for even more content. Ultimately, however, content can become too much for web staff to manage effectively.

At the same time, growth in the user base places greater demands on web staff, stretching technical support resources and taking time away from content management and growth. As content becomes neglected and technical support becomes spotty, users become disgruntled and leave.

Thus the fundamental challenge for webmasters becomes how to balance user base growth and content growth against available technical support and content management resources.

4.5. STAFF MANAGEMENT AND DEVELOPMENT

Many managers of large web sites cite the need for developing and supporting web staff. Initial construction of a site is usually carried out by members of the community who already possess the technical skills to design, build, and manage the site. However, as the family of participants grows, new content owners and site managers must often be trained and supported to do their parts effectively. This can become a severe constraint to the growth rate of a web site.

In addition, many part-time content providers join a project without a clear expectation of the time commitments required. As their normal (non-web) workload fluctuates, or as site management demands grow, they often become unable to meet the requirements of both. As a result, their supervisors call them back to their regular work, and the web content they manage grows outdated and undermines the value of the site.

The issues of staff management and development which must be addressed fall into the following areas:

- *Dividing duties.* Large-scale web sites often find it convenient to separate responsibilities into system design, content management, and system management/technical support. All sites researched here eventually turned to this strategy.
- *Making time commitments of staff explicit.* Making clear in advance the time requirements, as well as providing a sense of how these requirements may change over time, helps part-time staff to make an informed commitment to the site. The resource model described above can be very helpful in doing this.

- *Investing in tools to reduce workload.* The page design process can be greatly streamlined by providing web-page templates to designers. Customer service and technical support can be improved by writing troubleshooting checklists and protocols. Document management can be improved by creating interfaces to speed document uploading, editing, and archiving. For example, INSTALLWeb's design templates greatly accelerated the design process for staff, and the PCCB website used document management tools eliminate the hassles of posting content.

- *Securing agreement from staff's regular supervisors.* If an employee's regular supervisors agree that his web duties are an integral, rather than a peripheral, part of his job, then the employee can be recognized and incentivized for good web service and is less likely to be pulled away to other competing tasks.

- *Coverage of training needs.* Training should be made available to web developers as needed. SemiCo IT, for instance, offers free website design classes on a regular basis.

- *Support network of web developers.* As in any other professional activity, web staff can benefit tremendously from tapping into a network of other web developers. This allows sharing of best practices and coordinated lobbying to gain support resources from elsewhere in the company. INSTALLWeb used such a network for its staff, with much success.

4.6. DESIGN AND REDESIGN

Web sites frequently undergo redesign, many as often as several times per year. Because the cost of modifying a web site is relatively low, site designers have a strong incentive to make changes frequently based on customer needs and requests, or when new web technologies become available. Redesign thus becomes an essential part of keeping a web site highly customer-focused.

Web sites are often constructed on an ad-hoc basis in the hope that true customer needs will emerge spontaneously, and that more extensive effort will be put into designing the site based on the resulting information. Testimonials from web managers suggest, however, that this approach is rarely effective.

Customers have little patience with a site that is either designed poorly or which does not contain compelling content at the first visit. A negative first experience can deter customers from ever returning, even if the site is rebuilt well at a later time. Furthermore, a weak site does little to stimulate the customer's creativity about new information and features they would like to see.

We recommend a phased-design approach, in which each phase is well-designed and based on the content which is most likely to have high business value. We recommend a narrower focus on high-value content rather than a broad, speculative focus on a wide variety of content. Finally, we describe how to set up feedback systems and build in resources for responsive growth.

Phase 1: Initial site design

The initial site design often serves as a pilot or proof-of-concept. Because of this, it is often highly scrutinized, but at the same time must struggle to win an initial base of users.

- *Including critical content at opening.* Once again, users must have a solid business reason to come to the site. Some of the content deemed critical in the business purpose definition phase should be available on the site the day it is activated. If none of the critical content is available when the site opens, the site may alienate its customers.

- *Multiplatform testing.* If the potential user base is running a variety of systems or web browsers, testing and debugging of the site on most of these platforms should occur before the site goes live. Customers have little patience for poor color schemes, bad layout, or scripts that won't work on their machines.

- *High customer service levels.* Customer service is critically important in the first phase of the site for several reasons. First, particularly good or bad customer service can rapidly affect the site's reputation and the willingness of potential customers to try the site. Second, highly responsive customer service is the best way to obtain information on how to debug and grow the site. TransferWeb's 5-minute service pledge, for example, was key to bringing users to the site.

- *Data collection mechanisms.* Mechanisms must be put in place to measure site content usage and management requirements. Many sites only place hit counters on the front page of the site; in fact, counters should be placed on every page (and on individual documents if possible) in order to gauge usage of each area. In addition, the user should have a way (email link or phone number) to give instant feedback to the site managers. Finally, site managers should do their best to keep track of technical service problems and time expenditures on site management tasks. All of this information serves to make the Phase 2 site redesign highly effective.

Phase 2 and ongoing: Site redesign

Redesign can be as simple as the incremental addition of a new page to an existing site, or as complex as a complete restructuring of content and layout. Here, we will take redesign to refer to a rebuilding of the site which requires substantial one-time effort.

Based on the experience during the first few weeks (or months) of operating the site, enough information should be available to do an effective major redesign of the site. Redesign should focus on making the site easier both to use and manage, and on bringing in new content which users have demanded.

Redesign tasks typically fall into the following categories:

- *Unifying content under common template; setting standards.* Standards can be set for page design, layout, and management. Templates can be created to speed the construction of future pages.

- *Prioritizing valuable content and pruning away unused content.* Content which is used most frequently should be made available in fewer mouse clicks than less-requested content. Conceptual structure might be changed to more intuitive categories (for example, the shift from organization-based pages to event-based pages in TransferWeb). Content which proves to be of little interest can be removed, reducing website clutter and inefficiency.

- *Improving attractiveness.* Once the content and structure is well-defined, graphic design and visual impact can be improved to enhance the user experience and professional image of the site. Artists and designers might be brought in at this point.

- *Incorporating the most valuable content requests.* Major new additions of content can be incorporated at this time. New tools requiring special programming, or expansions to the site requiring significant development, can be built at this stage.

- *Setting up long-term resource needs.* Based on the data collected in the first phase of the site, much more accurate time and resource requirements can be estimated. The relationship with content owners can be reevaluated and renegotiated.

- *Revising customer support procedures.* Customer support protocols and help instructions can be expanded and revised based on knowledge gained in the first phase.

- *Switching to new technology.* Since web technology changes so rapidly, substantial advances in tools can occur during the first phase of the site. The redesign is an excellent time to switch to the latest web design or management tools.

4.7. SUPPORTING AND GROWING THE USER COMMUNITY

In business web sites, the web staff have to take on the responsibility of enhancing the user's experience and growing the user base. Users can be thought of as moving through a pipeline, from being potential users, to being actual users, to being former users (once their needs are satisfied or they grow frustrated and leave). This section details the critical efforts required to get users into the site and to keep them coming back for more.

Getting users

Getting users into the site for the first time is a delicate process. Success can be achieved by:

- *Including compelling content.* As has been described earlier, the most important draw for a web site is to have compelling business content which is more accessible via the site than through any other means.
- *Inviting users to the site the first time.* A site must be publicized effectively through formal or informal channels. Presentations (and preferably demonstrations) to key user groups build interest and reduce fear. Incentives, prizes, or gimmicks such as "stock ticker" applets may also help in bringing users to a site for the first time. Once the user has come to the site, a well-designed site will be inviting and relevant from the first page onwards. SemiCo sites have used posters, giveaway magnets, and fun themes to bring users in.

- *Reducing barriers to entry and guaranteeing access.* Lack of familiarity with web technology and perceived difficulty in getting into the site are some of the greatest barriers to using a site. Web staff may have to go to unusual lengths to make users comfortable, including offering classes or spending time with key new users on a one-on-one basis. The front page should have clear instructions as to what useful information is contained in the site, as well as how to use the site and how to deal with any security mechanisms or required permissions. Any processes to get access permissions or security passwords should be made as quick, painless, and unintrusive as possible. Finally, users must be guaranteed access to properly equipped computers on a convenient basis. FabWeb's training classes for technicians built much comfort and enthusiasm, but its access problem kept those same users out.

Keeping users

Once users have come into the site for their first few visits, keeping them relies on a new set of factors.

- *Responsive growth.* Users engage most fully with a site when they feel that the site staff are responsive to their informational needs. Sites must include a simple, quick mechanism for transmitting user feedback to the site staff. Site staff should do their best to bring this feedback into their growth and redesign considerations, and additions to the site should reflect this.
- *Making a strong pledge of customer service.* Users must feel that help is always close at hand, either on the web site or on the phone. At the same time, users are constantly afraid that technical support will cost them great amounts of time and money. Being able to pledge that calls will be handled in a fixed, short period of time can have a substantial impact on user satisfaction, even if service problems rarely occur.

- *Keeping content fresh.* Letting information grow outdated or unreliable can quickly sour a user's perception of the site; even a single experience with unreliable information may be enough to keep a user from ever returning to the site. Information should either be kept up-to-date or else retired completely.

Building conversation

In a newsgroup, bulletin board, or other environment in which the entire value of the site is in each user's communication with other users, building a high-quality conversation which keeps people coming back is the critical challenge. Unfortunately, it is rarely done well and almost never without a great deal of focused effort.

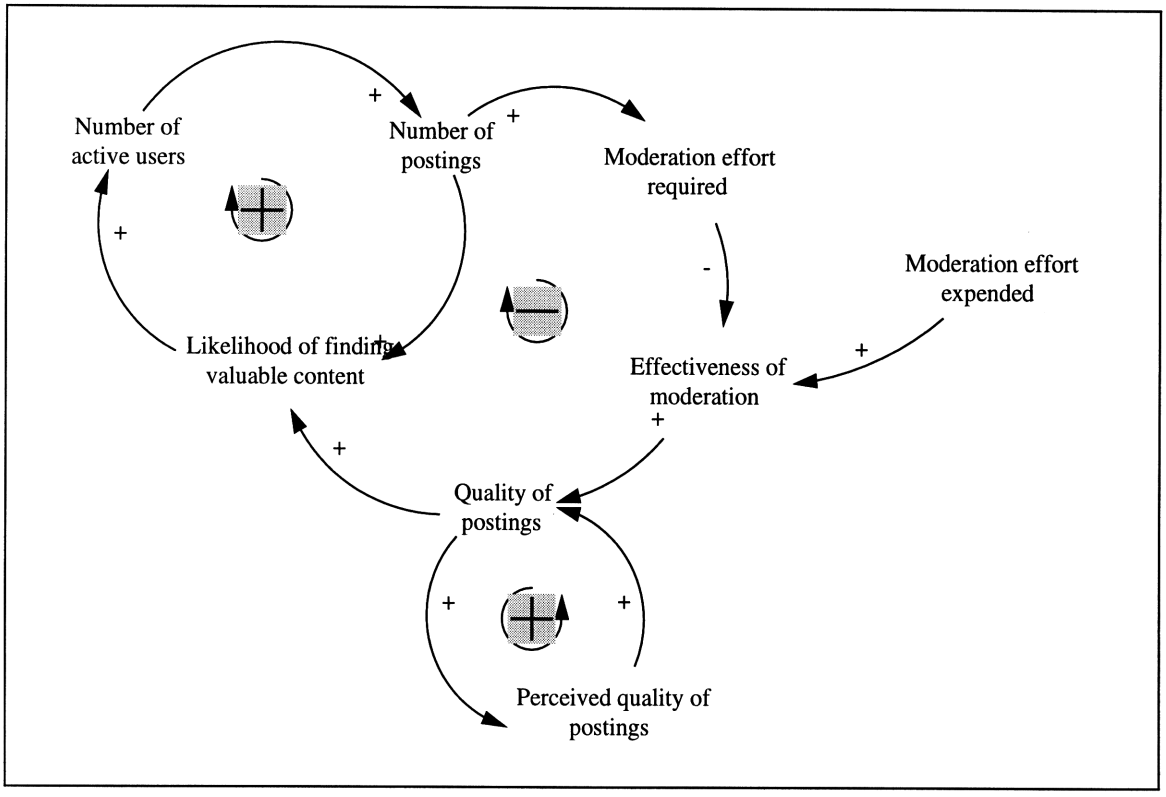

Figure 1. Dynamics of Growing Conversation

The process of building conversation in an online environment can be broken into four distinct stages:

- Removing barriers to conversation
- Building critical mass
- Managing for quality and growth
- Archival of important conversations

Stage 1: Removing barriers to conversation

Even before the first user visits the site, barriers to entry must be removed.

- *Technical barriers.* Many existing tools for online conversation, including newsgroups, can be very difficult for users to learn to use effectively, and severely hampers their willingness to participate. More recent tools, such as web-based discussion boards, are much more intuitive and can eliminate the need for training. Good tools will also incorporate search engines to allow users to search for messages of interest to them, rather than having to spend hours searching manually.
- *Cultural barriers.* Employees are often reluctant to share their problems or learnings for a variety of organizational reasons. These may include competition between business groups, fear of reprisal from superiors, or simply a culture which does not support frank discussion. While methods for addressing these challenges will not be discussed here, webmasters must be aware and deal with these difficulties before hoping to achieve success online.

Stage 2: Building critical mass

This stage is perhaps the most difficult in growing the conversation. Early in its life, a conversational web site has very few participants and is thin on content. Users have little idea of the scope of conversation and know that they are unlikely to find content which is of interest to them. Webmasters must find ways to jump-start the conversation.

- *Selecting high-priority topics and content for initial discussion.* Since conversation emerges most rapidly around topics of high current priority to users, setting the initial scope of the web site to such topics can be a great aid to growth. Webmasters can seed the conversation by posting current news, summaries of recent off-line discussion, and links to other online resources of direct relevance to this discussion.
- *Creating an initial community of participants.* Selecting a small group of startup participants can also help get the ball rolling. This group should consist of a few dozen users who have a stake in the initial topics of discussion and who are enthusiastic about the web site. They should be fully trained in use of the conversation tools, and perhaps should pledge to try to post messages a few times per week. Incentives for quality participation may also be considered at this stage.
- *Marketing the site to new users.* As the conversation begins to grow, webmasters should actively market the site to other groups which may have an interest in using the site.

Stage 3: Managing for quality and growth

As conversational websites grow, discussion topics begin to proliferate. New and interesting discussions may emerge, increasing the site's value to all participants. Inappropriate ones may also emerge, with users posting items which have no business relevance. Discussions may also become heated, and can degenerate into hostile attacks between participants or against outsiders.

Because of these dynamics, the webmaster must begin to focus on managing the quality of the discussion. The webmaster's role begins to shift to that of discussion moderator, setting the tone of the site, managing threads of discussion, and removing content which is inappropriate.

- *Setting tone and rules.* Explicit instructions should be given about what kinds of content are appropriate and discouraging users from abusing the site or making destructive comments to others.
- *Balancing focus and scope.* A given discussion board needs to have enough focus so that participants can find what they need and contribute effectively, but have enough scope so that new conversations can emerge and grow within it. The webmaster must manage this process; when new conversations grow large enough, they should be spun off into a new discussion board. Old conversations should be removed and archived if they have been productive.

Stage 4: Archival of important conversations

When a productive conversation has concluded, it is often valuable to store the conversation in some form so that it is accessible to later users of the site. It may be converted into a separate web page, or stored in a database of conversations. In any case, it should be made searchable so that it is easily found by users who might need to draw upon it at a later date.

4.8. INVESTING IN SPECIAL TECHNOLOGIES

It is often worth developing or incorporating more elaborate tools to assist in certain aspects of web design and management. Web software tools can help site managers achieve goals such as:

- Reducing staff workload, particularly in the areas of web publishing, document management, and security management;
- Enabling new kinds of communication and collaboration, such as groupware, online meetings, and bulletin boards;
- Absorbing information from other systems into web pages in order to speed data dissemination and analysis.

While many of these technologies are available off-the-shelf, highly customized versions must often be developed in-house, requiring substantial programming expertise and time. Furthermore, many business groups face the same needs for special technologies, but cannot afford do develop them individually. Providing a well-tested library of such technologies, along with a hardware and software infrastructure advanced enough to run them, is an excellent role for company-wide IT organizations.

4.9. INTERFACING WITH SUPPORT ORGANIZATIONS

Groups outside of the web staff and business groups can be instrumental in building the success of web projects. Some of these organizations are further discussed in Section 5.

Information technology departments

Information technology departments often manage the company-wide information infrastructure and policies. Because of this, their choices can profoundly influence the ability of business groups to build and manage web sites. IT departments can help in the following areas:

- *Providing servers and hardware support.* Hardware support tends to require sophisticated technical expertise which is expensive to cultivate in business

groups and part-time web staff. Furthermore, several business groups can often share a single server. IT can help business groups by providing these services.

- *Providing programming support at reasonable cost.* Like hardware support, applications programming is a specialized skill which most business groups do not possess and cannot afford to grow. IT should provide these services at a reasonable cost, and build up a shelf of useful tools which can be used by business groups.

- *Easy-to-use access technologies.* IT generally controls the information security environment. They should focus on making security systems easy to use for both web staff and users.

- *Training.* IT should offer of broker training services to business groups and web staff.

- *Technical support services.* IT can endeavor to increase the expertise of technical support staff (TAC), and to promote greater cooperation between TAC and webmasters.

- *Clearer roadmap of infrastructure technologies, created with input from web staff.* Changes to the information technology infrastructure can enable or disrupt business groups. If business groups develop their own sites, platform changes can render their systems obsolete. Business groups should be given a voice in infrastructure decisions and should be kept informed of changes on the horizon.

- *Fast-track approval of new tools.* If a group has to develop its own tools, IT should have clear and rapid processes for testing and approving them.

Business technology groups

Business technology groups, which will be described more fully in Section 5, serve as a bridge between IT and business groups. Because their staff members combine deep understanding of the business and substantial IT expertise, business technology groups can serve the following functions:

- *Design of special tools of use to a set of business groups.* A business technology group serving the manufacturing organization can develop web tools which are uniquely adapted to the needs of a production environment. Individual business groups within manufacturing can then deploy these tools in their own sites.

- *Providing a broad perspective on opportunities for capturing and using knowledge between business groups.* Since a business technology group serves an array of business groups within the same part of the organization, they are well placed to spot opportunities for groups to collaborate on new information systems.

Web developers' community

As described earlier, a company-wide community of web developers and content providers can offer great support and accelerate the pace of innovation in business web sites. Developers can share best practices and tools, and as an organized community can have significant leverage in pushing the IT organization to be responsive to their needs. Site managers can use the web developers' group to disseminate information about site policies and growth plans, as well as to gather information about what their own content providers need to make their jobs easier.

5. TOWARDS A NEW MODEL OF INFORMATION MANAGEMENT

As the overall costs of information management come down using the web and other technologies, managers have new opportunities to use information and knowledge to improve the productivity of their business groups. These opportunities produce new responsibility, however; managers must search more broadly for opportunities to capture and use information.

Finding these opportunities and implementing mechanisms to capture them is not a trivial task. Most organizations have learned how to manage the "low-hanging fruit" of business information. This information, which is deemed critical to the function of the enterprise, is formally captured and managed. But in most groups there exists *subcritical* information which can have economic impact but does not get captured. This is the next frontier of valuable business information for all organizations.

Unfortunately, this subcritical information can be hard to identify. It often exists in the gaps and space and time between business groups, or in the "blind spots" of a team focused hard on a single goal. To capture subcritical information, managers must instill a business culture in which information is valued and willingly shared; they must build relationships with IT groups to develop effective information management systems; and finally, they must keep an eye open for valuable subcritical information which can be captured.

This chapter addresses several issues. First, it examines the organizational and cultural challenges of creating an environment which values and manages knowledge effectively. Then, it discusses the operational issues of sharing responsibility for information across many people and organizations. Finally, it discusses the value and handling of "subcritical" information, the next frontier in productivity-enhancing information.

5.1. ORGANIZATIONAL CULTURE AND MOTIVATIONS FOR KNOWLEDGE MANAGEMENT

Since knowledge capture and management involves costs to business groups, this usually translates into time costs for individual members of the business group for whom this is only one of many job functions. A major challenge is how to create an environment which encourages employees to put in the effort required to make knowledge

management effective, and to constantly think creatively about new opportunities to enhance productivity with knowledge.

5.1.1. Pursuing a conscious approach to knowledge creation and management

A great strength of SemiCo is its explicit understanding of how knowledge is created and used in a variety of business tasks. One example of this is the manufacturing startup process described in the TransferWeb project. Managers are well aware of the value of the experience gathered during the first few weeks of production. During this period, engineers learn a great deal about how to run the manufacturing process in a stable fashion.

During this time, there is always pressure to ramp production as quickly as possible in order to get saleable product out the door. But a slower production ramp gives engineers and technicians more time to gather data, analyze it, and improve production yields based on these learnings. In startup group meetings, one can hear managers openly discussing how to tune the ramp speed in order to get the best balance of learning, improvement, and saleable production. This is a remarkable example of an explicit understanding of the value of business knowledge.

Developing a culture in which knowledge is valued explicitly and discussed concretely in the context of production sets the stage for aggressive, value-added management of information in a business group. Employees in such an environment will tend to look for ways to use information creatively to increase production.

5.1.2. The value of capturing knowledge to bridge organizational gaps

Most organizations have historically focused their IT efforts on facilitating the flow of business information within business groups, or between business groups which collaborate closely on business tasks. New techniques allow the bridging of larger gaps in time, space, and organization.

- *Organizations.* Improving the flow of information and knowledge across the boundaries of business groups allows for more effective coordination towards business goals. The Technology Transfer web site, for example, linked engineers, managers, and manufacturing technicians to coordinate startup tasks.

- *Space.* Tightening flows between geographically dispersed individuals and groups allows many facilities to function as one. This permits accelerated learning, improved product consistency, and dynamic allocation of resources between sites to optimize enterprise-wide performance. The Sort network is an excellent example, even allowing work-in-process to be shifted between sites on a weekly basis depending on equipment availability.

- *Time.* Capturing knowledge in a form which is accessible later in time can be extremely valuable. On a short time scale, it can facilitate problem-solving across manufacturing shifts in the same facility, or allow factories in different time zones to have productive conversation. On longer time scales (months or years), it can help groups benefit from knowledge generated earlier by other groups, even though those groups may no longer exist or the relevant personnel have moved onto other jobs. The Facility C KSN, for example, has captured key operating principles from engineers before they have moved on to other sites, and is actively used by new personnel who face similar engineering challenges down the road.

5.1.3. Motivating individual employees to manage and share knowledge

When employees spend time on knowledge management, they are ultimately working now to help others far away or in the future to benefit from their experience. The ultimate consumer of the information may be so distant as to be unable to reward the employee for good work. When ever-present time pressure causes immediate demands on the employee's time, knowledge management tasks may be the first to be shelved.

Ultimately, the only durable motivation for employees to conduct knowledge management tasks is that they see benefit in it for themselves—"one good turn deserves another". While this is often not reflected in the IT systems at SemiCo, it is reflected in the communications culture. A SemiCo employee can call another employee anywhere in the company and be reasonably sure that that person will give them an hour of their time to discuss issues of concern. Each employee benefits from this, and knows that doing the same for others is part of the model. Knowledge management systems must tap into this motivation in order to work effectively.

A complementary approach is to create an internal *market of knowledge*. This strategy, which can be implemented on an enterprise-wide basis, rewards employees whenever they spend time productively assisting others with their knowledge. At SemiCo, this currently takes several forms; one is in a series of internal conferences, at which employees can present their learnings and innovations to a wide audience, and a second is in the SemiCo training structure, which rewards employees for teaching classes related to their expertise. No system yet exists, however, for the sharing of smaller units of knowledge.

A final, but somewhat dubious strategy is *top-down management direction.* Business group managers can make knowledge management an official job function, requiring documentation of specified business activities. This top-down strategy can sometimes work well when the ultimate benefits of the knowledge will still accrue to the same business group, but is rarely effective if the beneficiary is elsewhere. An additional problem is that the employees who actually have to spend time capturing the information often do not buy into its value, and will do whatever they can to avoid doing it.

At SemiCo, efforts are underway to use top-down direction to capture engineering troubleshooting on the factory floor. Engineers are required to file extensive online reports describing the problem and solution. Unfortunately, because these reports take so long to prepare, engineers often do not file them for weeks; by that time, they have frequently either forgotten what they did or are so pressed to file many reports that they write as little as possible. In either case, the information captured is largely useless down the road.

5.1.4. Balancing openness versus security

Capturing knowledge and making it broadly accessible clashes with the traditional philosophy of releasing information on a need-to-know basis. Business groups must think creatively about how to maximize the accessibility of stored knowledge while maintaining trade secrets and organizational privacy.

SemiCo's IT group, for instance, has created a fairly clear classification system for different types of business information, which has greatly simplified the process for managing security and has allowed free internal flow of information in most cases.

5.2. A DISTRIBUTED MODEL OF INFORMATION MANAGEMENT

As the management of information by and between business groups expands as a business function, business groups are forced to "share the burden" of information management with other groups. First, business groups do not have time to build as many information systems as they can use, yet their deep understanding is required to design the systems effectively. This has driven the emergence of business/IT hybrids which are uniquely able to help these groups set up systems. Second, business groups now find themselves building information systems which will be used or inherited by organizationally, geographically, or temporally distant groups. These groups must find ways to cooperate on design and share in the long-term management costs of the systems they build. This section will address each of these issues in depth.

5.2.1. Keeping IT close to the business: the emergence of new business/IT hybrids

As business groups seek to develop information systems which are much more closely customized to their own information and decision needs, it becomes an increasing strain on the traditional IT organization to serve them. One strategy for handling this split between IT and business groups is to create a third group, a business technology group, which can offer information technology services for specific business group needs.

At SemiCo, the IT organization's focus was on providing IT infrastructure and software which was relevant to the entire enterprise. They offered custom design services to business groups, but business groups almost universally complained that these services were extremely overpriced (because of the time programmers would have to spend learning about the business group) and often unavailable due to lack of IT staff. Business groups which wanted to develop web sites of substantial complexity (involving actual programming) thus had to turn elsewhere.

To fill this niche, a variety of organizations grew up to serve the custom IT and programming needs of particular business groups. These new business technology groups appeared in the manufacturing, assembly, R&D, and engineering segments of the company.

Business technology groups at SemiCo were a hybrid form designed to offer sophisticated programming services while staying closely in touch with the needs of a particular business segment. They were staffed by full-time personnel drawn both from IT and from business groups, and they spent their time developing web technologies which business groups could incorporate into their own sites. Their services were generally provided to business groups free of charge.

For example, SemiCo's MSS business technology group was formed to develop new IT tools for business groups within the manufacturing arm of the company. The staff consisted of three programmers and three former manufacturing personnel. This group developed document management databases and knowledge sharing databases which were customized for engineers in factory environments. These databases have quickly been adopted by individual factories which did not have the time or expertise to develop their own systems.

5.2.2. Information lifecycle and archival responsibilities

The cost of capturing, maintaining, and archiving information, while declining, is still not trivial. Business groups have to balance this cost against the potential value of the information to other groups which are separated from them in space or time. New models may have to be created for sharing the costs of information between creators and users.

Good mechanisms for archival did not exist at SemiCo except for documents which had to be archived for legal or regulatory purposes. The Technology Transfer site, for example, had great difficulty finding a permanent home because all of the organizations it served only had a temporary life span. In this case as in many others, a simple agreement at the beginning of the project that each facility would inherit the web site during its own startup probably could have solved the problem.

5.3. FINDING AND MANAGING SUBCRITICAL INFORMATION

Businesses constantly make economic decisions about information. The economic value of information is weighed against the cost of capturing and managing it. If the value of a particular type of information is uncertain, businesses will be less willing to invest the time and money to manage it. In addition, as the costs of management come down (thanks to the web and other technologies), information of more uncertain or irregular value becomes economical to capture.

5.3.1. Critical and subcritical information

Because of the historically high cost (in time and money) of managing information, most organizations focus their efforts on information deemed to be *critical* to the operation of the business. This information, which is designated as critical because of its extreme economic or operational value, is generally captured in some formal mechanism (e.g. paperwork, database), and travels from party to party by some formal procedure. Users who require the information know where to find it.

Many organizations, however, have a layer of information which we will describe as *subcritical*. This information has economic or operational importance but is not captured in any formal channel; this may be because the information is too costly to manage, but is often because it falls into an organizational "blind spot" which is outside the focus or

interest of any individual. Subcritical information may flow through informal channels, or may not flow at all.

5.3.2. Examples of subcritical information

Example 1: Shift status information

One example of subcritical information which we encountered on the SemiCo factory floor was shift status information. No formal process existed to transfer shift status information from one shift to the next. Often during a manufacturing shift, unusual events would occur to disrupt production which would not be resolved by the end of the shift. These events could include an equipment breakdown, the introduction of mislabeled work-in-process, or an unusual routing of work-in-process through production. If these events were not reported to the next manufacturing shift, production could continue to be disrupted for multiple shifts until someone happened to notice the problem and resolve it.

This information clearly had substantial economic importance, but had not been captured by formal or informal channels for several reasons. First, there was a strong historical antagonism between shifts; each shift felt that the other shifts left it with production hassles, and so in turn did not try to them help out with information. Shift managers sometimes felt that regular shift-to-shift meetings to address the problems were a waste of their time. Despite this reluctance, innovative technicians and shift supervisors were beginning to use a combination of web sites and face-to-face meetings to capture and transfer this subcritical information effectively, and their efforts enjoyed a great deal of success.

Example 2: Operational innovations

A second example of subcritical information on the factory floor was operational innovations. Shift managers had substantial leeway in setting operating procedures and priorities for processing different products. Talented managers could improve production volumes significantly by designing new procedures. Unfortunately, these new procedures (a good example of subcritical information) often were not shared with other shift managers in the same factory, much less with those in other factories.

Interviews revealed that shift managers were judged against one another for performance reviews, and some managers saw their innovations as their only competitive advantage over others; this reduced their inclination to share. Furthermore, shift managers tended to view their management of operations as an art, and were afraid of being forced to conform to the practices of other managers. In this case, an information system would probably be of little help in spreading subcritical information because of the lack of a communication culture between shift managers.

5.3.3. Heuristics for finding subcritical information

Managers face the challenge of identifying subcritical information which might be worth capturing. General IT groups will be of no use in this endeavor; spotting subtle but valuable subcritical information can only be accomplished by employees who thoroughly understand the business function of the group. Business technology groups (as described above), however, may add value due to their business grounding and broad perspective.

A few rules of thumb exist which can help in spotting these opportunities. This list is not designed to be comprehensive, but simply to stimulate managerial thinking about new and non-obvious opportunities to increase productivity.

- *Looking where production errors have occurred due to lack of correct information.* This is probably the most obvious place to find subcritical information; effective quality programs will often catch and identify these needs. This type of observation led to many of Automation's information systems for the factory.

- *Listening to people's complaints about information that they never get on time.* Employees generally know best what information they need to do their jobs well, and will often be vocal about it. For example, hearing these complaints from Factory B employees helped Factory A set up an effective transfer site.

- *Looking for redundant learning-intensive activities in the organization.* Any organizational activity which generates a large amount of learning, such as a new facility startup or a new process, can benefit from similar learnings at another site. This was a large motivation behind INSTALLWeb, after managers realized that many installation teams were making the same mistakes and learning the same things at different sites.

- *Looking for organizational "blind spots" which lead to problems.* Every group is aware of some problems that exist at the periphery of their work and may have an eventual impact, but do not believe that it is their job to solve the problem. These problems, which fall between the cracks of business groups, often go unsolved indefinitely. The shift status example was an example of successfully identifying and closing a blind spot.

5.3.4. Capturing subcritical context of critical decisions

One of the most substantial challenges to capturing critical or subcritical knowledge for use by distant parties is in providing enough subcritical context to make the information valuable. For instance, the SemiCo white paper is an excellent example of critical information which includes subcritical context. The white paper document contains not only the proposed process change, but also the research, experimentation, and experience

which went into the process change. Later users of this document have a fairly complete record with which to consider to use of this process change in their own operations.

Websites can be used to archive decision documentation and speed search for relevant knowledge. Unfortunately, documenting decision context can be a highly labor-intensive process. Because of the uncertainty about what kinds of questions future users of the information might ask, documenters must often include a wide array of context information. Because of this high cost, comprehensive documentation is usually reserved for only the most critical decisions in a business.

Fortunately, a spectrum of possibilities exist for the documentation of knowledge. Business groups can use one or a mix of these strategies to handle knowledge capture.

- *Minimal documentation with key personal contacts for decisions.* Only a description of the policy is captured, along with a contact name who can provide fuller context on demand. This is the least costly to implement, but if the contact leaves the company or forgets the decision context, the knowledge is lost completely.
- *Partial documentation along specified parameters, along with key personal contacts.* In this case, a policy description is captured along with a specified set of context items and a contact name. These context items may include research results, problem description, decision constraints, or research results. This strategy is more costly than the first, but is more robust to personnel changes. This method fails if the user has questions which are not documented and the contact becomes unavailable.
- *Complete documentation of decisions, with no personal contact required.* This type of knowledge capture is highly robust to organizational changes, but is extremely costly to carry out. The principal problem is that if the documenter has

any uncertainty as to who the ultimate audience is, then he must capture a huge amount of context to cover all possible audience needs.

In choosing which strategy to use, the group must consider the nature and value of the decision, the extent and value of subcritical information, and the scope of possible needs of users down the line.

5.3.5. Subcritical information management: the next competitive edge

In conclusion, it is clear that significant opportunities and challenges exist for the management of subcritical knowledge in a driven business environment. Over time, managers of business groups will become more proactive and more effective in spotting these opportunities and making the investments necessary to capture their benefits. Companies which do this effectively stand to win productivity gains which will keep them ahead of competitors which do not.

6. CONCLUSION

This paper has attempted to provide a clear definition of the design, management, and organization issues that business groups must consider in attempting to use the web for critical business purposes. Use of this framework should increase the content focus, business effectiveness, and long-term sustainability of web-based information systems.

In addition, this paper has tried to raise important questions of information and knowledge management which are emerging because of the declining cost of information technology. While these questions are raised here, it will be up to innovative managers and designers to find solutions which capture the dramatic increases in productivity which will be available to business groups in the coming years.

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