# Building Knowledge Sharing Communities Using Team Expertise Access Maps (TEAM)

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## Abstract

It is difficult for organizations to effectively manage personal knowledge so it can be mobilized, shared, and rewarded to benefit the organization. The difficulties are compounded in large organizations where people with potentially valuable knowledge are unknown to one another and dispersed geographically. Issues that are potentially amenable to management include identification, indexing and codification of the knowledge held in people's heads, and the cultural issues of discovery, mutual trust and sharing at the personal level. A large engineering and project management organization ("EPMO") has prototyped a methodology to graphically codify, index and map staff knowledge using mind mapping technologies. Not only does the methodology provide a graphical structure making it easy for staff to determine who is likely to posses the kind of knowledge they need to find, but interview process is an important facilitator to precondition the knowledge bearers for sharing, and the content of the resulting maps tends to present the knowledge bearers in a more humanized way.

## 1. Introduction

### 1.1 Practical considerations for identifying and mobilizing personal knowledge

Human economic organizations are hierarchically complex systems, where knowledge pertinent to organizational survival may exist in worlds 2 and 3 in a variety of forms. Knowledge in human organizations is held in the minds of people belonging to the organization and in a variety of other forms, ranging from tacit organizational routines belonging to internal communities (Nelson and Winter 1982; Cohendet and Llerena 2001) to physical layout of plant and offices (Nelson and Winter 1982) and corporate documentation (Hall 2003a).

Organizations need to respond fast to deal with issues and solve problems. The rationality of organizational responses are bounded by limited resources and time to identify, access and assemble relevant knowledge. Normally, the best decisions the

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organization can strive for are 'just good enough', or 'satisficing' rather than optimizing (Simon 1955, 1957; Arrow 1974; Else 2004).

Much of what an organization knows can be articulated and documented, but because of time and cost it usually isn't, so its individual members hold a very much of the available knowledge (Lehner and Maier, 2000). People belonging to an organization also have lives and career histories beyond the bounds of organizations they may belong to (Arthur 1994; Arthur & Rousseau 1996), and in general will know a lot the organization (as an entity) doesn't know about, that could be valuable if means existed to identify and make it available or transfer it to the organization (Bhatt 2000; Day 2005). The idea that all organizational knowledge should be (or even could be) "codified" is a mirage.

Personal knowledge may be tacit, in the form of skills and understandings that cannot readily be expressed in words; or implicit, as knowledge the person could articulate and which could be shared if anyone knew to ask for it (Polanyi 1958, 1966; Snowden 2000, 2002; Bartholomaei 2005; Day 2005). However, because the term "tacit" has been used for so many different meanings (Gourlay 2004; Haldin-Herrgard 2004; Tsoukas 2005) we prefer to use the term personal knowledge, after the title of Polanyi's (1996) book. Even where the organization may hold large bodies of explicit knowledge, personal knowledge is still required to access and apply it (Cowan et al. 2000; Tsoukas 2005). It is people belonging to the organization who know:

- *what* knowledge is needed
- *who* may know the answer
- *where* the explicit knowledge may be found
- *why* the knowledge is important or why it was created
- *when* the knowledge was last needed or may be needed in the future
- *how* to apply the knowledge

An organization seeking to improve its performance needs to ensure (1) people in the organization who need particular knowledge to deal with an emerging issue can quickly identify and find those who may have the kind and quality of knowledge sought, and (2) that this knowledge will be readily transferred from those who have it to those who need it. How does an organization make personal knowledge more accessible?

## 1.2 Cartographic approaches

Skills databases, expertise locators and corporate "yellow pages" address some aspects of this need, but can be difficult to implement and maintain because of privacy concerns and legislation, or because some people are unwilling to serve as a reference service (Barnard and Rothe 2003). Also, such databases often only collect standard data about people, such as can be drawn from resumes and CVs (Ackerman and Halverson 2004; Becks et al. 2003). Such databases don't do a good job of 'personalizing' the contact information in a way that will help to facilitate the kind of interpersonal contact required to qualify and effectively use personal expertise after it has been found. The process to collect information for the database also does little to 'socialize' the contacts to condition them to provide help when requested. In other words, such yellow page databases are literally too 'impersonal'. In general, social networks are much better than databases for transferring knowledge (Newell et al. 2004).

Earl (2001) and Blackman and Henderson (2005) would classify yellow pages and expertise locators as "cartographic systems" in that they point to where knowledge may be held rather than serve up the knowledge themselves. To us, cartography implies the powerful image of drawing a graphical "knowledge map" to where the knowledge is held (Eppler 2001). However, in the literature even this term knowledge mapping is used loosely for a variety of techniques, including matrices (e.g., Speel et al. 1999) concept maps (Cañas et al. 2004, Coffey et al. 2002, Dumestre 2004, Epler 2001, etc.) and mind maps (Buzan 2004). Concept maps primarily focus on the logical development of empirical ontologies rather than providing a practical means to locate knowledge. On the other hand, "mind mapping", which we use in the study, provides a methodology for logically identifying and navigating to specific blocks of knowledge.

### 1.3 Community of practice approaches

Another way to connect people who have particular kinds of knowledge with those who need that knowledge is to establish communities of practice (CoPs).

Wenger (Undated) defined communities of practice as follows:

> Communities of practice are formed by people who engage in ... collective learning in a shared domain of human endeavor.... In a nutshell: Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.

A community of practice (CoP) supports individuals having related knowledge needs, where unifying causes or actions favor interactions of the individuals. Current KM literature identifies CoPs as fundamental aspects of complex human organizations that can emerge naturally, but that benefit nurture and sustainment. As discussed below, where a community becomes self-sustaining, it may be deemed as a self-defining or autopoietic entity in its own right according to Maturana and Varela (1980; Hall 2005).

### 1.4 The case study organization, EPMO

The organization studied is an engineering project management organization (EPMO) that manages large, complex and long-lived projects. Its major organizational imperatives are to qualify and win more contracts (increasing revenue), perform better on contracts won (improve ROI), continue to satisfy customers, manage and mitigate risks, comply with regulations, respond to community and environmental standards, and to increase shareholder value. All these imperatives must be achieved within a fiercely competitive environment. EPMO has grown over the past decade and a half from a company centered on a single large project, to a large and diverse organization with multiple business units, some with multiple divisions, where the largest division is itself distributed across several time zones.

Fluctuating employment in the engineering project management industry makes it difficult to build and retain skills within any single division - an issue that is exacerbated by a growing shortage of engineering skills. Without knowledge networks to help retain relevant skills and project know-how, competing successfully becomes increasingly difficult. Work groups often lack time and resources to adequately transfer past and current personal knowledge within and between various project functions. Successful sharing of personal knowledge requires an ability to navigate and exchange through complex and diverse communication networks that are both implicit and explicit (Choo 1998; Nousala et al. submitted 2005). Corporate history, geography and

attitudes of many line managers create many barriers and disconnects to impede the transfer and sharing of knowledge across organizational silos.

Optimizing the use of knowledge in EPMO is clearly imperative for future project and product development. However, given that project oriented engineering organizations are inevitably heavily regulated and hierarchical, it is difficult for knowledge networks to gain horizontal traction across different project teams, divisions or business units (Nousala and Terziovski pending). This study focuses on possible ways to achieve better use of the personal skills and knowledge of its staff.

### 1.5 Background for the case study

The present study, including experience with both mind mapping and CoP facilitation, began in a practical industrial need to share personal knowledge. It became connected to the theory described above only as the study progressed.

As a major EPMO division began to shed staff as it neared completion of a long-term engineering project, a need was recognized to identify at least some of the personal knowledge before it was lost. In early 2004 Hall and Kilpatrick (unpublished) conducted an R&D pilot project to test the feasibility of mind mapping for identifying and describing personal knowledge. Two people were interviewed, but due to line managers' perceptions of immediate priorities to maximize profit on a day-to-day basis, budget and permission to involve staff could not be obtained to continue the work - a barrier that may be typical in companies with distributed profit centers (Mønsted 1999).

In parallel with the mind mapping work, Hall and outside consultants employed by EPMO attempted to establish a small number of cross-divisional communities of practice, with some failures and some limited successes.

In 2005 Nousala, a professional community of practice facilitator also studying for her PhD, joined the organization as a "Knowledge Management Intern" and helped conduct several more mind mapping interviews out of hours. Nousala studied the results of the mind mapping interviews and the attempts to establish communities of practice against the background of her professional experience with other distributed organizations within the theoretical framework of organizational epistemology we are developing.

The research presented here is a work that is still in progress. What began as pragmatic R&D to facilitate knowledge sharing within the organization has also raised a number of theoretical issues and questions relating to a theoretical framework of organizational knowledge we are also developing that deserve much deeper consideration than we will be able to give at this point. However, connections between practice and theory need some discussion. Thus, the present paper includes two threads, (1) developing a practical methodology based on this understanding that can be used to facilitate knowledge sharing in the organization, and (2) gaining a better understanding of the theory of organizational knowledge.

## 2. Theoretical framework - Evolutionary Epistemology and Autopoiesis

This paper describes aspects of a work in progress to develop a new way of understanding organizations and the roles and growth of knowledge within

organizations. This involves both the development of theory and practical applications of that theory. The theoretical basis fuses Karl Popper's (1972) evolutionary epistemology with a theory of complex self-maintaining systems deriving from Maturana and Varela's (1980, 1987) concept of autopoiesis. As will be discussed in other papers, this theory has some resemblance to Tsoukas's (2005) understanding of the firm as a distributed knowledge system.

Popper grounded his evolutionary epistemology (1972, 1994) in a metaphysical ontology of three "worlds" or domains: World 1 ("W1") is external reality or everything that exists. World 2 ("W2") is the domain of cognition and embodied or "dispositional" knowledge. Polanyi's (1958, 1966) personal and tacit knowledge are encompassed within W2 (Hall 2005). World 3 (W3) is where explicit or "objective" knowledge such as the logical contents of books and computer memories or other persistent products of cognition is found (Popper 1972:115; Niiniluoto 1999). Comparable to radical constructivists (von Glaserfeld 1993, 1997, 2001; Riegler 2001), Popper (1972) argues that claims to knowledge are constructed products of life that can never be proven to truly reflect reality. However, Popper differs from the constructivist stance, in that the verisimilitude (truthlikeness) and utility of claims to know can over time better represent reality by iterating cycles of hypothesis, testing and eliminating errors (Popper 1972; Niiniluoto 1999; McKelvey 1999, 1999a). Hall (2003, In Press) notes that Boyd's (1996) Observe, Orient, Decide, Act (OODA) loop describes how the evolutionary theory of knowledge growth can be applied in practice. Boyd also argued that individuals or organizations able to complete OODA cycles faster than competitors could win competitions by observing and changing the competitive landscape before competitors could react to it - thus ensuring competitors' actions were no longer appropriate to the existing landscape.

The biological theory of organizational knowledge (Hall 2003, 2005; Hall et al. in press) combines Popper's evolutionary epistemology with the concept of autopoiesis (Maturana and Varela 1980, 1987; Lyon 2004), as first applied to knowledge management by von Krogh and Roos (1995) and Magalhaes (1996, 1999). Lyon (2004), following Maturana and Varela, argues that cognition and thus knowledge are fundamental properties of autopoietic life. Hall also argues that "knowing" and various forms of knowledge are fundamental in the emergence (Goldstein 1999) and evolution of autopoiesis at *any* level of organization, whether single cells, multicellular organisms or human organizations. Autopoietic organizations have emergent properties beyond any summation of the properties and capabilities of the individual human members of the organization. To survive in competitive environments, organizations must assemble, deploy, preserve and replicate knowledge in response to environmental demands. Knowledge in the organizational context is that which has survival value, e.g., Nelson and Winter's (1982, 2002) concept that organizations have "hereditary" knowledge in their own rights, comprising competence, learning and routines.

To date, most research and practice working with this biological view of organizational knowledge has looked at objective (i.e., explicit), infrastructural (Hall 2003a) and procedural (Dalmaris et al. in press) aspects of knowledge management. The present paper begins to apply and test the Popperian autopoietic epistemology of organizational knowledge on the roles and management of personal knowledge within the autopoietic organization.

Two terms are used throughout this work in ways that may be confusing.

"Ontology" is used here with two different meanings: (1) "*metaphysical ontology*", referring to the basic categories of existence, as in Karl Popper's (1972) division of existence into three "worlds"; and (2) *systems* or "*empirical ontology*", that attempts to provide a rigorous conceptual schema for a domain, such as that relating to a system (Lyon 2004). If the usage of the term is not clear from the context, the appropriate modifier will be applied.

"Knowledge" is a slippery term in the context of organizational knowledge (e.g., Bhatt 2000; Stenmark 2001; Tsoukas 2005). Particularly problematic is the relationship between the terms "information" and "knowledge". In this work, our usage follows Karl Popper's (1972) use of knowledge as a generic term for the product(s) of cognition, in whatever form (e.g., "tacit" or explicit).

# 3. Methodology

## 3.1 Methodology in relation to the theoretical framework

The theory framework provides the epistemology for constructing a strategy to address EPMO's needs to manage personal knowledge. The framework makes it easier to understand barriers to knowledge sharing within highly structured project engineering environments (Nousala et al. submitted). An empirical ontology developed in the present study defines knowledge-related processes in the organization, and helps to determine what is required for the emergence and sustenance of horizontal (i.e., cross-project and cross-divisional) networks for exchanging knowledge (Goldstein 1999: p. 50) Nousala et al. submitted). The following major steps were followed. Identify key questions/issues and plan the study, develop models and theories, test them in the case study situation.

### 3.1.1 Key questions and issues

Key issues and related questions pertinent to the study are:

1. What kind of knowledge exists in the organization, either in people's minds or as explicit documents?
2. What knowledge do people need to effectively complete their work?
3. What can be done to help connect their needs to what exists?
4. Where solutions to access knowledge can be offered, what can be done to support and sustain these solutions?
5. Considering that CoPs are popular solutions for the need to provide horizontal connections in distributed organizations, what can be done to support their emergence , (Goldstein 1999, p. 50) and sustain them?

Generally, the KM literature discusses knowledge exchanges in terms of tacit and explicit knowledge (Nonaka and Takeuchi 1995, p224; Polyani 1958). This does not adequately explain the emergence, support or sustenance of knowledge in a hierarchical organization like EPMO (Hall 2005; Tsoukas 2005). The theory of complex, hierarchical autopoietic systems (Salthe, 1985; Hall et al. In Press) provides a better framework for understanding the emergence and nature of CoPs, possibly as

autopoietic systems in their own rights, at an intermediate focal level of complexity between people and the complex organization as a whole (**Figure 1**). Treating CoPs as entities on the borderline of autopoiesis helps us to determine factors contributing to their emergence and sustainment or disintegration over time.

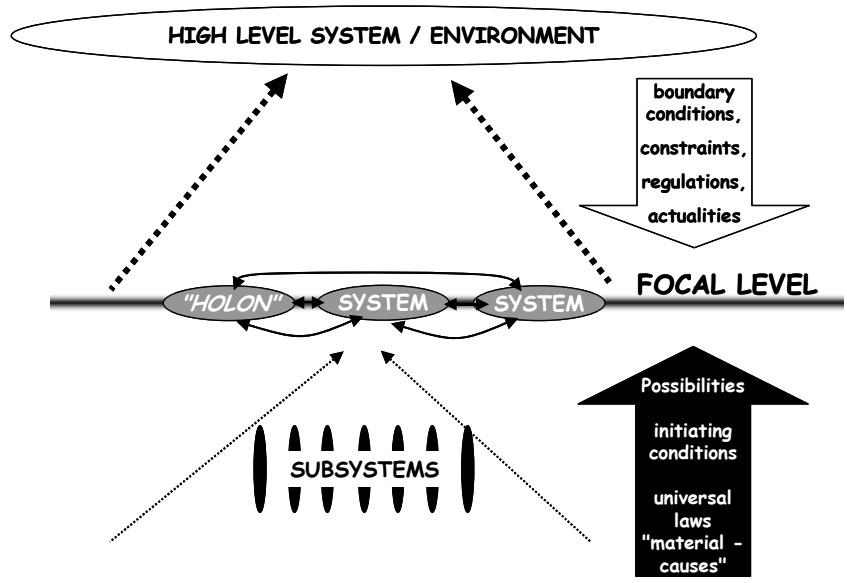


**Figure 1**. The systems triad in hierarchy of complex dynamic systems (Hall et al. In Press) after Salthe 1985).

3.1.2 Model and theory development

This section describes the historical development of the model of CoP emergence (Goldstein 1999) and sustainment used in this paper.

Nousala began her thesis research with the idea that knowledge was socialized in CoPs via an iterated cycling of knowledge from explicit to tacit, to explicit again, etc, as expressed in Nonaka and Takeuchi's (1995) SECI loop (see also Bhatt 2000). To her, this resembled the iteration of Popper's tetradic schema (1972, pp. 164, 243) and (1994, p. 55) for building knowledge (i.e., learning):

$$\mathbf{P_1 \rightarrow TT \rightarrow EE \rightarrow P_2}$$

where $\mathbf{P_1}$ is a problem situation, **TT** refers to a tentative theory to solve it, **EE** refers to a process of criticism for eliminating errors and $\mathbf{P_2}$ is the somewhat changed problem situation remaining after the relatively successful surviving theories have been applied. Popper (1994, p. 55) calls this

> a schema of the formation of theories: we start with problems, we put out tentative theories, then comes a process of critical effort elimination or criticism, and then the new problem arises… I assert that all organisms are all the time problem-solving… TTs the tentative trials, are very different at the different [hierarchical] levels. The individual itself constantly puts forth trials which it corrects by error elimination – not just human beings, but amoebae or bacteria…these trials are behavioral trials.

The evolution and refinement of problem solutions depends on continuing iteration between theorizing and error elimination, which in turn depends on exchanges between "dispositional" or tacit knowledge in W2 and articulated or objective knowledge in W3, as attempts are made in W2 to represent and interact with W1. Figure 2 and Figure 3

are stages in Nousala's extension of Popper's diagram (1994, p7) showing the emergent and fundamentally cyclical behavior of knowledge exchanges. Figure 4, emphasizes the cyclic aspect, formed the basis of the full model and elements, showing the CoP position, initiating points and interactive behaviors of tacit knowledge structure.

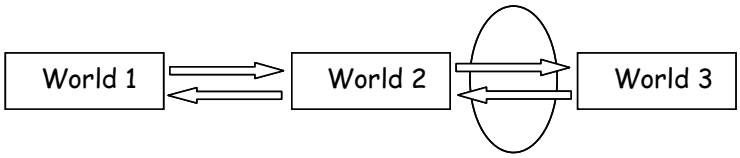


Figure 2. Modification of Popper's three worlds diagram to show cyclical movements, The circle emphasizes cyclic exchanges between world 2 and world 3 as world to attempts to represent and interact with world 1. (Compare with Hall 2003 Fig 1).

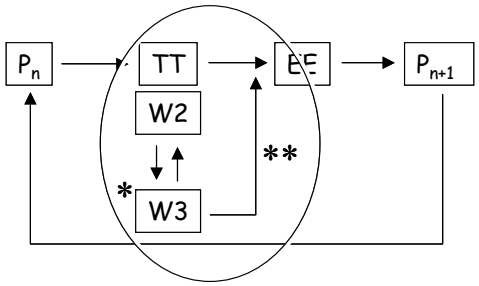


Figure 3. Modification of Popper's combined tetradic schema and three worlds diagram to show the beginnings of the cyclical nature of tacit knowledge exchange. * The tentative solution is objectified as a tentative theory in W3. ** The articulated tentative theory in W3 is subjected to critical analysis to eliminate errors. The circle emphasizes the area expanded in Figure 4 and discussed below.

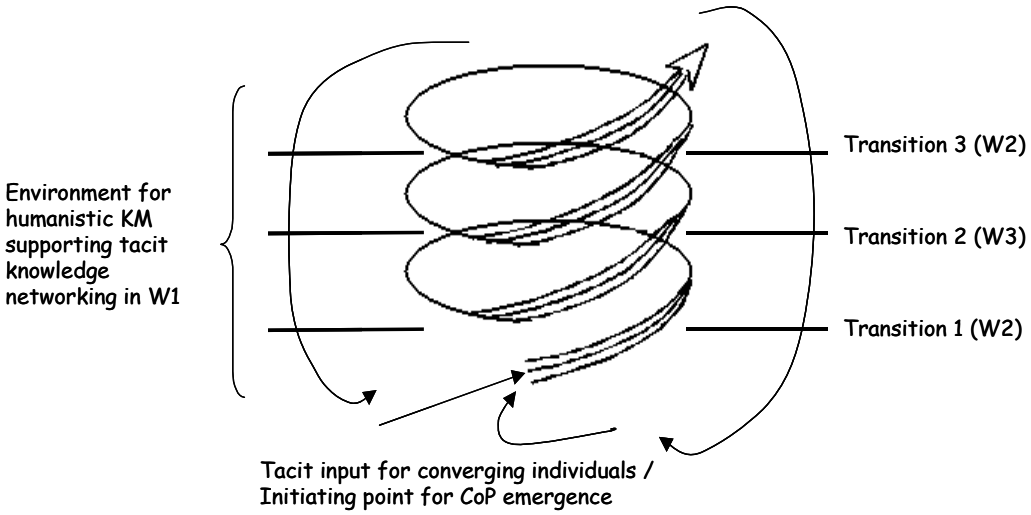


Figure 4. Nousala's spiral transition exchange model. Processes within the emerging CoP cyclically transform knowledge between tacit forms in W2 and explicit forms in W3. The vertical dimension shows time and practice = evolving to the next level of knowledge. Transition 1 = forming initiating points for tacit knowledge exchange (TKE). Transition 2 = TKE evolving to the next level. Transition 3 = reaching a problem solution for the cycle, with adjustments to constraints, with continuing iteration of the process. This CoP, as an entity, may join other CoPs to build larger knowledge networks either within the boundaries of the parent organization or crossing the boundaries of several organizations having similar knowledge needs. As Popper (1972) notes, the cycles are not exactly repeatable, as incremental additions of tested knowledge change the perceived problem states from one iteration of the cycle to the next.

"Time and practice" is required between each transition. Time is needed for the community to actually articulate and put its knowledge into practice (i.e., to test it). Each of the transition levels 1, 2 and 3 represent a tacit exchange or evolutionary increment through time in the quality of knowledge available to the CoP.

Transitions involve behavioral exchanges between individuals within a CoP and between the CoP abd the surrounding organization. These exchanges involve individual behaviors similar to those described by Nonaka and Takeuchi (1995; Garcia Muiña et al. 2002) in the SECI process. However, the sequence of transitions from levels 1 to 3, including the requirement for time and practice, correspond to the cycle of exchanges between Popper's worlds 2 and 3.

Managing human knowledge depends on dispositional or "routinized" aspects of organizational structure that either impede or facilitate knowledge exchanges across boundaries (Nelson and Winter 1982, 2002). The success of such management depends on continuing adjustments to culture, strategies, structure and environments (Nousala 2003; Nousala and John 2004).

Hall (2005) states that

> World 2 is the emergent body of knowledge represented in the dynamic structure of the autopoietic system as a consequences of its history of variation and survival (natural selection). Popper talks about "dispositions" of "subjects" (knowing entities). Personal knowledge in the form of instincts, talents, predispositions, etc. all qualify as dispositional knowledge. This is the only kind of knowledge possessed by primitive/recently emerged autopoietic systems.

Note that this dispositional knowledge at the level of the emergent community is not the same as the personal knowledge held by individual people forming the community.

The model in Figure 4 can be interpreted as an emerging community or potentially autopoietic component within the environment formed by the organization as a whole (for a CoP within an organization) or a potentially independent community entity within the larger multi-organizational environment.

Within hierarchy theory (Salthe 1985), in a scalar ("nested") hierarchy, the concept of triad defines three levels in the hierarchy relating to a selected focus:

1. the level of focus that contains a system of particular interest (a "holon");
2. the level of the hierarchy next above the focal level that contains a "supersystem" or the environment that contains the holon and other systems at the focal level; and
3. the level of the hierarchy next below the focal level that contains the subsystems and other components that collectively form the holon.

Figure 5 places Nousala's spiral transition exchange model in the complex systems hierarchy of an autopoietic organization. The dynamic activities of entities at the focal level within the triad are enabled by laws governing interactions of subsystems and constrained by conditions imposed by the supersystem (Salthe 1993; Hall et al., submitted). Subsystems comprising the holon (i.e., below the focal layer) determine what is possible for the system to do via initiating conditions and universal laws governing the interactions of subsystem components. The "environment" or super-system containing the holon as a component establishes situational boundary conditions

to shape and constrain or regulate the holon to determine its emergence and development through history.

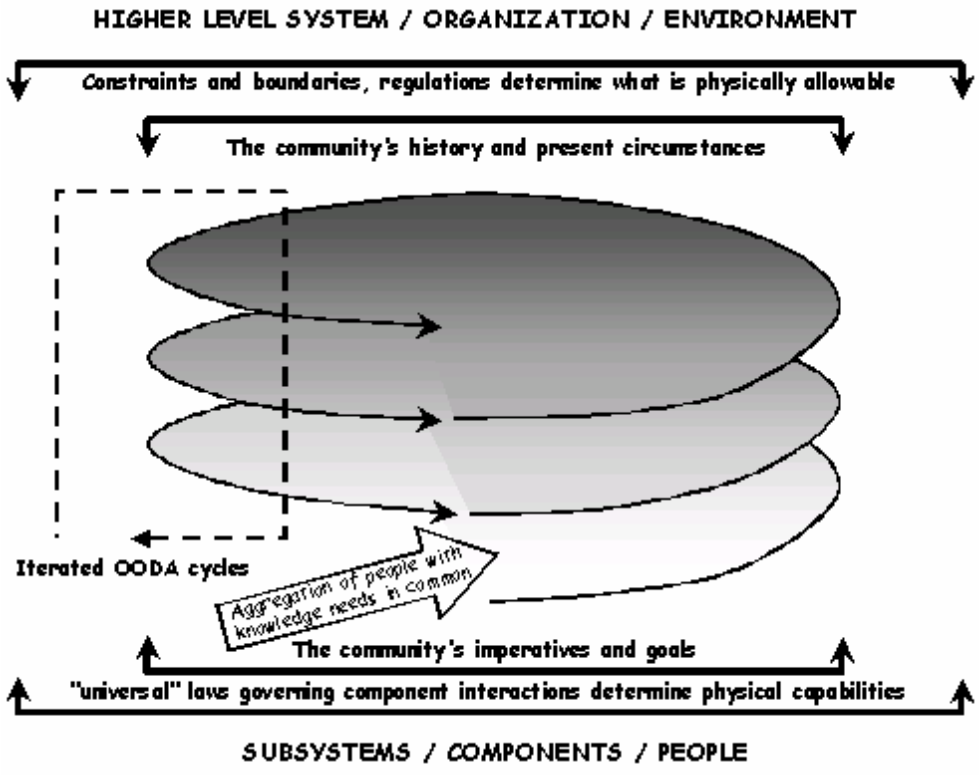


Figure 5. Emergence of an autopoietic community of practice.

Clarification of a CoP's position and significance within the tacit knowledge network can be understood through tracing emergence of the different attributes that collectively provide the properties of autopoiesis. From Hall (2005 p. 184):

> Still more interesting will be to explore the boundaries of the autopoietically learning organization. Most enterprises are founded by individual entrepreneurs, or as entrepreneurial partnerships or family concerns. They initially represent the economic activities of a single person, or small group and are managed as autocracies. However, if the business grows, at some point it begins to take on a life of its own. What happens in such transitions to cause the emergence of life? Answers here will provide some interesting feedback into studies on the origins of biological life, the possibilities for artificial life and forms of life not based on macromolecules with carbon background.

CoPs may offer an even more appropriate system framework in which to study the initial emergence of autopoietic systems.

Nousala's prior studies identified different types of communities involved in knowledge exchanges:

- *Community of Interest* (CoI) - Defined based on prior references, these are loose aggregations of people forming general communities or working groups around a common interest, which may also be linked to form more mature and sustainable (CoPs Nousala 2003; Nousala and John 2004). CoIs are formed of individuals that come together to share knowledge regarding common interests but have not as yet formed a practitioner group or community such as the CoP.

- *Expert Community of Interest* (ECoI) - that are groups of people with quite specific interests within the project environment (Nousala, in preparation)
- *Community of Practice* (CoP) - groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly (Wenger Undated). CoIs are transformed in to CoPs as they become more formalized,

Such communities often coalesce around particular individuals that Nousala (in preparation) defines as *human attractors*, who are charismatic or whose interests establish connections and a focus amongst a variety of other individuals sharing those interests in common. This research focuses on tacit knowledge networking (TKN) which is a network through which individuals within the CoI or CoP develop tacit knowledge for the purpose of sharing and exchange. This study considers and reflects the initiation point of CoPs of which COI or eCOI are crucial, as in the example of Seely Brown and Duguid (2000, p76) give in regards to the experience of Hewlett-Packard CEO Lew Platt, "it needs to take practice, practitioners, and the communities that practitioners form seriously. That requires two steps. First, managers need to learn what local knowledge exists. Then, if the knowledge looks valuable, they need to put it into wider circulation" - Nousala 2003).

The mapping of knowledge structures or flows can offer a great deal more understanding as to how individuals carry out processes and what type of data and information they need and use in a particular circumstances (Nousala et al. submitted) such as the transfer of competency from old timers to newcomers (Koskinen & Pihlanto 1999). When basic data and information are integrated into an empirical ontology recognizing knowledge networks and flows, this allows for greater understanding of how horizontal connections can develop within the organization without breaking down or altering the hierarchical structures that necessary exist within a project oriented engineering organization (Hall et al. Submitted, Nousala et al. Submitted).

### 3.2 Methodology

The research we are doing here is novel and interdisciplinary. For such research, "[t]here is no standard or uniform approach to qualitative analysis." (Ticehurst and Veal, 2000 p. 96). Our research combines methodologies of qualitative and quantitative approaches. The qualitative aspect refers to the ethnological approach to the data collection from the organisation:

1. The organization is approached with a view to observe and to record the experiences of individuals for the research
2. Action research is applied within the ethnographic approach (Ticehurst & Veal 2000),
3. In-depth interviews using a knowledge mapping tool to collect individual details.

We looked for emergent organizational phenomena, classified under complexity theory, as a way to analyze various observations for commonalities that would help identify any interactive behaviors.

Plan of the study;

1. Observe and describe instances or phenomena; using a phenomenological paradigm, combining action and ethnographic approaches.
2. Analyze the sustainability of emergent CoPs based on autopoiesis theory, within an evolutionary epistemology.

Areas of focus:

1. Why are CoPs important?
2. An understanding of CoPs is needed to develop an understanding of the research question.
3. The research in this paper began with recognizing human attractors who existed within the organization. Many belong to and help to identify the existence of ECoIs. These people also initiate links to CoIs.
4. This study focuses on the various dynamics and tensions that allow investigation into the development of new competencies of assessing the values of CoPs. This would support an increased understanding of the practical application and implementation of tacit knowledge networking with in communities and organizations.
5. Examination of any emergent elements required to create, sustain and develop these COPs.
6. Exploration of tacit knowledge networks of CoP with a focus on identifying common emergent descriptors or elements which had emerged from the literature and was useful as an initial point from which to design a model.

## 3.3 Implementing mind mapping

### 3.3.1 Background

The methodology used here was based on an unpublished feasibility study conducted in-house by Hall and Kilpatrick in 2004 with two respondents. Responses from this feasibility study were useful and the outcomes were positive. However, at the time, the work could not be extended to a larger scale because managers in the division concerned were totally focused on completing a large project and thought any KM initiatives would distract staff from production work at hand.

### 3.3.2 Method

We sought interviewees who we believed served as key human attractors possible identifiers or instigators of ECoI, CoI and/or CoPs in the organization and who were willing to share their experience. Our approach to selecting interviewees was important to help us gain peer acceptance within their particular ECoI, CoI, CoP or working group. A series of semi-structured interviews were conducted, guided by a familiar mind mapping tool, MindManager[2] that has been used for a wide variety of purposes in the organization. The semi-structured interviews closely followed those used in the prior feasibility study (see Appendix 1).

The most time consuming stages were information collection and final conversion into a comprehensive knowledge network capability in an electronic format, with a specific

[2] The mind mapping tool used was MindManager - http://www.mindjet.com/us/

user-friendly interface. The ease of conversion between MindManager and other digital tools was important, as this allowed all information to be managed electronically from the initial transcription. Even though analysis was required to fully understand the knowledge networks, transcribing the interviews into the mind mapping tool facilitated early access to individual experiences and processing for access and retrieval.

### 3.3.2 The Interview Process

The core aim of the entire interview process was not just to record the obvious kinds of personal data, but also to identify career knowledge brought to the company and gained on the job by the interviewee. This career knowledge included highlights before and after joining the company, "war stories", lessons learned, relational networks they had built, and types of knowledge tools they used. The primary aim was not to transform personal to explicit knowledge, but to identify and humanize the personal knowledge into an approachable resource that might later contribute to the organizational knowledge network. The interview process also preconditioned respondents to see and feel the value of sharing what they know with those interested or needing to know it. Several key factors contributed to a successful interview, the main ones being ethics, the process and the preparation.

- Preparing the respondent for the interview was very important. This preparation gave the respondent the opportunity to be a part of the process and to take responsibility for their part. The preparation typically involved initial discussion, making the appointment, distribution of methodology paper and map of the leading questions we would be asking and clarifying any queries or concerns.
- The preparation also introduced the ethics of process that created a platform for a good participatory engagement. A sample interview structure (as an MS Word document is attached as an Appendix).
- Interviews were normally conducted by two interviewers.
    - An "old hand" who knows the general history and significant issues of the organization. By following the format and guidance offered by the Mind Map the old hand could ask supplemental questions which highlighted critical areas of knowledge for the individual in relation to the organization as well as previous relevant experience.
    - A "naive student" who needs to understand the stories and explanations (i.e., to request translation of jargon that would be unfamiliar to company inductees and to retain focus on the big picture vs in-house minutiae) performed a vital role of clarification and more importantly provided a point of reflection for the interviewees.

  The interaction of the old hand/naive student roles is crucial, as this provided interviewees with opportunities to reflect on and clarify significant life experiences. The interview process is based on discovering the interviewee's significant experiences that support their specific lessons learnt. (Some of these experiences have been significant enough for the individual to have been retained - in some cases for more than 30 years - and recalled for the process of sharing).

### 3.3.3 Recording and Transcription

Analyses of individual transcripts focus on the respondents' careers. These are broken down into categories of knowledge in their career contexts. The mind mapping tool

assisted the respondent through the process by retaining the focus of their experiences as to who knew who, what, where, when, why and how.

The analysis of the results is based on a specific ontology developed from an initial study of the transcripts to capture the various experiences in context. The ontological structure also provides the basis to construct a corporate roadmap leading from categories of knowledge to the individuals who have it.

### 3.4 Observing community formation

Most observations of community formation and sustenance providing a background for this paper are based on Nousala's prior experience (Nousala, 2003, in preparation; Nousala and John 2004; Nousala et al., Submitted). However, additional information is provided by the established records in EPMO's KM portal system of fully supported and viable engineering and project management "councils", semi-successful experience organizing a CoPs around technical writing issues and specifications development, and by the recorded experience of a failed community in the area of quality assurance. Some interviewees participated in one or more of these communities.

## 4. Results

### 4.1 Interview maps

Interview durations depended entirely on the interviewee and their responsiveness - averaging around two hours. The mind map process provided a comfortable method to help the interviewee focus on essential issues and helped them structure their responses. Types of material solicited included "nuggets of gold", where they found knowledge and how they transferred it, learning experiences and the like (see Appendix). The interview process also had an initially unanticipated outcome - social facilitation. Several interviewees commented to us "Why hasn't anyone asked us this stuff before now?" And a few even offered that the process was one of the more enjoyable things they had done for a while.

### 4.2 Analysis

Human attractors in ECoI, CoI and CoPs are key individuals within the dynamics of a complex organization. Working outward from them we can begin to track, record and develop knowledge flows for implicit/explicit knowledge network structures and perhaps understand how these communities emerge and are sustained.

#### 3.4.1 TEAM transcripts

Transcripts were analyzed to identify and understand emergent local sensitivities, circumstances, potential blockages, etc. relating to knowledge sharing and networks from the respondents' experiences. The initial aim was achieved with the help of an initial ECoI relating to engineering knowledge management within the EPMO, which broadened over the months, and through which other key people were identified. Most respondents had some form of involvement with this ECoI.

The "formal" interviews using the mind mapping process established a clear protocol for a type of continuing informality that facilitated additional deep sharing of individual personal knowledge and experiences outside the interview process. Transcribing the first interviews to mind maps also helped build further spontaneous networks. The success of the facilitation was demonstrated through invitations for TEAM project people to join additional formal and informal meetings within the EPMO organization.

Mind mapping requires the analyst to trace the respondents' experiences as they occurred in relationship to overall job roles as described. Two threads were identified for tracking:

- *Key experiences*: The analysis requires key experiences to be identified as described by the individual or interviewee. These key experiences are important enough to the individual to be remembered and shared. These key experiences are then subsequently “followed” in context by the analyst, using the mind maps.
- *Contextual threads*: Contextual threads help to define relationships of key experiences to other aspects of the work, and potential clusters of key knowledge objects.

This is where the link between experiential and contextual threads provides the basis for developing an empirical ontology, using the individual’s highlighted experiences as the key “knowledge objects”. The ontology can then be structured to identify different elements of experience, depending on the access requirements to be determined at a later date, such as historic or current/continuing.

### 3.4.2 Deriving an empirical ontology from analysis

To build an ontology, the transcribed histories of the individual interviewees must be broken down into "contextual points", which then form the ontological structure. The contextual points in turn identify "information clusters". These information clusters are sentences or paragraphs that “belong together" or are held together by a theme based on the epistemology of the initial theoretical framework. The ontological structure imposed on the interview results (Figure 6) then determines what is possible to access and ultimately retrieve from an electronically organized database of the transcripts.

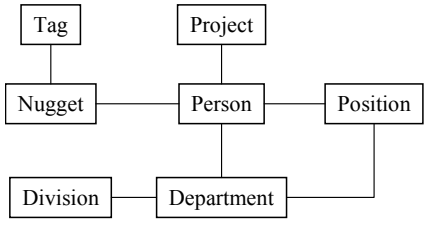


Figure 6. High level ontology for the TEAM database.

### 3.4.3 Defining human attribute ontology for a relational database search capability

The ontology should include both experiential and personal attributes (i.e., metadata) for knowledge containers. Personal attributes are based on both historical and present experiences.

The following is an example of defining human attributes for the ontological construction from contextual points. These contextual points are the "knowledge containers" to which the attributes are linked

- Knowledge sharing (difficulties and solutions)
- Physical organization and people structures
- Creating organizational models

Figure 7 presents the detailed ontology for the TEAM database, displaying the various attributes identified to this point.

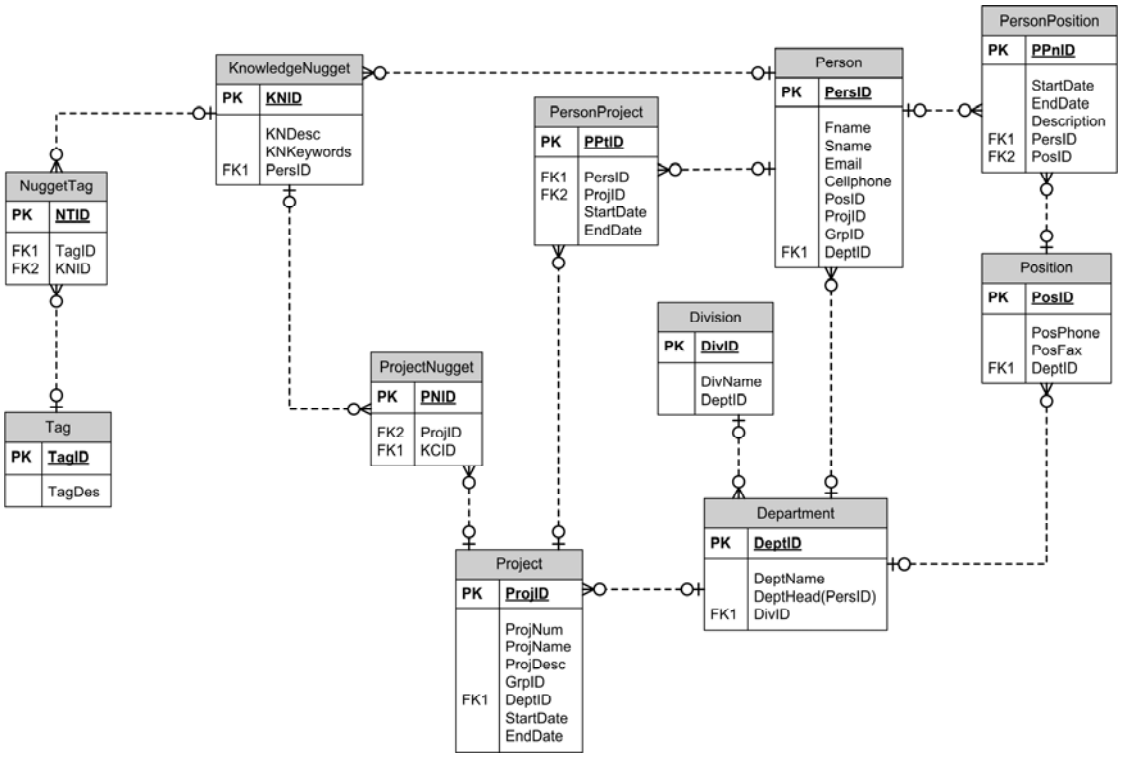


Figure 7. Detailed ontology with personal attributes and history (position, organization, project, length of time, project connections to other projects and people).

3.4.4 Prototyping a graphical user interface.

Miles used the Crossbow data aggregation and interrogation engine (Sykes & Hall 2003)[3] to prototype a graphical user interface for navigating the personal data and experiences as extracted from the TEAM relational database. The following graphics (Figure 8 to Figure 13) show how relationships extracted from the narratives can be navigated.

Where the focus during the information gathering stage was on the person whose knowledge was being recorded, in designing the application the focus had to shift to the users, the other members of the organization who are looking for either someone else's knowledge to assist them, or for someone else with the same opinion in order to develop a collaborative approach.

[3] See also http://www.tenix.com/Main.asp?ID=934.

Understanding the natures of "persons" and "knowledge nuggets" is key to this system. These are the references to "nuggets of gold" or crucial knowledge objects held by people that are identified in reviewing and analyzing transcripts of the TEAM interviews.

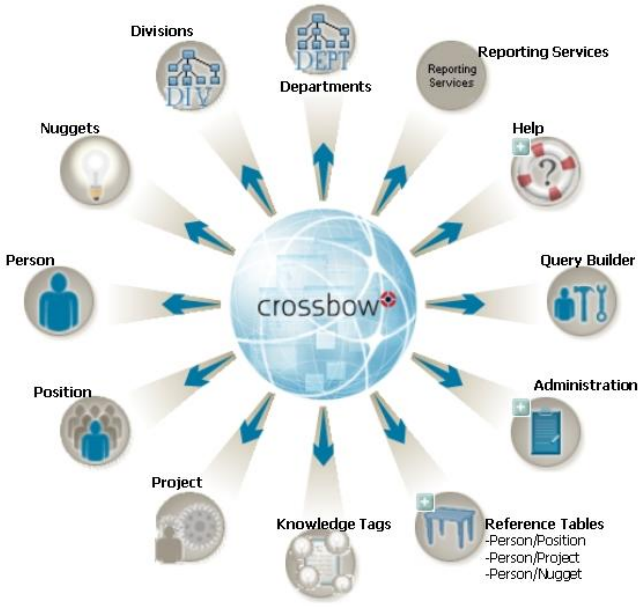


Figure 8. Icons used in Crossbow's star browser as implemented for the TEAM database

Of particular note in the following diagrams is the ability of the user to flow easily from a focus on one entity through other entities to a final focus quite different from the starting point. In most database system the focus is to find an instance or group of instances that match the search criteria, and while the TEAM database starts with this approach, its focus, as supported by Crossbow, is on the *relationships* between instances of entities.

As shown, the user can travel in a seamless thread from a knowledge nugget, through a person to their history. What is not shown due to space constraints is that the user could then move through a history item into a project, and from there into a department, or a person, or indeed back into other knowledge instances, this time focusing on the knowledge gained in that project instead of just the knowledge matching their original search. In a 'traditional' database application, the user would have to make repeated searches of the database of the database to follow the same approach, each time recording the details of the next search they wish to conduct.

Simply put, the TEAM database, as implemented using Crossbow, allows the user to follow their own train of thought through the information space to satisfy their needs, whereas traditional database tools only allow the user to make repeated attempts at defining a single view of this information space until their view finally includes the information they need.

This tool will be used in a busy environment where time is scarce, and as such must undertake to hold the users attention long enough to provide value. As stated above, a person with a decision to make will satisfice if they don't know that the knowledge

exists. They will also satisfice if they know the knowledge exists, but the cannot easily and quickly find it.

In the case of a traditional database, each of the repeated searches is a single user task, with the user completing the task when they receive the results[4] . If the results are not those desired, the user then has to make the conscious decision to start a new task with a new search string, and importantly may just as easily make the decision to give up and use whatever information is to hand. With the developed application the same searches are conducted, however from the user's perspective the task is continuous, with no single point of "closure" until the final information is found. As such the user is less likely to cease searching until they have achieved from measure of success.


Figure 9. The System Opening Page. In this case the user clicked on the light globe icon (representing knowledge instances, or 'nuggets' in the terminology of this system). This caused a search page specific to nuggets to appear on the left, where the user enters "*knowledge*" into the keywords field in order to find all instances of knowledge that include this word. Clicking the Search activates the query. For authorized staff (e.g., Knowledge Managers), the add button allows them to add information via the "Advanced" pane.

[4] In this case the word task is used as defined in Dix et al, (2004) being "operations to manipulate the concepts of a domain" in order to achieve a goal.

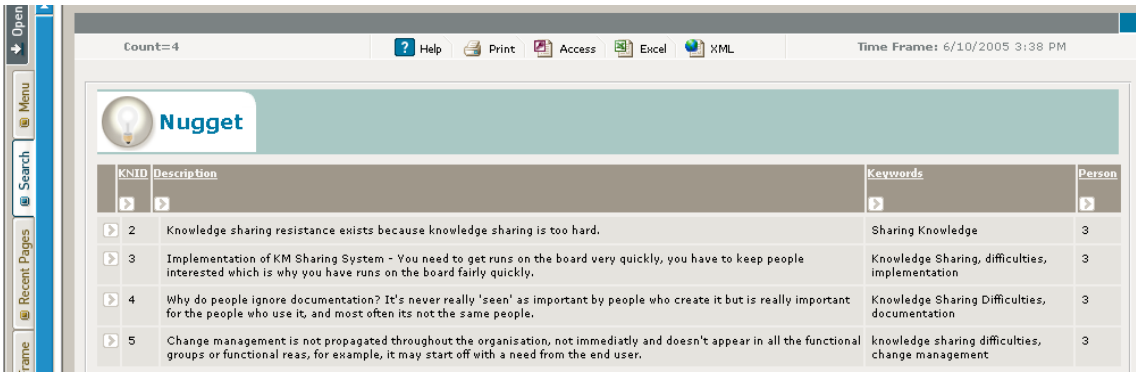


Figure 10. The user is then presented with a list of nuggets that match their search criteria. In this case the user selects one for more detailed investigation by clicking on the small arrow to the left of the item.

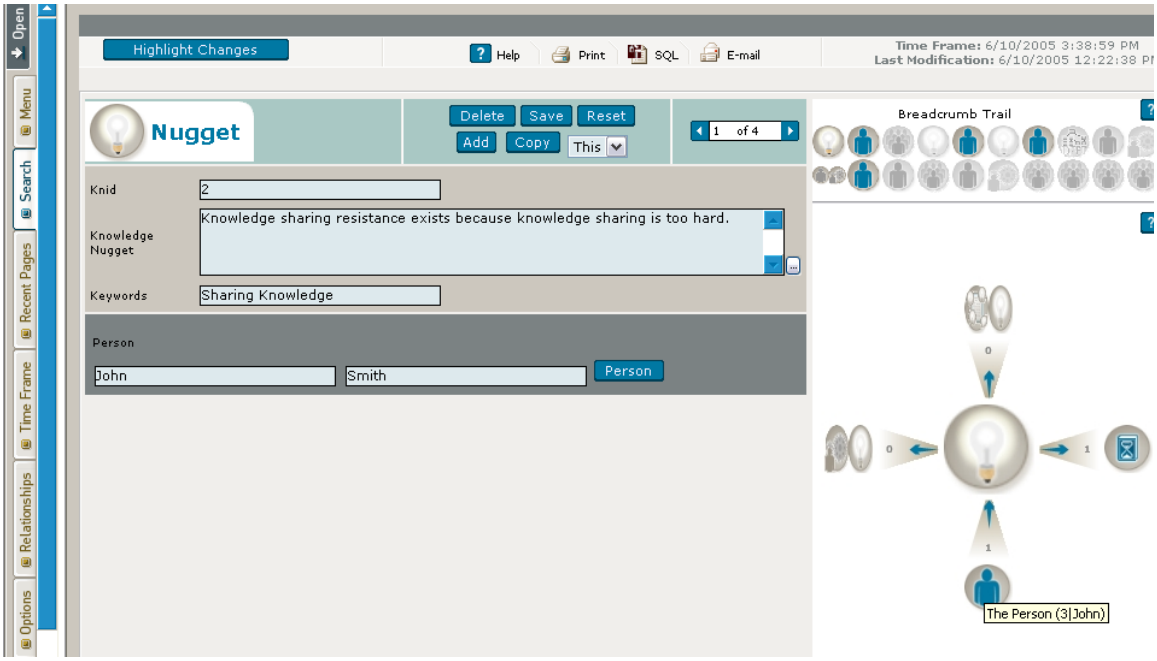


Figure 11. Which brings up a page of detailed information. Importantly, on the right is a star diagram that represents the relationships this nugget has with other entities. The user in this case decides that they want to look at who created this nugget, so they click on the person icon.

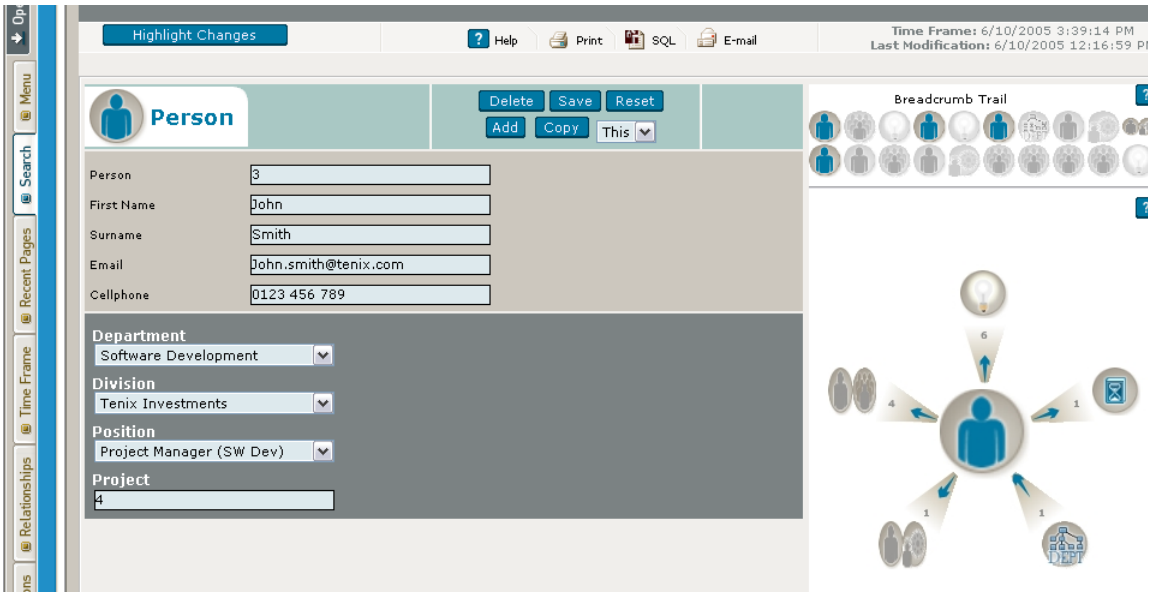


Figure 12. Which brings up all the details of the person. For further investigation into the persons background, to look for common ground, the user looks at previous positions that persons held.

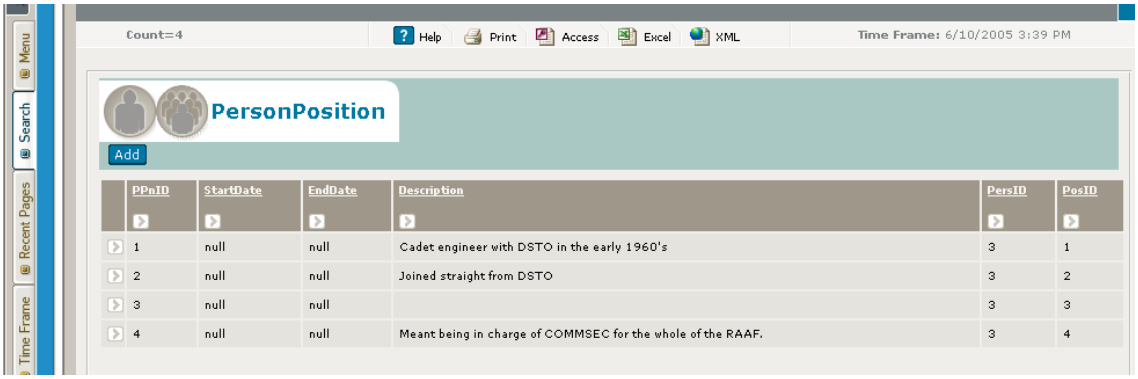


Figure 13. Person's history.

## 4.3 Observations

Even this pilot study revealed deep reservoirs of valuable personal knowledge that are not widely appreciated by present managers and other staff in the EPMO organization and thus have been untapped even when they would have been critically valuable to help resolve issues or to have avoided them entirely in the first place.

One of problem identified in the TEAM project so far is the issue of boundaryless careers (Arthur 1994; Arthur & Rousseau 1996). Divisional/project management requirements change with project phases. Many managers are only familiar with particular project phases and move from project to project or company to company where those phases are active, and thus may only ever know the competencies of their immediate jobs in relation to the current project phase. In other cases, individuals show career progression in relationship to particular projects they are involved with over their careers, and even when the individual progresses relatively directly from a journeyman to manager in the one company, other managers in the organization may still lose sight

of the personal competencies and knowledge relating to other project phases and types of projects that would be invaluable if anyone would only ask.

Much of what EPMO has learned is still retained in the careers of people who are still employed somewhere in the overall organization, but because their personal networks are constantly being broken and reformed in different contexts (1) by organizational restructuring within the company as needs change, and (2) by the frequent career moves typical of this kind of company, other people in present networks simply don't know where knowledge exists. What was once organizational knowledge has become only personal knowledge.

Successful knowledge sharing also depends on the willingness and eagerness of donors to share (van den Hoof & Hendrix 2004). An interesting observation in using the TEAM methodology was that not only were interviewees willing to share their knowledge, but in the process, some interviewees became so eager to share that it proved difficult to terminate the interviews. All indications are that a wider application of the TEAM methodology, combined with some community of practice facilitation, should be able to reestablish many of these connections to improve EPMO's overall effectiveness in its competitive environment.

# 5. Discussion

## 5.1 Success of the method

Building a TEAM database requires more labor than a "yellow pages" style skills database, but should still cost little to deploy compared to potential returns that may be gained from better use of presently unmapped staff skills. However, as noted earlier, given day-to-day demands on managers' scarce resources, we have had little success selling the idea in EPMO that the approach would be cost-effective - a situation that may be common in organizations with distributed profit centers (Mønsted 2004).

## 5.2 Benefits for the organization

The individuals interviewed all showed great allegiance to the organization even when they regard themselves as being under- or poorly-utilized by the organization. This highlights the importance of better using personal competencies of individuals within the organization, making a strong argument for this type of process to take place.

This work is particularly important in a project-oriented organization where individuals may focus on long-lived projects that span an appreciable fraction of their employment careers, and where there are several ongoing projects at different phases in their lifecycles, and where new projects periodically need to be mobilized.

Individuals clearly can't exercise all their competencies at once, but CoPs and CoIs can provide opportunities for sharing and mentoring where expertise can be shared with minimal time costs to main jobs via providing key ideas, guidance and mentoring.

Mind mapping competencies provides a method that allows peers and managers to locate hidden/forgotten resources in their own or sister teams relating to their current problems and needs. The narrative texts captured within the mapped structure gives a

genuine flavor of the personal competency (i.e., something approaching Koskinen and Pihlanto's (1999) "wholistic concept of man") and possibly even hints as to how particular problems were solved.

Mind mapping also gives HR and management a tool for understanding the kinds of personal training, skills and knowledge required to deal with particular kinds of situations. For example, used as an exit interview - particularly when numbers of experienced staff are lost with the completion of a large project, the methodology can record the kinds of knowledge lost to the organization with the departure of an individual and thus provide a much more effective search image of what should be sought in a replacement for the departing individual, and for induction/mobilization training when a new project is mobilized or reaches an equivalent stage.

### 5.3 Benefits for the individual

There are social rewards for experience and sharing, which can provide better security and the possibility of better remuneration, as job requirements change through the organization's increased competitiveness from better use of the personal skills of its members.

### 5.4 Theoretical implications

Even though the EPMO organization does not always fully use the career competencies of its members, it is clear that individual competencies do contribute strongly to the capabilities of the organization as an autopoietic entity in its own right.

## 6. Conclusions

Human attractors are important initiators of CoIs, ECoIs and CoPs in project-focused organizations, and probably have the power to apply appropriate constraints to assist in sustaining them (Nousala et al Submitted).

ECOIs and COIs are important because it is at this level where appropriate constraints are applied to determine whether the ECoI and CoI is to develop into a functional and self-sustaining autopoietic CoP. CoPs are important not just as a social science phenomena, but as a means of describing the view/perspective and interaction between working individuals around initiators – groups – working clusters – horizontal networking.

It is difficult to implement KM processes in project-based engineering organizations because KM involves horizontal activities cutting across strongly hierarchical and "stovepiped" project organizations and profit centers within the larger commercial organization, probably because the cost of resources expended to help other projects and departments are easily visible, while the value received in the form of help provided by other centers may not be so easily seen.

The practice of KM in project based engineering organizations is a specialty subdiscipline in a knowledge intensive society with increasing levels of complexity.

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# APPENDIX

# Team Interview Map

**1 Interview process**

1.1 Goal: Identify, value (and where possible, preserve) sources of knowledge that have helped us achieve a successful ANZAC Ship Project

1.2 Method: Interview key people who know or can help identify such sources

1.3 Classes of knowledge we want to know about:

1.4 What we want to know about each type of knowledge:

1.5 Ground rules

1.5.1 Voluntary interview. No one is required to participate in the study

1.5.2 Answers will be recorded and transcribed to ensure an accurate record of what we are told. Raw transcripts will remain confidential between the interviewee, the interviewers and the transcriber.

1.5.3 After transcripts are reviewed, Interviewers may request an additional interview to explore questions raised in analysis.

1.5.4 Interviewee will have the opportunity to read the transcript of their interview at each stage and make deletions, corrections and add comments as desired.

1.5.5 Only the final transcript as approved by you will be retained as a permanent record

1.5.6 Where interviewees do not wish possibly adverse stories/comments to be associated with their names, interviewers may include in the study in unattributable form lessons learned

**2 Questions**

2.1 What is your job history with Tenix?

2.2 What ASP roles have you performed for Tenix?

2.2.1 For each role:

2.2.1.1 Why is the role performed?

2.2.1.2 When is this role required?

2.2.1.2.1 What triggers you to perform the role?

2.2.1.3 How critical is the role?

2.2.1.3.1 What happens if the role is not performed

2.2.1.3.2 What can go wrong?

2.2.1.3.3 What happens if you do get it wrong?

2.2.1.3.4 What do you need to know to stop failures?

2.2.1.4 What are the outputs of the role?

2.2.1.4.1 Who uses them?

2.2.1.4.2 Where/how are they recorded?

2.2.1.5 What input information/ knowledge does the role require?

2.2.1.6 Who do you interact with to perform the role?

2.2.1.6.1 What is the nature of the interaction?

2.2.1.6.2 What input do you receive from them?

2.2.1.6.3 What information do you give them

2.2.1.7 Other than people, what sources do you use for this knowledge

2.2.1.8 How do you know what to do?

2.2.1.8.1 Training?

2.2.1.8.2 Process?

2.2.1.8.3 Intuition?

2.2.1.9 How did you learn what to do?

2.2.1.9.1 Prior training?

2.2.1.9.2 On the job training?

2.2.1.9.3 Learn by doing?

2.2.1.9.4 Mentoring?

2.2.1.9.5 Written process

2.2.1.10 Is the knowledge you produce in this role reusable?

2.2.1.10.1 Could you do better if an ANZAC Ship Project came up tomorrow?

2.2.1.10.2 Have other projectrs benefited from what ASP has learned?

2.2.1.10.3 Can this be transferred to commercial work?

2.2.1.11 What processes are involved in what you do?

2.2.1.11.1 Are the processes you use in this role documented?

2.2.1.11.1.1Where?

2.2.1.11.1.2What documents?

2.2.1.11.2 We need to identify the entrenched processes and procedures.

2.2.1.12 What are the most important lessons you have learned in this role?

2.3 What training would someone else require if they had to take over your job?

2.4 What knowledge/tools do you have in your office?

2.4.1 What is in your office that helps you do your work?

2.4.2 What about Dictionaries, CCH type information, do you use any of that?

2.4.3 Do you use any other publications?

2.4.4 Do you use the Internet?

2.4.5 Do you participate in any forums?

**3 Emergent Issues**