FROM INFORMATION TECHNOLOGY TO VALUE CREATION TECHNOLOGY

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Provocations

1) *All technology that does not support value creation will become obsolete.*
2) *All technology will become collaborative technology.*
3) ***Group** attention will be the future's scarcest resource.*
4) *Technological advancements in areas such as information assimilation and collaboration will keep increasing organizations' intellectual bandwidth.*

INTRODUCTION

Fifty years ago, the students at Carnegie Teach and other prestigious engineering schools could major in steam power. Today that focus seems quaint and dated. Steam power took center stage as Fifty years ago, the students at Carnegie Tech and other prestigious engineering schools the industrial revolution moved from sedate waterwheels and human muscle to the massive horsepower afforded by the exciting new technology. Steam faded to a footnote in industrial history because it was merely an instance of the more important issue of converting energy to work.

Steam is to energy conversion as Information Technology is to value creation. Fifty years from now, like steam, Information Technology may seem quaint and old-fashioned because it will have become but a part of the bigger picture of converting mind power to value. Information Technology took center stage because in the information age, information access was the most painful bottleneck in organizational value creation. The advent of exciting new computer technology provided massive horsepower for information access. The Holy Grail of the information age is "All information at your fingertips." With the Internet and the Web, with e-mail and voice mail, with data warehousing and knowledge management, that dream is about to become reality. And with it comes another reality: that information alone is not sufficient for value creation. *The focus of IT Methodology and Implementation must shift from informing to creating value.*

In this chapter we explain what we mean by Value Creation, and offer a simple model of an example. We then elaborate on that model by exploring the concept of Intellectual Bandwidth, a necessary, but not sufficient, prerequisite for value creation. We argue that IT professionals must look beyond information access, the traditional focus of IT, to information assimilation, collaboration, and the methodologies of work processes to fully enable and enhance the value an organization can create. We then draw inferences

from this model about the future of Information technology and practice, and conclude with calls to action for IT professionals and researchers.

VALUE CREATION DEFINED

Organizations form to create value that cannot be created by individuals. By value we mean anything that someone might consider useful, important, or desirable. As such, value can only be defined and measured from the point-of-view of a particular entity: a person, a group, an organization, or a society. Because people have many different kinds of needs, wants, and desires, organizations may create value along many dimensions:

1. Economic value -- wealth, resources…
2. Physical value -- well-being, rest, comfort….
3. Emotional value -- security, contentment, excitement…
4. Social value -- effective relationships among people…
5. Cognitive value -- knowledge, wisdom, lower attention demands…
6. Political value -- power, control, influence…

One may conceive of value creation efforts as having three different aspects: Information Assimilation, Group Dynamics, and Methodology (Figure 1). Each of the three aspect represents a different focus in the efforts of the people who are creating and implementing technology to support those who create value. Each aspect may build on and contribute to the other two aspects. Since each aspect deals with different problems and issues, successful value creation only occurs if all three aspects are addressed simultaneously.

<Insert Table 1 about here>

The Information Assimilation Focus

The first component of value creation is the one most central to today's systems professionals: Information Assimilation. This component addresses the amount of mental effort required for organizational members to find and understand needles of information buried in haystacks of vast data stores. The information age provides us with more information than we can search in a lifetime.

<Insert Figure 2 about here>

There is a continuum of technology that can enhance an organization's ability to assimilate information. For centuries the best one could do was to search paper and parchment documents manually for the required information. With the computer came the ability to do exact-match searching of flat data files, followed by more powerful, more flexible, and more efficient exact-match searching of database queries. With these technologies, however, one had to know a great deal in advance about how the data were stored and what they meant when they were put into the database.

Recent innovations in semantic queries have allowed some organizations to jump-start their value creation again. A semantic query, in effect, tells the computer system, "Go find what I mean, not what I say." For example, if you want information about international transportation of products in Europe, a semantic query might return information about commercial trucking in the Common Market. None of the words from the original query appear in the response, but the meaning of the original query is preserved and the response is appropriate. This seemingly magic capability is due in large part to innovative combinations of neural networks and standard query techniques. Specific instances of organizations' increasing their productivity with applications of neural network technology to semantic queries abound. The Tucson Police Department, for example, created a revolutionary crime reporting and analysis system called CopLink. Detectives enter the details of a crime into CopLink. CopLink records the details in its database. Then it examines every other crime report in the system, looking for links and patterns. If it finds something interesting, it alerts the detectives, offering information on possible suspects and other unsolved cases with similar features. The detectives using the system report that CopLink has helped them make connections between cases that might never have been made by human minds alone. It has helped them close cases that might otherwise have gone unsolved.

The University of Arizona uses similar technology in a system called Geographical Knowledge Representation System (GKRS) to find examples of geological features, plant life, and human development in vast unstructured stores of digital satellite images (Figure 3). A person provides the system with a satellite photograph of a known feature, say, an orchard of oranges or a stretch of sand dunes. The system then searches its store of images

to pinpoint similar features within a designated area. The system can also simply examine all the photographs, sort out the different kinds of features they contain, and organize the images according to the features it finds.

CopLink and GRKS are but two examples among many of the way that semantic queries can increase the productivity of an organization teetering on the brink of information overload. (You can learn more about these and other semantic processing systems at http://ai.bpa.arizona.edu).

The Holy Grail of Information Assimilation is automated sensemaking. In an automated sensemaking scenario, a person would describe to the system what he or she knows of a problem. The system would interview the user further, then collect relevant information, organize it, and suggest possible root causes for the problem. It might also gather information and suggest possible courses of action for dealing with the problem. If such capability should ever be developed, the value created by organizations that used it would be substantially increased.

A focus on information must embody the Siamese twins of data and communication infrastructure (Figure 3). Every step in a value creation process (discussed in more detail below) may require people to use information. The function of information is to increase the likelihood that people will be aware of the state of the world, and will expect the result they obtain when they make choices about scarce resources. Therefore, every reasoning and action effort may require that people:

1. Find,
2. Store,
3. Retrieve,
4. Transform, And Display information.

<Insert Figure 3 about here>

Every step in the value creation process may also require people to communicate information and ideas to one another in a variety of ways. In any joint effort people must communicate at some level. They must talk and listen, write and read, move and gesture, show and share and engage in a host of subtle non-verbal communication behaviors in order to create shared meaning and understanding.

In addition to the recent innovations in neural networks described above, ongoing research in visualization and information by attunement may someday make it possible for the human mind to absorb vast quantities of information with far less effort than is now

required. Innovations in networking bandwidth and communication protocols provide people with faster and more powerful communication capabilities, such as high quality video conferencing.

Information has value to the degree that it is timely, accurate, and complete. However, its value is offset by the economic and cognitive costs of acquiring, storing, transforming, retrieving, and displaying it. Furthermore, information alone is lifeless; it creates no value. Knowing is not the same as doing.

The Group Dynamics Focus – Collaboration

The second component of value creation is collaboration. *Collaboration* is the degree to which people in an organization can combine their mental efforts so as to achieve common goals.

The simplest form of teamwork is *collective* collaboration (Figure 5). Under this model each person makes an individual effort, but the efforts are organized to the point at which the individual efforts add up to productivity by the whole group. Counting votes and selling retail goods are example of tasks that may be done collectively. In each case individuals work independently, and the productivity of the group is simply the sum of the productivity of the individuals.

There are few opportunities for synergy or increased efficiency in this mode of work. Adding more people to an envelope-stuffing task is unlikely to change the number of envelopes stuffed per person/hour. Nonetheless, the value creation is increased over non-collaborative individual effort because the many minds are at least not duplicating or accidentally thwarting one another's efforts.

The sprinters at a track meet are a useful metaphor for collective work. Each

<Insert Figure 4 here>

sprinter runs an independent race. Each tries not to interfere with teammates' efforts, but none contributes directly to the success of the others. In the end, the finishing positions for each team member are simply added up for the team score.

A step up from collective collaboration is coordinated collaboration. Under this model tasks are differentiated People become specialists at doing pieces of the whole task. Each member of the organization works independently of the others, but each must

carefully coordinate hand-offs of deliverables because the work of each depends to some extent on the productivity of the others. Because people specialize and coordinate, there are opportunities for synergy and efficiency. Thus, value creation may be higher than for collective work.

Relay racers at a track meet offer a useful metaphor for coordinated team efforts. Each runner runs alone, but there are mission critical points in the race where one runner must coordinate the hand-off of the baton to another runner. Team productivity is not only a function of individual effort, but of the degree of coordination among those efforts.

<Insert Figure 5 about here>

The highest form of collaboration is concerted effort. Under this model all team members must be making the right effort at the right time toward the goal. The efforts of each member directly affect the efforts of others. Any local disruption creates global impact.

Team rowing and sailboat racing are useful metaphors for concerted work. In rowing, all team members must pull together. If one member gets slightly out of sync, it will interfere with the ability of other team members to row. Without a concerted effort, the best the team can hope to do is muddle the boat over to the bank and get out. With a concerted effort great synergy occurs. The boat springs to speeds that would be unimaginable for individual rowers. Likewise, with sailboat racing each member of the crew focuses on a different task, but all tasks must be conducted in concert for the boat to win. The cockpit crew must trim the sails just perfectly for the wind conditions. The tactitian must decide how best to out-fox the competition. The skipper must decide how and when the boat should be steered. All must execute their tasks perfectly in unison or advantage is lost.

In order to combine the power of many minds, a group must be able to create, sustain, and change patterns of interaction, or Group Dynamics. For example, they may:

1. Diverge or converge,
2. Organize or deconstruct,
3. Elaborate or abstract,
4. Analyze or synthesize, or
5. Move to consensus or polarize

Every step in a value creation process requires that a group go through some pattern of group dynamics. Consider, for example, the patterns of interaction that group members might create as part of a reasoning process in order to understand their problem.. They might:

1. Diverge from conventional thinking to find possible explanations for the unsatisfactory symptoms they observe. (For example, why is the paint peeling off the screws on our new product? Bad paint? The weather? Oil on the metal? Industrial sabotage? Bad karma?)
2. Converge on one or a few possible explanations. (The paint or the weather)
3. Explore, deepen and elaborate their understandings of these possibilities.
4. Agree on an explanation for their problem. (It's the paint).

Thus, to understand their problem a group might create a pattern of four different dynamics. Subsequently, in order to develop solutions for their problem, the team might create a pattern of two different dynamics:

1. Diverge in a brainstorming session to seek effective solutions. (Heat the paint shop? Paint everything in the summer? Find a paint that works in the cold? Move the plant to Arizona?)
2. Converge on a few solutions that seem worthy of further investigation.

There are technologies to support each level of collaboration. For example, shared network directories, word processors, and spreadsheets may be used effectively to support collective efforts. E-mail, team databases, and workflow automation may enhance the value creation of coordinated efforts. Collaborative reasoning tools may be used to enhance the value created by concerted efforts. Examples of collaborative reasoning tools include electronic brainstorming tools, group outlining tools, and idea categorizers, to name but a few. All participants can contribute to these tools simultaneously, and every contribution appears immediately on the screens of the other participants. The interfaces on these tools are subtly configurable so as to create the patterns of group dynamics required for the task at hand.

The creating of repeatable, predictable group dynamics depends on a combination of tool and technique; of how the collaborative reasoning tools are configured and what the

moderator says to the group. Consider how the same electronic brainstorming tool might produce very different dynamics under these two different facilitation techniques:

1. When you see somebody else's idea turn up on your screen, you can argue with it, you can elaborate on it, or you might be inspired to submit a completely new idea. (Free Brainstorming Technique)
2. Please enter your strongest argument in favor of your position on this issue. Now trade pages. You should see somebody else's argument on the screen in front of you. Whatever argument you see, enter the strongest counter argument you can think of. Trade pages once again. You should see a strong argument and a strong counter argument. Now type in an argument that bridges these seemingly mutually exclusive positions. (Point - Counterpoint technique)

In the first case, you are likely to get free-wheeling discussion and lots of out-of-the-box thinking. In the second case people may find common ground to break an impasse. For some tasks, the first technique is preferable, for others the second technique. Researchers and practitioners have recently begun systematizing these technology-support group dynamics techniques and giving them whimsical names like:

- Popcorn Sort
- FastFocus Convergence
- Pin the Tail on the Donkey
- GoldMiner
- Tag Team Brainstorming

These techniques become the building locks for collaborative methodologies that can move a group toward its goal. (For more examples and discussion of these techniques see http://www.groupsystems.com)

Each of the dynamics mentioned above (divergance, convergance, etc.) is really a category that represents far more complex and nuanced instantiations. For example, there are many different ways a group may diverge during a solution generation activity. A free brainstorming technique tends to cause a group to push for breadth rather than depth. A directed brainstorming technique, on the other hand, can cause a group to diverge along one dimension of the solution space even as they converge along others.

In order to create and sustain group dynamics to accomplish their reasoning/action process effectively, people in organizations require information. They cannot, for example, diverge in searching possible explanations for the problem if they have no information about the symptoms. At the same time, without proper group dynamics, people cannot effectively combine and synthesize their information. Therefore the Dynamics and Information Assimilation Focus are complementary.

The Methodology Focus

The third and final focus in the value creation model concerns the methodologies, or repeatable work processes an organization must use to create value. A methodology is a pre-defined set of steps and guidelines for attaining a particular goal. The methodology focus contains the fraternal twins: Reason and Action. The reasoning process is ubiquitous to human endeavor. It may be summarized like this:

1. Come to understand the problem. In this step people:
- Articulate the unsatisfactory conditions
- Distinguish between symptoms
- Determine which causes are within the control of the group

<Insert Figure 6 about here>

- Determine which symptoms can be alleviated if causes are unknown or uncontrollable

2. Develop alternative solutions. Creativity is paramount in this step. In this step people:
- Seek creative ways to affect causes
- Seek creative ways to alleviate symptoms
- Seek creative ways to capitalize on things that had been considered unacceptable.

3. Evaluate alternatives. In this step people:
- Articulate their values
- Define boundaries and constraints for acceptable solutions
- Develop criteria for judging their alternatives.
- Consider their options in light of their criteria.

- Choose a solution consisting of one or more of the identified alternatives. In this step the group must move from the "could-be" of the many alternatives to "should-be" of a preferred solution. In this step people:
- Decide how to decide -- Vote? Using what method? Let the leader choose? Let an expert decide?
- Make their decision, i.e. select one or more alternatives to be implemented as the solution for the problem.

4. Plan for action. Having settled on a course of action, the group is still not ready to act. Its members must decide:

- What actions must be taken by whom in what order
- What deliverables must be created from each action
- What deadlines apply to those deliverables
- What resources will be used for those actions
- What measures of merit will be applied to the results.

These steps appear in many different disciplines under different names and guises: Systems Analysis and Design, Problem Solving; Decision Making; Engineering; Scientific Method, and the list goes on. Although the names may differ, the underlying processes are similar.

People do not always reason in an orderly, well-structured manner. With poor reasoning, action can be effective only by accident. Sound reasoning is the cause of consistent, repeatable success. Nevertheless, while the steps in the reasoning process listed above appear sequential and orderly, they are seldom executed as if following a cookbook recipe. Frequently, they are carried out in an iterative or even nearly random fashion. If the problem is small enough, one person may be able to cover all the steps in his or her head, sometimes in parallel. As problems grow more complex, the details and complexities can exceed human cognitive capacities. Many minds focus on various aspects of the problem, and no one mind holds all the pieces. In other words, well-structured collaborative reasoning processes are necessary or unproductive chaos will reign. Effective reasoning processes may be embedded into repeatable methodologies to assure that teams reach their goals consistently and with predictable quality.

The second twin of the methodology focus is action. As a team takes action to achieve its goals, its members must know the plan, they must monitor the results of their actions with respect to the goal, and they must adjust both the plan and their actions to see to it that the goal is attained. Some people lump the Action process with Reasoning. We separate them here because the technologies to support reasoning may differ from those that support action. The action process involves:

1. Expending effort toward the goal,
2. Coordinating the actions of many people as they execute to a plan,
3. Monitoring the results,
4. Adjusting the plan, and
5. Controlling scarce resources.

THE SHIFT TO VALUE CREATION

Human attention resources are limited. When trying to achieve a goal (create value), one person can assimilate only so much information, perform only so much reasoning do so much, and take only so many actions in a day. The Information Assimilation focus and the Group Dynamics focus combine to produce a construct we call the intellectual bandwidth of an organization (Figure 7). The effectiveness with which an organization can create value is bounded by its intellectual bandwidth, which is its collective potential to acquire information, make sense of it, and take action with respect to a goal. The intellectual bandwidth of a team or an organization represents its potential to do meaningful work through the minds of its members. Intellectual bandwidth can be increased either by increasing a team's ability to assimilate information or by increasing the ability of its members to collaborate. However, multiple gains may be obtained by increasing both.

<Insert Figure 7 about here>

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In order to create value, groups must have sufficient intellectual bandwidth. That bandwidth derives from (1) their access to the necessary information and communication support to provide content for the reasoning processes, and (2) their ability to create, sustain, and then change their patterns of interaction, or group dynamics. Intellectual

bandwidth represents potential, not actual accomplishment. It sets the outside boundaries for productivity. In order to create value, people must go through a *value creation process* where they become informed, reason together, make a plan, and take action. Only when the process culminates in action is value created. It is the *work process methodology* that leverages available intellectual bandwidth to actually create value. Information is an input to the work process; group dynamics provides the building blocks of the work process. IT professionals must therefore broaden their focus from providing infrastructure for informing to include not only work processes but the group dynamics issues of collaboration so that Information Technology can finally become Value Technology.

IMPLICATIONS OF THE VALUE CREATION MODEL

If we accept that technology must evolve beyond its current focus on informing to embrace the whole of value creation, then there are several implications for the future development of technology.

IT Metrics Must Be Value Based

The success of an information system may be measured in many ways -- response times, validity of calculated outputs, accuracy and precision of query results, user acceptance, maintainability, and so on. However, standard metrics for IT success typically do not extend to their impact on created value. If the focus of IT is to shift toward value creation, then the metrics for the success must also shift toward value creation. In general, the measures of success must address the value goals of the team the system supports; they must address the systems value effectiveness. If a team is trying to create economic value, then the success of its technological support system must be measured in dollars. If the team has been designed to create political value, then success must be measured in terms its impact on control over scarce resources. If the team seeks to create emotional value, it may resort to surveys or critical analysis to measure the success of the system. Today's IT metrics of throughput, MIPS, usability, and the like are only secondary to the more important issue of value creation.

IS Development Will Evolve into Organizational Engineering.

Current systems analysis and design tends to focus on informing. Because organizations exist to create value, the focus of technology development methodologies may shift from information access to value creation. With the shift in focus from informing to reasoning and acting, strategic planning, work process design, and systems development may merge into a unified process. Organizations will decide on their missions, goals, and objectives, design the processes and systems to accomplish their mission, and design the systems to support all layers of the process -- information, group dynamics, and group process. As a result of this integrated approach to organizational and system design, everybody in the organization will be able to know how their work fits into the big picture. It will be possible to tie every action and every system back to an organizational goal. If an action doesn't map to a goal, the workers will either abandon the action or recognize a new goal.

Examples of the integrated approach exist but are rare. Researchers at Delft University of Technology, for example, have been working on such an integrated approach for over fifteen years. The (intermediate) results of these efforts have been successfully applied at organizations such as the Amsterdam Municipal Police Force, the ING Group, Heineken Breweries, and the South African Police Service. Using group modeling and simulation techniques, Delft researchers facilitated workshops where members of an organization designed their own work processes. Based on the specifications of the new work processes, instances of supporting IT were subsequently prototyped and evaluated. In similar vein, the research group at Lancaster University in the UK, led by Checkland, has been developing an approach called Soft Systems Methodology (SSM). This approach advocates the collaborative definition and analysis of purposeful human activity systems in an organization. The outcome of these efforts have been applied at Shell, the UK National Health Service, and ICL, and offer examples of integrated designs of new organizational structures, processes, and supporting information systems.

Nevertheless, there is a pressing need for more systems development that first considers the value to be created. Only then could work begin on methodology, group dynamics, and the information needs for creating that value.

All Technology Will Be Collaborative

If organizations form to create value that cannot be created by individuals, then it is obvious that organizations require collaborative work at some level (collective, coordinated, or concerted). People working alone on tasks can devote most of their attention to the task. People working together on tasks must spend part of their precious attention on one another. Therefore, as focus of technology shifts from information to value creation, all technology may become collaborative. This means it would help people create and sustain group dynamics even as it helped them find and make sense of information.

The embryonic beginnings of this trend are already with us. Traditionally single-user applications are taking on rudimentary collaborative capabilities, for example:

1. Word processors allow for after-the-fact integration of multiple revisions of the same document
2 Presentation Graphics Packages allow for synchronized presentations at remote sites.
3. Desktop applications allow for e-mailing copies from within the application.

A host of group-specific applications have sprung up. To name but a few:

1. Chats
2. White Board
3. Application Interface Sharing
4. Team Document Repositories (i.e. Lotus Notes)

Virtual Workspace products (Placeware.com; Info Workspace, and others) that make a suite of collaborative applications available to the user have recently appeared. To date, almost all the manifestations of the trend toward ubiquitous collaboration have been implemented with an Information Focus. The rhetoric surrounding these technologies focuses on sharing, communicating, storing, and searching.

There is some work with a Group Dynamics focus being done by Group Support Systems (GSS) researchers, who report on new and better ways to cause a group to diverge, or new and better way to move a group toward consensus. However, most of this capability is currently embedded in proprietary systems that offer only minimal integration with other applications. Over the next decades group dynamics capabilities

must become widely available in operating systems and in interoperable applications. At this time we see little effort being made to create technology that directly supports the reasoning/action process. Researchers and developers should begin to create technologies that will guide groups through collaborative processes so that best collaborative practices may be captured and reused.

This effort should continue to the point where the distinction between collaborative tools and single user tools becomes blurred, and finally lost. Operating systems should directly support collaborative services, so all applications could be collaborative by default. Users might then finally be able to conduct all their work -- collaborative or single -- in the same environment. Collaborative technology should become so ubiquitous that it no longer constitutes a separate field of inquiry.

Production Lines for the Knowledge Economy Will Emerge

If all technology becomes collaborative, there will arise a great need for people who understand how to use collaborative technology tools to create effective work methodologies based on those tools. Even today there exists a commercially available group support system with eight collaborative tools. Each tool has between 15 and 25 optional settings. Although this may seem fairly manageable on the surface, there are more than 9 million possible combinations of settings for this system, and each of those may a different impact on group dynamics. An inexperienced user who confronted with such a system has no way to know which of the 9 million possibilities is the one required for the task at hand. Thus a community of expert facilitators has begun to form to help manipulate collaborative technology on behalf of a team.

The need for these people may increase dramatically over the next decades However, few people have all the characteristics required for a good facilitator: And of the bright, articulate, problem-solvers with high interpersonal skills and good technical capabilities who qualify, only a few are willing be facilitators. There are many other rewarding ways such people can make a living, so good facilitators tend to be so expensive that few work units that can afford their own full-time facilitator .

The solution might be to have facilitators create repeatable methodologies based on the industry’s best practices for organizational tasks like risk assessments or strategic planning, and to embed the steps of those methodologies in a collaborative software

environment. The software itself might lead a group through a collaborative activity designed by an expert facilitator. People who then execute the steps of these methodologies would not be required to know the millions of possibilities offered by the collaborative environment. They would only have to follow the instructions for each step in their process.

The captured methodologies would be analogous to the production lines of the industrial economy. In a production line all the steps in a manufacturing process are designed in advance. Each station on the production line is equipped with the appropriate tools for its subtask. Each worker is trained in the requisite techniques for a given station. Production line operation produces more value with fewer skilled workers, lower labor costs and predictable quality than did the traditional reliance on mastercraftsmen prior to the industrial age. In the same fashion, a software system that could lead a group through the steps of an intellectual activity like cause-and-effect analysis or action planning might result in more value being created by people with lower skills, and at lower labor cost and with predictable quality. The intellectual capital of the most experienced facilitators could thus be leveraged across an entire organization.

Focus Must Shift from Search Engine to Sense Engine.

On many occasions and in many venues, Herbert Simon posited that in the future the most scarce, most precious resource would be attention. A recent study by Pitney Bowes published in Knowledge Management (November, 1999, p34) tells us that the future has arrived. The study reports that knowledge workers now average more than 200 messages per day, and average 6 information-related interruptions per hour. People have so much information coming in that they can't wade through it, and they have difficulty paying attention to the things that would actually make them productive.

Even with the advent of powerful search engines we can't always find the information we want because it comes buried in mountains of information we don't want. Because of the limits of human attention resources, we can't assimilate all the information we find. Accelerating interest in the development of technology to automate the sense-making process is inevitable. Such technology must have the capacity to combine, compare, and contrast with respect to the goal. The system must understand the goal as well as how the information it finds might support the attainment of that goal.

Current work in multi-agent systems may well lead to the availability of systems that can stand in for the user for certain cognitive tasks. For purposes of this chapter we will call these systems Personal Clones, or P-Clones. These computer-based entities with natural language interfaces would, on command, attend to status tracking, early alerts, briefings, automated sense making, synthesis, judgment, and other cognitive tasks. Hence, from the user's viewpoint, the main functions of a P-clone might include:

1. Natural language dialog to determine user's intent.
2. Collecting relevant information from the user, from other humans, and from other P-clones to initiate a task.
3. Presenting collected and synthesized results and/or briefings.
4. Reporting outcomes or results of performing user-delegated tasks and possibly explanations.
5. Presenting intermediate results and seeking additional information and guidance when necessary.
6. Alerting the user to changes and new developments in the environment and outside information sources that have potential impact on the user task in the current problem solving context.

In short, P-Clones should be generalized takers of orders. As such they should have far broader capability than do today's task-specific agents. For example, a military commander might say to a P-Clone, "Examine the terrain, then over the next month monitor the intelligence reports and watch the weather; let me know if you spot a condition green for an amphibious assault anywhere along the North coast."

An industry leader might tell the same P-Clone, "I've been hearing about paperless offices for years. Is there any value in paperless office technology for manufacturing businesses like ours?" The P-Clone would have to have to find, synthesize, and summarize information about paperless offices, learn about how manufacturing businesses work, then draw inferences about uses of paperless office by manufacturers, prepare a briefing, and present the results to the leader.

To be general problem solvers P-Clones would rely on modules of domain-specific expertise external to themselves. For example, a P-Clone might task a semantic search engine based on Kohonen neural networks to find and organize information about

paperless offices from a vast unstructured information store like the World Wide Web. It might then call on an automated summarization engine to prepare an abstract of its findings, with hyperlinks back to detailed documents. It might then call on a human to review and correct its summarization of the value of paperless office technology. It might then task a Hopfield neural network to find concepts in literature about battle staff operations that were related to the ideas it extracted about paperless offices. It might even validate its work by asking a human for e-mail addresses of war fighters, and sending them e-mail requesting feedback on its findings.

Crucial to the success of the P-Clone would be an automated sense-making capability. Sense making is the process of ascertaining whether a problem exists, and if it exists, what its causes might be. Sense making is a winnowing process during which problem-solvers gather and sift information as they try to separate symptoms from root causes. For example, military commanders may be surprised to find supposedly neutral forces massed near a border (a symptom). Should they care (does a problem exist)? Are neutral troops planning a hostile action (symptom/problem)? If so, why? What motivates them to hostility? What steps are they likely to take?

As problem-solvers identify root causes for the problem, they determine which causes may be amenable to intervention to correct the problem. For example, the neutral forces imagined above may be inspired by inflammatory ideology, fanned by food shortages, and emboldened by a recent infusion of warfighting technology from a hostile allied force. The problem-solver must decide whether any level of effort could affect the ideology, the famine, the flow of weapons, or the alliance with hostile forces. Thus the sense making process must, of necessity, precede course-of-action development and alternative evaluation. Something like P-clones may fill this need.

Mass Configuration Rather than Mass Customization

There are many kinds of value that may be created -- economic, political, emotional, physical, and so on. Furthermore, organizations or teams seek simultaneously to create many different mixes of these values. A cinema production, for example, might seek to create emotional, intellectual, entertainment, aesthetic, and economic value. People seeking to create value may take very different approaches, and as they seek to create value they may need many different group dynamics. Therefore, there can be no

universal recipe for creating value, and there can be no universal software support for value creation teams.

As the rising salaries of IT professionals attest, there are not enough software developers in the world to meet current IT needs, much less to build custom software to meet future demands for tools to support value creation. Custom-developed software may become increasingly economically infeasible. Software engineering practices that focus on reusable modules have reduced development costs significantly. However, reusability still implies that a software development project must create a version customized to the needs of the customer. The focus must therefore shift from reusable software modules to software products that are highly configurable without additional intervention from a programmer.

Current computer technology tends to have much of its functionality buried in a proprietary bundle which often can only be accessed through arcane API calls. We expect that over the next decades, technology should move towards a molecular architecture. Under this concept, computer functionality would be created in tiny atomic bundles that stand alone, but that may be assembled on the fly into complex tools or "molecules" to suit the needs of the day without the intervention of a programmer.

To illustrate the concept, consider how current GSS tools work. They tend to have a variety of collaborative capabilities locked in fixed juxtaposition to one another. A group outliner, for example, displays a textual tree to which all members of the group may contribute simultaneously. Double-clicking any node on the tree opens a text page under that node to which all participants may contribute. The tree and the text pages are in fixed juxtaposition, and that relationship cannot be changed. If you're a group needs a tree with, say, a graphic under each node instead of a text, it would take a massive programming effort to create the new tool.

Under a molecular architecture, the tree, the text page, and the graphics capabilities would each be created as a stand-alone tool that could be combined on the fly in any arrangement. For example, a user might decide that today he wants to start with a graphics page and have a tree buried in each object in the page. Tomorrow he may decide he needs a shared text with a tree under each graphic and a text under each node on the tree.

The molecular approach should allow for mass customization of technology without the intervention of programmers. Users may create the tool they need for their particular process without waiting for developers to program it. A molecular architecture, in turn, might allow computer functionality to break free from its proprietary environment to be available in other digital environments. Standards may emerge for the many ways collaborative technologies must interact with one another and the world.

CALL TO ACTION

If the focus of technology development is to shift from informing to creating value, how then should we live?

Technology engineers and developers must focus on value creation first, last, and always. They must begin by developing metrics for the value they propose to create, and must continue by evolving new development methods that lead to value creating systems instead of information systems. These methods must lead to a balance between three foci: work methodologies, group dynamics, and information access. The software produced by these methods must go beyond informing to actually creating measurable value.

Figure 1 A Simple Model of Value Creation

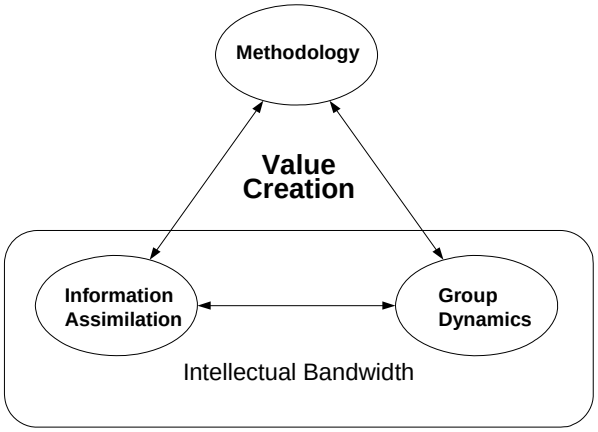


Figure 1. A simple model of Value Creation. In order to create value together, people must be able to find and make sense of information. But information alone is not sufficient. They must also be able to collaborate -- to combine the power of their minds to create value that cannot be created by individuals. In order to collaborate, they must be able to predictably, repeatedly create patterns of group dynamics. Information Assimilation and Group Dynamics combine to make up intellectual bandwidth. However, intellectual bandwidth alone is not sufficient to create value. Its components must be combined into a specific process (Methodology) that begins with making sense of the problem and culminates with action. Only through action is value created. Technology must grow to enhance the entirety of value creation, not just the information component

Figure 2 The Information Focus

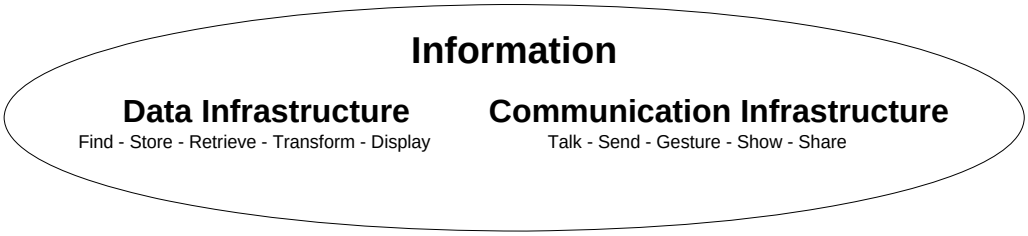


Figure 2. The Information Focus: Data Infrastructure and Communication Infrastructure. The Data Infrastructure provides standard IT capability: Find, store, retrieve, transform, and display information. The Communication Infrastructure refers to the things people must do in order to collaborate: Talk, send, gesture, show, share, etc.

Figure 3

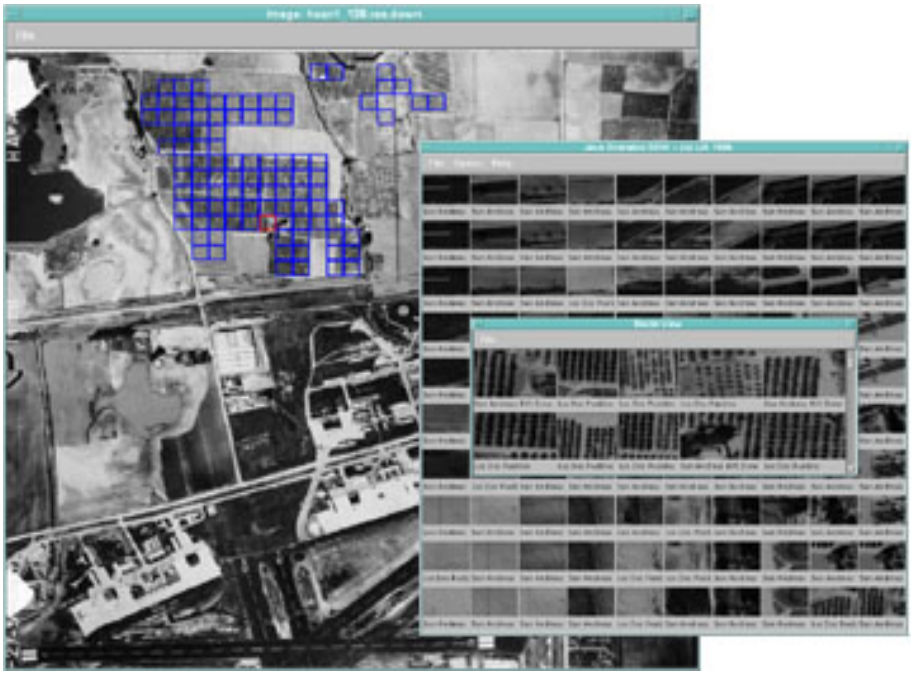


Figure 3. The Geographical Knowledge Representation System (GKRS) at the University of Arizona's Al Lab. A person provides the system with a target image. The system searches a database of satellite photos and identifies the areas tin the photos that are most like the target image.

Figure 4

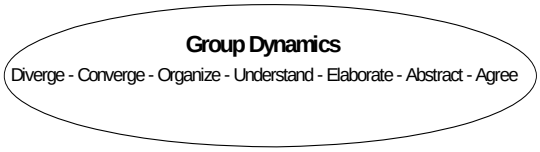
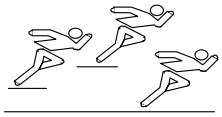


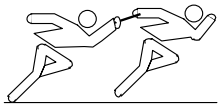
Figure 4 Th Group Dynamics Focus. Groups create processes from group dynamics building blocks. Technologies are available to help create, sustain, and vary group through its value creation process.

Figure 5



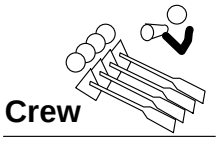
Sprinters

Collective Effort:
Uncoordinated Individual Effort



Relay

Coordinated Effort:
Independent effort, critical hand-offs



Crew

Concerted Effort:
All must contribute simultaneously

Figure 5. Three levels of Collaborative Effort. People can collaborate on three levels in an organization. With collective effort, people work on their own. Group productivity is simply the sum of individual efforts. At the coordinated level, people make individual efforts, but they have critical hand-off points and the productivity of the team depends not only on the level of individual effort, but on the coordination among those efforts. With concerted effort all members must make their effort in sync with other members. The performance of any member directly affects the performance of the other members. There are no individual efforts

Figure 6

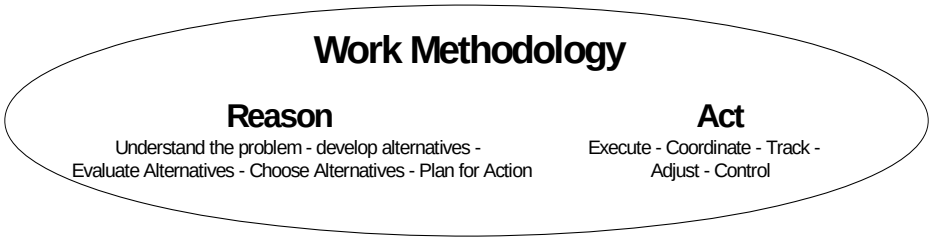


Figure 6 The Work Methodology Focus.

Figure 7

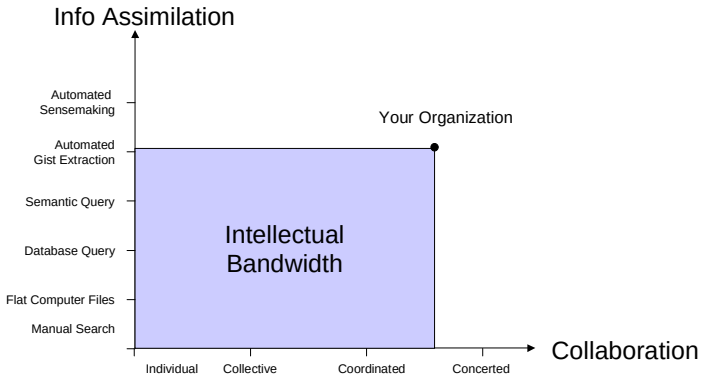


Figure 7. The Intellectual Bandwith of an organization is the product of ability to assimilate available information, and the ability of available people to collaborate. Information technology and collaborative technology both can enhance the intellectual bandwidth of the organization. This model assumes the availability of significantly more information than an individual could reasonably assimilate