From Information Technologies to Knowledge Technologies?

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Abstract. In spite of the large variety of technological means available today to obtain and share knowledge needed by the progress of our Society, the relation between the knowledge produced and the knowledge required is not sufficiently facilitated. This paper aims to provide a partial answer to this issue. It proposes a NIAM/ORM formalization of exchanges between producers and users of knowledge. The resulting model is used to analyse and to discuss the deficiencies of the current technologies as well as to outline some ways of evolutions for better collaborative knowledge exchanges.

Keywords: Communication, Knowledge Modelling, Ontology, Semantic Web, Ambient Intelligence, NIAM, ORM.

1. Introduction

In the information age, Information and Communication Technologies (ICTs) tools and especially those related to the Internet are enabling the deployment of global business or of research processes and facilitating, at the same time, the interoperability of the information systems in which they are supported. Moreover, the major challenge of scientific community is to intensively deploy new efficient ICTs to face up the increasing amount of scientific information available today. To illustrate it, we will limit our purpose to the particular case of knowledge exchanges between Researchers and Engineers which can be considered both as producers and users of knowledge. Through the analysis of this case, we wish to contribute to answer the following question: in the same way as ICTs support information, is it possible to imagine that KCT technologies (Knowledge Collaborative Technologies) could support knowledge in a collaborative process mixing efficiently humans actors and numerical agents?

What is expected by users of ICTs is that delivered information correspond to the knowledge he wants to build based of this information and which is at the origin of his quest. On the other hand, when a user want to put at disposal knowledge via ICTs, he expects the return of knowledge from ICT's as he defined it.

But, it is now an acknowledged fact that a key issue of ICTs means still remains the coherence between information delivered by ICTs and what is expected by a user to build his own knowledge.

What can be notice is, that in spite of advanced ICTs solutions to embed knowledge into communicable information, the relation between the knowledge which is expected to be communicated by ICTs as an usable information and the Knowledge that must be refund to the user is not enough efficient.

Indeed, it is an established fact that one of the key issues of ICTs is still the lack of relevance of their answers in response to specific information or knowledge searches. Currently, these problems are mainly treated by technological ways such as Semantic Web [2] (W3C[1]) or by more conceptual ways such as Ontologies [3]. Their aim is to give a better structure to the information contained within Web pages by giving them a form allowing a more direct access to their semantic content. This evolution stresses the fact that information is not knowledge and that knowledge is not information. Information is considered as a support to communicate knowledge, and "to inform" is the activity to transform knowledge into communicable and usable information [4]. It can be noticed that, in spite of advanced ICTs solutions embedding knowledge into communicable information, the relation between a knowledge needed by a user and the knowledge (or "information"?) he receives remains however not sufficiently relevant. One of the main originality of our paper is to base the analysis of these insufficiencies on a modelling of the knowledge exchange processes between producers and users of this knowledge. The proposed modelling uses a method based on linguistic principles, the NIAM method (Natural language Information Analysis Method or Nijssen Information Analysis Method) [5][6] also well known as ORM (Object Role Modelling) [7]. On the one hand, this method enables to model an informal Universe of Discourse (UoD) expressed in natural language into a semi-formal model containing the semantic description of the significant concepts of the UoD. On the other hand, it enables to compare an equivalent of the resulting model in natural language with the original discourse allowing a more significant validation of its content, because stated in the same (natural) language. In this paper, we will use NIAM to gradually formalize the different available means supplying knowledge exchanges between producers and users.

2. NIAM Method: an example of modelling

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[1] World Wide Web Consortium (http://www.w3.org/)

The NIAM method is most frequently used today in the field of Software Engineering. It is essentially dedicated to the design and the implementation of Information Systems. The way to formalise a UoD into a conceptual model consists in (Figure 1).

1. Understanding of the UoD (by interviews of experts, reading of reports, etc.) and linguistic analysis of the natural language sentences (elementary sentences, constraints, etc.) describing the UoD (Figure 1.a),
2. Modelling in NIAM/ORM formalism the elementary sentences and the related constraints (Figure 1.b),
3. Validation of the resulting NIAM/ORM model by submitting the equivalent of the model in Binary Natural Language to the experts (Figure 1.c).

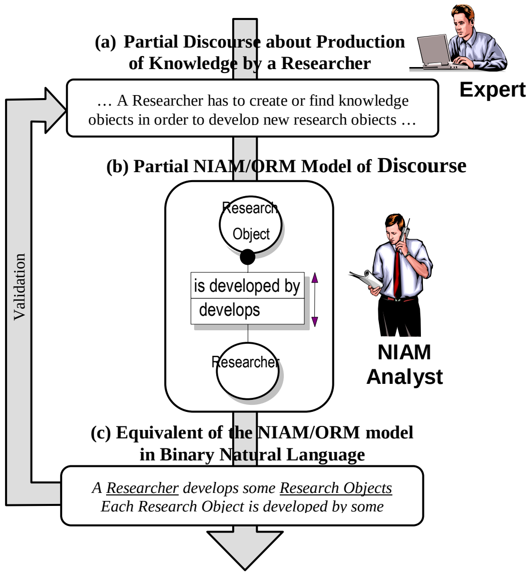

Fig. 1. Partial NIAM/ORM Model of the development of a Research Object by a Researcher.

This linguistic analysis method leads to a model that formalizes the knowledge extracted from the textually formulated information. The resulting model holds more semantics than the initial expression, in the sense that it includes the expression's context and minimizes its implicit character. The NIAM/ORM models presented in this paper have been designed with the Microsoft VisioModeler case tool[2].

3. Knowledge exchange process between an Engineer and a Researcher

Considering the knowledge exchange process between an Engineer and a Researcher, we propose firstly to analyse separately their respective UoD. For a Researcher, there is mainly two ways to justify the production and the use of knowledge. The first one aims "Applied Researches" that encourage the researcher to develop new Research Objects (e.g. a new material, a new process) by applying to it a Knowledge Object (e.g. a theory, a method, a model) already defined. The second way corresponds to more "Academic Researches" which consist for the Researcher in creating new Knowledge Objects only for the evolution of the scientific knowledge (not necessarily and directly applicable to a particular research object). To create new Knowledge Objects, the Researcher has previously to consider other existing Knowledge Objects (Figure 2) produced by other Researchers (or by other sources of production). Based on this "State of the Art", the Researcher potentially produces new Knowledge Objects (in various forms: PhD thesis, publications, conferences, etc.) that become themselves new basis to create new knowledge.

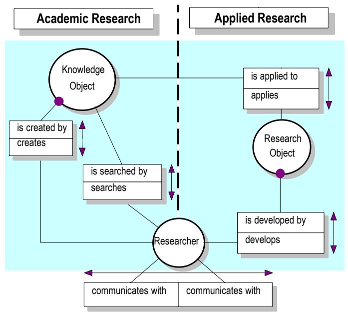

Fig. 2. Partial NIAM/ORM Model of the knowledge production and exchange processes in the Research UoD.

The means classically used by Researchers to search such existing Knowledge Objects perform asynchronous and/or synchronous processes. Search bibliographical references in a university library, consult references of scientific editors or search directly on the Web are some examples of asynchronous accesses to existing knowledge. Synchronous processes can be illustrated by direct discussion between Researchers during scientific events or by using current communication technologies (e.g. phone, phone conferences, video conferences, sharing of software applications, etc.).

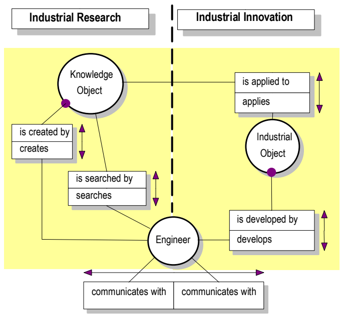

Fig. 3. Partial NIAM/ORM Model of the knowledge production and exchange processes in the Industrial UoD.

The same activities and means also exist in the Engineer's UoD (Figure 3). In fact, an Engineer also creates and uses Knowledge Objects in the frame of Industrial Projects aiming the development of new Industrial Objects (e.g. new products, new services, etc.). He uses similar methods to those used by the Researcher to search and find existing Knowledge Objects: by asynchronous mode, for example, by consulting technical reports and professional reviews, or, in the synchronous mode, by direct contact with others Engineers for example during technical exhibitions or in the frame of his professional relations (customers/suppliers).
The Industrial Innovation process, which is similar to the Applied Research, potentially exists when an Engineer wants to develop new Industrial Objects applying to them Knowledge Objects coming from

[2] © Microsoft Corporation

his own research works or from other production sources. It is to be noted that, both in the Research and Industrial UoD, the loops introduced by the creation, the search and the application of Knowledge Objects induce a “capitalization process” as defined by Dieng [8]. Even if we have firstly distinguished the Research and Industrial UoDs, we have also outlined some similarities in the knowledge production and exchange processes respectively performed by Researchers and Engineers. Nevertheless, if we consider that these two actors can be alternatively and indistinctly producers and users of Knowledge Objects, the two previous partial models (Figures 2 & 3) can be connected by a same Knowledge Object (Figure 4).

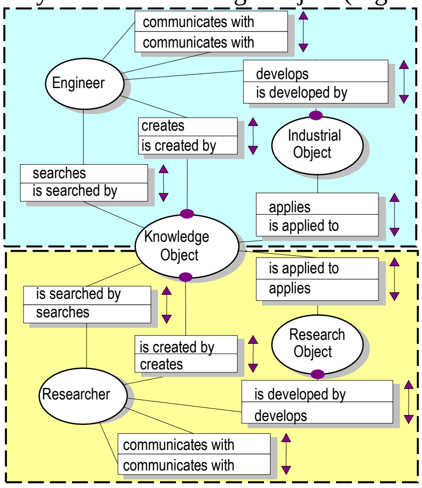

Fig. 4. Partial NIAM/ORM Model of the knowledge production and exchange processes in Research and Industrial UoDs.

Beyond this hypothesis, we could consider that the Research Object and the Industrial one are also shareable. It would be modelled by one unique NOLOT replacing the “Research Object” and the “Industrial Object”, entitled for example "Research and Development Object" and jointly developed by Researchers and Engineers (as it is the case for example in France with CIFRE[3] contracts). In order to simplify the analysis, we will not integrate this hypothesis in this paper. Thus, only considering the Knowledge Object as shared by the Research and Industrial UoD, we clearly outline that a knowledge can be created by a Researcher (*vs* by an Engineer) with a specific formulation and be searched by an Engineer (*vs* a Researcher) in another one, each of them having different UoD.

4. Communication Process between Researchers and Engineers

These differences of formulation partially explain that, in spite of the NTIC evolutions, the effective sharing of Knowledge Objects between these two UoD is not complete. As modelled in Figure 5, the best way to limit the effects of such differences is to promote a direct communication between producers and users of the knowledge (❶ in Figure 5).

[3] CIFRE: Industrial Contract for Research Training, ANRT (http://www.anrt.asso.fr)

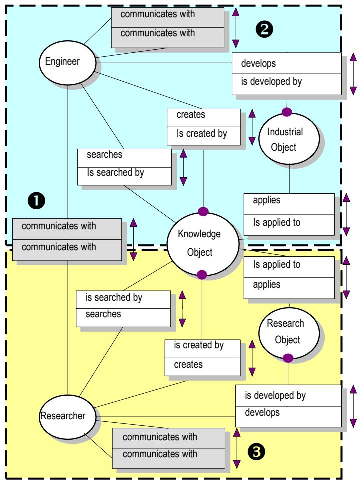

Fig. 5. Partial NIAM/ORM Model including direct communications between Researchers and Engineers

In other words, while the production and search of Knowledge Object are mainly asynchronous processes, the direct communication between the different human actors by more synchronous exchanges ensures a better common understanding of the knowledge. This communication can take several forms: intentional contact between a Researcher and an Engineer during conferences or trainees visits in companies, contacts caused by a third part such as Centres for Technology Transfer, or contractual relations, for example, in the frame of R&D projects where Researchers and Engineers are closely linked for the development of common Knowledge Objects.

The NIAM/ORM Model in Figure 5, even if not exhaustive, reveals from our point of view the more significant objects and their relations involved in a knowledge exchange process. On this basis, we have identified 3 main categories of technologies whose finality is to support and facilitate the different identified relations: "human-human" relations, "technological" relations or "techno-human" relations.

5. “Human-Human” relations

The "human-human" relations are represented in the NIAM/ORM model by the 3 relations entitled "communicates with" between Engineers (❷ in Figure 5), between Researchers (❸in Figure 5) and between Researchers and Engineers (❶ in Figure 5). As suggested previously, the synchronous exchanges between human actors must be considered as complementary to the asynchronous relations performed during the production and the search of Knowledge Objects. This synchronous / asynchronous complementarity integrated today in the collaborative platforms is one of the success factors of this technology [9]. In fact, from our point of view, this technology gives more importance to an integration of the knowledge search and communication means than to a real homogenization of the knowledge representations facilitating the semantic relations between producers and users of this knowledge. In fact, these platforms really improve the distant access to information in many various forms, but don't bring new solutions for a better understanding of the knowledge embedded in this information?

6. "Technological" relations

Other categories of technological means used to support the search of Knowledge Objects corresponds to the classical search engines which can be found on the Web and which give access to thousands of Web-pages available on any subject. Even if Boolean operators are used or not to target a search, the results are often disappointing. Who has not found information with these engines without really seeking it? This technique defined as the "serendipity" can give some positive results in contribution to Disruptive Innovation as shown in [10]. But, for general knowledge exchange, the results are more hazardous. In fact, the principal problem of these search engines lies in the bad synchronization between the results of the search and the keywords used to configure this search. We can also find today a lot of tools that can help to get information via channels RSS[4] allowing to display a permanent updated Web-page or to use automatic alarms on an electronic mailer. These automatic alarms use a technology based on "numerical agents" [11]. But, their role is limited to extract automatically information without real semantic analysis and to alert of the search results periodically. In fact, these agents have no more ability to find a required knowledge than human users they try to replace and who have configured them. Thus, as well as for collaborative platforms, we can doubt of the real contribution of these technological means to the improvement of the semantic level of the Knowledge Objects they find?

7. "Techno-Human" relations

This lack of semantic analysis and the waste of time that results from this, very often encourages companies to contact expert companies in economic intelligence. These companies propose to personalize the search of information in the Web by taking into account the specificities of the customers and the requests. The visual result is generally presented as a Web portal. This type of Web solution, which corresponds to the Semantic Web, aims at extending the simple search of information using syntactic comparison with *key words*, by supplementing this information syntactic definition by a more formal semantic characterization of its contents via metadata schemes. Tim Berners [12] stresses that "*…the Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation …*". As the technological means previously discussed, this concept uses autonomous and adaptive search agents which are the continuity of the relational agents defined by Alan Newell and Herbert Simon [13]. The semantic complement brought to the representation of information is based on a specification and a formalization of the Knowledge Objects (and their relations) characteristic of a given skill (UoD) and defining an Ontology.

The Semantic Web proposes a new structure for this "Communication Object" that is a Web page, trying to give more semantic to its syntactical content, bringing closer to the Knowledge Objects that the Communication Object is supposed to support. The "techno-human" technology represented by the Semantic Web gives the user more precise results. But, can we say that a semantic description added to the information representation is sufficient to transform it in a real knowledge?

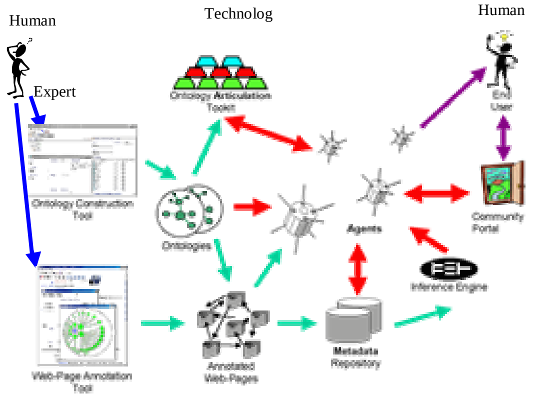

Fig. 6. Semantic Web as a Techno-Human technology (http://www.semanticweb.org)

8. Toward an integrated Knowledge and Communication Object

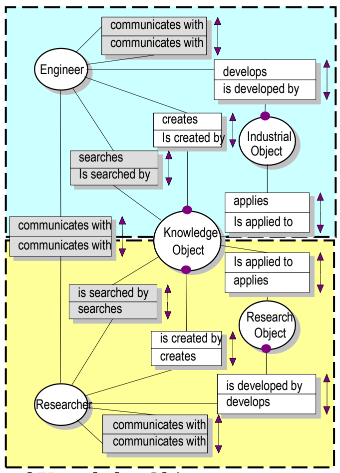

Fig. 7. NTIC and Knowledge Object

So, we can note that the "human-human", "technological" and "techno-human" means seem to be dedicated to only transmit information and not knowledge embedded in this information. Even if these means really facilitate the search and the exchange of information, the user is still in charge of the extraction of the knowledge from the information he has received. Adding easily new information on the Web, finding very quickly any information resulting from a very powerful search are not sufficient facilities to solve the main

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[4] Really Simple Syndication

problem of extraction and common understanding of knowledge included in this information.

So, we propose an alternative to these current approaches that promote extensions of the Communication Objects by integration of some features of the Knowledge Objects to be communicated, but maintaining a separation of their respective technologies. On the contrary, our approach aims to deduce the Communication Objects from the Knowledge Objects to be exchanged and to better integrate their respective technologies. Let us comment this approach by illustrating it on the NIAM/ORM model presented in Figure 7.

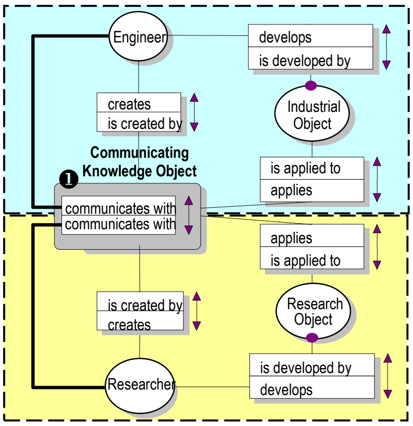

Fig. 8. "Communicating" Knowledge Object Model

The grey relations in this figure show the classical communication and search tools supported by the NTIC. We can note that these relations are all distinct from the Knowledge Objects even if they allow reaching them. Our proposal, formalized in Figure 8, is to entirely replace these relations by a single relation between Engineers and Researchers deduced from the Knowledge Object to exchange.

The representation of this transformation of the Knowledge Object into a communication relation can be described in NIAM/ORM by the use of the "nesting" (or "objectification") [14] mechanism (❶ in Figure 8) consisting in transforming a relation into an object (NOLOT). In fact, we will use this mechanism in the other sense that is by transforming the object into a relation (mechanism that we could call "verbalization").

An example of such an approach was already validated by previous research works presented in [15]. The main objective of these works was to allow the designers of machines (particularly, mechanical presses) to have a more direct access to normative knowledge related to safety of machines.

In fact, the concerned standards are classically presented as textual papers but also as numerical documents facilitating the access to the information but not solving the problem of the access to the knowledge embedded in it and still limiting the use of the standards by the designers of machines. One of the main results reached by these works was the prototyping of a communication tool (ACOMAS in French, or CASA: Computer Aided Standard Application) directly deduced from a NIAM/ORM model of the knowledge extracted from the standards. The general method used to develop this tool is illustrated by Figure 9.

The Universe of Discourse (❶ in Figure 9) was composed of the standards and the experts, authors of these standards. The analysis of the normative texts, supplemented by interviews of experts, was performed by using the NIAM method and led to the development of a normative knowledge model (❷ in Figure 9). This model was then transformed in Binary Natural Language in order to compare it with the initial texts and to validate it by the experts. Once the model validated, the software engineering case tool ISW [16] was used to translate the NIAM model into two complementary logical models: a relational data structure (❸ in Figure 9) and a prototype of man-machine interface (❹ in Figure 9) specifying the possibilities and constraints to access the knowledge in conformity with the NIAM model.

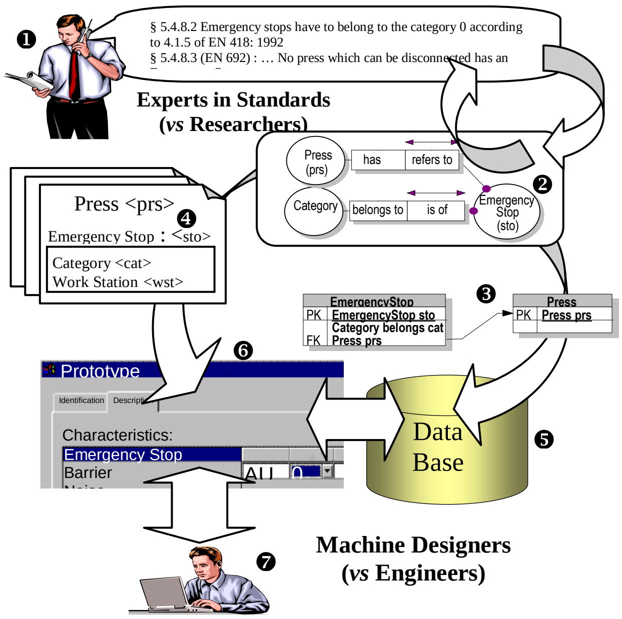

Fig. 9. Overview of the ACOMAS/CASA Method

The result is a software prototype that is composed of a physical database (❺ in Figure 9) generated from the relational data structure, and a "Windows" interface (❻ in Figure 9) generated from the man-machine interface specification. The use of this ACOMAS/CASA prototype (❼ in Figure 9) has shown the interest to enable direct interactions with the normative knowledge rather than to use their textual form. Finally, if we transpose the ACOMAS/CASA approach to the purpose of this paper, for example, Researchers could be assimilated to Experts in Standards (knowledge producers) and Engineers equivalent to Machine Designers (knowledge users).

9. Conclusions and Perspectives: toward new Knowledge Collaborative Technologies?

The production of a knowledge model, as realized in the ACOMAS/CASA approach, requires a long and expensive effort to identify and formalize significant Knowledge Objects. Furthermore, the

modelling process must be repeated for each occurrence of new Knowledge Objects. This effort constitutes today a major obstacle against the generalization of such an approach.
So, are we able to create new methods and tools assisting or automating the modelling process of knowledge as soon as new ones occur? Pushing this idea, the perspective of a world with or without computers in which the knowledge transmission would be almost instantaneous and constraint-less, is it possible or a utopia? Nijholt [17] has imagined such intelligent environments in which we would not be worried by the use of computer or software. This environment would propose a dialogue with a “virtual man” rather than a screen. Can we imagine "humanized" interfaces provided by more interactive agents having verbal or not-verbal (capable of feelings) communication capacities? This concept is currently studied by the Philips Company [18]. In fact, research works in this field are very advanced. As the European ISTAG project [19] plans for 2010’s, the concept of Ambient Intelligence will allow the usual physical objects of our environment to communicate together and with men. This project is organized in three parts: "Ubiquitous Communication" which concentrates on the various possible communication methods between physical objects of our environment; "Intelligent to Use Interface" which relates to advanced interfaces between people and physical objects; and finally "Ubiquitous Computing" which concerns the processing part based on numerical agents and their architecture. Integrating Nijholt futuristic vision and Ambient Intelligence concepts is, from our point of view, a frame to develop future Knowledge Collaborative Technologies (KCTs) contributing to better exchanges of knowledge between humans by using more “transparent” technologies. As a result for our purpose, Engineers searching specific knowledge produced by Researchers would be able to understand them in they own language and with they own terminology by the use of a simple dialogue with an "intelligent" interface. In fact, the Knowledge Objects would configure or generate the adequate Communication Objects in order to make the knowledge more understandable by any user taking into account its individual preferences. In the same time, these “ephemeral” Communication Objects would also contribute to the evolution of the Knowledge Objects from which they was created. It is in this way that we develop our current research works in order to contribute to the emergence of such KCTs in the frame of an "extended" Ambient Intelligence, i.e. indistinctly integrating human and numerical agents in a same "System Intelligence" allowing them to share and develop together common Knowledge Objects in more transparent ways of communication.

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