Information System Metaphors

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Abstract

Metaphors are useful because they are efficient: they transfer a complex of meaning in a few words. Information systems are social constructs. Therefore, metaphors seem to be especially useful for explaining the space of possible meaning complexes or designs of information systems. Three information system metaphors and the associated meaning complexes are explained: the mill, the cell, and the mind. An information system as a *mill* is characterized by the efficient processing of large quantities of information. The processing has to be done using fixed, that is, *invariant*, rules en patterns that may be very complex. An information system as a *cell* is characterized by its fluent and adequate interaction with people. The information system consists of objects that take care of preserving their own integrity and that react on events. The cell metaphor is characterized by *interaction* and *integrity*. The information system as a *mind* appears as an intelligent assistant embodying that mind. An information system as a mind is characterized by capabilities like *knowledge use*, *autonomy* and *learning*. These three metaphors can be combined, and are combined, in real-life organizations.

1. Information System Metaphors

1.1. Metaphors

Metaphor: a way of imagination

A *metaphor* is an imaginative way of describing something by referring to something else that has the qualities that you are trying to express (Collins, 1987). Metaphor has been studied extensively in semiotics. Metaphor is a way to express meaning in a condensed manner by referring to qualities of known entities. The use of metaphor is not without puzzling aspects. For instance, in most cases, the intention of the speaker using the metaphor is often clear, although the metaphor, if taken literally, would be not true.

"A metaphor substitutes one expression for another in order to produce an expansion (or a "condensation") at the semantic level. . . . A metaphor is easily recognizable as such because, if it were taken literally, it would not tell the truth (since it is not true that Achilles was a lion)." (Eco, 1990: 138, 139).

Metaphors are complexes of meaning

Metaphors work because they transfer meaning by way of analogy. Metaphors are useful because they are efficient: they transfer a complex of meaning in a few words. For instance, if you say that the camel is the ship of the desert, you do not only say that you need camels as means of transport to cross the desert, but also that the desert is like the sea because of its vastness, lack of drinking water, the danger of storms, and so on. For finding your way in the desert you need navigation like you would need on sea. Sitting on a camel may make you seasick. The horizon in the desert is like the horizon at sea. An oasis is like an island. The use of 'ship' as a metaphor opens up a meaning complex, a web of connected metaphors that add to the content of the analogy. Ship is related to ocean, islands, waves, storms, navigation, seasickness, and so on.

Social constructs

It is useful to see organizations and information systems as *social constructs*. This implies, according to Hacking (1999: 6, 12):

"Social constructionists about X tend to hold that:

(0) In the present state of affairs, X is taken for granted; X appears to be inevitable.

(1) X need not have existed, or need not be at all as it is. X, or X as it is at present, is not determined by the nature of things, it is not inevitable.

Very often they go further, and urge that:

(2) X is quite bad as it is.

(3) We would be much better off if X were done away with, or at least radically transformed."

Metaphors are useful for characterizing the meaning complexes that can be associated with social constructs like organizations and information systems. In organization and management theory, metaphors have been used to explore the interpretation frames used by organization theories. The use of 'the machine' or 'the organism' as a metaphor for the organization is a convenient way to characterize the presuppositions of a certain organization theory in a short and condensed fashion. This facilitates the comparative investigation of organization theories, as Morgan (1986) has shown.

1.2. Information systems and metaphors

Information systems

Information systems can be seen as parts of virtual organizations. A *virtual organization* is an organization that consists of human actors and virtual actors. An organization that only consists of human actors is a real organization; an organization only consisting of virtual actors is an information system. In virtual organizations, human actors and virtual actors have different capabilities and responsibilities. Information systems generally *represent* things and concepts in the world, but also *create* (determine) things, concepts, events etc. in the world by making *pre*presentations of these entities. An *information system*, therefore, seems to have two parts:

- a *virtual actor* part that creates (determines) new entities, and

- a *representation* part that represents or prepresents entities in the world.

Virtual is something intangible, nonmaterial that we can imagine based on perceived images or practical experiences.

Metaphors reveal information system design space

Information systems are social constructs, even more than organizations are, because human beings construct them consciously in steps of, amongst others, design and programming. An information system is not a neutral representation of an objectively given world. Conceptualization is needed when constructing an information system (Checkland and Holwell, 1998: 233). Therefore, metaphors seem to be especially useful for explaining the space of possible meaning complexes or designs of information systems. Doing so, metaphors explain that a certain way of designing information systems is not based on an inevitable law of nature, and that alternative designs are possible. Metaphors are also useful for stimulating the imagination when working on a information system design. When new concepts are created and explored, metaphors are often the best instrument for communicating what is meant.

Information system metaphors

A short search on Internet yields a variety of information system metaphors. [1]

(1) Sometimes, a specific information system architecture is also called a metaphor, although it is not a metaphor in the sense defined above. Examples are the model-view-controller metaphor, and the detector-selector-effector metaphor.

Metaphors express the nature of the design of the information system (island, architecture, zoning plan), its behavior (clock, apprentice, reporter), its use as a tool (spreadsheet, notepad, bulletin board, desktop, checklist), its character as a space or virtual world (library, superhighway, net, tree), and the nature of the interaction it requires (conversation, navigation).

Architecture is a metaphor that is often applied to the way of construction of socially constructed entities. Architecture can be applied to organizations, information systems, and virtual organizations. Architecture is the way a system is composed of subsystems that each have a specific functionality or responsibility (a *design*), and the rules governing the cooperation of these subsystems (a *norm system*). Architecture normally is specified at several levels of functionality or granularity, in a consistent way. Architecture levels can be distinguished based on Stamper's (1973) semiotic ladder:

- Social

- Pragmatic

- Semantic

- Syntactic

- Empiric

- Physical

Virtual organization architecture has to do with the top three levels (social, pragmatic and semantic). At each level there will be a design and a norm system. Component architecture has to do with the syntactic and empiric levels. Technical infrastructure has to do with the physical level. In the description or the design of a virtual organization at the social level, it is important to design organization units based on capabilities and responsibilities. For the determination, or the imagination, of adequate capabilities of virtual actors (information systems) information system metaphors can be very useful.

A further explanation of information system metaphors can be done based on three basic metaphors: the *mill*, the *cell* and the *mind* (Gazendam, 1993: 282-293). Each of these basic metaphors leads to a meaning network composed of connected metaphors, associated theories, and associated design patterns.

2. The Mill Metaphor

2.1. The mill

Whole

A mill is a factory.

"A mill is any machine, or building fitted with machinery, for manufacturing processes" (Oxford, 1977).

A mill is also a pumping-station, originally wind-driven, to remove redundant water from a polder, thus keeping Dutch feet dry.

Parts

The parts of a mill are cogs, wheels, and instruments attached to a machine that generates and distributes energy [2].

(2) According to Castells (1996), the industrial age is characterized by the automatic generation and distribution of energy, while the information age is characterized by the automatic generation and distribution of information.

Environment

The environment of a mill consists out of a *network* of canals, roads, and railways for the transportation of raw materials and products.

Process

So a mill processes *water*, pumping it into a channel, or it processes *raw material*, turning it into *products*.

Objectives

The quality of the mill is that, as a machine based on the generation and distribution of energy, it can process large volumes of material in an efficient, precise, reliable and rapid manner. The objectives of a mill are to work in this way, as planned.

Development

The realization of the mill is done by building it, fitting wheels and other machinery parts together, following a *design*, and using craftsmanship. The cohesion of the mill as a whole is a result from a top-down design process. In the design, best practices based in experience are used.

Connected metaphors

The mill is a large machine. Small machines can be used as *instrument* or *tool*. The emergence of effective windmills in the Netherlands in the seventeenth century coincided with a golden age in science and arts. Printers like Elsevier distributed scientific texts all over the world. This contributed to the development of the age of enlightenment, characterized, amongst others, by a drive to systematize knowledge in encyclopedia and libraries. In this way, the *book* and the *library* are connected to the mill.

2.2. The information system as a mill

An information system as a *mill* is characterized by the efficient processing of large quantities of information. The processing has to be done using fixed, that is, *invariant*, rules en patterns that may be very complex.

Process-oriented design: automata theory

The mill metaphor is consistent with a large part of traditional information systems theory, in which an information system is seen as an automaton processing data to render information. In computer science, the mill metaphor finds its fundaments in the concept of the *automaton*:

"Thus, a finite automaton is a machine that can exist in a finite set of states, where the particular state it is in at any given moment depends on the inputs it has received and upon its previous states. The set of states in an automaton serves as its 'memory': the only information that an automaton has concerning its past operation is the current state it is in; at least, this is the only information it can use in deciding its next state and its next output when it is given an input symbol." (Jackson, 1985: 45).

The traditional way to design information systems is to analyze business processes, their relations with organization units, and their information input and output (Lundeberg, Goldkuhl, and Nilsson, 1982; IBM, 1984). In this analysis, business processes are decomposed, as well as input and output data sets. The input data and output data lead to a database design. The subprocesses to be automated are chosen and redesigned.

Data-oriented design: the library metaphor

The capabilities of the computer with respect to data storage and retrieval have led to an information system concept analogous to a library. The information system is seen as a large library in which information is stored in an orderly and systematic way. The use of the library consists of retrieving the information one needs in the form of books. This approach to information systems was as *data-oriented design* revolutionary in the 1980s (Martin, 1982; 1983). Processes are seen as operations on a database. The database is ordered according to object types and relationship types. In the database, stable states are distinguished. Transactions are the transitions of one stable state to another; program modules are based on transactions. Transactions can be thought as being composed of basic operations on attributes of object types; in object-oriented databases these basic operations are defined as methods. A special type of transaction is concerned with the derivation of attributes based on the values of other attributes; this derivation can be based on a special inference engine that uses inference rules.

The capabilities of the computer with respect to computation lead to efforts aiming at the design of the most efficient algorithms to perform a certain computational task. In the spirit of Taylor, one should redesign each computer task using the most efficient algorithms, thus specifying a method that minimizes the use of precious computer time. In this way, a library of algorithms or program modules can be formed that can be used to compose

larger programs. The transactions and inference methods of the data-oriented design are examples of these larger programs.

Processing of data to get information

A mill processes water or other material. Data can be seen as raw material, while information is a product. An information system is often seen as an automaton that processes raw materials (data) in order to get products (information).

"An information system is a set of organized procedures that, when executed, provides information to support decision-making and control in the organization" (Lucas, 1986: 10).

"Computers have become an essential part of organizational information processing because of the power of the technology and the volume of the data to be processed" (Davis and Olson, 1985: 4).

"Information is data that has been processed into a form that is meaningful to the recipient and is of real or perceived value in current or prospective action" (Davis and Olson, 1985: 200).

Information can also be seen as water flowing through a channel (Davis and Olson, 1985: 202).

Coherence by design

In a case that coherence only can be brought about by a top-down design, integration of information systems at design time is important. Such an integration of information systems has the following objectives (Theeuwes, 1986: 96):

- tuning of the information systems to the business processes;

- integration of information systems and data collections;

- development of new information systems by projects based on strategic data planning;

- planning and management of the technical infrastructure necessary for the integrated information systems;

- design an organization for the development and maintenance of information systems and data collections.

The informational aspect system

The integration idea leads, in its most extreme form, to the concept of *one information system for one organization* (the total information system). A related idea is the integration of information systems from the viewpoint of the informational aspect system of the organization. This idea is related again to the idea of control by aspect systems: financial control, human resource control, material resource control, and so on. With respect to this control, a neat planning and control hierarchy based on Anthony's (1965) theory is strived after. It is consistent with this concept to consider 'the' information system as an aspect system of the organization, comprising:

"- the organizational subsystem made up of people and procedures;

- technical appliances;

- programs

- data" (Boersma, 1989: 6).

The organization's information system has to be managed as a whole by an information manager and a data administrator. This abstract information system is often subdivided in integrated aspect-oriented information systems for finance, marketing, personnel, materials management, and so on. Information is seen as a resource to be managed centrally. Data are processed by transaction processing systems and by management information systems that produce information necessary for decision-making. Standardization of financial procedures, intensifying financial control, integration of the components of the organization's information system, and

centralization of data administration are seen as important topics for information management. Because of the uniqueness of the organization's information system, software has to be tailor-made.

The resulting planning and control design leads, however, to problems. It is an example of controlling organizational activity by planning and control organized by aspect systems. Kastelein's (1985: 204) view on this type of control is:

"There is an unstoppable process of interweaving and stitching through of the organizational web in which the organizational units are embedded, resulting in the increasing restriction of substantial change possibilities, and the suffocating of already going change processes."

Another result of thinking in terms of an informational aspect system is the resulting passivity of managers and users, who leave the design and building of information systems to the computer specialists.

Design of architectures and building activities

A central role in the design of integrated information systems is played by the architectures distinguished in the strategic data planning approach to information planning (Martin, 1983, 1984; IBM, 1984). To optimize an information system, the principle of minimizing information exchange between subsystems is used. This principle is based on Simon's (1962) 'nearly decomposable system' concept. Simon argues, that processes that are subdivided in hierarchically organized subprocesses are more efficient than non-subdivided processes. This is a result of the localization of the effects of external disturbances during execution.

After planning, determining requirements and design, the information system has to be built. This is traditionally accomplished through structured programming techniques (Lundeberg, Goldkuhl, and Nilsson, 1982; Jackson, 1983). In short, for designing and building information systems based on the mill metaphor, a well-developed toolkit exists.

Internet

The environment of a mill metaphor information system is a network. Like its name says, Internet is a global network of communication channels. Channel capacity is important. Internet is also an information superhighway, on which traffic has to be regulated. It can also be seen as a global library.

2.3. People, organization and the mill

Business process redesign and job redesign

The design of a mill focuses on finding the best method of accomplishing a certain job. Efficiency, precision, reliability, and speed are important criteria. Thus, the major objective of computerization is -according to the mill metaphor- the best way of organizing business processes. Together, information systems and humans can do many jobs much better than a human can do it alone. Thus, jobs and business processes have to be redesigned in cases where the computer is used. In this redesign, one tries to make an optimal use of the capabilities of the computer in the field of data storage, data retrieval, and computation. The character of mill metaphor information systems is especially clear in the design of the human-computer interaction. Here, the user is guided along the path that is considered the most efficient one, and no discretion is left to the user regarding leaving that path and choosing his or her own one.

People become wheels in the mill

Garson (1988: 10) uses the mill metaphor --she calls it the factory of the past-- to describe the process of computerizing white-collar work. People become wheels in the mill.

"In the modern factory, parts move continuously along an assembly line that human beings feed and tend as necessary. Everything seems bent on production.... Soon, when you walk into the fully automated office, it will seem equally ordained and complete." (Garson: 1988: 261).

Work is degradated, like blue-collar work in the industrial revolution:

"Both these systems were designed to capture the skill of the individual griddleman or broker and transfer them to a program. Thereafter, the job can be done by workers with less skill and knowledge." (Garson, 1988: 11).

People and information systems are not equal partners. Most people are 'slaves' of the information system, which is controlled by a happy few:

"In almost all cases we'll be looking at, the effect is to centralize control and move decision making higher up in the organization." (Garson, 1988: 11).

Attached to a mill metaphor information system, people can be monitored. Examples of monitoring are reading Email, automatic registration of time spent on tasks via applications used, automatic registration of Internet use in the office and sometimes even at home. Monitoring, however, is a moral problem. People don't like to be monitored; they don't like to be in a situation where *"Big Brother is watching you"*.

McDonaldization

Ritzer (1996: 1) describes McDonaldization as

"the process by which the principles of the fast-food restaurant are coming to dominate more and more sectors of American society as well as of the rest of the world"

McDonaldization is an organization form based on efficiency, calculability, predictability, and control. McDonalds is an example of the process organization, which is characterized by the following principles:

- strong standardization;

- what can be automated, is automated;

- flat organization resulting from the fact that the logistic information system takes over middle management functions;

- the principle of the working customer (where IKEA is the paradigmatic example);

- registration of customer data (based on credit cards or customer cards) for customer oriented marketing and sales.

McDonaldization and the redesign leading to process organizations can be seen as examples of business process redesign, which is associated with the application of the mill metaphor to information systems.

Criticism of the mill metaphor

Garson criticizes the mill metaphor information system because of its degradation of work. Ritzer criticizes McDonaldization because of its dehumanization and its illusions of low cost, fun, and reality. The question is whether these criticisms are not too severe. They may be inspired by an anti-machine nostalgic romanticism. Of course, there are examples of mill metaphor computerization that have gone on the wrong, dehumanizing track. But there are also examples of process organizations that combine efficiency with a social orientation. Valens (1994) remarks that many people are happy to work in a well-organized process organization like Albert Heijn.

3. The Cell Metaphor

3.1. The cell

Whole

The cell is something that lives. It can be autonomous, or part of a larger living being.

"A cell is the smallest part of an animal or plant that is able to exist by itself" (Collins, 1987).

"A cell is a small usually microscopic mass of protoplasm bounded externally by a semi permeable membrane, usually including one or more nuclei and various nonliving products, capable alone or interacting with other cells

of performing all the fundamental functions of life, and forming the least structural unit of living matter capable of functioning independently." (Webster, 1980:177)

All organisms are composed of cells, or consist of one cell.

Parts

A cell is made up of a cell wall and cell contents. Protoplasm is the material bearer of life. Cells can multiply themselves, forming cell clusters. In cell clusters, cells can differentiate related to their function; this process is called morphogenesis (creation of forms). The cell contents consist of a transparent material (protoplasm) carrying several organelles, bodies with a specific function (Koningsberger, 1962). Of these organelles the kernel, which carries the inherited genetic information, catches the eye. Grown above a certain size, the cell divides itself. Individual cells have a limited lifetime. although the cell cluster or organism they are parts of may live a lot longer.

Environment

Organisms live in a spatial-temporal environment in which they wander and coexist with other organisms. These other organisms will be of a great variety. Organisms generally need to interact, rely on each other, for example for food, and form in this way an ecosystem. In a spatial environment where dangers can await you, you have to be cautious. For traveling long distances, you need navigation.

Process

Cells communicate and interact by sending and receiving streams of material through their walls. The structure of the walls and the laws of osmosis regulate these streams. Cells need food in order to survive, to grow and adapt. In an organism, special cell types process raw material to material that cells can digest. Organisms are very busy with preserving their *integrity* (feed themselves, repair themselves), and with *interaction* with the environment.

Objectives

Organisms want to survive. They have a variety of biological needs like eating and sleeping. They also strive after mating and reproduction in order to preserve their genetic information. Their behavior is structured around biological rhythms, habits, moods, daily paths through time and space, handling impulses. There is no global rationality; there are only local needs, local perceptions, local actions (*principle of localization*).

Development

Cells are created by cell division. Later they grow and adapt. Organisms are created by sexual procreation. They grow by cell division, and adapt to the circumstances in their environment. The coherence of an organism is based on gene-directed growth. They learn habits. Individuals can be seen as bearers of genes and memes. Memes are packages of cultural information, sign complexes.

"Examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or building arches." (Dawkins, 1976/ 1989: 192).

Genes and memes strive after survival, and strive to spread themselves over the world. Species adapt by mutation and selection (biological evolution).

3.2. The information system as a cell or organism

The behavior and structure of cell metaphor information systems

An information system as a *cell* is characterized by its fluent and adequate interaction with people. The information system consists of objects that take care of preserving their own integrity and that react on events. The cell metaphor is characterized by *interaction* and *integrity*. Using the cell --or the organism-- as a metaphor for an information system, we see the following characteristics. If we see an organization as an organism, an information system is a specialized cell or organ. An information system encapsulates itself within a kind of cell wall, thus maintaining its own integrity. An information system consists of smaller bodies (objects) with a specialized function, of which the bearer of inherited, type-determining information is the most noticeable. An information system can also be seen as a larger cluster of cells (objects), of which each cell maintains its own integrity, while

these cells communicate by sending and receiving messages through their cell walls. Communication is regulated by the cell wall encapsulating private material and behaving according to its structure, only permitting access to recognized material. An information system is grown, not built. Grown above a certain size, an information system tends to divide itself or to disintegrate. Information systems have a limited lifetime, but their type-determining information may be copied by new information systems. Information systems need information (food) to grow and to live, and can process raw material into food for themselves and other components of the organism.

Object-oriented analysis, design, and programming

Growing information systems

The objectives of the cell metaphor information system are first and foremost the survival of the organization, and secondly the survival of the information system during its natural life cycle. The development of information systems is primarily seen as an evolutionary process, in which competition between information systems and incremental change play roles.

The principle of growing is recognizable because object-oriented systems are grown by feeding them -as running symbol systems- with information.

"When my program is running, I am typing in some new statements, and then he is actually eating it and growing by it." (Wouter Gazendam, 11 years old, 1990).

According to the cell metaphor, information systems must be grown. There is empirical evidence for the success of such an approach (De Jong and Gazendam, 1991:

"Group by group tasks have been computerized using microcomputers. Most computerized systems were database applications that could be realized in a short period of time using a fourth generation language; a result with which the users were pleased. These modular systems, developed according to the zoning plan, were disseminated throughout the whole organization, where they were subsequently incrementally changed and used... the developed systems were step by step integrated...leading to a decrease in the abundant streams of forms... one of the consequences was the possibility to work client-oriented... There is empirical evidence that the zoning plan approach is substantially more efficient than the blueprint approach..."

Genetic algorithms (Holland, Holyoak, Nisbett, and Thagard, 1986; Goldberg 1989) can be used for creating descendant objects from parent objects, and provides also selection mechanisms for the survival of the fittest. Artificial life consists of very simple beings that develop and reproduce in a virtual environment (Holland, 1995; Ward, 1999).

The methodology of planning, designing, and developing object-oriented information systems has developed rapidly in the last decennium. Experiences have been documented as patterns (Gamma, Helm, Johnson, and Vlissides, 1995; Fowler, 1997; D'Souza and Wills, 1999). A universal language for analysis and design, UML, has been developed (Rumbaugh, Jacobson, and Booch, 1999; Booch, Rumbaugh, and Jacobson, 1999; Jacobson, Booch, and Rumbaugh, 1999).

Event-oriented design

The capabilities of the computer with respect to the graphical presentation of objects and interaction with the user, and with respect to communication with other computer systems, lead to event-oriented design. In *event-oriented-design*, the events that are relevant for the computer system are identified. These can be events caused by the human user, or time events resulting from the computer clock, or events in the sphere of communication with other computers. For each event type, an appropriate reaction of the computer system has to be designed. In object-oriented analysis and design, methods for the analysis of interactions have been developed based on use cases (Jacobson, Ericsson, and Jacobson, 1994) and standard communication patterns (Dietz, 1992; 1996).

The world-wide web

The environment of a cell metaphor information system is a virtual spatial and temporal environment, a web of daily paths through time and space (Giddens, 1984: 116) in which meeting places exist. Information systems that have the form of autonomous agents wander around in this environment, and communicate by sending and

receiving signs. In the ecology of the information system, the human organization is very important. A cell metaphor information system needs human attention; otherwise it will die.

3.3. People, organization and cell metaphor information systems

The congruence hypothesis

In the ommon interests lie mainly in the fields of technical infrastructure and timetables specifying information exchange.

People and information systems as partners

As seen by the cell metaphor, people are fellow organisms, having the ability to form dynamic self organized systems. They are the growers of information systems. In fact, the information systems develop and grow by using them, incorporating information and adapting to their users. People are not slaves of the information system, such as in the mill metaphor. People and information systems are equivalent components of a wider ecological environment, to which both are subjected. There is no separate role for information system builders here, only for people who help self organized groups by offering their experience.

4. The Mind Metaphor

4.1. The mind

Whole

The mind is the faculty of thinking as well as the domain where thoughts are.

"Your mind is where your thoughts are" (Collins, 1987).

"Mind is the faculty of thinking, reasoning, and acquiring and applying knowledge" (Microsoft Word for Windows Thesaurus).

The concept of mind is often used for an entity functionally embodying the unity of human cognition (Anderson, 1983: 1):

"The most deeply rooted preconception guiding my theorizing is a belief in the unity of human cognition, that is, that all the higher cognitive processes, such as memory, language, problem solving, imagery, deduction, and induction, are different manifestations of the same underlying system.... The view that the mind is unitary is certainly not universally held; it may not even be a majority opinion."

Parts

Another opinion is that the mind is no unity, but a society of semi-autonomous subsystems (Minsky, 1986). Although it is not uncommon to see an organization as a multi-actor system, to see a mind in such a multi-actor way is still uncommon. Viewing the mind as a multi-actor system would provide for an explanation of the massive parallel processing that takes place in the human mind.

Explaining the structure of the mind as a metaphor for an information system is a kind of bootstrapping because the computerized information system has been used as a metaphor for the mind. An example is Anderson (1983: 19) who uses the decision support systems architecture --consisting of data base, model base, and active interface-- for his ACT* cognitive architecture. The major components of the cognitive system are the background memory (the world model), the structure of problem spaces (the views), the working memory (the controller), the sensors, and the effectors.

Environment

The environment of a mind consists of the world that can be perceived (the spatial, temporal, ecological *environment* like in the cell metaphor), and of other actors that have minds. Actors are organized in *families*, *organizations* and *societies*. These collections of organized actors can be seen as multi-actor systems (Gazendam

and Jorna, 1993). Because minds create and process knowledge, the books and other media that provide knowledge and entertainment are appreciated. So the world is also some kind of *library* for the knowledge-seeking mind.

Process

The mind processes information in a way that we call intelligent. Information comes in various kinds and structures, ranging from the direct representations that are received in perception, via language expressions that are used in communication and thought, to conceptual representations that form networks of concepts used in language processing and thought.

Objectives

Because of its roots in a biological organism, the mind wants to survive, and help to fulfill the basic needs of its organism. Because of this, it is coupled to biological rhythms (e.g. sleep), and the associated moods, habits, and so on. But it has also its own dynamics as a mind, it wants to experience new things, to learn, to be creative, to process information, to be entertained.

Development

The mind develops by learning. There are different kinds of learning, for instance learning by imitation, rote learning, learning by experience (building a world model), and learning by creation and assessment of new ideas. Logically, learning can be described as a combination of processes of induction, abduction, and deduction. Coherence of the mind is brought about by its growth as a biological organ, and by processes of information processing and learning that are more or less coherent. Coherence of the multi-actor system is brought about by social structure and culture, based on interactions, mutual learning, contracts, and power structures.

4.2. The information system as a mind simulator

The information system as an assistant or virtual actor

The information system as a *mind* appears as an intelligent assistant embodying that mind. An information system as a <>

The theoretical basis for the mind metaphor is the artificial intelligence theory about symbol systems (Newell and Simon, 1972; Anderson, 1983; Newell, 1990). A running information system, as well as the human mind, can be seen as a *symbol system*, thus enabling the simulation of the human mind by computers. An information system can be perceived as a symbol system simulating human intelligence partially, comprising human knowledge, and assisting people within organizations.

Symbol systems theory (Newell, 1990) distinguishes the following components:

- the problem spaces,

- search control,

- the background memory or knowledge base,

- the sensor and the effector.

These components, together, can simulate an intelligent agent. The actor communicates with the user by its sensor/effector interface, reading and generating messages or actions. If we take the virtual actor interpretation literally, the components of the cognitive architecture of the virtual actor --e.g. the problem spaces-- are cognitively impenetrable by the user; only the messages and actions generated by the virtual actor can be perceived. Most expert systems work in this way. However, for the virtual actor designer, its components have to be cognitively penetrable.

The semiotic Umwelt

The virtual actors, or intelligent assistants, have to get some place in the human semiotic Umwelt in order to be useful. The semiotic Umwelt (Von Uexküll and Kriszat, 1936/ 1970) is an environment around a human being or

animal consisting of the signs and symbols that it creates and perceives. The types of signs and symbols that can be created and perceived depend on the biological species. Humans like to have an Umwelt filled with books, paper, pencils, writings, drawings, television, computers and other artifacts that contain symbol structures (information and knowledge in the form of pictures, stories, and so on) they have created themselves or that stem from other sources. Knowledge workers like to have a semiotic Umwelt that stimulates their creativity, quality, accuracy, and so on, in writing and other design tasks or information processing tasks.

The semiotic Umwelt and virtual actors

As a virtual actor that assists people in performing their tasks, a mind metaphor information system has to function in a semiotic Umwelt. We imagine that such a semiotic Umwelt presents itself as a working environment in which the user has the initiative, in which programmable documents (spreadsheets, hypertext documents, animations) -or other virtual objects behaving in a way that is familiar to the user- represent the products of user thought, and in which tools are present for the creation and manipulation of these objects (Gazendam, Jorna and Blochowiak, 1991). Such an environment can be visible as a kind of desktop on which the documents mentioned above lie (the desktop metaphor), or as another simulated reality (the virtual reality architecture). Young (1987) has described such a working environment aimed at decision support as well as creativity support.

The desktop metaphor

In the *desktop metaphor,* the user elaborates his or her ideas by manipulating the programmable active documents on his or her desktop, and asks for help from the virtual actor by using a tool or special document. The virtual actor responds by doing a certain task in the field of document manipulation, or starts a conversation with the user using a special document.

Virtual reality architecture

In the *virtual reality architecture,* the user explores a virtual reality consisting of simulated objects and actors. Virtual actors communicate by means of putting messages on several documents or blackboards and reading these messages from these documents or blackboards. The user participates in this multi-actor organization. The user has tools for moving around in the virtual reality, for inspecting and manipulating objects, and for communicating with the actors. The virtual reality architecture fits in a larger architecture consisting of communicating actors of different kinds: human beings, simulated intelligent actors, and virtual actors that are guides to semi-intelligent databases or object bases.

Meaning of the Internet in the mind metaphor

The Internet is a library consisting of documents in that store knowledge, and try to communicate knowledge. Furthermore, Internet is a society in which you can meet other actors, real or virtual. Internet is organized based on families that each have a site where they live, a site where their home is.

4.3. People, organization and mind metaphor information systems

Assisting or replacing people?

The information system that is a virtual actor assisting people within organizations will be termed the *mind-1 metaphor*, because another alternative is possible. Instead of writing 'assisting', 'replacing' could have been written. The view corresponding to 'replacing' will be termed the *mind-2 metaphor*. With its position, the mind-1 metaphor opposes the mill metaphor, which makes people slaves of the system. The mind-1 metaphor puts the information system in the role of an semi-intelligent *assistant* of people, consequently having to adapt itself to the characteristics of human cognition. The mind-2 metaphor is compatible with the mill metaphor with respect to its aim to replace people by computerized information systems. Expert systems are examples of the mind-2 metaphor. Knowledge engineering aiming at expert systems tries to absorb the knowledge of experts in computer systems, for the rest following the approach of the mill metaphor. Decision support systems, including KB-DSS (Klein and Methlie, 1990) and thought support systems are examples of the mind-1 metaphor.

Thought support

The decision support systems movement has been emphasizing the support of individual people by information systems for decades (Sprague and Carlson, 1982). Thought support is essentially different from task automation (Young, 1987):

"One can automate doing, one can only support thinking."

The goal of thought support is not 'controlling thought processes' or 'automating ways of doing', but 'stimulating and supporting creativity'. An important point in thought support is that the user is at the *driving wheel*, not the computer program. The user develops ideas or decisions by a unique combination of mental objects and a self-chosen chain of cognitive tasks. In group decision-making, idea representation and manipulation is necessary for group learning processes and getting consensus about certain idea's or items. This means, that thought support systems are essentially different from expert systems where the solution generating process is automated, and controlled by the computer.

5. Discussion

The foregoing explanation of information system metaphors tries to make the design space visible that organizations and individual designers have in describing or designing an information system. The explanation of these metaphors also tries to stimulate the imagination, and to facilitate new directions in information system research. Two questions that remain are:

- how do the three metaphors (or metaphoric meaning complexes) relate to each other?

- can these three metaphors be combined in a single organization?

Of the three metaphors, the cell metaphor seems to be the most general. It has a time scale that encompasses life and death of information systems, and transfer of genetic information. It also has a spatial scale in which an organization or information system with integrated rationality is only a local region, bubble, or niche. The mind metaphor is clearly derived from the cell metaphor. It depends on the biological characteristics of the cell metaphor and could be seen as a specialization of the cell metaphor, a species of organism specializing in intelligence, language and symbol structure use. The mill metaphor relates to the mind metaphor as follows. A mill is a machine, an instrument, or tool, made and used by an intelligent being (a biological species of the mind metaphor type). Social structure in the multi-actor society of mind metaphor beings leads to a possible misuse of these mills.

The three metaphors can be combined, and are combined, in real-life organizations. Hagel and Singer (1999) describe such a composite organization. They think that organizations will unbundle their core processes, leading to specialized parts for:

"

- customer relationship management (identify, attract, and build relationships with customers);

- infrastructure management (build and manage facilities for high-volume, repetitive operational tasks); and

- product innovation (conceive of attractive new products and services and commercialize them)." (Hagel and Singer, 1999: 135)

We see that organizations can be composed of subsystems that specialize in a certain direction. For instance, an innovation-oriented subsystem using mind metaphor information systems, an efficient processing system based on mill metaphor information systems, and a system giving attention to people based on cell metaphor information systems.

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