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## BEYOND GROUPWARE AND WORKFLOW

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### THE THEORY OF COGNITIVE INFORMATICS AND ITS IMPLICATIONS FOR A PEOPLE-BASED ENTERPRISE INFORMATION ARCHITECTURE

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#### ABSTRACT\*

Groupware and Workflow Management Systems are now moving into full-scale implementation in enterprises. Many organizations are now capturing competitive advantage from these systems. What will be the next IT opportunity for competitive advantage?

This paper lays out elements of an enterprise information architecture, based on the view that the next IT opportunity lies in enhancing the ways people work. This view is expressed in the field of Cognitive Informatics (CI). CI is a theory of information systems in the enterprise which provides a basis for the design of IT support. The premise of Cognitive Informatics is that the role of IT is to enhance people's ways of working. Building on this premise, an information architecture of an enterprise can be developed.

As individuals, people think and act schematically, executing previously-learned patterns of thought and action. As groups, informally or in organizational units, people act in programmed or unprogrammed ways, often executing previously-learned or taught patterns of behavior. People's work thus involves the execution of previously-learned processes and the development of new processes or revisions of old processes.

Therefore, a key element of an enterprise information architecture is how individuals can access knowledge through utilizing a library of patterns, and how they can apply this knowledge by executing selected patterns to perform desired tasks. A number of present IT directions can be unified into an overall architecture in this way. Particularly important are present desktop office suites, Workflow Management Systems and other forms of Groupware, intelligent agents, hypermedia, Personal Information Managers including new forms called Personal Construct-based Action Support Systems, document management systems, and others.

This paper outlines key elements of this architecture and shows how these directions of software development can be integrated into a unified architecture which meets the needs of the organization and the needs of individuals and workgroups.

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### *Objectives*

This paper addresses the question, What is the future of Groupware and Workflow? Some observers might think that it is premature to address this question now. After all, isn't the Groupware market still evolving? Isn't Workflow still an embryonic product category just beginning to have impacts, and serious market share? In our view, while these observations may be true, it is imperative to see the outlines of the broader future for these product categories, because it is in this broader future that the true potential lies.

We address the future of Groupware and Workflow by exploring several questions:

- What are the central features of Groupware and Workflow, and how do they fit into the overall technology environment?
- What strategic imperatives are driving the future of the enterprise information architecture? What will be the competitive differentiators of the future?

Our goal is to show how several directions coalesce into an integrated approach for the information architecture of an enterprise:

- the strategic imperative, which we have described as the need to build Truly-Productive Organization; a key characteristic is effective Knowledge Management;
- the cognitive theory that people think and act schematically, applying previously-learned patterns of thinking and acting;
- the evolution of current software technologies in the enterprise.

We show how these three themes come together and have specific operational implications for the extended enterprise. We call this integrated approach Cognitive Informatics.

### *Current Software Directions: a Platform for Strategic Change*

We begin with our assessment of the key forces in information technology today. We discuss these briefly in terms of the general context, elements we take as givens, and in terms of specific forces or elements which are particularly relevant to the proposed directions.

### *The General Context*

We take these as givens, in the emerging information technology environment:

- mobile computing: people working anywhere, anytime, with desktop computers and portable computers
- electronically-connected organization: people and workgroups interconnected through continuous or dial-up access, over LANs, WANs, and interactive services

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(synchronous or asynchronous) of various kinds, including proprietary (Compuserve, Advantis, etc.) and open (Internet, e.g.) systems

- virtual documents: consisting of compound packages of multiple components and multiple media; e.g., a car design may consist of CAD drawings, text documents, photographic images, video clips, etc., all grouped into one master object with multiple component sub-objects
- virtual work and virtual organizations: people working with other people, anyone, any place, any time
- distributed computing: with the individual at the desktop drawing on computing power not only on her desktop or laptop machine but also in one or many servers which may be physically anywhere in the world; and accessing virtual documents which have components residing physically in one or more locations anywhere in the world
- common desktop environment(s): with one of a small number of operating systems environments and with relatively standard user interfaces at the mechanical level (but we will say more about the functional level of the user interface below)
- objects, encapsulation: Object-oriented development is beginning to be accepted among product developers and internal business IS shops. Standards are being formulated (Object Management Group, CORBA, Microsoft OLE, OpenDoc) and while apparently not completely accepted are emerging. Some vendors and some IS groups are encapsulating legacy applications in order to treat them as (large) objects and call them from applications in modern client/server or desktop environments. Apparently a number of major vendors are joining in a coalition (the Open Application Architecture Association) to modularize their applications to support a more modular, object-like approach to interfacing their major applications (e.g., SAP, McCormick-Dodge, and others).
- VAR channel importance: Software channels continue to be complex and varied. However, the role of Value-Added Resellers (VARs) continues to be important in many markets. VARs are important in vertical markets, e.g., transportation vehicle dispatching, health care-hospital management, health care—physician practice management, etc. VARs are also important in horizontal markets, e.g., small-business accounting systems, sales support contact management systems, etc. Often, in addition to reselling standard hardware and/or software, VARs add value by adapting software products to their markets or combining several products into integrated applications.
- application development by multiple players, including vendors, VARs, internal IS organizations, and local business-unit experts, as well as users: Many different participants are involved in application development today. This will continue.

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- continued importance of end-user application modification and limited development: The end-user's ability to make her own modifications to an application will continue to be a competitive advantage. From the very beginning of the PC revolution, users' control over their own personal environments and applications has been a driving force. While the resurgence of IS control through network support, anti-virus initiatives and other thrusts has reduced personal independence in many organizations, users still strive to have significant control over their personal computing environments (e.g., witness the variety of screen saver products on the market).
- continuing evolution of software functionality to more and more specialized applications: The battleground has shifted from the standard office applications of word processing, spreadsheet, and presentation graphics, to increasingly more-specialized business applications: business planning, personal financial management, personnel review writing, etc.

### *Groupware, Workflow, and Other Communication and Collaboration Technologies*

These general elements provide the technology support to virtual work: the ability of people to work any time, any place, with others in their own organization or in different organizations. In this context, the role of technologies that provide specific and focussed support to communication and collaboration is critical. This group of technologies for communication and collaboration is called Groupware, and includes electronic mail, Workflow Management Systems (including Forms Management and Document and Image Management Systems); and the networks on which they operate.

We see these trends emerging, first with respect to networks, and second with respect to Communication and Collaboration technologies:

- the Internet widely available: The Internet is a loosely-connected global network which provides a number of separate services. Email using the Internet is very common. Most recently, the World Wide Web has become a major social phenomenon, providing a capability for linked documents to be made widely-available to anyone who is interested. Internet functionality can be provided on public networks or on private networks. Internet functionality often is used internally in an organization, a form called IntraNet.
- seamless integration of networks, including internal private networks, external semi-private networks, and external public-access networks: LANs, private Wide-Area Networks, internal intranets, and external Internet networks provided by dedicated and public-access carriers to different subdomains will become integrated, with appropriate bounds on access through firewalls and other security and toll-collection devices. From the user's perspective, there will be no need to know where an

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information or processing resource is located; the mouse-click on a location will take the user to the desired information or application wherever it is.

- emergence of the Web: The Web provides users access to a very rich, flexible, and rapidly-evolving world-wide information resource. The key features of the Web from our perspective are these:
  - The Web is widely accessible to anyone who obtains access to the (public-access) Internet and a “Web browser,” a widely-available software tool for accessing documents on the Web.
  - The Web is composed of multiple documents, connected by hypertext links. The user can scan a page of a document, select any link on that page, and “jump” to the document at the other end of the link. That connected document may be physically on the same computer or on another computer on the Web anywhere in the world.
  - A “Home Page” is a master document posted on the Web with a Web address (called a URL or Uniform Resource Locator) that can be widely-circulated; and thus the Home Page serves as a symbolic and real gateway to a set of related pages.
  - Many independent authors and publishers can create Web pages and documents, and can link their pages to the pages of others, thus providing unique information and unique “packaging” of access to information provided by others. So for example a home page(s) can lead the user to a rich range of resources provided by others, whether individuals, other associations, vendors, organisms of government, etc. Thus, the Web can be used to create a virtual library of documents that are interconnected and provided and maintained by many individuals and/or organizations.
  - Executable routines can be launched from Web pages. (Java is one new language designed to support this, but other approaches are also being used.)
- emergence of the Internet and the Web as a social phenomenon: At present, the power of the Web technically is also becoming a power as a popular phenomenon. Some examples:
  - A recovered cancer patient posts a home page as the Patient Information Page, and provides a regularly-updated site which points to a wide variety of relevant information resources on a particular type of cancer (in this case, melanoma)
  - Mothers post family news on Mom’s Pages, providing updated information on their children and family activities for the benefit of relatives and for the children to participate in a family creative activity
  - A vendor of industrial products to other industrial users provides a site with a catalog and shopping function, supported by technical information, and by chat forums for customers with similar interests to trade ideas and share problems and solutions (AIndustry.Net).

As a result, the Web has become at the same time a tremendously rich and versatile

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repository of human knowledge, and a repository so large and diverse that it is difficult to find the knowledge that is most useful.

- all applications mail-enabled: Any object created in an application, whether text document, graphic presentation, CAD drawing or whatever can be easily mailed to one or several others. Email is now very widespread, and increasingly disconnected islands of vendor-specific Email systems are being connected through gateways and other devices. The emergence of Internet-based Email provides a unifying common - denominator, so that almost all vendor-specific systems are now providing translation to and from Internet-mail, in addition to other standards.
- Groupware functionalities widely available: Groupware systems (GW) support collaboration among people. These include electronic mail, voice mail, discussion forums, brainstorming, voting, audio conferencing (teleconferencing), video conferencing, shared whiteboards (where people at different sites can work simultaneously on a document, presentation or other object), group scheduling (e.g., for multiple individuals to find a common time slot available for a meeting), WorkFlow management systems, and others. Many such products are now available (400-500 such products have been identified). One of the leading products in this category is Lotus Notes, which provides many of these functionalities in an integrated, highly-secure, flexible environment. Microsoft has announced Exchange, a product which may eventually have many of the features of Notes. Novell offers GroupWise, which also has a subset of Notes features. Netscape has acquired Collabra and is integrating its groupware tools into its Internet-based client and server strategy. Many other vendors offer subsets of groupware functionalities. Groupware systems can be very effective in supporting the activities of people in many different modes of interaction. The integration of groupware and Email is particularly powerful. Email, a simple form of Groupware, is already being used in many organizations; other products such as Notes provide Email features and in addition provide a range of additional capabilities.
- Groupware functionality integrated into focussed applications: Increasingly, focussed applications, such as word processing or spreadsheets or document management, are being provided with some level of Groupware functionality. Initially, this may simply be the ability to mail a word processing document or graphic presentation to someone else directly from the application; or the ability to control who can share a copy of a file. Increasingly, more carefully-articulated strategies are being developed (for example, Avanto's ManagePro and NetManage' ECCO are shrink-wrapped software tools for the workplace which provide information sharing capabilities in a GroupWare mode).
- Workflow management capabilities becoming widely used: Workflow Management Systems (WFMS) are software used to structure the flow of work among individuals and units in an organization. Wherever a process is repeated many times and involves

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multiple individuals or units, Workflow systems can be usefully in systematizing those processes and making them more efficient. For example, the process of receiving a customer request for publications, sending that request to the warehouse, processing the order in the warehouse, sending a shipment notice to a carrier, processing the order through accounting, etc., can be viewed as a Workflow process. Similarly, the process of publishing a document is a Workflow process: the author submits copy for editorial review, the copy editor makes suggested changes, the author incorporates changes and resubmits the document, the copy editor sends it to design, the designer lays out the document for publication, a proof copy of the document is sent to the author for final review and indexing, the author sends it back, etc.

- implementation of multi-enterprise workflows through effective adoption of Workflow Management Coalition standards: The Workflow Management Coalition is a group of more than 150 vendors of WFMS products. They have just published a set of standards for interoperability of workflows among multiple vendors' servers, and for interoperability of software applications and workflows. Together with the fact that many WFMS vendors provide systems that operate in multiple client and server environments (e.g., IBM's Flowmark products operate on PCs, mid-size, and mainframe servers), these standards provide the potential that *workflow becomes the glue that ties the enterprise together*. This is beginning to be evident in vendor offerings which integrate GroupWare and WFMS, as in IBM's recent announcement of a Notes client that accesses both Notes and Flowmark messages and servers; and in many WFMS vendors offering integrated document and image handling capabilities (e.g. FileNet among others).
- Collaboration Technologies in the Infrastructure: Within a few years, we will see basic Groupware functionalities (including email, Workflow Management Systems, and document and image management systems) integrated with almost all applications. Thus, every application, whether word processing, CAD, or order-entry systems, will have on its pull-down menu the options of: mail this, post this for discussion to group XXX, share this with Joe, Mary and Koji, forward this to Pierre following Workflow Marketing Budget approval-3.1; and so forth.

The implications of all of these forces are profound.

First, communication and collaboration will become activities integrated with, and natural components of, all aspects of daily, electronically-mediated, work. Groupware of all types will move into the infrastructure, providing powerful and widely-used technologies.

Second, these forces in combination define a context—electronically-mediated work environments—in which the thrust of the information architecture of the enterprise can become something substantially different from that of the past: enhancing personal power to think and act more effectively. But, what **should** this environment become? What business imperatives **should** drive the uses of this infrastructure?

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### THE STRATEGIC PERSPECTIVE

#### *Opportunities for competitive advantage: enhancing people through IT*

One set of strategies for gaining competitive advantage is based on a simple principle: **Use information technology to enhance the ways in which people work.** [2-4] In applying this principle, the emphasis shifts from using IT to replace people through automating organizational processes, to designing appropriate balances of human and computer skills.

#### *The strategic opportunity: the “Truly-Productive Organization” (TPO)*

For reasons outlined elsewhere [2-4], we have defined a business strategy goal as to build a “Truly-Productive Organization:” one which utilizes its resources effectively over the long term, one which is able to deal with new and novel situations efficiently, and has these characteristics. It is customer-satisfaction focussed, disciplined yet innovative, stable yet experimental, simultaneously global and local, committed to continuous, rapid learning, committed to dynamic knowledge management, committed to effective management of interpersonal relationships, simultaneously tight-loose, and focussed on the ways that people work:

*Customer-Satisfaction Focused.* Many management experts argue that, by focussing on total customer satisfaction, a company can improve its processes to deliver better service at a lower cost. Customer-satisfaction driven is often described as the next step beyond TQM, total quality management: the objective is not simply to deliver some abstract definition of quality, but to deliver total satisfaction to the customer, of which the delivery of quality is only a part.

*Disciplined, yet Innovative.* To keep costs down, an organization must have a high level of discipline: each person knows what needs to be done, knows how to do it, and does it quickly and efficiently. This argues for the organization to have a high degree of **standardized procedures**, and for everyone to be trained in these procedures and to execute them without question.

Yet, in an ever-changing market place, it is important to also be able to innovate, to offer new service packages and new organizational linkages with the customer. To do this requires a discipline of change that encourages innovation, and yet retains the stability of existing procedures until innovations are ready for wide-spread adoption.

*Stable, yet Experimental.* In a highly-disciplined organization, it is risky to experiment. Yet, experimentation and risk-taking is essential, for an organization to adapt to a rapidly-changing environment successfully. Therefore, an organization must develop ways in which experimentation can be accepted and risk-taking rewarded, at the same time as maintaining a disciplined approach to existing processes.

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*Simultaneously Global and Local.* “Glocability” Each customer and each local situation will be different. If a company is serving a major multinational customer, then it will have to provide, or coordinate the provision of service, in a number of different countries and regions. In each situation, there are unique local characteristics, customs, business practices, and ways of getting things done effectively. The same global procedures cannot be applied uniformly in every local situation. There has to be a balance between the desired uniformity of global practices, and the local variations.

We define “*Glocability*” as the capability to act locally with a global perspective, and to be effective globally with both global and local perspectives. The roots of this concept are in product planning and design, where many companies are striving to develop global products. Global product can be a single standard product; or it can be a generic product with specific local variations for a several local markets. The term “glocalization” is sometimes used to describe the development of a product design which can be modified for specific sets of local markets.

*Committed to Continuous, Rapid Learning.* The need for continued learning is acute in today’s competitive environment. As new teams are formed, individuals must be able to learn rapidly what is needed to deal with a new set of issues. As new knowledge is developed, it must be made available to other members of the team and to individuals in other parts of the larger organization. While responsibilities for maintaining formal assemblies of knowledge (e.g., libraries, data bases) may lie in specific formal organization units, making that knowledge available on an as-needed basis throughout the larger organization is an important element of competitive advantage. Clearly, the ultimate objective is to make a piece of information available to an individual who doesn’t even know he needs it!

*Committed to Dynamic Knowledge Management.* Corollary of the need for continued learning is the need for continuous acquisition of new knowledge and the management of modifying it and disseminating it throughout the organization or to those for whom it is relevant.

*Committed to Effective Relationship Management.* People in organizations are not automatons. To get work done effectively with high quality and low costs requires building and maintaining effective interpersonal relationships—among individuals in work groups, formal organizational units, and in the various organizations participating in strategic alliances. A truly-productive organization has to be successful at effective relationship management.

*Simultaneous Tight-Loose.* One way to summarize the implications of these dimensions of management style is in the descriptive phrase, “simultaneously tight—loose.” An organization must be “tight” at the same time that it is “loose.” By *tight*, we mean the need to have a lean, disciplined operation, in which there is a strong and ceaseless attention to keeping costs down and providing quality service at the same time. By *loose* we mean the need to be innovative, to be responsive to customers’ needs, to be flexible and adaptive to changing conditions and changing customer needs. This requires, for example, the ability to

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be able to customize capabilities so as to provide customer-specific tailored services, together with customized information systems support.

*Focused on the Ways People Work.* This is perhaps the most important element of all. The work of an organization gets done by people, **aided by machines**: the ways in which people work is central to the competitive effectiveness of an organization.

### *Building a Truly-Productive Organization*

How can a Truly-Productive Organization (TPO) be developed? In our view, there are several key elements in building a TPO:

- enhance individual work
- enhance collaborative work
- use “patterns” as a resource for individual and collaborative thought, management and action
- enhance individual learning and empowerment and continuous knowledge management, to manage patterns and pattern evolution and the mastery of new skills
- provide the integrated information architecture to support these goals.

Thus, “patterns” are central to our argument.

### *Patterns*

From a behavioral perspective, patterns are the ways in which individuals or groups of individuals think and act. These processes are guided by the patterns that they have learned. When a new process is implemented, one of the major tasks is to teach people the new patterns of working (and ideally to revise the process design based on what people learn about the workability and effectiveness of the new patterns).

Patterns can be descriptive—here is how people answer customer telephone calls today. Patterns can be normative—this is the way that people should answer customer calls to achieve our goals of total customer satisfaction. Patterns can be individual, workgroup, or organizational. Patterns can be static or evolving. Patterns can be highly-specified, or broad templates which need to be specified in detail when instantiated for application in a particular situation.

### *The strategic role of patterns of thinking and acting*

Elsewhere we have argued that building a TPO means building an organization in which “patterns” of work are managed as critical resources. In the narrow sense, high productivity is

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achieved by people working hard and efficiently by executing rapidly previously-learned patterns of behavior. In a Taylorist or machine-age perspective, people behave like machines, concentrating on executing rapidly the previously-learned patterns of work. In the broadest sense, high productivity is also achieved by people working hard and sufficiently industriously, but with patterns of behavior that allow innovation, richness, problem-solving and other flexibilities. Thus, a key to building a Truly-Productive Organization is to help people develop patterns of thinking and acting which embody the desired patterns of behavior. [2; 3-4]

To understand how patterns enter into the processes of organizations, consider how the organization deals with various types of situations. In a disciplined, stable organization, there will be patterns of performance which individuals will follow in performing their work. Examples include:

- patterns for answering the telephone
- patterns for setting meeting agendas
- patterns for being effective in a sales call on a customer
- patterns for implementing Total Quality Management and ISO 9000. As discussed in [2-4], TQM is an example of the application of patterns: the objective of TQM is to change the patterns by which people operate in their company; and many others. [6-13]

A Truly-Productive organization utilize many patterns. As illustrated by TQM, effective process change requires changes in patterns:

- patterns define the *content of change*. to bring about change means to change the patterns of the ways in which people work: what they perceive, what they act on, how they act on it, what results they try to achieve, what skills and knowledge they bring to bear on the task, and so forth
- patterns underlie the *process of effective change*. to be effective in bringing about change requires using some patterns for interaction with others, what to do and how to do it, which will increase the likelihood of successful change and acceptance on the part of those involved in the processes to be changed. [2-4].

Business process redesign can be understood as a process of changing people's patterns. When a process is redesigned, it is still a "paper" design. To be effective, the paper design must be implemented, that is, translated into action as a "live" process being used by the organization.

The range of patterns is very broad. An overall process design is a pattern; the way a screen display for data input is constructed is a pattern; the way a customer service agent tries alternative search patterns to query a database for information requested by a customer, is a pattern (more precisely, a pattern of patterns).

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Patterns play a powerful role in guiding personal action, whether in work or in personal life. Patterns are manifest in individual and organizational behavior (Programmed and Unprogrammed behavior, e.g.).

### *Example: Patterns for effective management of environmental, health and safety issues*

Many organizations have a critical need to manage changing knowledge about Environmental, Health and Safety. *See* Environmental, Health and Safety (EHS) issues in a dynamic way: as new information is developed, its operational implications need to be assessed and the changes in operating procedures disseminated throughout the organization to those whose behavior needs to be affected.

For example, consider a company that manages terminals and storage facilities for environmentally-sensitive liquids. These liquids may be loaded into or discharged from trucks, barges, ships, railcars, pipelines, and/or storage containers. Every step of the process—what valves to turn when, what inspections to make, etc.—needs to be specified so that operating personnel at the field level follow the right procedures for every specific type of liquid. To ensure that people actually follow these procedures, there have to be procedures for disseminating the new procedures to the field, training people in the new operating procedures, and monitoring and assessing the procedures in practice and the extent of conformity to the procedures.

The overall process itself is a pattern, which includes a number of procedures as component patterns:

- patterns for assessing new information and determining whether changes in procedures are required
- patterns for developing the new operating procedures when needed
- patterns for disseminating the new procedures to the field organization
- patterns for training people in the new procedures
- patterns for monitoring and evaluating the changed procedures and people's conformance to the changes.

In organizations that have developed an effective approach to EHS management, such procedures have been developed and implemented. *Once this has been done, the knowledge of how to do this, how to do it well, how to deal with changed situations, etc. becomes a key knowledge asset of the organization* the organization is now an effective responder to changes in externally-driven EHS requirements. In an organization that has not developed such patterns, each change in EHS requirements is a crisis and is dealt with as it needs. Thus, EHS management is a good example of the importance of the ability to develop, implement, and follow desired patterns of behavior.

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### *Patterns as templates but not constraints*

Do patterns imply that an organization is constrained and “bureaucratic,” in the sense that there is only one right way to do something? Not necessarily, though that danger always exists. The key is to recognize that patterns are templates, not necessarily rigid procedures; and that patterns are implemented by individuals [6,7,16,17].

Part of the repertory of patterns of the organization is patterns for developing and modifying patterns. For example, there need to be patterns for flagging when a process is not working, and needs to be reexamined. There also should be patterns for thinking creatively; for example, a pattern for initiating a “brainstorming” session, or a “issue surfacing” session. There need to be patterns for accepting criticism, initiating experiments (“intrapreneurship,” e.g.), for rewarding and recognizing risk-taking even when experiments are not successful, and so forth.

Patterns are templates. Sometimes, the patterns available to an individual will be fully-specified operational procedures. More often, the patterns will be templates, or frames, which an individual then operationalizes by creating an instance in the context of a particular situation and the information he/she has about that specific case and circumstances. Often, too, each individual will have unique, personal ways in which they tend to instantiate patterns. Put another way, there will usually be organizational template patterns, and individual template patterns, as resources; and the specific actions taken by an individual will utilize case-specific patterns derived from these templates.

### *The links between patterns and groupware*

Patterns have many links to Groupware and Workflow Management Systems.;

First, many patterns deal with collaboration and cooperation. For example, patterns for various forms of interactions are provided as templates in groupware systems such as Lotus Notes. Notes includes templates for: shared news databases, simple discussions, basic customer service or help desk applications, and other forms of processes. To use these, an individual (with the right access rights) takes a template and creates an instance of it. For example, any team member might have the capability to create a specialized discussion database among a specific set of individuals concerned with a particular set of issues; Notes powerful access control capability allows the application developer to provide different levels of access to different team members.

Workflow management systems require Workflow designs, or patterns, for their execution. Based on the nature of the task to be accomplished, a process pattern is selected and launched for each new instance of a task.

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Second, the development, selection, and use of patterns should be a dynamic and collaborative process. Groupware functionality supports the collaboration of users around the use of patterns. Every pattern is subject to discussion and debate; out of this dialectic emerge revised patterns, or alternative patterns, which are richer and more powerful. A groupware component is essential for the dynamic management of knowledge when embodied in patterns. Every pattern library must have capabilities for mail, discussion, and possibly even Workflow. As appropriate, the development of new or revised or supplemental patterns might be managed with a structured Workflow. Thus, Workflow or groupware patterns are used to manage and support the evolution of patterns.

Third, many patterns will deal with the processes of developing and maintaining interpersonal relationships, where those relationships are supported by groupware functionalities, including email, news, discussions, document repositories, workflows, and others. Thus, team leaders concerned with effective relationship management (ERM. *See* Effective Relationship Management)—building and maintaining effective relationships—will use patterns of team management that will be supported by patterns of use of appropriate information technology. Consider for example Gabarro's model of four phases of evolution of inter-personal relationships [26]: team leaders in a multi-organization partnership might consider adopting this pattern as a process model for building and maintaining effective working relationships. They might then choose a combination of email, and discussion and Workflow patterns, that would most effectively support and reinforce the process model.

Fourth, the evolution of patterns in the pattern library is a form of learning and of knowledge management. Every organization needs to develop and use appropriate patterns to support learning and knowledge management in general, and especially about patterns. Groupware and Workflow components will be key elements of these processes., as discussed in the next section.

### Patterns and knowledge management

The role of patterns in knowledge management can be illustrated by the example of a Multi-Service Architecture, using different functionalities in an integrated way.

Consider the tasks of an insurance company, in receiving and processing various transactions with customers and agents. In this kind of organization, some processes are highly-structured, while other are unstructured. In *structured processes*, all of the process can be embodied in software, and once data is entered, no additional input from humans is required. In contrast, in *unstructured* and *semi-structured processes*, human input plays an important or even dominant role. To assure appropriate integration, an enterprise information architecture must involve appropriate roles for unstructured and semi-structured processes, as well as structured processes, and these roles must be coordinated.

To support this mix of processes, we need a library of patterns for dealing with all of

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these types of processes. Some patterns will be embodied completely in code, triggering the execution of structured processes. Other patterns will involve mixtures of code and human roles. Some semi-structured processes will be supported by Workflow patterns, executed under control of Workflow management systems and using both human and software agents. Unstructured processes will be supported by patterns for person-to-person interaction, including face-to-face meetings, and the full range of groupware functionalities, including voicemail, email, discussions, videoconferencing, etc. Then, these patterns are complemented by an overall process management pattern, which scans an incoming message and determines through a triage function which pattern to apply.

For example, in Wuerttemberg Insurance Co. [8,12], routine policy renewals are routed by the triage process to host-based transaction processing applications with no human involvement; minor claims are routed to Workflow processes with some human involvement in reviewing the claims; and requests for new types of insurance coverage are routed to a groupware process for electronically-supported discussions.

We call this overall pattern a Multi-Service Architecture pattern: a triage function uses patterns to decide which patterns to execute, and the range of patterns for execution covers the range of structured, semi-structured, and unstructured processes.

The Knowledge Management dimension of this process is especially interesting. Consider the design of a new organization: at first, the basic processes are poorly-understood, and so operate largely at the level of unstructured processes. As experience is gained, patterns are identified, and these patterns are used to provide structure in the form of groupware patterns (always email Henry with a copy to Mary on this type of issue ), and eventually Workflow patterns. Finally, as experience is gained with the Workflow patterns, even the role of the human in some workflows can be eliminated, and everything accomplished in transaction processing patterns.

Thus, as increased knowledge is gained, patterns of unstructured process form are evolved to semi-structured forms, and then structured forms.

Consider what happens when there is a disruption: a new situation arises, an old pattern is discovered to be no longer workable, a change occurs in the organization's environment, such a change in regulations or markets, etc. What was previously a structured or semi-structured pattern now needs to be replaced by unstructured patterns or at least by new patterns; patterns must be evolved again. Structured processes become semi-structured, and possibly even unstructured.

Thus, one key dimension of the management of organizational knowledge is the management of the evolution of patterns. And of course, appropriate patterns must be established to support this knowledge management process. A key element of the knowledge management process is the use of groupware and Workflow for supporting the collaboration and communication dimensions of formulating, revising, and evolving patterns.

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### **Patterns: Cognitive Perspective**

From a macro perspective, patterns are organizational processes. From a micro perspective, patterns are cognitive processes; the basis of individual patterns is cognitive. The role of patterns is as a guide to individual thought and action. Isenberg's studies of managerial effectiveness [11-12, 18-19] showed that effective general managers were effective precisely because they had libraries of mental patterns which they could execute effectively and efficiently, with little waste of mental energy.

### **Schemas: The cognitive bases of patterns**

Mental patterns are stored and retrieved as structures called **schemas**. Manheim and Isenberg [1] showed the link of Isenberg's results to the concept of schemas [14-17]. The skills of effective managers can be described as the ability to store a large variety of patterns, to retrieve appropriate patterns quickly, and to adapt patterns or invent new ones effectively as needed for novel situations.

### **Schemas and an IT architecture**

These findings were used in the design of Symbiotic DSS and Personal Construct-based Action-support Systems (PCAS)[20-22]. We now propose that schemas as cognitive constructs are key elements of an enterprise IT architecture, not just of support tools for individuals.

### **We argue that the IT architecture should**

- support the enriching of the variety of schemas which people can apply in their thinking and acting;
- support the rapid execution of previously-learned patterns, either as learned or as adapted in context;
- support the development of new patterns; and
- support the users use of a rich variety of support tools in the form of software modules or applications.

### **Cognitive Informatics**

Thus, there are several roles of patterns. First, patterns are behavioral at a macro scale: what are the patterns that from a strategic perspective should be used by an organization to implement its strategic goals, such as those of being a Truly-Productive Organization? Second, patterns are behavioral at a cognitive, or micro scale: what are the patterns of thinking and acting that can or should be reinforced or enhanced? Third, patterns are also elements embodied in software, software that is designed to support and enhance peoples' ways of working.

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Before we go into detail on the software issues, we first summarize briefly the theory that unifies these several perspectives.

We define Cognitive Informatics (CI) as follows:

*Cognitive Informatics is the use of knowledge about how people think and act to design information technology (IT) support that enhances the ways people think and act.*

CI is a normative theory based on a descriptive theory: we must first have a valid theory that describes how people think and act [1]. Then, we ask, how can we enhance the ways people work? The answer is a normative theory, a set of propositions about what to provide in IT support (and other dimensions, such as organizational reinforcements) to enhance work.

CI is based on these principles:

- **Schematic Basis of Thinking and Acting:** Human thought and action is based substantially on the rapid execution of previously-learned patterns, either executed as learned or as modified in the process of execution. These patterns are stored in memory and activated. Mental patterns are termed schemas.
- **Appropriate Software Support can Enhance Human Thinking and Acting:** A variety of software tools can assist people in thinking and acting more effectively. Especially useful are tools based on the application of schemas.
- **One Important Objective of Information Technology in an Enterprise is to Enhance the Ways in Which People Work, through Enhancing Patterns of Thinking and Acting:** Based on strategy research, we conclude that the goal of creating a Truly-Productive Organization (TPO) is a very important one and that a TPO See Truly Productive Organization can be a source of a competitive advantage. Key to this strategy is enhancing the ways in which people work, and finding ways in which people can be simultaneously tight—disciplined, executing rapidly previously-learned procedures—and loose—able to vary procedures quickly, to be innovative and to be flexible. IT can help people in doing this effectively.
- **The Information Architecture of the Enterprise Should Reflect the Preceding Principles:** That is, the information architecture of an enterprise should support achievement of a Truly-Productive Organization by providing integrated software support to enhance peoples' ways of working through supporting patterns of thinking and acting.

We now look at the Information Architecture implications of Cognitive Informatics.

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### Key Elements of a Person-Centered Enterprise Information Architecture

#### *Where does all this lead?*

- The emerging industry trends create a rich, varied, and almost bewilderingly complex environment of electronically mediated work.
- The variety of internal and external information resources, whether in structured databases or out someplace on the Web, becomes immense. Individuals now begin to have access to a tremendous variety of riches: it is as if all of resources of all of the libraries in the world could be reached by simply walking around my room and picking a book off the shelves. At the same time, the immensity of this resource is overwhelming—how do I find what I need when I may not even know precisely what I need?
- Strategically, organizations must become truly-productive. How can individuals' work be supported in a more effective way?

Patterns are powerful possibilities, reinforcing schematic thinking. But what is the relation to an IT architecture?

In this section, we describe a number of features of the proposed enterprise information architecture [23]. Our approach is normative: these are some of the key features which we believe should be provided to enhance the ways in which people work. Limitations of space mean we describe here only a few key features of the architecture that we are developing. The features are organized under thrusts. In addition to this theoretical work, we are developing functional prototypes that illustrate key elements of the architecture.

#### *Thrust: Focus software support on the individual's ways of working*

In today's business world, the individual is still the focus of work. Substantial components of work may be delegated to automated processes; but the individual is still key. Computer support must be focussed on enhancing the ways in which the individual works.

The individual sits at her computer, receiving information, searching for other information, assessing the information, and taking actions. The individual engages in thought, and uses the computer as an aid to thinking and to implementing the actions decided upon. Face-to-face interactions with others, in meetings and other formats, and management by walking around are all important aspects of the individual's work activities; but the electronically-mediated environment is a primary place for storing, managing, and working with the material of work: mail, documents, presentations, notes, etc.

***Key Feature:* Provide support for the basic activities of the individual work cycle: receiving new information, scanning it and assessing it, organizing priorities and to-do's, selecting processes to execute, executing processes and reviewing the results**

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There is a basic cycle of work that every individual follows as he or she does their daily work, often while sitting at their computer. The cycle begins with the receipt of information from multiple sources—messages, documents, data, etc. For each new piece of information, the user assesses the content: what questions does it raise? What issues does it pose? What potential actions need to be considered? What goals could be achieved by taking various actions? What people might be involved? What resources are needed to deal with this? Where are they available? And so forth.

As she reflects on questions such as these, she assesses possible actions and prioritizes the need for action—how urgent is it? Can it be put aside for a while? Can it be delegated to someone else? Based on the resulting priority assessment, she selects a process to follow to take the appropriate action, and executes that process—maybe doing some work on the issue, passing it to someone else, or filing it for future action or simply trashing it.

Every individual follows a cycle or cycles something like this. Though there are many individual variations in what is done, how, in what sequence, the general process is roughly the same.

One key objective of an information architecture is to provide support for each individual's execution of this basic work cycle, in the ways that they choose.

Figure 1 shows the Basic Work Cycle as a cognitive process, in which schemas stored in memory are retrieved and applied in scanning information, in assessing the information, in identifying issues, formulating goals, choosing actions and to-do items, assessing people's roles, assess priorities, selecting processes to execute, and executing them, leading to results which, when observed, become information inputs triggering a repeat of the cycle.

The two-headed arrows and unconnected arrows suggest the multi-dimensional interactions of these activities. Figure 2 shows the Basic Work Cycle as a process supported by information systems. This is similar to the cognitive process, except the role of schemas is augmented by the Pattern Library. The Pattern Library provides templates that are applied in a number of ways in the process of thinking and acting, as discussed in the following paragraphs. Particularly important are the patterns that become, once selected and instantiated, the processes to execute.

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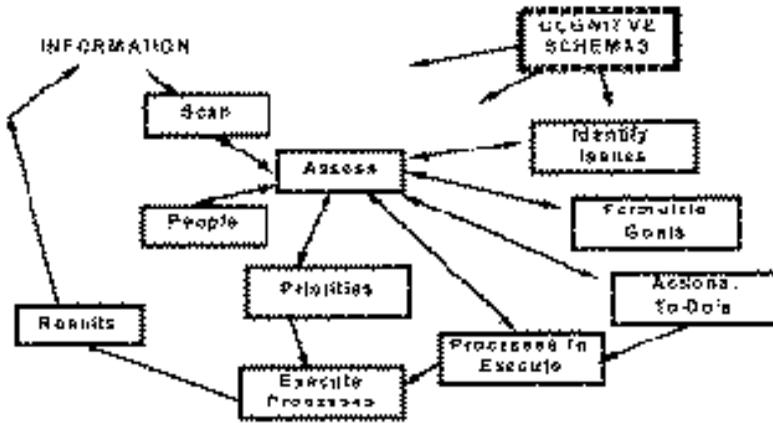


Figure 1

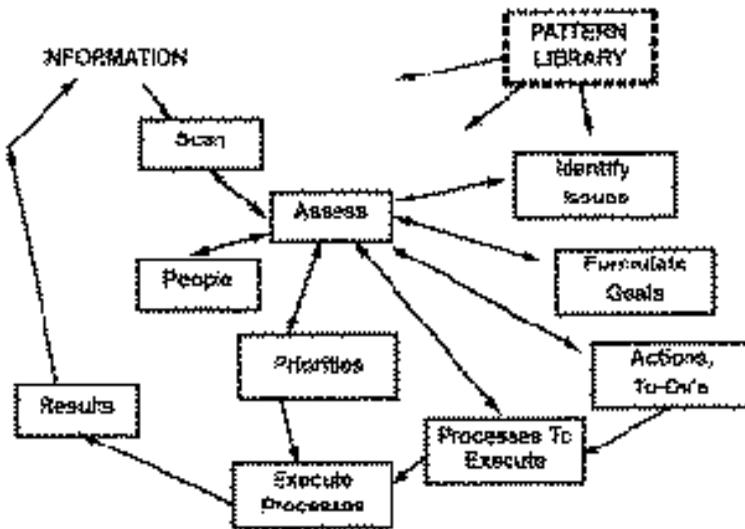


Figure 2

## BEYOND GROUPWARE AND WORKFLOW

***Key Feature: Provide a stable user working environment independent of the processes to be executed***

All of the key functionalities of the user working environment should relate to the basic working activities of the user, and should be independent of the specific processes or applications to be executed. However, execution of a process may take the user temporarily into a special subsidiary user environment. In other words, the user begins to have available a large number of specialized applications—not simply word processing and email, but discussion databases, presentation graphics packages, order entry applications, bid pricing applications, etc. etc. ***The user needs to think in terms of processes to be executed and not the application with which to execute the process. Patterns are independent of the applications.***

The following features address key functionalities to be provided in this top-level user working environment.

***Key Feature: Provide a universal in-box***

The individual will be receiving many different forms of information electronically: Email from multiple mail systems and on-line and Internet services, task assignments from workflows, EDI messages and messages from other structured formats, faxes, documents, graphic files containing presentations, multiple-media packages such as a product design, voicemail and other sound files, document images coming from scanners, responses to database queries, alerts from software agents of various types, etc. It is especially important to recognize that workflow tasks are only one component of this family of incoming inputs.

The individual needs to receive all of these elements in a single, universal in-box. The in-box needs to be in a form that allows a rich variety of views to be constructed (see discussion below on knowledge structures and PCAS).

***Key Feature: Provide support for managing a personal “to-do” list***

The individual is continually developing and modifying a personal to-do list. This includes tasks assigned or requested by others, both humans and software agents (e.g. workflow tasks, agent notifications), as well as self-generated tasks.

***Key Feature: Provide support for managing a rich variety of information***

As the individual receives information in mail, EDI messages, documents, images, etc., she stores it with a variety of descriptors for accessing it. Support is provided for sorting and retrieving all types of information in a uniform and standard way. This can include storing and retrieving information from remote repositories.

***Key Feature: Provide Support for a personal note-taker***

Every individual takes notes. Today, to be useful, they are primarily on paper, whether a steno pad, Post-It™ Notes, or a daily agenda book. There is a need for a personal note-taking capability. The notes should be able to be text or graphics, and in entry free form. In addition, there needs to be capabilities for sorting and organizing these notes in various ways, and linking them to other elements: e.g., all notes regarding a particular customer account and linked to a presentation and an appointment.

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### ***Key Feature:* Provide support for keeping track of issues**

One special form of view of the notes in the note-taker is the Issues Manager. This is a set of notes about key issues that are the focus of the individual's attention. Scanning and monitoring issues is a key element of the individual's management of priorities. For example, a workflow system may assign tasks to an individual and when those tasks become critical, they become issues to be resolved.

### ***Key Feature:* Provide support for keeping track of goals and progress toward achieving them**

Most individuals pay some attention to their goals, and in some organizations there are formal processes for establishing goals and monitoring performance in achieving them. In addition, anyone with supervisory responsibilities for others is concerned with setting mutually-agreed goals or commitments and overseeing progress in achieving them. Goals are another special class of notes that need to be defined, viewed, and managed separately. (Commercial products such as Avantos Performance Systems' ManagePro demonstrate elements of what can be achieved with thoughtful goal progress management.)

### ***Key Feature:* Provide support for keeping track of people, teams and organizations**

Every individual uses a name-and-address book. This needs flexibility for keeping track of individuals and formal organizations, and also of teams and their members, and other loose associations or "networks" of people.

### ***Key Feature:* Provide support for keeping track of personal schedules and other time commitments**

Most people use an appointment book of some sort to keep track of appointments and other time commitments. In a computer-supported environment, appointments are a key element of personal control over work.

### ***Key Feature:* Some of these functions relate to the common personal information manager (PIM)**

Some of these features are provided in today's marketplace by Personal Information Managers or PIMs. Typically, PIMs provide a name and address book, a calendar for personal appointments, and a capability for managing a simple list of to-do's or action items. Some PIMs provide additional features to add value and differentiation. For example, Lotus Organizer provides blank notebook pages for miscellaneous notes, and provides the capability for linking notes or appointments or people. See further discussion about PCAS.

### ***Thrust: Provide each user with a rich library of patterns***

### ***Key Feature:* The user acts by selecting and executing patterns and their associated processes**

What does the user do as she receives this information and assess it? She determines which actions to perform, using or applying those actions to specific components of the information.

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***Key Feature:*** A pattern is information presented to the user and, optionally, an executable process

To achieve the strategic objectives of a Truly-Productive Organization, as discussed above, the information architecture envisions that each user has available a rich library of patterns. These patterns are software objects; think of them initially as forms or documents. These patterns have names, descriptions, and other descriptive attributes. As the user assesses available information, she selects one or more patterns for review and /or for execution.

***Key Feature:*** The patterns that a user has available provide the user with a rich variety of possible processes to execute

The patterns cover everything from word processing, spreadsheet and presentation packages, to groupware, to development of marketing plans, to development of corporate business strategies.

***Key Feature:*** Patterns provide a basis for user action but are not constraints

Patterns may be executable as they stand, but more often they are templates, which require additional information to be specified before they can be executed. Further, there are often a number of variations on particular patterns, and the user has the capability to modify her patterns as desired.

Examples:

- **Word Processing-Based Pattern:** One pattern is, send the customer an invoice. This pattern pulls up the user's word processing package with a template for an invoice. The user fills in the customer name, a software agent fills in the address, the user fills in the names of the items, a software agent fills in the part numbers and prices and the customer's discount, and totals the bill. The user examines it and sends it, selecting among fax, email or physical mail.
- **Presentation Graphics-Based Pattern:** Another pattern is, prepare a marketing presentation for a sales meeting tomorrow. When the user selects this pattern, the preferred presentation graphics package is launched and a dialog box lists the names of three templates for marketing presentations (the current release of Freelance Graphics for Windows has two marketing presentations as SmartMaster templates). The user chooses one and then begins providing data for each text box on each page of the template.
- **Lotus Notes Discussion-Based Pattern:** In a third pattern, the user reviews an incoming message and is presented with a menu of choices. One choice is to forward the message; if selected, the user specifies to whom and optionally a message to that individual. Second choice is to draft a reply; if selected, the user is then presented with a draft of a standard reply letter selected by an agent which made inferences from the parsed text of the incoming message. Third choice is to discuss this message with others; if the user selects this, a discussion template in Lotus Notes is launched, the user is asked to specify the participants in the discussion, and fills out an initial

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discussion topic incorporating the received message and her own comments. Then the discussion template is instantiated, with the selected individuals placed on the Access Control List as approved for participation in the discussion, the initial discussion topic is loaded into the discussion database, and an Email message is sent to the named participants inviting them to discuss the issue by a specific designated deadline.

- Compound Pattern Based on Notes Discussion, Word-Processing, and Presentation Graphics and supported by a WorkFlow Management System: In a fourth situation, the user receives a message from a customer complaining about a quality issue in the firm's product. The user, after reflection and taking some notes in his Note-taker, launches a Notes discussion to get the views of designated colleagues, by a specified deadline. At the deadline time, the process, controlled by a workflow management system, brings the discussion database up on the user's screen for review, together with a word processing template for a letter to the customer and with the relevant notes from the user's NoteTaker database. The user drafts the letter and, committing to a presentation to the customer in two days, launches a presentation template for Presentations to Customers about Problem Resolution Strategies and begins to fill it out with a draft presentation.

*Thrust: Implement patterns in software*

**Key Feature:** Patterns have attributes by which they can be stored and retrieved

**Key Feature:** Patterns can be composed of other patterns

An application is a pattern, built up out of component software modules (Building-Block Functions). A workflow is a pattern that may call many other subsidiary patterns. In the general case, high-level patterns will build up out of large numbers of component patterns.

*Thrust: Provide users with the capability to manage a library of patterns*

Users should have the capability to manage their personal libraries of patterns however they wish. Typically, a user will have a large library of patterns. Some will be quite personal and private; others will be shared with various degrees of access control for different groups. A system should provide tools for managing personal and shared pattern libraries, provide capabilities for storing, organizing, retrieving and applying patterns; provide tools for constructing, testing, revising patterns; and provide capabilities for sharing and controlling access to pattern libraries.

*Thrust: Support User-centered development and modification of patterns*

Users will develop and use their own patterns, and will use patterns developed by others.

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***Thrust: Package major software functionalities in modules to be used as pattern components—building-block functions (BBF)***

Our objective is for pattern management to be the primary basis through which users call on and use applications. To support this approach, applications must be made modular and the modules encapsulated in building blocks that can be documented, handled as objects, and used in building complex patterns. Building-block functions (BBFs) [24] are software components that are packaged as reusable modules. Applications can be built by linking together BBFs either in an interpreted or compiled mode, or at run-time. They are understandable by and useable by knowledgeable users. BBFs are at a higher level than most software objects, but may be high-level objects. In general, they are at a lower level than applications.

***Thrust: Package existing IT applications as modules for use in patterns***

IT is being used today to support patterns of work and thought in a variety of ways; however, at present they are independent implementations.

***Key Feature: Exploit patterns in existing software products***

Present desktop packages come with a number of patterns. A wordprocessor typically comes with templates for business letters, invoices, social letters, newsletters, etc. business presentation package (e.g. Lotus Freelance) comes with design templates with different visual design treatments such as typefaces, colors, etc. Especially importantly, Freelance also includes presentation designs that are patterns for marketing plan presentations, business plan presentations, and other.

***Key Feature: Treat workflows as patterns***

Workflow management systems are used to manage the flow of work among individuals, roles and/or organization units, to accomplish a business task—e.g., process an insurance claim. The data of a workflow is in the form of a pattern: a set of conditions under which a workflow might apply (e.g. the type of claim), and the rules for passing the responsibility for task execution among different individuals or units. The work of the Workflow Management Coalition (representing some 150 vendors) is very important, in that they are developing a set of standards for interoperability of workflow processes among the systems of different vendors. In particular, the Coalition's standards will include a standard data structure for managing workflow patterns independent of which engine will execute them.

***Key Feature: Provide patterns for groupware***

Most groupware products are designed as pattern libraries. For example, Lotus Notes is an application-development platform for groupware applications. A Standard client package includes a number of templates for possible applications, including a discussion template, a customer service template, and others. To use Notes, a user or developer takes a template as a pattern, and creates an instance of it, establishing the name of the discussion instance and which users have access to that discussion.

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### ***Key Feature: Provide personal construct-based action-support systems***

Basic Personal Information Managers (PIMs) include address book, calendar/schedule, and note-taking capabilities. Advanced PIMs provide the ability to manage information according to personal constructs. Tools like Lotus' Agenda, Zoot, See and NetManage's Ecco allow the user to create text items such as "discuss Acme marketing plan with Mary before Friday" and have these categorized and assigned to personally-defined constructs such as Mary, Acme, Marketing, and indirectly to constructs such as high priority, management problem, staff recognition opportunity, etc. Tools such as Avantos' ManagePro provide a structure and library of a number of management-specific constructs.

These advanced PIMs provide, by their capabilities of linking text (and other objects) to user-defined constructs, the capability for the user to focus his/her actions on key issues and priorities. Thus, we call advanced PIMs with these features Personal Construct-Based Action-Support Systems (PCAS. See Personal Construct-Based Action-Support Systems). PCAS provide tools for applying patterns to managing personally defined issues, goals, priorities, and actions. [21]

### ***Example: Managing Software Development***

We are presently developing several prototypes of a Pattern-based information system. One prototype is designed to be used by managers of software development projects in a large insurance company. The prototype is being implemented in Lotus Notes, Release 4.

The central patterns being developed in this prototype include:

- patterns for the basic cycle of work, including patterns for expressing issues, goals, and actions
- patterns for assessing software development risks, including patterns for managers to consider using to minimize or avoid particular types of risks
- patterns for building and maintaining support of key stakeholders
- patterns for managing the detection and resolution of bugs.

These patterns can be applied as is by the user, or can be modified and evolved. One advantage of a platform like Notes with replication, mail, and discussion capabilities, is that patterns can be readily discussed, exchanged, and modified. Thus, this prototype also demonstrates the power of patterns as the basis of a knowledge-management architecture.

## CONCLUSIONS

A major source of competitive advantage for organizations lies in the development and adoption of a new information architecture, based on enhancing people's capabilities through the use of patterns. Through this architecture the rich variety of technology elements in the emerging work environment can be unified and made more accessible and useful for users.

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People think and act schematically. Their work involves the execution of patterns, representing previously learned processes or the development of new processes or revision of old processes.

Therefore, a key element of an IT-based strategy is how individuals can access a library of patterns, use patterns and associated processes to perform desired tasks or achieve desired goals, and manage the evolution of their patterns and processes, both individual and organizational.

An integrated pattern-based architecture will involve the following components:

- an application-independent and document-format independent pattern library
- a user-oriented capability for applying patterns as is, or for modifying patterns or developing new ones
- a library of standard optional patterns, such as office application suite components, workflow management, groupware, and PCAS-type patterns
- continuous learning and evolution of knowledge expressed as patterns and other features.

At present, many software applications provide support for the uses of patterns, but the patterns are very specific to an application context and usually hidden in the application. What is needed is an approach that unifies these uses of patterns by providing a generic approach to the management, development, and use of patterns, and makes patterns the top level of the user's access to the resources of the IT-enabled work environment. With the proposed approach, the top-level user functionality remains stable, oriented around patterns and their application, while the functionality that can be accessed continually grows in power and in variety. Accessing a document on a web server should involve the same pattern as accessing a document in a local or distant database; from the user's perspective they are the same things.

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