Knowledge, Practice, Activities and People

Maarten Sierhuis

NYNEX Science & Technology, Inc.
400 Westchester Avenue, White Plains, NY 10604, USA
sierhuis@nynexst.com

William J. Clancey

Institute for Research on Learning
66 Willow Place, Menlo Park, CA 94028, USA
bill_clancey@irl.org

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Abstract

The perspective of modeling knowledge in Artificial Intelligence is that these models are equal to the knowledge itself (e.g. equate the map with the territory). This encoding view treats knowledge as if it were primarily verbal and assumes that verbal concepts themselves can be replaced by descriptions of concepts—as if a body of descriptions and neural categorizations were equivalent mechanisms for generating behavior.[1] This paper describes a number of concepts around the notion of 'situatedness': situated cognition, situated action, situated learning, and the concept of autopoiesis as an organizing principle. Situatedness changes the way we think about how knowledge is created (learning) and applied (action). In this light knowledge management changes its meaning from managing the knowledge of an organization to managing the situation in which learning happens. Collaboration and participation become the key management principles. In this paper we propose that Brahms (Business Re-design Agent-based Holistic Modeling System), an activity-based multi-agent modeling environment, allows us to model knowledge in situated actions and learning in human activities.

Introduction

In an article on Mr. Michael. Hammer in the Wall Street Journal[1], the following is stated: After BPR has died, due to large scale failure, there will be a new management fad. This new fad is called "Knowledge Management."
In this same article, Mr. Hammer admits that he has made a mistake. His mistake is, as he states: "I forgot about the people." After making millions of dollars, and many thousands of people being laid-off he admits that BPR forgot that people are important in a work system.[2] Our fear is that we will see history repeated. Once management starts to embrace knowledge management we fear that, again, we forget about the people.
Knowledge cannot be disembodied from the people and the situation. In this paper we first discuss four concepts that are central to the notion of situatedness. Situatedness changes the way we think about how knowledge is created (learning) and applied (action), and managed. In this light knowledge management changes its meaning from managing the knowledge of an organization to managing the situation in which learning happens. Collaboration and participation become the key management principles. We propose that Brahms (Business Re-design Agent-based Holistic Modeling System), an activity-based multi-agent

[1] 'Next Big Thing': Re-Engineering Gurus Take Steps to Remodel Their Stalling Vehicles, *Wall Street Journal* 11/26/96

modeling environment, allows us to model knowledge in situated actions and learning in human activities.[2]

People and Knowledge

We propose in this discussion that we should put people in the center. People are the most important asset in an organization. Van der Spek and Spijkervet write: "Knowledge […] enables people to act and to deal intelligently with all available information sources."[3] We go one step further and say, knowledge is embodied in the practice of people. Knowledge does not exist without pr actice. Practice does not exist without action. We cannot disembody knowledge, we can only make a *representation of the knowledge* of a person whom has evolved his or her knowledge in practice. However, equating a representation of knowledge with knowledge is like equating a map of New York City with New York City itself. Having a map of New York City does not allow us to understand why the cultural art-center is in Soho, and why the theater district is centered around Time Square. If we would like to change these cultural centers in any way the map will not be enough to go on. A situated view is that we need to understand more about the people and the action in these cultural centers. This is a view that changes how we think and manage the concept of knowledge in organizations. A situated view of knowledge management states that the concept of managing knowledge is useless if we don't have an organization with people. People are the "carriers" of knowledge.

Situated Cognition

Situated cognition is a new field in cognitive science that has muddied our "knowledge" waters [4][5]. Situated cognition does not equate knowledge with descriptions (aka. " symbolic representations") of knowledge. The theory of situated cognition claims that human knowledge is dynamically reconfigured—as perceptual motor coordination [6], during transactions in an environment [7], within the person's conception of context as a social actor. [8] Situated cognition suggests that human knowledge does not consist of pattern descriptions that are encoded in the brain (i.e., verbally modeled in the brain like frames or rules in a knowledge base). Situated cognition stresses *what people conceive* and how this relates to their physical and social coordination of activities and actions. Situated cognition stresses knowing in action [7]—re-perceiving, re-conceiving, and re- coordinating while a cting. In this sense, a person's knowledge—ways of categorizing and coordinating behavior—is dynamically reconfigured and cannot be seen as things existing independently of an interaction or environment. Knowledge descriptions can be stored in a model, but knowing is situated.

How then can we disembody knowledge from the actor acting in a situation? If knowledge does not exist outside of the situation, how then can we manage knowledge? We should view management as not only managing processes, but also managing the situations in which people act. For example: In rethinking how the to eliminate errors on order forms, we not only need to rethink the sales process, but also how the sales representative and the engineering manager can collaborate better in their activity of solving the errors that are being introduced (e.g. assuming that a process re-design alone will eliminate all errors is wishful thinking). We need a) to nurture the situation, b) view managing knowledge as the ability to manage the learning situation, and c) view knowledge as something that only exists when people can act in a way that allows them to interact, collaborate and learn. Repeating a task without learning is merely an information process, or a non-knowledge intensive process. Acting is creating knowledge and thus learning at the same time. It is not executing a description of knowledge, like an inference in a rule base. Acting is knowledge creation in action.

Situated Action

Situated Action defines actions as always being taken in the context of concrete circumstances. From this, Suchman concludes that actions are never planned in the cognitive science sense. [9] Suchman questions that plans, as representations of action, are the basis for taking action in particular situations. The key idea is that animal behavior is not as strictly serial, from perception to action or from plan to action, as architectures based on instantiating behavior descriptions suggest. Perceptions and actions develop together; plans are re-conceived as action is already occurring. Yes, there are levels of "thinking what to do" and then doing it, but these levels are all that we have in models based exclusively on descriptions of the world and behavior. What is left out is how conceptual re-coordination changes how we see the world and how we understand our plans, in the very process of moving. Models of plans are reconstructed retrospectively, and filter out the situatedness of the actions being taken. Actions are inherently situated, and therefore always in some respect ad hoc or improvised. This view of human behavior, actions and plans creates the need to rethink the use of models of knowledge in situation-specific activities. On a larger scale it takes into question the ability to manage people's activities through the modeling of their knowledge. Suchman proposes an alternative approach to knowledge management. The aim

[2] Brahms is being developed at NYNEX Science & Technology, in collaboration with the Institute for Research on Learning.

is not to create formal models of people's knowledge and actions, but "to explore the relation of knowledge and action to the particular circumstances in which knowing and acting invariably occur."[9]

Situated Learning

Situated Learning defines learning as a situated activity within the process of "learning while doing." Central to this notion of learning is the process of *legitimate peripheral participation* . This is the process by which a newcomer becomes part of a community of practice. Legitimate peripheral participation takes a deeper look at *apprenticeship* as a way to absorb the knowledge, and pra ctices of the community. The important notion is that in order for a newcomer to participate the community has to legitimize the participation of the newcomer in the activities. The concept 'peripheral' does not imply that the newcomer stays on the boundary of the activity, but instead it means becoming part of the community of practice (e.g. a full practitioner) is a cyclic developmental process that is socially based. "The person has been correspondingly transformed into a practitioner, a newcomer becoming an old-timer, whose changing knowledge, skill, and discourse are part of a developing identity." [10]

This notion of learning changes how we might think of a learning organization. Creating a learning organization is a by-product of allowing people to be legitimate peripheral participants in the communities of practice within an organization. The notion of learning by "listening to stories" is changed to "participating in the creation of the stories", i.e. being situated within the activity, as opposed to hearing about it post mortem. Van der Spek and Spijkervet write: "An important aspect of knowledge management is improving an organization's learning capability." [3] In the view of situated learning, knowledge management becomes the management of the process of legitimate peripheral participation.

Autopoiesis

Autopoiesis is a concept from the field of biology. Autopoiesis, organization, structure and autonomy are four concepts that are very much related. Maturana and Varela describe autopoietic systems as follows: "The most striking feature of an autopoietic system is that it pulls itself up by its own bootstrap and becomes distinct from its environment through its own dynamics, in such a way that both things are inseparable. Living beings are characterized by their autopoietic organization. They differ from each other in their structure, but they are alike in their organization." [11] Another important aspect in biology is the fact that living beings are "autonomous." Maturana and Varela propose that the mechanism that makes living beings autonomous is autopoiesis. They then go on to say that if we want to understand living beings we need to understand the organization that defines them as an *unity*.

What we'd like to propose is that we look at an organization in a company (or the company as a whole) as an autopoietic system. It might be useful, as in descriptive analysis, to break the world into parts, but in dynamic systems, as in biological and social processes, parts do not have such an existence independent of their interaction.[12] Maturana and Varela state that the only product of an autopoietic system is itself, with no separation between producer and product, and the being and doing of the organization. We can say the same for an organization of people in a company. An organization in a company can be looked at as trying to sustain itself. In that way the only product is the organization itself. An organization only exists when it is in action, i.e. the being and doing of an organization is inseparable. We call this a *human activity system*.[13]

This view of a company as an autopoietic organism can bring us closer to viewing the people as the most important units of the structure. Autopoietic organization can be attained by many different components. As Maturana and Varela suggest, only certain components possess the right characteristics for creating a unity. The same can be said for people in human activity systems. The "components" in a human activity system are people. From this it should be clear that an organization of people can only sustain itself if the people (units) act, collaborate, learn and evolve as an unity in action. Separating the knowledge from the people is impossible in the view of autopoiesis, because it tries to separate the knowledge of people from the interaction of people, and therefore from the autopoietic dynamics.

Managing the activity

Situatedness changes our view of knowledge, learning, and organizations. Creating models of the knowledge intensive processes of an organization may lead us to a description of the problem solving processes. What situated cognition puts into question is whether we can equate these models to knowledge, and whether we can call creating management processes around these descriptions of knowledge intensive processes knowledge management. A situated approach states that we are able to manage knowledge and learning by understanding the activities that are carried out within the organizational processes. Knowledge management is managing the activities that people engage in.

Knowledge is created, and learning takes place during the activity of participating. For example, in the morning

coffee meeting where a manager assigns new jobs for the day to the technicians, there are discussions around the problems that were faced the day before. One technician explains why he couldn't finish a certain job, and that he has to go back and finish it today. This changes the way the manager assigns the other jobs of the day, because he cannot assign a new job to him. In a scenario like this, what makes the manager react in this specific way? Why not just give the job to the next guy? This is knowledge in action. There is no fixed plan or set of plan fragments that generate all aspects of the manager's job assignment decisions. Some aspects are improvised; some might require re-conceiving how assignments are made. The manager plans in action. The ability to react to the situation is knowledge created in action. We might model the manager's problem solving process in this situation, but the next situation will be just a little different and create a different interaction, different stories to be told, different people to speak up, such that the manager comes up with a different plan. In traditional planning models, all such re-conceptions are modeled as re-assembly of existing descriptions. Situated cognition suggests that the person can appeal to more: to other modalities of conceptualization (imagery, sense of timing) [14] and to emotional values. [15] What about the learning that takes place in this situation? It takes too much space to write a bout all the possible learning situations that take place in this morning coffee activity, but we can all imagine what it is that the people in this meeting will learn from this sit uation.

Instead, what the current, most prevalent, view of knowledge management will drive to do is re-engineer away the morning coffee meeting, because it is "a waste of time", and develop a knowledge-based system that assigns the jobs for the day for the manager. What is not understood is what is lost with such a solution, let alone the fact that a knowledge-based system does not have the ability to react to the activity-specific context. The dynamic situation that constitutes the activity is part of an autopoietic system. The knowledge that is used within this activity does not exist outside of it. In other words, the knowledge is in the dynamics of the situation. Eliminating the possibility for this situation to take place eliminates the creation of this knowledge, as well as the situated learning. In contrast, if we understand the dynamics of the activity we understand that changing it will change the knowledge and the learning. If we have a way of understanding the dynamics of an activity we will have a better way to manage the knowledge and learning.

What we propose is that knowledge management is not just about modeling problem solving and expert knowledge. Knowledge management is also about modeling the dynamics, social and cognitive, of a human activity system. In the next section, we propose an activity-based modeling technique that allows us to investigate dynamic activities in which groups of people communicate and collaborate to perform a certain task. Activity-based modeling helps us to understand the situatedness of people's knowledge in activities.

Brahms - an activity-based multi-agent dynamic modeling environment

Brahms is a multi-agent simulation framework for modeling work practice, incorporating state-of-the-art methods from artificial intelligence research and insights about work and learning from the social sciences.[16] Brahms was developed for use in work systems design, instruction, and as a language for software agents: Brahms models consist of groups of agents with context-sensitive, interactive behaviors. Agents are located, mobile, and have knowledge and changing beliefs. Groups may define job functions, teams, people at a certain loca tion, or people with certain knowledge and beliefs.

Brahms enables modeling *activities* of people during the day—how people spend their time—emphasizing informa tion processing, communication in different modalities (phone, fax, voice mail, face-to-face, databases), and location-specific interaction (meetings, chance conversations, teamwork). Thus, Brahms allows modeling *a community of practice*—a group of people who participate in some shared, choreographed interaction, usually involving collaboration between individuals with different roles and experience.

Brahms combines the functional perspective of *business process models* (orders, organizations, roles, product flow) and the knowledge perspective of *cognitive process models* (transformation of representations, flow and storage of information, error detection and problem solving) with models of active objects (e.g. fax machines, workflow systems).

Brahms models are designed to make social processes visible by incorporating *social knowledge* —what people know about each other, relevant to assigning jobs, getting assistance, and prioritizing work.

Brahms models incorporate generic protocols and objects, such as computer terminals, phones, and fax machines, and how to engage in a face-to-face conversation.

Thus, Brahms models provide a holistic perspective on *how work gets done*, emphasizing informal, social, *circumstantial* practices (rather than policies or procedures), while incorporating standard "task flow" views and productivity statistics.

How is Brahms different from other current "distributed AI" or agent simulations?

In Brahms one models what agents do during a day—*activities*—not just tasks .[17][18] Activities model *scoped*

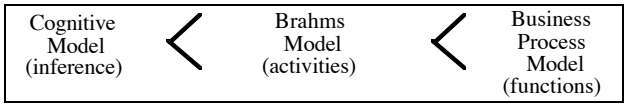

Figure 1 Relation of Brahms to other models of work.

focus of attention, such that different "concerns" may be a ctive at one time. Rather than viewing activities as proced ure calls, every activity on a current hierarchical path rem ains active—just as a person is simultaneously conversing with a colleague, attending a meeting, on a business trip, representing an employer, pursuing a career, being a citizen, etc. Each level of activity establishes the context for what is noticed in the environment, how beliefs are modified, how work is prioritized, and how communication occurs. Activities define what problems need to be solved; goals and tasks arise in the context of activities.

For example, in Brahms models one might represent that what an agent does between 9 and 10am is quite different from the habitual practice at 4:30pm—even though the agent is doing the same "job." Similarly, a worker might engage in the activity of a coffee meeting, at which time a supervisor hands out the days' job assignments and workers bring up problems that occurred the previous day. Thus, problems are articulated and resolved in the context of activities. This context establishes what information is conveyed by whom, who participates in problem solving, and what actions are available. Activities, unlike tasks, do not have well-defined goals, whose accomplishment by definition terminates the task (e.g., "being a computer scientist" has no well-defined termination condition at which point we could say that the objective had been reached).

How is Brahms related to knowledge acquisition?

Most knowledge acquisition efforts are focused on problem solving: The reasoning involved in planning, designing, diagnosing, controlling some system in the world. Such reasoning requires data which is gathered from instru ments by asking other agents. Models of practice place rea soning in context: Brahms models agent behavior rather than only inferences. Nevertheless, standard knowledge a cquisition techniques are useful: Observation, interviews, scenario definition, and case analysis.

A simple example is illustrative. In developing a medical diagnostic expert system, one might ask the physician what kinds of patients he or she sees, what information is used, etc. In developing models of practice, one would start with questions like: Where do you work? What time do you start working each day? What do you do first? Is your schedule different during the week? Whom do you work with? How do you communicate with other people and what kinds of conversations do you have?

A typical Brahms model captures a day in the life of some main character in a community of practice, or perhaps some key collaborative event in development of a work product. To make the modeling manageable, one thinks in terms of writing a play: There is a stage, main characters, a point of view, and probably some climax scene. For example, in our most elaborate model, the climax is a three-way conference call by which a "turf coordinator" brings together a service technician at a customer site and another craftsman in the central office.

Models of practice include the lowest level tasks of a corresponding business process model, but omit the cognitive modeling level of reasoning and calculation one might find in a typical expert system. For example, we might model a person as filling out a form, but not indicate the inferences necessary to do this. The information required to fill out the form and the changes to the form are only modeled to the extent necessary to represent what triggers or modifies another person's activities. Especially, we model information and tasks that might be in error or produce error. But the distinction is subtle: A Brahms model might represent the specific inferences by which a supervisor prioritizes the day's work and assigns jobs to particular workers. Unlike in an expert system, the simulation of this "scheduling task" might include an interruption by a co-worker, an inability to log onto the computer database, running out of time, copying information to paper, etc.

In summary, Brahms models are not as detailed as models of cognitive skills, nor are they as general as functional models of business processes. They do not describe just what people are supposed to accomplish (functional transformations of materials), nor do they describe the intricate details of reasoning or calculation. However, Brahms models describe people's situated activities, collaboration, and interaction. In short, Brahms models human activity systems.

Representation Language Details

The most central representational unit in Brahms is called a *workframe* (Figure 2), a situation-action rule consisting of preconditions (what the agent must believe to be true), actions, detectables (what facts in the world might be noticed, with what probability and when during the actions), and consequences (changes to the world or this agent's beliefs that result). Workframes are organized hierarchically into activities. Actions in a workframe may be primitive (just indicating a name, duration, and priority) or composite (another activity). Primitive actions also include movement to another location and communication (described below). Consequences and actions are ordered and interleaved. Detectables may be indicated as "impasses" that interrupt the workframe or as

"end conditions" that end the workframe or its encompassing activity.
Workframes are inherited by agents from all groups to which they belong; groups may belong to other groups. Priorities allow workframes to interrupt each other or carry out specific aspects of a more general protocol. For example, workframes at the "all groups" (top) level specify how to use a telephone and have face-to-face conversations; these have intermediate priority. Workframes that trigger conversations are most specific and have the lowest priority. Workframes that specify what to say during certain kinds of conversations have the highest priority. By this simple scheme, it is possible for one agent to initiate a conversation and for the responder to "remember" something he wanted to tell the first agent when he called; thus a give and take may ensue.
Thoughtframes model agent reasoning about implications of beliefs, leading to changes in what they do next (thus a distinction is drawn between "action rules" and "thinking rules") Thoughtframes take no time, and are similar to rules in a rule-base.
Changes to beliefs may occur by virtue of: broadcast (e.g., speaking outloud), transfer from agent (telling or asking), transfer from object (e.g., reading a database or a fax), detectables, and consequences. Activities are spatially-dependent:

> *location goals* cause an agent to move to a location when a workframe is enabled (e.g., "Move to location X.")
>
> *location preconditions* depend on agent location (e.g., "Is the current agent at location X?")

Workframe: WIRE-T.1-END-SECTION

Pre-conditions:
located at customer floor
have wire
have jack
have tools
customer is aware of your presence

Action: wire end section & install jack

Detectables:
jack wrong or broken (probability 10%), action: impasse

Consequences:
jack installed (fact & belief)
end section wired (fact & belief)
need to talk to TC about overall test (belief)

Figure 2 Example of a workframe, written informally.

Objects embody stored information about the world, modeled as the "beliefs" of the object (e.g., a database). *Factframes* model object behavior, including what they detect and how they change state. Object instances may be created by an action (e.g., fax transmission creates a paper copy at the receiving station).
Facts are an eagle-eye view-from-nowhere—the outsider's view of the simulation, for example, the state of telephones, location of agents, etc. Detectables specify what facts an agent might detect during the action of a workframe. Beliefs are propositions agents believe about objects (state of the world) or other agents.
A communication may involve asking or telling. A communication may be from an agent or object to a specific agent or object, a group of agents, a class of objects, or may be a broadcast. For example, a factframe for the fax object broadcasts to every agent within geographical proximity that a fax has arrived.
Brahms currently models geography in a rudimentary way, consisting of regions, buildings, and their connections. Duration of movement is simply proportional to distance; for convenience movement between non-connected locations takes no time.
In general, descriptions of activities are associated with groups. In practice, there may only be one member of a group in a given workplace (e.g., one "physician's assistant" in a medical care module) or roles may be highly differentiated (e.g., the role of the "physician in charge"). Depending on the purpose for building the model, models may represent:

> particular people (Dr. Axelrod in Redwood City),
>
> types of people ("an HMO physician at CareGood"), or
>
> pastiches ("a typical nurse, patterned after Mr. Reno at San Joaquin Valley").

Agents that are not central to the work being modeled may be modeled as an individual representing a group. For example, an aggregate "customer" for a workgroup could generate orders.

Conclusion

In this paper we have presented a different view of knowledge management. We make an argument that those who are responsible for creating this new management field should not forget about the people—the most important asset of an organization. We argue that knowledge is situated in the activities of people, and cannot be disembodied from the situation. We also argue that learning is situated in action, and that creating a learning organization should be a by-product of the management of legitimate peripheral participation. Last, we present Brahms, an activity-based modeling environment. Activity-based modeling is a new modeling

paradigm for knowledge management that differs from traditional knowledge modeling. Brahms models focus on the collaboration, communication and situation in the daily activities of people in organizations. In Brahms we can model communities of practice, and the situated knowledge of the people in them. We propose that further research be done to investigate whether activity-based modeling can specifically be used to model knowledge in action, which will help us to better manage the knowledge and learning in an organization.

Brahms exists as a prototype developed in G2 on a SUN workstation, and Visual Basic on the PC. The system has a useful, but rudimentary interface, editor, and trace/debugging package. Current work includes comparative studies of tools and exploratory use on client projects. The name "Brahms" stands for "Business Redesign Agent-based Holistic Modeling System," but it applies to any human activity system.

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