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Knowledge Management and Cognitics

Some Fundamental Aspects

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Abstract

Knowledge management(KM) has been a hot subject in business administration for about 10 years now. The paper presents a brief overview of KM. But for this specific concept of knowledge, as for most of cognitive notions, the scientific community is lacking clear definitions and metrics. The author has already published several papers on an original model for cognition (MSC), which has the particularly interesting feature of being also applicable to machine-based cognitive systems. The word cognitics has been coined, which denotes the science and techniques of automated cognition. The basic MSC is finally used in order to shed some light on the traditional knowledge management domain, and to suggest some appropriate directions to move through it in some effective ways. While information, messages and documents are static, knowledge and expertise are essentially associated to cognitive systems, which are dynamic and act. The latter must also be considered in KM. The whole gets even more interesting when the enterprise as a whole is viewed as a cognitive system.

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1. INTRODUCTION

It is common to hear, especially in business reviews , that we are in the midst of a new "information age," that should revolutionize how workers work, how companies compete, perhaps even how thinkers think. Information Technology has become a giant industry : in America especially, where more that 50% of all capital spending goes into IT (3 trillion dollars in 10 years), accounting for more than a third of the growth of the entire American economy in the last four years. And yet, by almost all accounts, IT hasn't worked all that well. Why is it that so many of the companies that have invested in these costly new technologies never saw the returns they had hoped for? And why do workers, even CEOs, find it so hard to adjust to new IT systems?

If one is to cope effectively with such problems the concept of information is no longer sufficient. We have to deal with more elaborate cognitive concepts such as knowledge, abstraction, expertise or know-how.

Knowledge management has been a hot subject in business administration for about 10 years now. Various approaches are advocated in order to improve matters. Classical or novel ideas range from rather conceptual (e.g [1], [2]), to more pragmatic (e.g. [3], [4], [5]) or even very much applied (e.g. [6], [7],).

In our view, the major problem is that for the specific concept of knowledge, as for most of cognitive notions, the scientific community is lacking clear definitions and metrics. And if moreover we are interested in the related machine-based, automated approaches, the IT concept is too general and we should focus on cognitics [8-14].

In this paper we give an overview of current approaches in knowledge management, then present core concepts in cognitics, and finally revisit the major so-called knowledge management topics with this new light.

2. KNOWLEDGE MANAGEMENT – CURRENT VIEWS

The view of Bellinger is a good example of the way knowledge management is perceived today in the business administration context : « the value of Knowledge Management relates directly to the effectiveness with which the managed knowledge enables the members of the organization to deal with today's situations and effectively envision and create their future ». And he defines knowledge as a category of intermediary complexity between information and wisdom (he takes complexity in the sense of Csikszentmihalyi : a balanced development stage between descriptions of two opposite types: complicated and mundane, i. e. excessively differentiated and excessively integrated) :

Information relates to description, definition, or perspective (what, who, when, where).

Knowledge comprises strategy, practice, method, or approach (how).

Wisdom embodies principle, insight, moral, or archetype (why).

Knowledge management most often implies for companies in practice to rely on external consultants (at least in the initial phase), then to develop explicit procedures, such as the ones familiar in quality management, and, usually, to essentially implement a computer/network based document management system. For example excellent works of the latter type as been reported in our European ICIMS NoE, by Klaus-Dieter Thoben's group from BIBA, Univ. of Bremen.

Typical products on the market today allow, for about 10'000 $, to implement a web interface and an effective workforce support for implementing services such as help desks, FAQs posting or basic content (i.e. document) management. Distribution can be done in-house and to customers, This type of products rely heavily on SQL and Microsoft technologies (Office XP, .NETtechnology, Windows 2000 Server).

A revolution which has arrived is the « blog/blogging » phenomenon (contracted form of the weblog /weblogging expressions)[e.g. 18]. Blogging, the publication of running commentary on personal online weblogs, in the past couple of years has exploded from a curiosity into an home industry churning out increasingly compelling content. In 1998 there were about 30,000 weblogs; today, there are some 500,000. Tools exist which make it simple and cheap to update personal web content instantly (e. g. Blogger). Blogs may well be an interesting complement to a company knowledge management system. The key aspects are the easy ways people can 1. make their information, knowledge, or know-how explicit and 2. share it with others, boosting company/network learning capabilities and expertise. A convenient (automated) edition of remarkable blogs is continuous made by various "aggregators".

Research is being made in more fundamental directions. Knowledge management may share grounds with a variety of other disciplines (table 1) ; notably, a strong correlation is perceived nowadays between knowledge representation and human language issues [15], more specifically semiotics in computing, ontology engineering, modelling formalisms, languages and notations (e.g. UML).

Databases and Information Systems Integration
Artificial Intelligence and Decision Support Systems
Information Systems Analysis and Specification
Software Agents and Internet Computing

Table 1 Areas commonly perceived as related to knowledge management

Human language technologies address challenges in human computer interaction, information access, and knowledge management, with automated operations such as indexing, retrieval, transcription, extraction, translation, and summarization. This offers new capabilities for conducting business, ensuring e.g. enhanced awareness, creation and dissemination of enterprise expertise and know-how.

3. COGNITICS

Natural sciences progress in synergy with tools and techniques. Better devices and procedures have allowed improvements in sciences ; and reciprocally. The claim is here that the state of development corresponding to the advent of information is passed and that now we are well ahead in the cognition phase.

3.1 FROM INFORMATION TO OTHER COGNITIVE CONCEPTS

Information is a notion which is widely referred to and which is considered to be well known. But who can readily give a satisfactory definition ? and who can estimate it quantitatively ? Of course this is not impossible, yet people who can routinely do it are not common either.

Information seems to be an old concept. Yet it is only during the last century that it has been rigorously defined. This was a natural development at a stage where, similarly, novel electronic devices were capable to sense, amplify, transmit and reproduce information (signals).

In (electronic) communications, a theory for information has been defined, very appropriate for that context. With traditional electronic devices, such as telephones, sound transport devices, modems (modulators-demodulators) or codecs (encoders-decoders), this was perfect.

At this stage, information is « processed », but in a very limited way (sensing, amplification, possibly logical control) when compared to human capability. Applied to humans, the notion of « information processing » is awkward. We feel there is somehow a different nature of « operation » between the traditional devices mentioned and what humans usually do. Humans perceive, understand, reason, decide, create. The classical field for that is not « information processing » but « cognition ».

Advances in computer technology and software engineering allow to consider, and reciprocally require, a rigorous theory for cognition. Precisely, we have introduced MCS – our Model for Cognitive Sciences – and coined the word « cognitics », to denote the science and techniques of automated cognition.

Examples of core concepts in cognition/cognitics are the ones of complexity, knowledge, expertise or learning . Examples of core operations in this context include the ones of accessing and sorting.

Appendix A gives a short list of definitions, in alphabetic order, for MCS concepts ; most of them can be quantitatively assessed with specific units (metrics).

3.2 INFORMATION AND MODELS

Although the initial idea was to build upon the classical information theory (re. Shannon), experience shows that this is not as simple and direct as initially imagined. Bases need first be reinforced.

Classical equations are totally valid and beneficial. But two points require a particular development. First, in classical context, information is “flowing” from an emitter to a receiver; and the devices at both end of the link are a priori roughly similar in terms of complexity. And second, the probability calculus which allows to measure information quantities typically rely on some kind of “absolute” model, which is static and external both to emitter and receiver.

When we get more general, there is a strong dissymmetry which appears between emitter and receiver. In cognitive context, the emitter can be ignored, in the sense that just anything may be a pertinent source of information. It may be a highly structured source, such as a TV channel, but it may just as well be “nature” without any constraint e.g. a noise, the sun, etc. On the contrary, the receiver is critical. It is the instantaneous state of the receiver’s model which essentially defines the instantaneous quantity of information conveyed. Thus the very same message may carry a lot of information or no information at all, depending on receiver’s identity and time (to “whom” and when).

When we start measuring information flows, it becomes obvious that the underlying models are always infinitely incomplete with respect to reality. Sorry for those who want(ed) to know: impossible[1]. But in life this is not a problem. The paradox of models has already been introduced [9]: "The better, the more false"! The crucial thing is to act well i.e. to reach the goal (under constraints of natural and social laws; the ultimate constraint is survival). Experience commonly shows that very crude representations (incomplete or even false) prove usually sufficient.

4. KNOWLEDGE MANAGEMENT – A NEW PERSPECTIVE

In the early days of computers helping business, we had « information [management] systems ». Nowadays, the trend is to speak of knowledge management [systems]. What is the difference ? Is this adequate ?

As stated in the introduction, there is an interesting difference between the classical information context and cognition. One may see information as "facts" while more elaborate cognitive properties (including knowledge) relate to "procedures".

This difference has in particular two extraordinarily important consequences: 1. knowledge allows to spare acquisition and/or storage of infinite amounts of information (10^{∞} bit). 2. knowledge requires an engine (cognitive system).

Knowledge is the property of a system capable to generate pertinent information, "to do right". This, per se, is not so interesting (we could ironically speak of the "professor syndrome"). What really matters is expertise: "to do right and fast" (maybe not so right, but in practically acceptable time delays). While it is hard to find an alternate term for knowledge, many synonyms exist for expertise: know-how, skill, competence… Even words such as science or ability which may seem closer to knowledge relate usually more to expertise though.

The obvious traditional cognitive system (the "engine") was the human brain. To some extent, we had also the group, society.

Today development is boosted by 3 major types of explosions:

1, ACS:. numerous, pervasive, inexpensive microelectronic devices, which are artificial cognitive systems.

2. Communications: numerous, pervasive, inexpensive communication systems (this makes systems at a larger scale possible and/or more effective: superACS; groups and societies in a totally new sense; networks).

3. S&T (sciences and techniques): novel methods and procedures (in the IT world, but also among humans). Consider the relative number of publications and patents made in the last 20 years versus the total number in historical times! Though intangible, these resources are not to be neglected.

In old times, the only cognitive systems available were human. Organizations schematically relied on two types of solutions in order to manage knowledge and expertise. One was appropriate for sparse, literate people: use books, libraries (i.e. information management). The other one was relying on direct example and communication: master-apprentice training, family and street culture (human resource management).

Today, why not tap into these 3 explosive sources of cognitive power?

Only the 3rd of the 3 types of above mentioned explosions still is in the realm of information management. And yet it has taken here a new twist: constantly updated information must not only feed humans but also organizations and ACS; therefore certifications, mobility, cultural events, and automated periodic software and database updates are examples of new appropriate measures.

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[1] When we know, we know the model (e.g. Kant's categories). Experience and MCS equations show that the difference versus reality is infinite. It is not than just a poor image (re. Socrates's reflection on walls) ; the world we believe to perceive is *essentially* made of mental contructs (re. Hegel).

And we have to go further than just information management. Consider knowledge and –better yet - expertise management and harness what the two other changes can do:

1. ACS: we have no longer just humans for cognitive work. Make use of computers and automated systems as much and as soon as they cross the critical cost curve (bearable market price; this does sometimes mean replacement of human workers but mostly allow for new applications – e.g. ubiquitous 24h automated crossroad/traffic controls; or 100% quality control).
2. Make use of new and better communication possibilities in order to increase the complexity and speed of systems, thereby their expertise level (emails, blogs, mobile phones, virtual enterprises, networking, roaming access, distributed control technology).

More broadly, the enterprise as a whole may be viewed as a cognitive system, which must deliver the pertinent output either proactively or in response to partner and environment inputs. Thus when we think “expertise management” (expertise in the sense of the MCS briefly presented here) it becomes obvious that rapid prototyping, TQM or Agile manufacturing are excellent ways to go. All this means much more than just managing messages and documents (information); this means forcing changes on the “cognitive engine” e. g. restructuring facilities and organizations.

6. CONCLUSION

In common views, knowledge is not defined formally, Knowledge management is typically addressing the processing of information in organizations, at abstraction levels higher than those of traditional messages and signals. On the “higher” end, people tend to limit the scope of knowledge management at the boundary where the choice of actions is to be done. Here people feel that we enter another domain: wisdom, ethics, etc.

Typically, companies that implement knowledge management nowadays write, store, distribute update documents. This has various benefits, including those of making part of tacit knowledge explicit, and developing a company culture (internal model) which improves communication and the collective expertise/skill of enterprises. Nowadays, specialized products are easily found on the market, relying typically on Microsoft techniques and tools. A particularly inexpensive and flexible new way for similar purposes consists in managing weblogs. On the advanced side, approaches for world modeling, relying on the traditional representation power of human language is a very promising trend.

In fact a model for cognitive sciences has been elaborated, featuring clear definitions and a metric system. Examples of such cognitive concepts include complexity, knowledge, abstraction and expertise. All this is based on the classical information theory and the traditional probability-based modeling approach which is essential for it. The science and techniques related to automated cognition and such artificial cognitive systems shape up as a totally new domain of its own: cognitics. Notable results include the two following assertions: 1. While knowledge allow to do right, expertise (skill, know-how, competence) is the property of systems which do “right and fast”[1]; 2. Models are highly subjective, volatile, and infinitely incomplete representations; but nevertheless they are measurable, necessary and extraordinarily capable of making systems expertly act in reality.

When looking through the MSC lens, it appears in particular that moving from information to knowledge and skill is not just walking up a step on a vague abstraction or complexity ladder. It means trading a static “dead” world (information is most often fixed) for a dynamic “living” world: knowledge (and other cognitive properties) is (are) the feature(s) of systems capable of delivering the pertinent answer (output information). Thus knowledge and expertise management implies not only storing or working with messages and documented procedures but imply also controlling and tuning

[1] There is an exciting book announced for next year : Let’s hope the content will match the title [16].

up the cognitive system. (analogy in current IT: not only the CD, but also the computer!). For IPLnet a good KM/EM approach includes naturally maintaining a common IT platform but also in particular getting partners meet, communicate directly, exchange experience, knowledge, competences, building up a common culture and thereby an effective network; like here in Saas Fee.

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APPENDIX A MCS - ESSENTIAL DEFINITIONS

The appendix briefly presents, by alphabetical order, the core definitions in MCS - our model for cognitive sciences. It can validly be viewed as a glossary, an ontology or an axiomatic declaration. The number behind each concept denotes the logical order in which definitions are introduced.

Abstraction (3b). Property of a system which generates less information than it receives. The abstraction index, iabs, is the ratio of incoming information quantity (ni [bit]). over the outcoming information quantity (no [bit]). Inverse of concretization. Equ.: iabs=ni/no [without unit]

Complexity (3a). Property of a model which requires a lot of information in order to be exhaustively described. Quantitatively, complexity is the amount of required information. Unit: same as information, i.e. [bit]

Concretization (3c): Property of a system which generates more information than it receives. The concretization index, ic, is the ratio of outcoming information quantity (no [bit]). over the incoming information quantity (ni [bit]). Inverse of abstraction. Equ.: ic=no/n1 [without unit]

Experience: (4b) Property of a system which has been exposed to a cognitive domain. Quantitatively, it is usually evaluated in terms of time (duration) [s]. An alternate (better?) view is to assess experience, R, in terms of number Na of witnessed input-output associations. Equ.: R=Na*(ni+no) [bit]

Expertise (5a). Property of a cognitive system which delivers fast the pertinent output. Quantitatively, it is the product of knowledge, K, and fluency, f. Equ.: E=K*f . The unit is [lin/s]. In general terms, synonyms for expertise include know-how, skill, competence and excellence.

Fluency(4c): Property of a system which delivers information fast. It can be viewed as a processing speed. Fluency, f, is the inverse of the time duration , Δt, necessary to deliver output information. Equ. : f=1/Δt [1/s]

Information (2). Information is what allows a receiver to update his model. Quantitatively, it is the difference of model size in terms of information content, between the states "before" and "after" message arrival. Computation is made on the basis of message probabilities, which are essential elements in the model Consider that the incoming message is one among N possible variants. If the probabilities of those various occurrences of the message are pi, where pi is the probability of the ith message, then the average quantity Qa is given by the following equation: Qa:= Sum $_{\text{for i:= 1 to N}}$ of (pi log 1/pi). The log is usually taken in base 2, thereby yielding [bit].

Intelligence (7). Intelligence is the property of a system capable of learning. In quantitative terms, intelligence can be assessed as an index, i, which is the ratio of learning with respect to experience. Depending on the intuitive or more rigorous choice of formulations introduced for experience, we have two equations. Equ.: i=L/Δt [lin/s^2] (or i=L/ΔR [lin/s/bit])

Knowledge (4a). Knowledge is the property of a system which delivers the pertinent output, either proactively or in response to incoming messages. Quantitatively it is given by the following equation: K=log(no*2^{ni}+1). The log is in base 2, and the unit is the [lin].

Learning (6). Learning is the property of a system capable of increasing its expertise level as time goes (or better: as experience goes). Equ: L=E(t1)-E(t0) . Alternate view: L=E(r1)-E(r0). In both cases the unit is [lin/s]

Model (1). In general terms, a model is a simplified (that is, incomplete by essence) representation of reality, which is found useful in order to reach some specific goal. In MCS the basic reference model is behavioral. It can be viewed as a kind of (virtual) table, which contains as many states as possible incoming message types; each state contains the instant probability of occurrence for the corresponding input message, and also contains the corresponding output message. The goal of this model is to allow the quantitative assessment of key cognitive properties, such as knowledge, expertise, or learning.

Reductibility (5b): Property of a system which can be implemented by subsystems of integral complexity smaller than the complexity of the system itself.

Simplicity (4d): Property of a model which requires little information in order to be exhaustively described. Quantitatively, simplicity, exactly like complexity is the amount of required information. Unit: same as information, i.e. [bit].