Knowledge Transfer in Collaborative Knowledge Management: A Semiotic View

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ABSTRACT

Codification and transfer of knowledge is essential in the practice of knowledge management. Theoretical knowledge, like scientific theories and models, by nature comes in coded representation for the explicit purpose of transfer. Practical knowledge, as involved frequently in engineering or business operations, however, is *a priori* uncoded, making transfer for further use or the generation of new knowledge difficult. A great deal of systems engineering effort in recent years has been focused on resolving issues related to this sort of knowledge transfer. Semantic technologies play a major role in here, along with the development of ontologies. This paper presents a semiotic perspective on transfer of knowledge within collaborations.

Keywords: Knowledge management, collaboration, knowledge transfer, semiotics, semantic technologies, ontologies

1 INTRODUCTION

Current semantic technology engineering builds upon the use of ontologies for the description of factual, conceptual or procedural entities. The goal is to make information machine–readable and –interpretable so that the meaning of given data can be grasped for further use, in particular for further processing in electronic systems and applications. In business practice, the information needed to run operations or manage transactions is always related to a specific business context. Information gets its meaning in that context, and usually triggers a decision, an action or activity in it. The flow of meaningful information, we say the transfer of knowledge, guides the operations of an organization. Clarity and unambiguity of knowledge transferred thus become essential requirements to ensure an operation will function well, or a transaction will lead to the desired result. This applies in the case of single organizations, but even more to collaboration across several different organizations. Process, data and application integration across organizational boundaries require as a precondition well defined and implemented routines for knowledge transfer; and the knowledge exchanged must be interpreted correctly to entail the appropriate action. This raises the question of equal understanding of knowledge objects by all actors involved in a collaborative activity, each one having their own contextual sphere of interpreting a unit or set of information.

The predominant approaches for handling this question using information technology are subsumed into the term semantic technologies. In general they build upon ontologies, i.e., referencing schemes comprising vocabulary and syntax to describe a certain knowledge domain. The aim is to construct comprehensive languages that can be used for electronic documentation and communication of information, in particular in machine-readable form. In recent years, a number of standards and tools for the construction of ontologies have been developed, and various examples of domain specific ontologies have been suggested. The general concept is that all communication systems work on the basis of underlying codes [3]. While this does not necessarily mean that all signs used with a code are verbal, or can at least be attributed to the rules of language [4], semantic technologies at present are very much focused on verbal codes. However, the issue of semantic variety [12] requests, in particular in the case of automated machine-based communication, to take into view the unambiguous understandability of every message transferred. A sign – and consequently a term – is something that stands for some other thing, in a certain respect or based upon a certain capacity of someone [11]. Any coded information then gets its meaning not independent from connotation, but within an actual context ideally providing that connotation. These considerations suggest taking a view of knowledge transfer and semantic technologies facilitating it from the perspective of semiotics.

The focus on machine-readable information is not however exclusive. Some of these same issues will arise in requirements analysis and design of collaborative information- and knowledge-intensive systems, including but not limited to software development. In fact, since there is more awareness and more study of the former, we will consider both issues in the balance of this paper.

The paper is structured as follows. At first, the field of semiotics is characterized as described by Eco, Saussure, and Peirce: every communication is based on codes consisting of systems of symbols/signs established by cultural convention. This has numerous implications for the sourcing, sharing and use of knowledge. Such implications of semiotics for knowledge management are discussed in the second section, in particular for the externalization, internalization and transfer of knowledge in collaborative settings. In section 3, recent advancements in the area of semantic technologies, as provided for example by the Object Management Group with their Semantics for Business Vocabulary and Business Rules [9], are investigated as to their supporting function for the engineering of knowledge transfer systems. Basic issues still remaining unsolved are identified, such as the management of non-verbally represented knowledge in collaborative activities, the question of semantic synchronization when ontologies are being used for formal representation of knowledge [12], and collaborative knowledge capture [5]. Finally, we draw conclusions in particular for the facilitation of knowledge transfer within collaborations and further work relating to that.

2 SEMIOTICS: THE THEORY OF SIGNS AND THE RELATION BETWEEN CODE AND MESSAGE

Semiotics is the theory of signs (or symbols). Its objective is to investigate the conditions that make messages mediated by signs understandable. According to Eco [3], signs represent 'something' and are always related to codes. Subject to investigation therefore is the general relation between code and message.

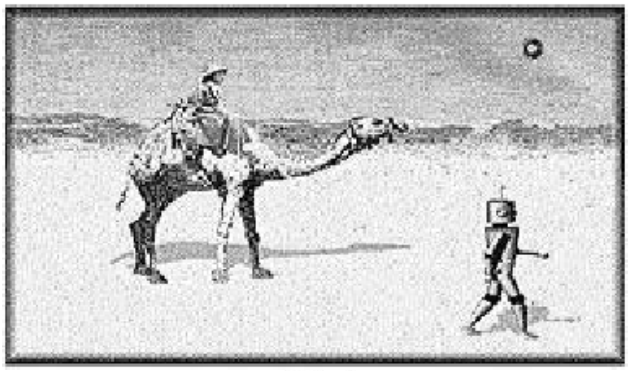
Signs are not necessarily verbal, but can also for example be visual, like pictures. There are basic signs (e.g. elementary predicates) and composed signs (e.g. sentences), see Exhibit 1.

Exh. 1

Both Eco [3] and Peirce [11] point out that signs do not represent 'something' in its totality, but specific aspects according to a certain perspective or practical interest. Such aspects can also be functional, as is the case when pictogrammes (for instance showing an escalator, Exhibit 2) are used to point to the function (get to the upper floor).

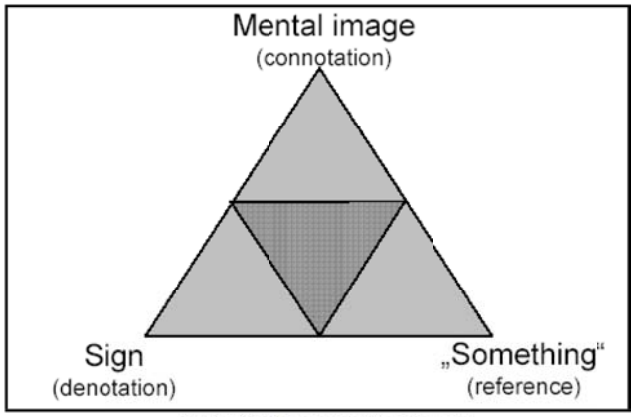
Exh. 2

However, following Saussure [4], semiotics has been focusing on the investigation of verbal signs, taking into view syntax, semantics and pragmatics; other signs are predominantly being considered only within this horizon. It should be noted that Scholz [13] points out the particular nature of pictures (as signs) being that these, different to verbal signs or mathematical and design notations, cannot be decomposed into an alphabet or vocabulary of distinct syntactical entities. Exhibit 3 illustrates this phenomenon.



Exh. 3

The basic concept of semiotics involves the semiotic process, see Exhibit 4: something is being signified by a sign – (denotation); this sign is perceived, connotative aspects are – mentally – added, resulting in a cognitive signification (connotation); this signification refers to an instantiation of the something (reference). Obviously this concept requires cognitive capacity with the perceiving subject for creating the mental image. The semiotic process is characterized by the fact that there is no direct, immediate influence of a something on the recipient. The relation between something and recipient is mediated by a representational object. This object, the sign, may be a written text, verbal expression or even a picture, which, in the case of an intended communication, bears some meaning to be communicated.



Exh. 4: The semiotic process

Denotation, connotation and reference are the procedural elements of the semiotic process; the sign/symbol is the mediating object which bears the meaning. When signs are used

to communicate information – or transfer knowledge – it appears immediately that the (intended) communication will be successful only if each of the subjects communicating makes an equivalent (or at least compatible) reference to the something in general and in a specific instantiation. Hence the necessary condition for signs to be understandable.

A prerequisite for a sign to be understood by a recipient is correct decoding. In order to be able to decode, a code must be available. The underlying hypothesis of semiotics is that any communication system works on the basis of codes. Codes are systems of symbols which are determined by cultural convention for the purpose of representing information and transferring it from a point of origination to a destination. They must be shared so that decoding becomes possible. According to Eco [3], a code can be vague or weak (change quickly), incomplete, temporarily provisional, or inconsistent. Every communication, however, happens to refer implicitly or explicitly to a code that must be available for each communicating party. So does the exchange of information, and the transfer of knowledge:

(1) In the most simple case of a *signal processing* machine, a code is used to identify certain conditions occurring in a real process (that are relevant to be communicated), and transfer this information to a recipient which, referring to the same code, reconstitutes the message.

(2) The more complicated case is when two or more systems using their specific codes each (for example, components in a supply chain using their individual product numbering schemes) exchange information which originates from processing within one code scheme and generates processing in the other code scheme. *Interoperability* then can be achieved if and only if there is a bijective relation between the code schemes involved, i.e., when semantic variety or ambiguity is reduced to zero. (This can be relaxed if some codes are allowed to correspond, perhaps non-bijectively, to exceptions or error conditions.) However, remaining issues here on the organizational as well as the IT systems side are openness, flexibility with regard to modification and adaptation, and configurability [7]. Similar concerns apply to the use of different processes, vocabularies or design notations, even when used by a single development team.

(3) The complex case is that of *collaboration,* i.e., when information resulting from an action or activity on one side is being transferred to another where it becomes the source of, again, an action or activity, depending on its interpretation, where that response is not necessarily pre-determined. The interpretation of the information being exchanged (or: the knowledge being transferred) is not unconditionally unambiguous. It is influenced by the set of connotations the recipient has, which in turn depends on the functional context, defining in which respect and with which mental capacity the recipient views the information, and the cultural context, providing the wider sphere of the whole of applicable connotations. (While this situation can arise with collaborating autonomous agents, it is more likely and more problematic for teams of human developers and their IT support.)

It is crucial here that both sides agree upon a common set of connotations, through a combination of fixing it in a glossary when setting up a collaboration, and aligning it dynamically during the run time of the collaboration. In some cases, glossaries must be expanded to add missing connotation "overtones", or to soften existing and misleading overtone connotations within the social (and less frequently political or business) culture pertaining at one or more of the collaborators.

In the next section, we consider issues affecting such human teams, and to a lesser extent, those affecting their IT support frameworks or their eventual product.

3 KNOWLEDGE MANAGEMENT: THE EXTERNALIZATION, INTERNALIZATION AND TRANSFER OF KNOWLEDGE

Knowledge management is understood as the organization of the utilization of explicit, implicit, tacit and collaborative knowledge in and between enterprises, organizations, and institutions. Issues relating to the transfer of knowledge in the context of business practice have been identified for example in [5]. Difficulties inherent to knowledge management in inter-organizational collaborations have been taken up in [9], while the considerations there were mainly focused on non-technical challenges. The following sections present a discussion of the codification problems related with the transfer of knowledge in collaborations.

In a single organization/culture/community, practical knowledge (and ritual) are each given meaning by a predefined set of constructs and attitudes. Many of these are kept implicit. While in a single society/community, explication in a literal sense is desirable as insurance against social (in a broad sense) change and the effects of time, explication via decodification (and possibly recodification on the other end) is absolutely needed for collaboration across major cultural (in a broad sense) boundaries, where the context and the implicit structures are lacking. In its absence, shared work toward common goals is only achieved in the unlikely event of multiple parties pursuing closely aligned goals for fortuitously coincident rationales. But this is an unacceptable risk when multiple partners engage in a collaborative project or process.

Thus the primary drivers of codification are standardization and risk, and the main problems are cultural incoherence, miscodification of tacit knowledge, and loss of knowledge:

1. Within a single organization, in a single cultural setting, with a single project team, or tightly coordinated teams, the main risks are (1) improper codification of knowledge and practice aimed at standardization and quality control/assurance, and (2) risks due to change – turnover in management, key personnel, information technology and other tools, and changes in standards, statutes and regulations, business processes and practices, and so on. The tacit and implicit knowledge encoded in the interaction between human agents and tools (and among tools) is especially vulnerable to changes on either side of the exchange.
2. In a distributed project, still within a single cultural and organizational setting, additional risks include different understandings of processes and tools. Also, if key personnel and domain experts are associated with one of the teams, the understandings in that relationship have to be externalized if other teams require that specialized knowledge.

3. In a multi-organizational context, teams in different organizations will have different organizational cultures, different understandings of the relationship between technical and management teams, and possibly work in a different platform/tool environment, including but not limited to IT support.
4. In a multi-cultural environment, there is in addition the usual difficulty with different connotations, and often different denotations, of certain actions, decisions, and statements, particularly if elliptical, partial, or non-committal, and different customs and interpretations for physical gestures and movements.

In cross-organizational and cross-cultural contexts, a single perspective may not suffice. Multiple perspectives and/or filters may be needed in order to assure a common or overlapping understanding, whether through provision of different intermediating routes to a common connotation, or actually by creation of distinct connotations that interact with existing culture and perspective to provide a shared or at least mutually comprehensible understanding. These multiple perspectives will be most important for business, project and process narrative and its underlying cultural fabric, but may at times be important even for more structured artifacts.

Applying the concept of the semiotic process now to the transfer of knowledge in a collaboration, there is a need to extend every denotation, i.e., codification of a thing or a concept, by appropriate connotation of the contextual sphere in accordance with a specific perspective applied, in order to ensure proper understanding of the concept by the interpreter (cf. [7], [8]). Explication then is achieved by decodification. Connotation can be appended to a denotation in a generic way, or by means of linking the denotation to a specific ontology. This affects the externalization of knowledge on the originating side, its transfer and the internalization on the destination side.

The connotative sphere of a sign, for example the escalator pictogramme mentioned in section 2, is in many cases constituent for its proper understanding, especially if it is a non-verbal/non-textual sign. A nomad in the desert who has never seen an escalator nor has any knowledge of such a thing, when getting to see the pictogramme would not connect any denotation with it, neither with its function. The semiotic process – if there is any – will not lead to understanding. (The fact of the perception of signs without any or with only rudimentary factual or mental connotation is an issue worthwhile to further investigate, though – in particular with regard to its stimulating potential for the generation of knew knowledge.)

4 THE ROLE OF SEMANTIC TECHNOLOGIES

The transfer of knowledge, as shown in the previous sections, requires appropriate formal representation of knowledge as a basis. Formal representation comprises not only a certain terminology (or vocabulary), but also syntactic structure and semantic rules, and in the end could include also pragmatic references. It goes down to the proper encoding of information within coding schemes that are generally embedded in cultural context (section 2), and particularly are specific to a given domain of knowledge. Codes consist of a set of conventions, hence are culturally co-variant and subject to change as context changes over time. Furthermore, knowledge transfer in collaborative settings within procedural practices, such as business, puts relevant challenges on bi- or multilateral synchronization of understanding (section 3). In [9] we argue that the codification of collaborative knowledge is a prerequisite to its transfer. Technological support for the externalization, transfer and internalization of knowledge is provided by shared infrastructures, process models, and semantic technologies. Semantic technologies, while very much restricted to verbal/textual representation of information, these days are considered the most promising approach to the challenge of formal representation of knowledge. Their role in cross-organizational collaborations shall be considered in this section.

Semantic technologies provide the means to develop ontologies for practical use. The general purpose is to enrich information with meaning, by making use of appropriately defined vocabularies within well-constructed syntactic and semantic frameworks. For the field of business, the Object Management Group (OMG) recently have presented their specification of 'Semantics of business vocabulary and business rules' SBVR [10]. It adds to existing business ontology specification frameworks like OASIS Standard UBL, UDEF, or ebXML. Like these it is targeted at business vocabularies and rules, and does not comprise for example business processes. It supports the externalization of knowledge making use of verbal representation. It does not offer means to deal with knowledge objects that are represented non-verbally. For the purpose of knowledge transfer related to business transactions and its automation, this is sufficient. Out of its scope is the integration of business processes at the pragmatic level, and the facilitation of the management of non-verbal/-textual knowledge involved in collaborative action. Thus it is in support of the transfer of collaborative knowledge, while being limited though as far as non-verbalized knowledge is excluded. This is a basic issue to be noted.

Within these limits of current semantic technologies, the question of ontology mapping in collaborations needs being addressed. Collaboration means that two or more organizations mutually connect some of their activities based upon their established processes. This can be done by integration of their existing processes, at the risk of losing flexibility, but with the option of gaining benefits through automation; or by coupling processes through less automated interfaces. In either case, there is significant need to transfer knowledge between the collaborating entities. Each of these may have its knowledge base, which may be available in machine-interpretable formal representation, but need not be necessarily complete or consistent. So each one owns an explicit or implicit ontology being, perhaps partly, used in the collaboration, but also in other operations and processes that are not directly affected. Consequently, the underlying ontologies of collaboration partners are being practically mapped through daily collaborative practice, while each collaborating unit will generally keep their own one for continued use in other operations.

IT applications in support of the collaboration will build upon these ontologies. Knowledge transferred will make use of the vocabulary and the referencing schemes represented there. Hence a need arises for their alignment. This goes beyond just

the implementation of unambiguous relations between, for example, product numbers or document ID's at the formal level. It affects as well the use of denotations at the content level.

From a business integration view, these issues have been dealt with in [12], resulting in the provision of a solution offering semantic synchronization services for ontologies, called the Ontologies-based Reconciliation for Business Integration – ORBI Ontology Mediator. The system resolves the problem of disambiguation in ontology mapping by making use of user-generated ratings and contexts for the synchronization of semantic references. It thus facilitates evolving context-sensitive mapping which is driven by users. An issue with practical application of this system in a collaboration is the need to convert knowledge bases existing at all partners into ontologies. As these knowledge bases may be built upon different standards or on proprietary non-standards, this conversion effort can become a significant challenge. This is another issue to be noted.

For intra-enterprise collaboration, semantic technology services have been suggested in [1], based upon the Activity Context Ontology ACO. They are limited in the number and scope of collaboration concepts the ontology is build from. This leaves much of the difficulty with setting up a comprehensive ontology for collaboration to the extraction of context information, which is an issue similar to the one identified above with the ORBI Ontology Mediator.

A third suggestion for the collaborative capturing of knowledge in ontologies has been provided in [5]. It is aimed at the capture of domain expert knowledge from the Semantic Web. Based on concept maps, a prototype of a Collaborative Ontology Environment COE for the construction of ontologies as formal representations of distributed knowledge bases is described.

Overall, semantic technologies have to be considered a promising approach to the transfer of knowledge in collaborations. Knowledge that can be formally represented in ontologies, and thus becomes machine-interpretable, can be managed either in shared ontologies or by making use of ontology alignment techniques. At the time being, however, they appear to provide little support to the dealing with knowledge which can not, or not easily, be formally represented verbally/textually. On the other hand, there is also certainly a great deal of work—some centuries old—on translating between pairs of notations, diagrams, encodings and/or models in the mathematical or related domains, even though, in some cases, the correspondence is not total or is modulo some equivalence relation. Standard examples include the correspondence between elements of a power set and characteristic functions, between Boolean matrices and directed graphs, between regular expressions and finite state automata, between probability distributions and moment generating functions, and between invariants and symmetry groups (the Noether correspondence). A trivial software development example would be the correspondence between sequence and interaction diagrams in UML [2]. Where this is important for collaboration or collaborative development, this can easily be added, as long as relevant "parsers" are available.

Nonetheless, the problem of converting existing knowledge into suitable ontology representation puts another challenge on the management of knowledge in collaborations.

5 CONCLUSIONS AND FURTHER WORK

This paper presents an investigation of the management of knowledge in collaborative environments from a semiotic angle. Besides the non-technical challenges related to the sourcing and use of knowledge in collaborations, the need to codify knowledge for the purpose of making it available to and transferable between collaborators raises the problem of its formal and machine-interpretable representation. Our considerations on the role of semantic technologies brought about a number of technical challenges that are still to be resolved. They will be addressed in our further work.

One of these is ontology alignment and semantic synchronization in collaborations. Promising approaches in this respect will have to be further engineered by applying "knowledge testing" – an interaction with selected individuals to determine the effectiveness of a selected encoding. Further, an important task of knowledge engineering in this context will be to identify efficient ways of using existing knowledge bases. And longer term work shall be dedicated to the problem of formal representation of non-textual knowledge.

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