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Quality of Service and Pricing Differentiation for IP Services

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The Dashboard: a knowledge conversion tool

Nathalie Cassaigne, Senior Member, IEEE

Abstract – This paper focuses on tacit and explicit knowledge conversion as conceptualized by Nonaka and Takeuchi [13]. It presents a decision support tool (Dashboard) that supports the conversion of domain expert knowledge in such a way that non-domain expert can understand, internalize, combine explicit expert knowledge to inform their decision. The Dashboard approach to knowledge conversion is presented.

Index Terms -- Knowledge conversion, Dashboard, Domain Expert, Non-domain expert, Knowledge Management, Knowledge representation, QOSISPS.

I. INTRODUCTION

Knowledge and Knowledge Management (KM) appear to have become the buzzwords of the 21st century management practice. Amrit Tiwana [1] gives the following definition of KM “Management of business, customer, and process knowledge and its application for adding value and competitively differentiating products and service offerings”. In other words, any business is based and depends on the knowledge the company or its employees has of its business environment. This knowledge needs to be shared between the members of the company. This is also the role of KM seen as a discipline that provides strategy, process and technology to share and leverage information and expertise [2]. Expertise “is the growth of knowledge and skills through experience.”[3]. The term expert will be defined as a person who has worked at a task for a significant period, usually several years, with a relatively broader range of experiences than other workers, and with mastery of a wider set of skills than most other workers. Dreyfus & Dreyfus [4] describes how people who have mastered a skill can perform it without conscious analysis, and so an expert would be a person who had achieved such a mastery for a greater number of skills in a given domain.

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Nathalie Cassaigne is with the University of Manchester Institute of Science and Technologies, Sackville Street M60 1QD, UK. Tel: +44 161 200 3358, e-mail N.Cassaigne@co.umist.ac.uk

Organizations have to deal with two typical situations which are (1) knowledge needs to be transferred, shared between two (or more) domain experts and (2) knowledge must be transferred from a domain expert to a non-domain expert. The first situation mainly deals with knowledge acquisition. The underlying assumption is that two experts from the same domain of expertise should be able to communicate “easily” using a common language and/or formalism. Therefore knowledge representation is taken care of through the domain of expertise.

The second situation typically covers the case when domain experts must explain a technical situation to “general” managers who do not have a technical background. In this situation, the most important aspect of KM is knowledge representation, i.e. expert knowledge must be represented in such a way that non-domain experts are able to interpret it and if possible, to operated on it. Both aspects deal with knowledge conversion i.e. the transfer of knowledge from one form to another.

Examples of knowledge-based support systems based on experts’ knowledge are the market adaptive pricing technology from KSS [5] and the bid pricing hybrid system developed by the DTG 0. Both elicit, externalize (represent), tacit knowledge from sales and marketing teams and then combine and process the resulting explicit knowledge with the objective to increase the effectiveness of decisions, i.e. they compute a set of prices that optimize profit under strategic and commercial constraints.

This paper focuses on the knowledge conversion. One of the bottleneck for both knowledge acquisition and knowledge representation is that the form in which a domain expert expresses his/her knowledge is different from the way a non-domain expert needs this knowledge to be expressed in order for him/her to comprehend, process and assimilate it. The concepts of tacit knowledge and knowledge conversion explain the gap between domain experts and non-domain. These concepts had been used by an application called Dashboard which objective is to present to top management key knowledge that had been collected or generated from two domain specific applications i.e. the Pricing Module and the Quality Module. These three modules, shown in figure
have been developed has part of the EC funded project QOSIPS. The Dashboard had been designed with the objective to rapidly construct a knowledge asset that is reusable and easily maintainable in rapidly changing environment. The approach followed supports:

1. The representation of domain expert knowledge in a way that non-domain experts can easily comprehend, process and assimilate.
2. The formalization and integration of non-domain expert explicit and tacit knowledge.
3. Complex problem modeling and solving by non-domain experts through the creation of “graphical” experiments and rules.
4. The reuse of the newly generated knowledge.

Fig. 1. The QOSIPS system is composed of three modules. The Pricing Module and Quality Module are specialized technical application used by domain experts to perform their specialist tasks. The Dashboard is a tool designed to bring top managers a few key information about marketing and network. The dashboard supports (1) the integration of non-domain expert own implicit knowledge to domain expert’s explicit knowledge, and (2) the combination of explicit knowledge to (3) generate new explicit and implicit knowledge that (4) can be shared with other non-domain experts.

The paper is organized as follow. Section II introduces the general concept of knowledge and defines tacit and explicit knowledge. Them, it presents Nonaka and Takeuchi’s approach to knowledge conversion. Section III discusses the Dashboard’s four steps knowledge conversion approach. Section IV concludes and briefly introduces further work.

II. DEFINITIONS AND METHODOLOGY

A. Knowledge

Knowledge is the capacity to act on patterns in our experiences that we have perceived by relating them to a learnt tacit background. We exercise this capacity when we properly recognize and extrapolate patterns[6].

By tacit background, we mean that knowledge depends on people’s context, experience and interpretation[7]. Knowledge is a personal capacity that results from the combination of information, experience, skills and attitude an individual has at a given point in time [8]. Values and culture of upbringing and living also influence the way knowledge is formed. Because this individual knowledge had been formed through the spatio-temporal combination of so many factors, it is difficult to both explicit the process of knowledge generation and transmit it to other individuals in a form that will directly be usable by them. The assumption is that knowledge is created through the interaction between tacit and explicit knowledge.

B. Tacit and Explicit Knowledge

For Polanyi [9], tacit knowledge refers to personal, context-specific knowledge, and therefore it is hard to formalize and communicate, while, on the other hand, explicit or “codified” knowledge, refers to knowledge that is transmittable in formal, systematic language. Thanks to our tacit knowledge, we are able to interpret the meaning of information. “Rather than the words themselves carrying meaning they are related to a tacit background that provides their context” [6]. In other words, we actively interpret our experiences to give meaning to the information we receive [10], [11]. In addition, it helps us to comprehend things that cannot be codified, like how to ride a bicycle. “Thus tacit knowledge is both the background of interwoven experience and the automatic capacity we have to relate experience to it. It is hard (if not impossible) to codify and transmit because it is the background to which codified transmitted information is compared” [6].

Tacit knowledge includes both cognitive and technical elements. The cognitive elements center on what Johnson-Laird [12] calls “mental models”, in which individuals create working models of the world by making and manipulating analogies in their minds. Mental models, such as schemata, paradigms, perspectives, beliefs, and viewpoints, help
individuals to perceive and define their world. On the other hand, the technical element of tacit knowledge includes concrete know-how, craft, and skills[13].

Polanyi [9] argues that human beings acquire knowledge by actively creating and organizing their own experiences. “As we experience more this background builds up and we learn. Learning is not just getting more information, as it involves recognizing patterns and connection between memories. The more background knowledge we have, the more context we can give to our experiences and with this, the larger our capacity to understand becomes.” [6]

Individuals, groups and organizations can only generate knowledge through an active cognitive process. This process can be unconscious within individuals but it must be intentional in an organization. Nonaka and Takeuchi [13] go even further when they claim that knowledge can only be created in an organization when five enabling conditions are met. These are the organizational intention to acquire, create, accumulate and exploit knowledge, the autonomy of each individual so that “unexpected opportunities” may be introduced in the system, the creation of fluctuation and creative chaos to stimulate the interactions between the organization and the external environment, the redundancy of information to create overlaps between viewpoints and finally, the requisite variety that responds to Ashby’s recommendation that an organization’s diversity should match the variety and complexity of its environment [14].

C. Approach

The Dashboard had been designed as a decision tool that supports knowledge conversion through interaction between tacit and explicit knowledge as conceptualized by Nonaka and Takeuchi [13]. They postulate the following four different modes of knowledge conversion:

- **Socialization** or creation of new tacit knowledge such as shared mental models and technical skills through the process of sharing experiences. By discussion, observation, new perspectives are created. It is to be noted that any tool that support knowledge conversion will be constraint by the fact that the transfer of information abstracted from “associated emotions and specific contexts in which shared experiences are embedded” [13] is not a very effective way to create new tacit knowledge. People need to share their mental models to be able to transfer their tacit knowledge.

- **Externalization** or articulation of tacit knowledge into explicit concepts such as concepts, hypotheses, models. Metaphors and analogies are also widely used in this conversion from tacit to explicit when expressions are “inadequate, inconsistent, and insufficient” [13].

- **Combination** of different bodies of explicit knowledge or “reconfiguration of existing knowledge through sorting, adding, combining, and categorizing of explicit knowledge” [13] to lead to new knowledge.

- **Internalization** or process of embodying explicit knowledge into tacit knowledge. This is a form of learning when explicit knowledge is internalized into the individual’s own experiences. We usually learn from our own experiences (with or without having externalized our knowledge) but we also can learn from other people’s experiences for example from the reading of a book.

For Nonaka and Takeuchi, knowledge is converted in a spiral that starts with socialization and goes through externalization, combination and internalization before moving to successive iterations.

The following section details the knowledge conversion approach as supported by the Dashboard.

III. THE DASHBOARD KNOWLEDGE CONVERSION APPROACH

The approach followed supports:

1. The representation of domain expert knowledge in a way that non-domain experts can easily comprehend, process and assimilate. This corresponds to the externalization of domain experts’ tacit knowledge into explicit knowledge. In order to ensure the understanding of such externalization by non-domain experts, a socialization process is also been carried out.

2. The formalization and integration of non-domain expert explicit and tacit knowledge. This corresponds to the internalization by non-expert domain of this explicit knowledge into its own tacit knowledge.

3. Complex problem modeling and solving by non-domain experts through the creation of “graphical”
experiments and rules. This corresponds to the **combination** process where a re-structuring of current knowledge can generate new knowledge.

4. The reuse of the newly generated knowledge. This phase can be seen as the first step of the iteration of the knowledge spiral with further **socialization** of knowledge.

A. **First step: knowledge representation targeted to non-domain experts**

The objectives of this first step are a) to externalize domain expert tacit knowledge and b) to ensure that this externalization allows non-domain experts to comprehend, process and assimilate the resulting explicit knowledge.

First, through **externalization**, domain expert’s knowledge had been extracted and represented in a form that is easily understandable by other domain experts. This externalization is mainly been carried out through the technical applications (Pricing and Quality modules). E.g. the Pricing module utilizes the concepts of demand/price elasticities, price differentials, cross effects, etc to express the demand model and computing the optimized set of prices for a portfolio of products and the resulting revenues, profits, subscriber base, new subscribers, etc. The Quality Module uses sophisticated, non-intrusive, real time measurement technology to come up with quality measurement expressed in terms of jitter, packet losses, one-way delay, availability, throughput, etc.

![Pricing Domain Experts](Marketing, Product managers)

![QoS Domain Experts](Network, Product managers)

![Expert representation of concepts, information and graphs](Externalization)

![QoS Domain Experts](Network, Product managers)

![Shared Mental Models](Pricing Domain Experts) (Marketing, Product managers)

![Non-Domain Experts](Top managers)

Fig. 2. Externalization of domain expert tacit knowledge into explicit knowledge. Through the Pricing Module and the Quality Module, experts use a number of concepts to represent their view of the world or mental models. They can easily communicate their explicit knowledge to other domain experts specialized in the same area but the chance that non-domain experts fully understand their explicit knowledge and can act upon such knowledge is limited. Therefore a simplification and explicitation (socialization) process needs to follow this externalization process.

Second, **socialization** had been initialized through brainstorming and demonstrations (trial and errors). As a result, typical and representative meaningful results from both the Pricing and the Quality Modules had been selected by a group composed of both domain and non-domain experts in order for the domain experts to check and validate the meaningfulness of the representation of domain knowledge and for non-domain experts to check and validate the understanding and interpretation of such knowledge.

As the result of the socialization process, pricing domain expert external knowledge is being graphically represented through commercial and financial information, while quality information is represented through a limited number of graphs that only shows aggregated weekly and monthly information for the overall network.

![Socialization](Validation of representation of typical concepts, information & graphs)

![Mental Models shared through trial-errors, validation of easiness of understanding by non-domain experts.](Pricing Domain Experts (Marketing, Product managers))

![Basic knowledge bricks](Non-Domain Experts (Top managers))

![QoS Domain Experts (Network, Product managers)](Shared Mental Models)

Fig. 3. Socialization has taken place through presentation of expert concepts, brainstorming and demonstrations. During the discussion, a number of analogies have been used by both domain and non-domain experts such as comparison with the day-to-day management of a division. As the result a number of graphical representations have been elaborated.

Third, once established, the information that supports the representation of the explicit knowledge is automatically extracted from the Pricing & Quality Modules (through XML parser), aggregated when necessary and stored in a
relational database, where the relations between entities convey the context. This is an explicit representation of the domain specific knowledge. Further work would be to introduce explanations, comments from domain experts to explain their mental models. In a similar way, a number of standard graphs have been elaborated and their representation had been stored.

We consider this knowledge representation as the “basic” knowledge bricks that non-domain experts need to appropriate in order to be able to enlarge their own knowledge base and model and solve complex problems by combining them.

B. Second step: formalization of non-domain expert’s tacit knowledge and integration with domain expert explicit knowledge

Non-domain experts (target users of the dashboard) need to be able to integrate or **internalize** this basic knowledge into their mental models and tacit knowledge. For Nonaka and Takeuchi internalization is closely related to “learning by doing”. The solution implemented in the Dashboard provide the user with the possibility to experiment with the external knowledge by changing its format and by adding their own implicit and explicit expertise in a attempt to make it more familiar and/or meaningful and to integrated it to their existing mental models and tacit knowledge.

In order to control the appropriateness of their learning process, and limit the distortions, non-domain experts are constraint in their possibility to “twist” the external knowledge that is passed to them. The Dashboard limits the representations they can use, e.g.:

- Users have been given the possibility to reformat graphs but the list of possible graphs had been limited, in accordance with domain expert advice, to meaningful graphs.

- Users have only the possibility to externalize their own tacit knowledge by using the concept of targets (e.g. sales target, quality targets, etc.).

C. Third step: Complex problem modeling and solving by non-domain experts through the creation of “graphical” experiments and rules.

The next step in the non-domain expert learning process and knowledge conversion process is to allow him/her to experiment using the newly acquired knowledge integrated to his/her own tacit knowledge.

In the second step, each basic knowledge brick was obtained and used individually. In consequence, the user was only able to experiment on the representation of each individual brick.

From now on, non-domain expert has the possibility to freely use and combine any of these knowledge bricks in an attempt to integrate domain experts’ experience (**internalization**), explicitly model his/her own perception of the “world” (**externalization**) or to let emerge or generate new knowledge (**combination**).

The intellectual process involved in **internalization**, **externalization** and **combination** can be described using Turro [15] suggestion that it involves creating a “stable and self-consistent interpretation of a phenomena or event”. This is done by firstly fitting data into pre-existing patterns (tacit or explicit knowledge), and secondly by recognizing and generating new patterns. Then, the new patterns are tested against tacit and explicit knowledge. If they pass the test they are accepted, if they are dissonant, their underlying assumptions will be reassessed.
Figure 5 presents these three processes and in addition includes the next socialization step.

In order to support these three knowledge conversion modes, the Dashboard allows the user to combine on the same graph information that was not previously represented on the same graph. I.e. different bodies of explicit knowledge can be used and combined. An example being that the user can not only mix and match pricing and quality information on the same graph but also perform sophisticated operations that are directly derived from the explicit knowledge externalized through the Dashboard (combination). For example, he can forecast quality taking into account the increase in number of subscribers due to a change in price planned for the following month.

In addition, the user can perform elaborated operations using (additional) tacit knowledge (externalisation and combination). For example, he can estimate the valuation of the company in 6 months time based on the forecasted based of subscribers and revenues.

The only technical constraint the user has (due to the use of Hanengcharts [16]) is that only a maximum of 5 curves can be drawn on each graph. But each curve can represent complex knowledge.

D. Fourth step: The reuse of the newly generated knowledge.

Once new knowledge arises, its external representation can be stored, emailed to another person, retrieved, for reuse, further validation, etc.

This step supports the socialization of the newly acquired knowledge in order to disseminate it and initiate a new increment in the knowledge spiral.

IV. CONCLUSIONS AND FURTHER WORK

Knowledge management’s major problem is the transmission of knowledge between domain experts and non-domain experts. Unfortunately, organizations cannot ignore this problem as an important number of managerial information is based on technical (domain specific) information and no-one’s domain expertise can cover all the variety of domains dealt within an organization. The objective of the Dashboard is to give top managers access to a specific range of domain expertise, support its internalization and combination to produce new knowledge.

The previous section has demonstrated that the Dashboard supports Nonaka and Takeuchi four modes of knowledge conversion. Internalization, externalization and combination are the key modes supported by the Dashboard. Further work would involve the development of a number of tools to support more effectively the sharing of mental models by improving the transfer of “associated emotions and specific contexts in which shared experiences are embedded”[13] and the possible use of metaphors and analogies.

A partial solution could be to let users note comments, record a video or audio clip to explain their mental models. Unfortunately, the day-to-day use of such time-consuming tools has not been successful in business environments. More sophisticated solutions would require extensive research in the domain.
REFERENCES


[10] N. Cassaigne (SM’01) is a Lecturer in Decision Technologies at UMIST, Manchester, UK. Prior to joining UMIST, she was head of new business development at Knowledge Support Systems Plc where she co-specified and co-designed the Intelligent Tactical Decision Support System TelPrice. TelPrice won the European IST Award 1999. This award is sponsored by the European Commission, administered by the European engineering academies (Royal Academy of engineering for UK) and is given “for excellence in converting information technology research into innovative products for the marketplace”. Nathalie has over ten years experience in helping senior executives unlock the personal and corporate benefits to by supporting and optimizing strategic and tactical decisions. She has operated in a wide range of organizations in the private and public sectors including telecommunication, manufacturing, aerospace industries and government