Transactive Memory System in Clusters
The Knowledge Management Platform Experience

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Abstract: Clusters produce social and cognitive proximities that support knowledge flows and combination. As such, clusters affect both members' motivation to engage in collective knowledge creation processes and their ability to identify actors' expertise and then to exchange and combine distributed pieces of knowledge. In other words, social and cognitive interactions within a cluster should affect the development of Transactive Memory Systems (TMS). This paper proposes to extend the TMS concept at the cluster level. Based on an integrative design science methodology, this paper makes theoretical contributions on how a TMS within a cluster functions with the assistance of social interactions and information technologies. The study builds on the design of a semantic web service of competencies within the Sophia Antipolis telecom cluster. This study provides empirical support to the potential benefits of the TMS approach at the cluster level and specifically the ability of an IT to support the development of an effective TMS in a cluster.

1 INTRODUCTION

A vast literature emphasises the crucial role of cluster, defined as localized network, in building learning and innovative capabilities (Kogut, 2000; Maskell and Lorenzen, 2004; Nooteboom, 2005; among others). From a Schumpeterian perspective, Nelson and Winter (1982) treat innovation as a search process that explores the space of possible combinations of pieces of knowledge to create new or better alternatives. Cluster and network favour interactions among actors, which in turn produce social and cognitive proximities supporting knowledge exchange and combination (Kogut, 2000; Maskell and Lorenzen, 2004). As such, clusters affect both members' motivation to engage in collective knowledge creation processes and their ability to identify actors' expertise and then to exchange and combine distributed peaces of knowledge. In other words, social and cognitive interactions within a cluster should affect the development of Transactive Memory Systems (TMS).

We propose to extend the notion of TMS at the cluster level. TMS refers to a collective system that individuals in closed relationships use to encode, store, and retrieve knowledge about different substantive domains (Wegner, 1987). A commonly used of TMS is a shared system that provides hints about "who knows what" (Ren and Argote, 2011). Whereas TMS were originally observed in small groups, some recent researches wondered if the TMS concept would "scale up" to fit well within organizational settings (Nevo and Wand, 2005; Jackson and Klobas, 2008). If the TMS concept shows promise for being generalized to the organizational level, our understanding of how an organizational TMS functions remains limited (Ren and Argote, 2011). In addition, extending the TMS at the organizational level introduces the question of how IT can support the development of effective TMS (Nevo and Wand, 2005).

Based on an integrative design science methodology, this paper makes theoretical contributions on how a TMS within a cluster functions with the assistance of social interactions and information technologies. The study is based on the Knowledge Management Platform (KMP) project within the Sophia Antipolis telecom cluster, one of the main European centres of high tech. We explore technological interventions to assist clusters' members in building R&D collaborative projects

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through the design of a map of competencies. The KMP project is an experimental IT infrastructure based on a semantic web service of competencies.

The KMP experience provides empirical support to the potential benefits of the TMS approach at the cluster level. Our study provides specific guidelines to create an IT to support the development of an effective TMS in a cluster. Based on an appropriate formalization of knowledge about "who knows what" (the map of competencies), this IT creates an artificial directory to link different organisations and subgroups in order to facilitate knowledge exchange and combination.

The argument in this paper is organized as follows. First, we articulate the literature on knowledge creation within a cluster with TMS discourse. Second, we describe the methodology adopted in this paper. The argument then turns to a case study of designing and developing a map of competencies for fostering knowledge creation in a telecom cluster. Finally, the findings from this case study are discussed and implications for future research are explored.

2 THEORETICAL FRAMEWORK

2.1 Knowledge Creation inside a Cluster

According to Kogut and Zander (1992), Nahapiet and Ghoshal (1998) and Shawney and Prandelli (2000), organizational knowledge creation is above all a social process. Moran and Ghoshal (1996) and Nahapiet and Ghoshal (1998) enhance in a schumpeterian perspective that organizational knowledge creation is based on two key mechanisms: exchange and combination. Creating new knowledge therefore requires combining elements previously unconnected or developing novel ways of combining elements previously associated. When various agents hold resources, exchange is a prerequisite for resources combination. Nahapiet and Ghoshal (1998) identified four conditions that would favour knowledge exchange and combination: 1) the opportunity to engage in exchange and / or combination; 2) the capability to anticipate knowledge combination value; 3) the motivation to engage in exchanging and combining knowledge and 4) the capability to combine knowledge.

This approach of social knowledge creation emphasizes the necessity for organizations to open themselves to the outside in order to reach new knowledge (Van de Ven, 2005). The network then represents a privileged source of knowledge exchange, and provides structures and stability that can be used for collective learning (Kogut, 2000). Hence, the network appears like an organizational configuration able to create, accumulate and transfer collective knowledge (Baskerville and Dulipovici, 2006). Moreover, cluster capacity to formulate collective entrepreneurial projects becomes nowadays crucial (Crevoisier and Jeannerat, 2009). This gives way to combinatorial territorial dynamics that are mainly based on the anchoring of composite fields of knowledge (Antonelli and Calderini, 2008). Beyond that, the key factor is the capacity to act collectively (Crevoisier and Jeannerat, 2009). These capabilities emerging from interactions of actors within networks are named "network capabilities" and included two main aspects: the architecture and the identity (Kogut, 2000). Network architecture refers to the links structure, the types of actors and the coordination mechanisms. Through identity, individual anchors their perception of self and other and attach meaning to membership, as well as in the categories of skill and knowledge that define a spatial and cognitive division of labour. In addition, Dyer and Nobeoka (2000) emphasise that if agents are able to represent a shared space, knowledge combination can be easily generated. Architecture and identity thus allow to coordinate specialized and distributed knowledge (Kogut, 2000). As such, they enable the flow and the combination of knowledge across organizational boundaries (Mitchell and Nicholas, 2006). In sum, network innovation capabilities rely not only on the existence on a broad range of knowledge (cognitive variety), but also on the ability of cluster's members to access and combine this knowledge, knowing 'who knows what' and sharing mental models (transactive memory).

However, network capabilities, and more specifically the capacity to act collectively, are rarely formed by design but rather "arise from inherent characteristics of technologies that populate an industry, as well as social norms and institutional factors that favour the operation of particular rules" (Kogut, 2000: 410). Thus, the question of how to build effective network capabilities in order to foster innovation through knowledge exchange and combination is still open. In other words, can a technological system support the development of a transactive memory within a cluster defined as a localized network in cases where it does not develop naturally?

2.2 Transactive Memory System at the Cluster Level

A Transactive Memory System (TMS) is a shared system that people in closed relationships develop for encoding, storing, and retrieving information about different substantive domains (Wegner, 1987; Ren and Argote, 2011). The basic idea is that individual knowledge in a group consists of internal knowledge (held in his mind) and external knowledge (which the individual can access using the TMS) (Jackson and Klobas, 2008). As such, TMS supposes that individuals play the role of external memory for other individuals who in turn encode meta-memories (i.e., the label or subject of the knowledge as well as its location, but not the knowledge itself) (Nevo and Wand, 2005).

TMS at the group level

Originally, researches on TMS were developed at dyad or team group level of analysis. TMS implies a cooperative division of learning, remembering and communicating knowledge within the group (Wegner, 1987). Over time, knowledge in TMS becomes more specialized or differentiated among members as a result of the division of learning; at the same time, shared or integrated knowledge increases as individuals develop a shared cognitive representations of "who knows what" (Brandon and Hollingshead, 2004; Ren and Argote, 2011).

As a result, three components are crucial to TMS: cognitive interdependence, expertise related to task and people, and shared mental models (Brandon and Hollingshead, 2004). First, cognitive interdependence describes the extent to which team member's work outcomes depend on a combination of their own input and the input of others members. As such, it motivates and sustains the development of TMS. Task interdependence led thus to a higher level of TMS, which in turn led to improved team performance (Ren and Argote, 2011). Second, Brandon and Hollingshead (2004) expand the basic notion of labels and location (who knows what) into a more explicit portrait of relations between Task, Expertise and People (TEP). Third, shared mental model concern not only a shared representation of "who knows what" or "TPE" units, but also macro-organizations of those "TPE" units. These shared mental models have implications for the effectiveness of the TMS. Brandon and Hollingshead (2004) propose to evaluate their development along three dimensions: accuracy, sharedness and validation.

TMS at the organizational level

Only four studies have recently extended the TMS concept to the organizational level (Ren and Argote, 2011), including one case study (Jackson and Klobas, 2008). Generalizing TMS to the organizational level raises several challenges (Ren and Argote, 2011). First, members might have more trouble identifying who knows what in large organizations than in small groups. Second, organizations are composed by multiple subgroups increasingly geographically distributed with less communication and knowledge sharing across these subgroups. Finally, when tacit knowledge is available in a distal part of organization, retrieval becomes difficult. Because organizations are larger than work groups and geographically distributed, Nevo and Wand (2005) shows that TMS might rely upon advanced technology to locate and shared information. They suggest that a general directory of meta-memories should be formed, linking the different communities and supporting knowledge transfer between individuals in different communities. In this case, knowledge transfer is not provided through repositories but rather through technology mediated connections.

Extending TMS to a large group requires the use of artificial directories based on formalized meta-knowledge integrating three main dimensions (Nevo and Wand, 2005): conceptual, descriptive and persuasive. In fact, a set of concepts is needed to describe the subject of knowledge (ontology can be used here). Descriptive knowledge can be formalized to describe the author of knowledge (location) and to characterize the knowledge (date, format…). At the persuasive level, source of credibility and perceptions of expertise should be formalized. In this line, Jackson and Klobas (2008) add two insights: in an organizational TMS people access each other's knowledge through a combination of personal and codified directory system; maintaining these directories which can be activated for retrieving knowledge when it's needed (passive allocation) is more efficient than storing the knowledge and sending content trough a system network (repositories and active allocation).

Finally, TMS at the organizational level raises two main questions (Nevo and Wand, 2005; Jackson and Klobas, 2008; Ren and Argote, 2011). How an organizational TMS can be developed with the assistance of social network and information technologies? How manage the ability to keep the meta-knowledge directories updated? These two questions that remains unanswered at the organizational level become more crucial at the cluster level. Indeed, clusters are larger than organization and composed by multiple entities which both compete and cooperate.

3 METHOD

This section describes the KMP experience which was conducted in the well-known technology park of Sophia Antipolis (SA) in France (Castells and Hall, 1994). In this project, we applied an integrative design science methodology (Pascal et al, 2013) to create an interactive map of competencies to enhance knowledge creation through partnerships within the Telecom Valley cluster.

3.1 The Knowledge Management Platform Project

Since the mid 1990s, the SA cluster has progressively developed from a computer industry to a telecom and IT industry cluster (Krafft, 2004). As such, Telecom Valley, a non-profit organization, was founded in 1991 by eight leading firms and other organizations in order to facilitate collaboration.

In 2000, the main characteristics of the Telecom Valley (TV) cluster could be summarized as follows (Lazaric et al, 2008). First, firms in this cluster were evolving in a diverse technological context, covering a wide range of industries (e.g. computing, multimedia, space, information processing, on-line services and networking, and microelectronics). Given that most parent companies were located elsewhere, the participants in the cluster had been developing strong external links. The internal dynamics of the cluster arose from the interactions in several communities, associations, clubs, and so forth, but also revealed a huge potential synergy between agents in the cluster that was still largely unexploited.

The lack of internal dynamics was the starting point of the KMP project, launched in 2001 by TV. Because they only have a partial view of the different flows of knowledge developed by the actors of the cluster, members of TV asked a map of competencies to create strong local links with local high-tech SMEs and research institutes. The objective of the KMP project was thus to build an interactive map of competencies which suggests a lack of shared representation of who knows what within the cluster.

3.2 An Integrative Design Science Methodology

Design science research develops knowledge in the service of action and problem solving in organizational settings. To address the research objectives, we thus rely on an integrative design science methodology that connects two perspectives on design: *science-based design* drawing on design propositions grounded in research and *human-centred design* emphasizing an active and systematic participation by users and other stakeholders (for more details on the methodology see Pascal et al, 2013). This methodology is relevant in the case of designing an innovative solution, where there generally is no or limited scientific and practical knowledge that is closely tied to the design goals at hand (Pascal et al, 2013). It is also pertinent because it assumes that technology per se and therefore TMS based on an IT cannot determine work practices and thus incorporates an enlarging network of users at different stages of the design project (Newell et al, 2009; Nevo and Wand, 2005).

This methodology involves six steps. These steps typically need to be taken in many iterations, acknowledging that each step overlaps and is highly intertwined with other steps.

1. *Problem awareness*. Before one can identify any knowledge relevant to address a particular design challenge or assignment, a clear understanding of the nature of this assignment is needed.

2. *Developing design propositions*. The scientific knowledge relevant to the key problem addressed is identified and synthesized into design propositions thanks to the CIMO logic. CIMO involves four components: (1) a problematic *Context*, in terms of the surrounding (external and internal environment) factors and the nature of the human actors influencing behavioural change, (2) which suggests a certain *Intervention* type that managers have at their disposal to influence behaviour, (3) to produce, by way of particular generative *Mechanisms*, the processes that in a certain context generate (4) the intended *Outcomes* (Denyer et al, 2008).

3. *Creating scenarios of use.* Scenarios of use serve to explore the organizational context where work practices are meaningfully accomplished (Pascal and Rouby, 2006) and serve to convert and articulate tacit knowledge of practitioners, and as such, provide input for enriching the design propositions (Plsek et al, 2007). Scenarios of use therefore prevent the IT to interfered with the implicit encoding system of the actors (Ren and

Argote, 2011).

4. *Designing and developing artefacts.* Drawing on input from the (initial set of) scenarios of use and design propositions, design work on artefacts is conducted. Artefacts are the tangible result from the design process and arise from contextualizing and applying design propositions to particular practices.

5. *Experimenting with prototypes*. For any information technology (IT) artefact, the design evaluation process can not be limited to IT performance but has to involve an in-depth study of the (intended) artefact in its business environment (Hevner et al, 2004; Pandza and Thorpe, 2010). As such, the experimentation process exploits the potential role of prototypes, extending the similar role of other artefacts (e.g. drawings) developed and used in earlier stages of the design process.

6. *Organizational transformation.* Finally, the collaborative learning process may progressively change the organizational context (or fail to do so). As a result, the initial managerial problem typically evolves, leading to redesign efforts or an entirely new design cycle. At the same time, these transformational processes modify, and possibly enlarge, the network of users that support and apply the tool (Akrich et al, 2002; Tatnall and Gilding, 1999).

3.3 Main Actors, Data Collection and Analysis

Researchers from different academic fields composed the project team: economics and management, computer science and ergonomics, telecommunication sciences. The number of users engaged in the project has gradually grown from two TV working groups and several pilot users to representatives of all TV' actors. At the end of the project, all other TV members, several clubs and associations in the SA territory, and IT firms located outside SA participated in the project but without a direct involvement as pilot users.

We gathered data from three types of sources: (1) interviews (26 open interviews with key stakeholders, 52 semi-structured interviews with pilot users, and 21 interviews with users as well as other stakeholders to evaluate the prototypes); (2) steering committee and working group meetings; and (3) occasional meetings. Overall, we employed a purposeful sampling strategy (Kumar et al., 1993) towards all key stakeholders of the KMP project. In particular, we drew on an iterative process of simultaneously collecting data, analyzing data, building conjectures (the design propositions) and testing them through action (via artefacts). At the same time, we were seeking new users to embed and integrate the KMP portal in the users' network in and around TV.

Data analysis follows the different design cycles. The first round of data analysis was guided by the central research question on the dynamics of knowledge creation inside a cluster. This initial stage was based on the method of constant comparison (Conrad, 1982; Glaser and Strauss, 1967). In a large number of iterations, data from many informants are compared to identify differences and anomalies and to identify and define major categories, dimensions, themes, or processes (Agar, 1986; Miles and Huberman, 1984; Spardley, 1980). At this stage, five researchers analyzed the data. As such, by examining the congruency of data patterns among informants, we obtained a clear picture of the cluster, its dynamics of innovation, and barriers and difficulties in knowledge sharing and creation.

During the second and the third design cycles, operating logics and practices have been described within scenarios of use. These scenarios of use were used first to build the tool and subsequently to evaluate it. Two types of scenarios of use were analyzed: the process of looking for a partner and the process of co-evolution between the firms and the cluster. The method of constant comparison served to identify differences and anomalies. Specifically, the analysis strategy was the synthetic one (Langley, 1999) and was mainly based on the different categories of the scenarios of use : (1) who was the informant; (2) how the informant describes his/her activities; (3) the information needed for performing these activities; (4) the problem encountered while performing these activities. Two researchers coded each semi-structured interview to develop the scenarios of use. Once developed, the scenarios of use served to ask critical questions and introduce alternative interpretations regarding regularities, contrasts and/or anomalies in the data (Nemeth et al., 2001). The data analyzed in interaction with the literature served to create new design propositions for developing and implementing new functionalities of the portal. These design propositions were evaluated by testing and using the different prototypes. Data obtained from the (evaluation-oriented) semi-structured interviews with users as well as other stakeholders (e.g. associations), steering committee meetings and meetings with potential users were analyzed and synthesized by examining the congruency of data across informants, in order to inform the design team about the usefulness of the portal and potential modifications that would enhance this usefulness in a pragmatic view (Dewey, 1938; Rorty, 1999).

4 RESULTS

Based on the literature review and our first local practices analysis, we rapidly defined a meta-design proposition that ensures the development of the KMP platform: in a multi-actor cluster with a broad scope of technologies (C), an interactive map of competencies (I) will serve to foster knowledge creation through R&D collaboration (O) by reinforcing the four potential mediators of knowledge creation: *opportunity*, *anticipation ability*, *motivation*, and *combinative capability* (M). This proposition does not specify the intervention modalities, in terms of what kind of solution is needed to activate each of the generative mechanisms, and how to develop it. Three new design propositions have thus been developed through three successive design cycles between 2002 and 2006 (see Pascal et al, 2013) aiming at foster TMS in the TV cluster in order to enhance innovation.

4.1 Mapping Competencies: Highlighting "Who Knows What"

Following the first design proposition, we investigate the development of a 'competencies map' in order to create the computerized directories of meta-memories of "who knows what" and thus to foster TMS. We choose to describe competencies instead of knowledge because competencies combine knowledge in action for the output at hand. As such, describing competencies enriches the comprehension of "who knows what" by linking task, expertise and person (Brandon and Hollingshead, 2004).

However, mapping competencies within a cluster raises many challenges. First, it is necessary to identify the appropriate level of competencies description (individual or collective). The second challenge is to describe competencies across the cluster in sufficient detail without disclosing strategic know-how. Finally, using an IT mapping raises the issue of data collection and updating. Combining literature review and local practices, we established the following design proposition.

DP1: In a multi-actor cluster with a broad scope of technologies (C), an interactive map of competencies (I) provides relevant information that enhances *opportunities* (M) for finding the good partner for R&D collaboration (O). To trigger the opportunity mechanism, a competency is defined as an action that mobilizes technical, scientific and managerial resources to produce deliverables that are likely to create value in a business activity.

Given the size of the cluster, we decided to describe collective competencies at the team level which is the appropriate level when looking for a R&D project partner. We defined an abstract model of competencies, based on the four abstract categories: action / resources (including knowledge) / deliverables / business activity (Rouby and Thomas, 2004). These abstract categories are the first codes shared by the community and the first bricks for building shared representations. They constitute the roots of the elaboration of four specific ontologies (action, resources, deliverable and business activity). An ontology is "an object capturing the expressions of intensions and the theory accounting for the aspects of the reality selected for their relevance in the envisage applications scenarios" (Gandon, 2001). The model of competences and its four constitutive ontologies permit to locate the competencies and to compare them depending on the interest and vision of the actor which can choose in its queries its relevant and appropriate combination of categories. Users scenario points different kind of queries: simple queries on, for example, a particular technology (e.g. "which firms are working on J2ME?"), a delivery (e.g. "who has successfully produced video games?") or a business activity (e.g. "which firms are doing work for the 3G mobile sector?") as well as more complex queries which combined several categories such as technology and business activity.

Once competencies are identified and located, an accurate description is suggested including what is the problem solved by the competency (for instance the storage of data on electronic chips), how this problem is solved (the know-how, skills, equipment on the building of chips), and the patents, publications, R&D collaboration, and industrial partnerships involved. These additional details are essential to a proper understanding and to reinforce the credibility of a partner's competencies. This description is not based on formal categories allowing firms to be more or less precise on this strategic aspect and to use natural language in this purpose.

Ontologies used in the KMP project are relevant because:

- A semantic representation of information allows for more precise research and increases the degree of answer liability. Ontologies improve the retrieval of knowledge because they can focus the results on a specific subset and then reduce the set of results (Nevo and Wand, 2005) or conversely to enlarge it if necessary.

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- Ontologies allow to acknowledge different points of view held by spatially distributed and heterogeneous actors. For example, for actors belonging to the commercial professions, 3G (third generation in telecommunication) and multimedia are ontologically equivalent. Conversely, in the technologically oriented professions, 3G and multimedia are quite distinct because they belong to separate technological trajectories. This is the reason why the two terms will be considered distant in the ontology of the technological resources, while they will be very close in the business activity's ontology.

Finally, to face the size and the large scope of technologies characterizing the TV cluster, data collection and updating were highly decentralized and manage by teams composing the different organizations. Each team described its own competencies (between 5 and 10) and added when necessary new concepts in ontologies. Several expert groups first agreed on the basic roots of these ontologies. New concepts were then integrated as competencies' description increases and were regularly validated by expert groups.

4.2 Common Space: Highlighting Similarities and Complementarities

The second major issue in designing the competencies map involved developing a shared identity of the cluster. Members of TV's board raised two problems regarding this lack of identity: (1) "It has always been ambiguous whether Sophia is more telecom or software"; (2) "We never know when we have to accept the entry of a consultancy firm. Generally, the decision depends on the size of the firm. Thus, we lean more on political aspects than on industrial or innovation logics. We are not satisfied by this way of thinking, but we don't know how to do it otherwise".

Regarding the cluster identity issue, the literature reveals that the representation of a common space may help individual to develop a shared meaning of membership and a shared representation of the cognitive interdependences of labour (Kogut, 2000; Dyer and Noboeka, 2000). After several design loops, a design proposition on the cluster's common space representation was therefore stabilised.

DP2: In a multi-actor cluster with a broad scope of technologies (C), building a common space representation of the cluster (I) reinforces the *motivation* of actors and their *ability to anticipate* value created from knowledge exchange and combination (M) to effectively engage in R&D collaboration (O).

This common space has to exhibit the following properties: (a) it represents all actors in terms of their main competencies: scientific and technical competencies (key stakeholders), managerial competencies (support) and relational competencies (facilitators); and (b) it positions the competencies of stakeholders in technological poles (similarity concept) as well as value chains (complementarity concept).

To evaluate the degree of similarity and complementarity, the map of competencies draws on the following definitions: competences are similar when they share the same resources, and complementary when sharing the same business activity.

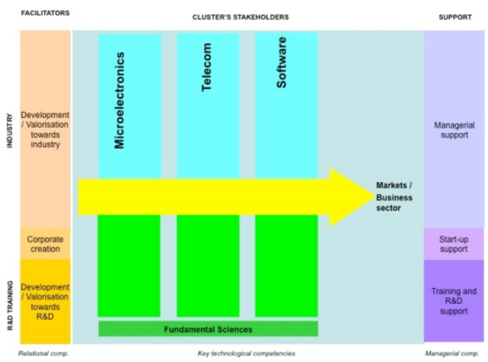

Figure 1: the cluster common space representation.

As figure 1 shows, the common space representation identified three kinds of actors:

1. The stakeholders who participated in knowledge creation in the cluster; that is to say those who had technical competencies such as firms and public research laboratories. The competencies of the stakeholders are positioned on the technological poles depending on the main resources they mobilized. As such, a firm

can be present on different technological poles.

2. The facilitators, including all associations, clubs or service providers, whose goal was to help find partners (relational competencies).
3. Support organizations in the area of law, finance and management that would ensure partnerships by providing managerial competencies.

This representation identifies technological poles with actors who shared similar competencies and value chains which combined complementary competencies. Value chains are business-driven and composed with competencies which shared the same business activity. These competencies are different but complementary by producing interrelated outputs for the same business activity. Value chains are not given, but dynamically built from the particular competencies described by the users in the platform. In addition, the representation allows, through ontologies, to define general overviews on business activity sector (eg the telecom value chain) or precise overviews on market segment (eg the bluetooth or 3G market). It also provides a diagnosis of the weaknesses and strengths of the cluster in terms of the nature and number of competencies in each technological domain for a specific value chain.

The distinction between similar and complementary competencies supports the development of a shared understanding of the cognitive division of labour. It resolves the perceived ambiguity on the cluster identity by showing that the cluster enjoys a lot of software competencies (which contribute to a technological pole) which mainly addressed the telecom market. More generally, the interactive representations of the common space have effects on motivation and ability to anticipate. By increasing the actors' self-consciousness about the competencies distributed in the cluster and their interrelations, it reveals actor's games of interests. For example, firms in the software pole realized that they could gain more in being partners than being fierce competitors and began to develop partnerships about joints solutions, aiming to reach more and bigger customers, within and outside Sophia Antipolis.

Finally, the KMP project showed that the progressive design of the common space representation really mobilized all the TV' actors and consequently motivated them to engage more actively in the project (Pascal et al, 2013).

5 DISCUSSION AND CONCLUSION

This study provides empirical support to the potential benefits of the TMS approach at the cluster level and specifically the ability of an IT to support the development of an effective TMS in a cluster. A TMS cluster exhibits specific characteristics different to those of groups or organizations. It needs appropriate directory structures and shared models to an organizational context including a wide range of actors (and expertises) who both cooperate and compete. In line with Nevo and Wand (2005), our results demonstrate the ability of IT to extend the notion of TMS to large groups including clusters.

Our study suggests that artificial directory of meta-memories can be formalized in order to link different organisations and sub-groups (eg teams) and to facilitate knowledge exchange and combination. It provides specific guidelines to create an artificial directory based on an appropriate formalization of knowledge about who knows what in a cluster. This formalization integrates the three main dimensions highlighted by Nevo and Wand (2005):

- the competency model based on four abstract categories (action / resources / deliverables / business activity) and their ontologies constitute the conceptual dimension of knowledge. It allows to accurately identify and locate the expertise within the cluster.

- this expertise described at the team level is then completed by additional information (eg know-how, skills, equipments, partnerships, patents…) constituting the descriptive dimension.

- these additional details which are more or less precise regarding the firms' communication strategies reinforce the credibility of a team's competence ie the persuasive dimension.

While using a simple model (based on only four categories) enables sharedness, the building of ontologies for each category and the combination of these categories in the encoding and retrieval of competencies allows accuracy. In addition, ontologies allow knowledge to become more specialized or differentiated among members even in context where members in different groups not share concepts to describe the contents of knowledge. The formalization of competencies in the KMP project thus achieved accuracy and sharedness, two dimensions of TMS effectiveness (Brandon and Hollingshead, 2004).

Our project also reveals that building an artificial directory to identify and locate expertise is not sufficient to support an effective TMS. The IT has to create structures that highlight the coordination or combination of distributed expertise. In the KMP project, this structure is based on the common space representation which creates a share cluster identity and a mutual understanding of the division and coordination of labour and expertises in the cluster. This identity and shared understanding constitute motivational factors that affect the development of TMS. Indeed, according to Ren and Argote (2011: 204), "in groups where members identify with the group, they are more likely to invest in developing the specialized division of labour that is defining characteristics of TMS". In addition, identity and mutual understanding affect members' motivation to engage in collective processes of communication and knowledge exchange and combination (Kogut, 2000; Dyer and Nobeoka, 2000). As such, the common space representation supports the interpersonal side of the TMS development.

In sum, an IT that supports TMS at a cluster level must rely on two main characteristics: to combine both accurate descriptions of knowledge at a micro level (team) and macro representations of the cluster knowledge; to favour both interpersonal and technological approaches of TMS.

Several paths for future research can be derived from the work described in this paper. One strand of research might be to study the dynamics of cluster TMS development with attention to how the technical and interpersonal approaches of TMS evolved and enriched each other over time. Other research should focus on clusters with a well-developed identity and architecture in order to analyse the existence of an effective TMS in its four dimensions: accuracy, sharedness and also validation and convergence. Finally, a promising new direction is the inclusion of innovation as an outcome of TMS. Whereas team performance is traditionally the focus of analysis, our study examines the effect of TMS on how knowledge is combined and recombined. Further investigations are needed to analyse the relationship between TMS and innovation at the team, organisational or cluster level.

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