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Knowledge Diffusion via AUTomated Organizational CARTography [AUTOCART]

Mounir Kehal
Esc Rennes, France, mounir.kehal@esc-rennes.fr

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Mounir Kehal, PhD

Associate Professor in Business Information Systems, ESC Rennes School of Business

2 Rue Robert d'Arbrissel, Rennes, Brittany, 35065, France

mounir@kehal.net

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Abstract: The Post-Globalisation aeon has placed businesses everywhere in new and different competitive situations where knowledgeable, effective and efficient behaviour has come to provide the competitive and comparative edge. Enterprises have turned to explicit- and even conceptualising on tacit- Knowledge Management to elaborate a systematic approach to develop and sustain the Intellectual Capital needed to succeed. To be able to do that, you have to be able to visualize your organization as consisting of nothing but knowledge and knowledge flows, whilst being presented in a graphical and visual framework, referred to as *automated organizational cartography*. Hence, creating the ability of further actively classifying existing organizational content evolving from and within data feeds, in an algorithmic manner, hence potentially giving insightful schemes and dynamics by which organizational know-how is visualised. It is discussed and elaborated on most recent and applicable definitions and classifications of knowledge management, representing a wide range of views from mechanistic (systematic, data driven) to a more socially (psychologically, cognitive/metadata driven) orientated. More elaborate continuum models, for knowledge acquisition and reasoning purposes, are being used for effectively representing the domain of information that an end user may contain in

their decision making process for utilization of available organizational intellectual resources.

1. Introduction

Throughout the last decade a new range of business improvement philosophies, approaches and methodologies has been continuously developed. This development has been largely based on various combinations of business practices, management perspectives, and subject related research. Examples of these approaches are innumerable and include organizational learning, the learning organization, total quality management (TQM), business process re-engineering (BPR), quality circles (QCs), and so on. Of more recent times, especially in the past five years, Knowledge Management (KM) has started to emerge as an area of interest in academia and corporate worlds. The literature reveals a rapidly increasing body of knowledge relating to KM, which cross level and cross-link many different disciplines and areas of interest to academics and organizational practitioners, especially those areas that Knowledge is a common factor or input, on a parity with labour, capital and so on, being whilst a knowledge that is put in context and incurred to and from organizations and what could be referred to as corporate milieus. Many important questions and issues arise in regards to KM.

2. Knowledge Management Literature Synopsis

While definitions of any subject matter can be helpful in regard to clarifying the scope and depth of the subject under consideration, they can also be notoriously difficult to articulate. Definitions can often result in unwarranted simplistic reductionist arguments. When the subject that is being considered is in the management domain, the difficulty is compounded even further due to the subjective and diverse nature of the field.

Going further into an in-depth discussion of knowledge management, without considering the scope knowledge could offer would be a biased analytical approach. Some authors in the field have tried to provide a significant and diverse range of definitions for knowledge. Hedlund, for example, used ‘knowledge’ and ‘information’ interchangeably and although he acknowledged that they should be distinguished, his use amounts to treating them as identical (Hedlund, 1994). Myers called organizational knowledge, or for the least referred to it as ‘processed information’.

Nonaka and his colleagues describe knowledge as ‘a meaningful set of information that constitutes a justified true belief and/or an embodied technical skill’ (Myers, 1996).

Knowledge Management is … knowledge creation, which is followed by knowledge interpretation, knowledge dissemination and use, and knowledge retention and refinement. (De Jarnett, 1996)

One could consider Knowledge Management as a framework providing the ability to utilize the available knowledge resources effectively, and in a timely manner, for organizational benefit and advantage. Essentially, it can be evident in organizational processes, the combination of data and information sources, the processing capacity of IT solutions and people, and the creation and innovative sharing of knowledge throughout the organization. Such framework would inevitably lead to a true managing of knowledge, on a contextual basis that maximizes the utilization behind available know-how, -why, -what, -when, -where, -who.

2.1. Knowledge Category Models

Such types of model categorize knowledge into discrete elements. For instance, Nonaka’s model is an attempt at giving a high level conceptual representation of knowledge management and essentially considers it as a knowledge creation process. *Figure 1* shows Nonaka’s knowledge management model reflecting knowledge conversion and dissemination modes.

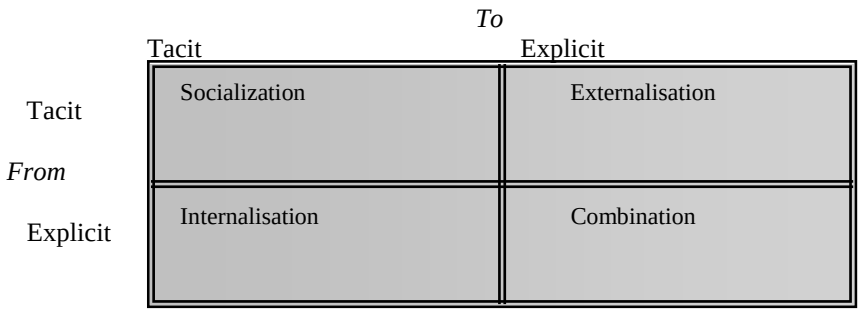

Figure-1 Nonaka and Takeuchi’s Knowledge Management model (Nonaka et al, 1995)

As can be observed from the figure above, knowledge would be composed of two constituents, Tacit and Explicit. Tacit Knowledge is defined as non-verbalized, intuitive, and unarticulated. Explicit or articulated knowledge is specified as being formally structured in writing or some pre-defined form. However, is it appropriate to solely categorize knowledge in such a way? Another approach is the concept of P and

Q knowledge (Mcloughlin et al, 1993). P being programmed knowledge and Q is knowledge gained by questioning insights. Tacit knowledge does not exactly map onto Q, neither does explicit knowledge exactly map onto P. Thus P and Q represent a different categorization, or taxonomical approach with regards to knowledge. Hence, from an analytical and critical standpoint, Nonaka and Takeuchi's categorization of knowledge is perhaps limited and one-dimensional in its approach, by trying to decompose the very nature of knowledge.

However, their model assumes tacit knowledge can be transferred through a process of socialization into tacit knowledge and that tacit knowledge can become explicit knowledge through a process of externalisation. The model also assumes that explicit knowledge can be transferred into tacit knowledge through a process of internalisation, and that explicit knowledge can be transferred to explicit knowledge through a process of combination. Accordingly, the knowledge transforming processes are,

- Socialization, everyday comradeship
- Externalisation, formalizing a body and framework for knowledge
- Internalisation, translating theory into practice
- Combination, combining existing theories

Figure 2 shows Boisot's model, which considers knowledge as either codified or uncodified, and as diffused or undiffused, within an organization. Boisot uses the term 'codified' to refer to knowledge that can be readily prepared for transmission purposes (i.e. specialist data). The term 'Uncodified' refers to knowledge that cannot be easily prepared for transmission purposes (i.e. experience). The term 'diffused' refers to knowledge that is readily shared while 'Undiffused' refers to knowledge that is not readily shared.

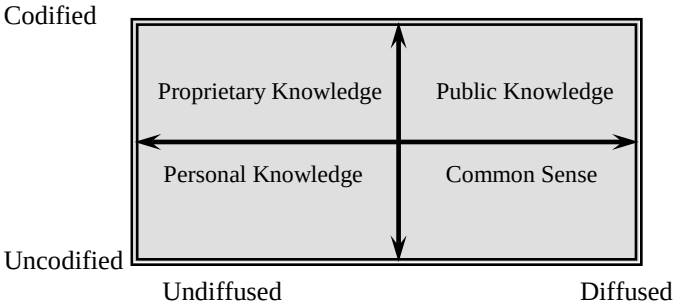

Figure-2 Boisot's Knowledge Category Matrix (Boisot, 1987)

Provided above is a selection of the germane knowledge management models by which knowledge constituents (tacit, explicit) and its conversion phases were presented. Boisot's model rather reflects knowledge flow within organizations and the *stratum of semantic relevance* within and for their units, rather not in an explicit manner as his model provides the top layer of where textual content may reside or belong to, and not just being mediated through technology. For which we aim to approach such problem from a computational modelling perspective, by tackling content in a 3-hierarchical layered mechanism whereby knowledge lifecycle is deemed.

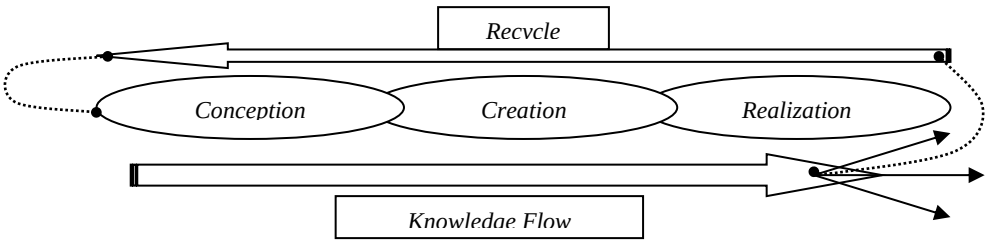

Figure-3 Three-Tier Knowledge Lifecycle

In accordance to diagram above, we believe that knowledge creation undergoes a nested set of computerized processes [explicit] and accompanying practices [tacit], allowing as well for its inter-linkages and cross levelling to diverse specialist areas of expertise and to those it would tend to restrain, as knowledge would be considered as highest level available for awareness on the object of concern. Hence, aim is rather to *acquire automatically*, *represent visually*, and *reason collectively* on textual content contained. Thus, a computationally mediated tool is conceptualised upon subsequently, being referred to as AUTOCART, *AUT*omated *O*rganizational *CART*ography, supporting knowledge evolution studies, knowledge sharing and corresponding flow representation.

3. Organizational Cartography and Knowledge Mapping

According to Oxford English Dictionary, *Cartography* is the drawing of charts or maps. Our aim is to generate cartograms representing stored content attained from specialist data feeds. Hence, the generated map is one on which information is presented in an illustrative form. Reflecting content by means of expressing it in terms of its textual constituents, sources of data feeds, relations and dependencies, and so forth as pertinent to its effective visualization. *Figure 4* represents, the characteristics by which 'information in context', knowledge, is dealt in the process of its

acquisition. From internal to external sources, and from being data that is interpreted, to one that mirrors certainty with intent to validate its semantics, the following structure aims to portray knowledge acquisition and conversion spectrums.

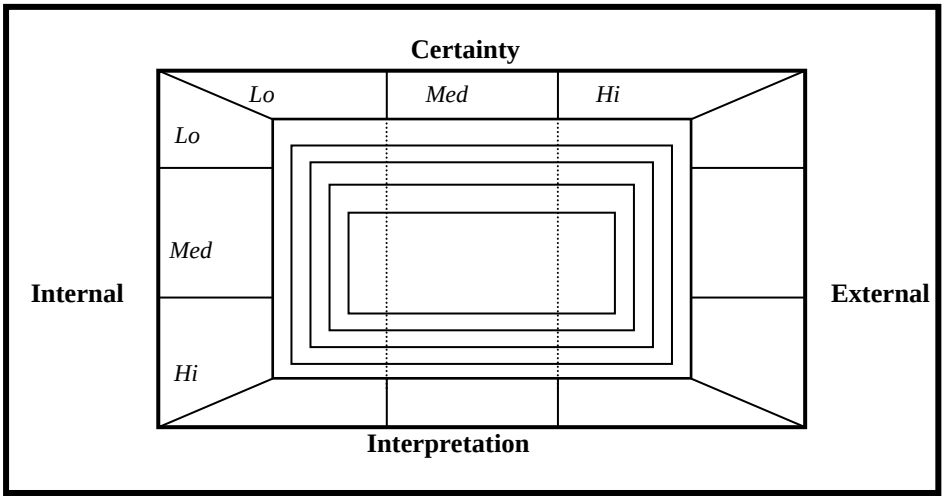

Figure-4 Knowledge Acquisition Spectrum

Hence from *Figure 4*, Certainty, Internal, Interpretation and External are all knowledge instances attained by means of extraction of contained-tacit and/or stored-explicit knowledge, with possibly varying values, states and roles, from data feeds, and the levels of processing achieved by a mediated computation. *Figure 5*, below reflects the nature anticipated by such processing in a framework that models parameters of consideration from which knowledge may be viewed, or rather represents and embeds itself in the form of an [intangible object] action, thinking, [tangible object] archetype, human.

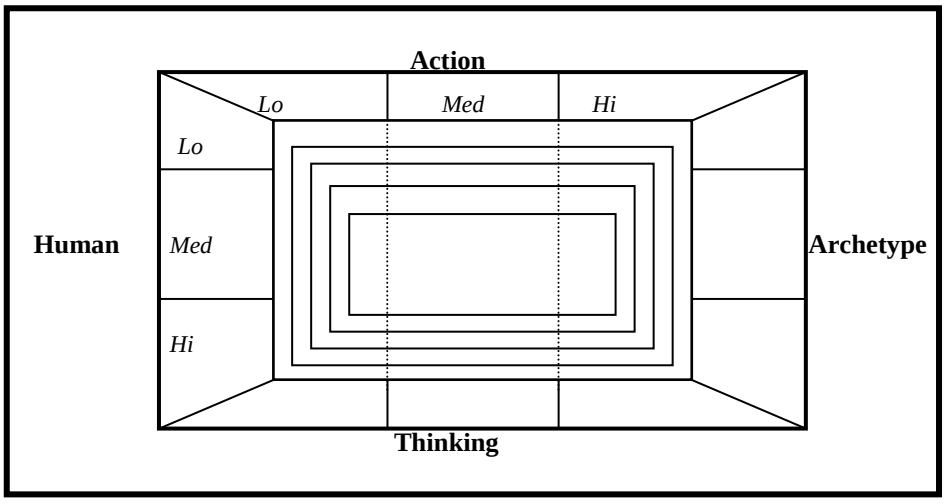

Figure-5 Knowledge Conversion Spectrum

3.1 Systematic view of AUTOCART

The knowledge spectrum models covered above would provide us with a framework for the development of AUTOCART, represented at a finer degree of abstraction in Figure 6 AUTOCART Meta level model, by use of dependency relationships and associations among processes and/or instances of objects. The Relationships and associations are stereotyped as <<refine>>, in accordance with the UML notation (Booch et al, 1999).

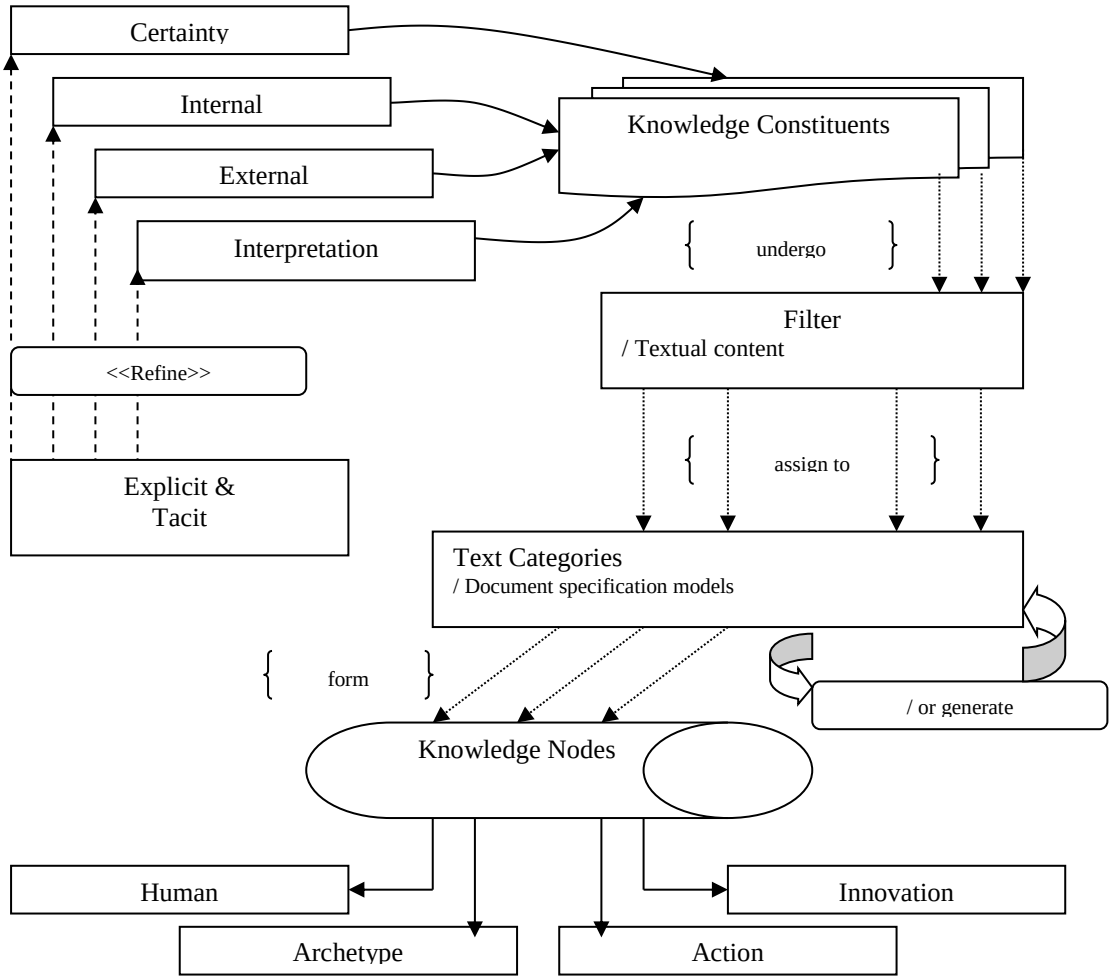

Figure-6 AUTOCART, Meta Level model

These dispositions of knowledge comprise parts of the Knowledge Constituents, which embody the 'raw' material of the organisation in question. Therefore, a generalisation relationship is used to depict the more specific kinds of knowledge elements in relation to the 'whole'. Knowledge Constituents undergo some form of filtering, based on criteria derived from the document specification model and partly determined by the textual content. These functional processes are modelled in the next model, Figure 7, which focuses on functional requirements at a lower level of processing. In like manner, each knowledge element, texts in this case, is assigned its

textual category, primarily determined by its textual contents opted for in a pre-defined algorithmic manner, using principles of Kohonen Nets, and directions towards an automated learning environment through induction and hence possible alterations in terms of activation and threshold functions deterministic weights, leading to toggling between unsupervised and system-supervised learning for a networked representation of data. To establish the textual category is vital in classifying textual content and, along with characteristics such as links, directly added from the filtering process, forms the Knowledge Nodes. Consequently, the outcome of the AUTOCART Meta level model is considered to be an entity containing knowledge, possibly representative of peak levels of innovation feeding to actions, mediated by physical end users and presented in the form of archetypes. These specific types of knowledge representation are linked to the Knowledge Node using a generalisation relationship, following the notation of (Booch, 1999).

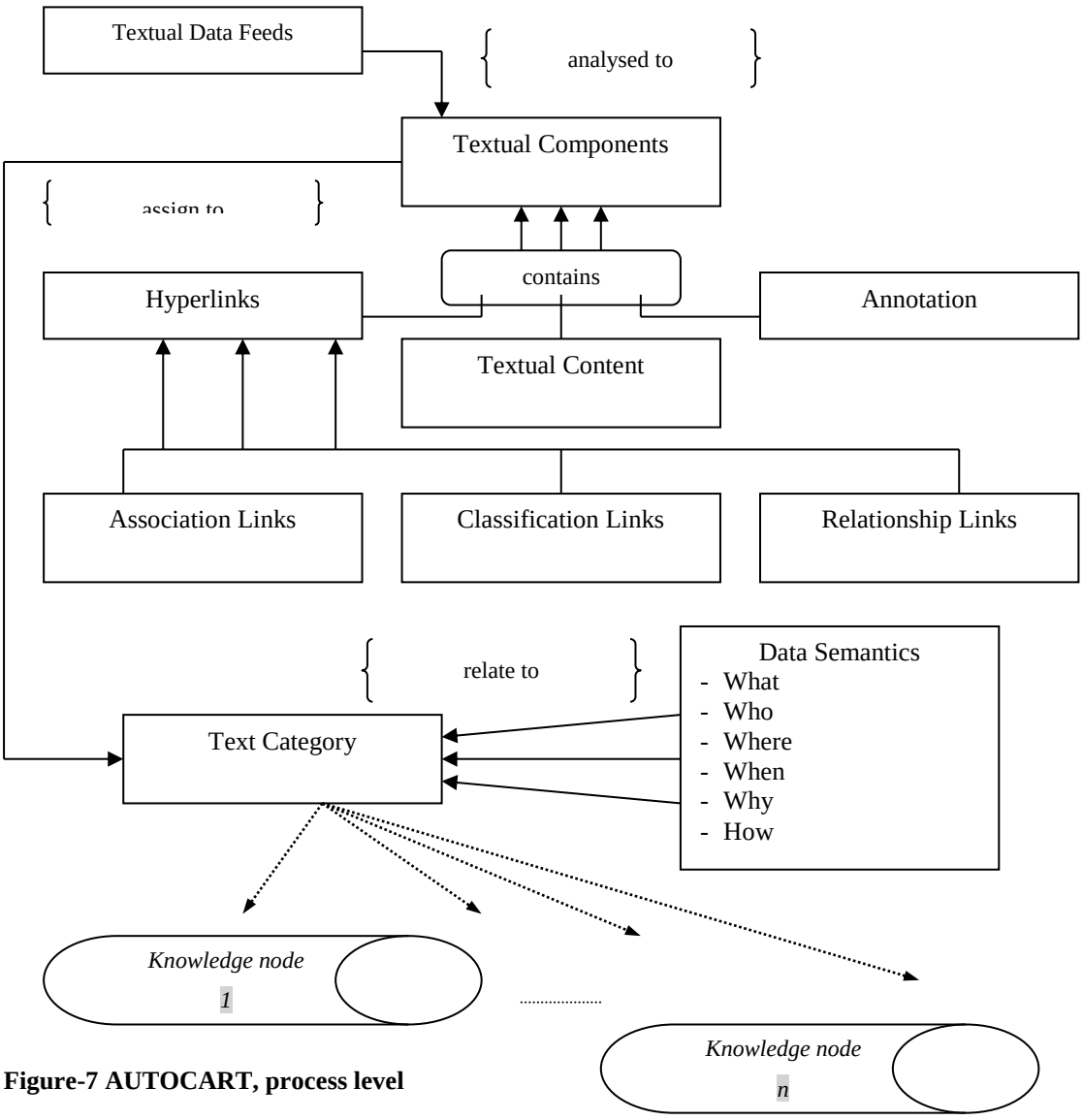

Figure-7 AUTOCART, process level

At process level, Data Elements within Knowledge Constituents are to be filtered and then accordingly classified. The overall aim is to surface the latent semantic structure of the Knowledge Constituents. The filtering process is primarily based on a document specification model – incorporated in Figure 6 – which is an aggregate of textual components. These can be identified as being the actual text of the document, annotation apparent in the document and the links present. The latter can be further specialised into association Links – pointing to and from related documents – and classification Links, including domain, project and user specific links, and other relationship links as a build-up of the data semantics is incurred based on semantics of content. Once text components have been determined, each text is assigned a Text Category, driven by the cohesive relation between the document specification model and the textual content. In case the category is not readily known, a Category Generator is invoked, whereby assigns a category in an algorithmic manner. Effectively, the process of textual categorisation and filtering results in assigning some kind of index to each textual input – in the form of data entries per document – in an attempt to reveal the latent semantic structure underlying the organisational knowledge elements. The associated data semantics form the core of the Knowledge Nodes, as aim is to miniaturize node's content, though maintain original semantics already contained. AUTOCART at process level model, portrayed in Figure 7, provides an architectural view of the anticipated processing for generation of Knowledge Nodes, mainly through links – obtained from the filtering process – and latent data semantics as determined by specification, categorization, and classification of the input data, from designated data streams, Web Technology (intranet) and thus Network-enabled. For which (intelligent) iMap, would be the tool instilling for an enhanced representation of knowledge embedded within, from and by such data feeds.

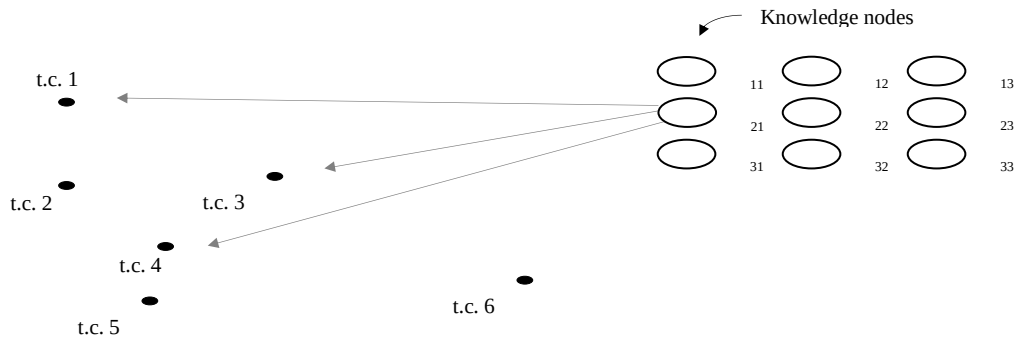

Figure-8 iMap (intermediate state diagram), illustration through Kohonen Nets

Figure 8 demonstrates the modelling of knowledge nodes generation, after textual content have been categorized, following practice given by Kohonen Nets. The text categories produced by AUTOCART, in a way illustrated in *Figure 8*, may form the core of the knowledge nodes, accompanied by reference information such as extracted documented experience within the organisation, related communities of practice and referenced expertise. This enhanced structure serves our purpose, which is not only the administration of electronically available information, but also a viable representation of the intellectual environment aiming to make information actionable and relevant within contexts of expertise coverage. Put simply, we aim to combine all valuable reference information in a framework to which everyone can relate to, effectively leveraging the organisational intellectual assets. These knowledge nodes shall be of little value unless presented in an illustrative form. Therefore, it was chosen to generate cartograms to reflect knowledge instances comprising such nodes. Our approach is to be heavily based on the concept of self-organising maps (SOM). Predefined text categories, either domain or project or user specific, play the role of input vectors while knowledge nodes correspond to neurons. The main concept behind this analogy is to place the winner topologically in the text categories space, according to its relevance for containment of the surrounding text categories. *Figure 8* is representative of the intermediate step of this approach. In effect, spatial proximity – among knowledge nodes and predefined text categories – is taken to reflect semantic relevance and fit, a concept inherited by basic Information Retrieval models. This shall be applied to each knowledge node provided as output of *Figure 7* and used as input for i-map, depicted in *Figure 8*.

4. Knowledge Diffusion

Definitions of *Knowledge Management* upsurge in the literature on management of organisations and within a range of scientific domains. Most of these definitions focus on the short and long term benefits of managing a business by focusing on its specialist expertise in an organization, produced in differing forms (i.e. prototypes, services, products, models) from the *knowledge creating crew* (Nonaka *et al*, 1995). In this context, knowledge management is important because it is assumed to increase the ability of an enterprise to find and act on the information that its employees already know. This type of knowledge management is said to provide one of the only sustainable competitive and comparative advantages in the current global economy,

being based on existing knowledge. Under this umbrella, the scope of knowledge management also may include efforts and research to nurture the people, processes, and tools that enable an enterprise to invent new business and technical expertise. Examples of new business and technical expertise include satellite constellations (i.e. Disaster Monitoring Constellation created and managed by Surrey Satellite Technology Ltd). If both dimensions (business and technical expertise) of knowledge management could be achieved and leveraged, an enterprise may envisage having durable comparative and competitive advantages. In terms of business and technical expertise, attempts to manage knowledge may occur by examining its diffusion (Kreng et al, 2003; Quaddus et al, 2005; Bradley et al, 2006), through patents for instance (MacGarvie, 2005). We have focused on an empirical base for the conduct of the research contained herein, to portray in a novel way how knowledge diffusion may take place in the form of specialist text (i.e. collections of commercial and research documents) and amid knowledge workers (i.e. employees depending on specialist domain knowledge).

Organisational knowledge creation comprises the social sharing of vague, ambiguous and contradicting information, and thereby discovering novel concepts according to Nonaka *et al* (1995). Knowledge is seen as one of the most important success factors that organisations are to own and manage. Similar to the significance of technologies and mechanical machines during the industrial revolution, knowledge creation, knowledge management, and organisational innovations will play the pivotal role in the future of businesses (Drucker, 1993). The creation and acquisition of knowledge as well as its efficient utilization will be for utmost need for maintaining or achieving the leading edge in successful markets. Under these conditions, it makes perfect sense to talk about successful products as being the coordinated and reified knowledge of some production enterprise. Knowledge creation and knowledge management is recognized to be of paramount importance to the competitive advantage of organisations in the current post-modern and global aeon. This research empirically investigates the creation of new technical knowledge, and in particular how it diffuses (flow in addition to adaptation), text being the chosen *currency (symbol of exchange)* for communicating descriptions of such specialist knowledge. It extends Nonaka *et al*'s (1995) organisational knowledge creation theories (*knowledge conversion model*) into the area of research and development ventures, within satellite engineering, that

may be requiring a cooperative, computer mediated environment. A multi-method approach using quantitative and qualitative data conducted and collated from and within Surrey Space Centre, in line with a set of refereed and industry related research. Forming the basis for the direction of this research as illustrated, we had adopted case study research theories for an observational study within an organization. As well as analyzing some of the specialist text stemming from it and its environment, in pursuit of grounding whether SMEs (Small to Medium Enterprises) create dynamics of innovation.

Knowledge is perceived to include believing, and a change of belief is assumed to cause creation or adoption; thus adaptation, of new knowledge. Hence, flow of knowledge may relate to articulation and disarticulation of such belief. However, such may be embodied into a language, representing and describing the diverse objects and corresponding characteristics contained. This language is perceived to be abounding with specialist terms, that some may be emergent. Making the flow of knowledge amongst peers or within an organization, a task that needs continuous monitoring and requires facilitation at different stages of the transfer or exchange of the domain knowledge. Due to the evolving genre of the language used, for the specialist domain. Science and business are different yet symbiotic activities that may be represented by such a language. Science (i.e. onboard satellite computation) feeds into the business world (i.e. core competencies) for instance new ideas, assumptions, and theories; to develop and conduct new business activities. Being supported by development and creation of new technologies, the flow of knowledge within such activities may be facilitated by these technologies and business practices (i.e. resource conservation) created and tailored for effective use of such technologies. Research at Surrey Space Centre, has evolved from development of amateur antennas and LEO (Low Earth Orbit) satellite systems, to the creation of mini- to nano-satellite technologies. Thus for example, it has led to the creation of a collection of satellites to better monitor specific earth activities, under the umbrella of a DMC, Disaster Monitoring Constellation. This can be representative of an articulation of a belief (use of LEO satellite systems for cheaper access to space) to its disarticulation (use of science and development of technologies to support the belief) across a set of fields and organizations, i.e. business organizations, higher education institutions. Accordingly creation of knowledge is encouraged through the displacement of belief. Such spiral

of knowledge, that its creation follows a (semi) structured manner, is referred to by Nonaka *et al* as the *knowledge conversion modes.* Being assumed to reflect four stages for the conversion of knowledge constituents (tacit and explicit): onto one another (tacit to explicit and vice versa) or just onto another instance of the constituent (tacit to tacit, or explicit to explicit). These modes are assumed to be possibly interwoven for ideal situations of organizational knowledge creation, to reflect such a knowledge lifecycle under differing conditions and intentions.

If new knowledge may be created and some previously documented one is utilized, for such belief to be articulated or disarticulated. Knowledge is to flow from one place to another or from one person to another. Such knowledge is to embody or rather be embodied into a multitude of representations. Thus whether being of subjective or objective nature or belonging to a paradigm. Knowledge can be regarded to portray a particular framework of understanding of a domain. For which one or a collection of domains can fuse together to lead to a paradigm, as well a paradigm is believed to be recognized in two basic ways (Kuhn, 1962),

- "sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity"
- "sufficiently open-ended to leave all sorts of problems for the redefined group of practitioners to resolve"

Kuhn regards a paradigm as a model constituted of "law, theory, application, and instrumentation together" and from it springs "particular coherent traditions of scientific research". In similar manner to the "shared mental space, Ba" that Nonaka et al (1995) refer to, in terms of an environment for creation of knowledge. Existence of a paradigm is therefore defined by the group of its adherents. Traces of specialist knowledge are believed to exist in text possibly articulated or disarticulated by these adherents. Illustrating to a certain extent such paradigm (that of nano- to mini-satellite technology engineering for instance, "cheaper access to space"), such text may take the form of a specialist or even general language at times. It depends on the (sub) domain (s), and the intent behind reporting (i.e. scientific discovery, financial analysis, journalistic/political science and so forth). Diffusion of knowledge is perceived to take place amongst peers or communities of practice, which share a common goal by sharing such knowledge that is of utility to the individual or group.

According to Nonaka et al's "knowledge conversion model", it is assumed that knowledge can be composed of tacit (informal, uncodified, undocumented) and explicit (formal, documented, codified) elements. Such terms coined for this purpose to present a dichotomy for knowledge. It is suggested that knowledge undergoes a *spiral* of evolution and consolidation. An interchange amongst the knowledge conversion modes (i.e. socialization, combination, internalization, externalization) leads to organizational creation of knowledge, for its sharing to follow. Kuhn has "forever changed our appreciation of the philosophical importance of the history of science" (Friedman, 1993: 37). For Kuhn, a historian (of science) becomes a "language teacher and shows the reader how to use the terms […] when the narrative of science [of development of science over time] began but is no longer accessible in the language shared by the historian and his or her readers" (Friedman, 1993:320). This awareness in terminology by Kuhn, in terms of how it is used to represent evolving knowledge encourages us in our belief that special languages do have a key role in the flow and adaptation of knowledge, among and between communities of knowledge specialists. Since specialist terminology is assumed to liaise with representation of traces of knowledge. It may help describe emergent technologies, evolving knowledge, and that knowledge consolidated form different domains.

5. Research Study Framework for the Diffusion of Knowledge

One can distinguish to a certain extent the highlights of the research and experimental phases in research documents, and that of consolidation and utilization in commercial documents. The transformation of ideas from science onto business applications is a complex and at times an enduring process. The articulation of ideas and knowledge throughout such process be represented by the specialist terminology, that created and evolving within the domain. The figure below represents a possible spectrum of documents within the domain investigated and field project in particular. Such can be referred to as formulating the basis of a knowledge repository that is in turn formed of sets of text repositories. For the purposes of this research study, the regions covered by research and commercial documents in the spectrum below are assumed to be overlapping at times. As research documents are thought to feed into commercial

documents for the case of this field project, representative of knowledge diffusion (i.e. flow and adaptation a.k.a. acquisition and conversion).

The use of terminology by scientists reporting within the collection of documents was identified to be differing. Though within the same domain, it tended to relate to different phases of a knowledge lifecycle - from conception to utilization, thus containing traces of the domain knowledge at differing levels of an organization and consideration by domain experts.

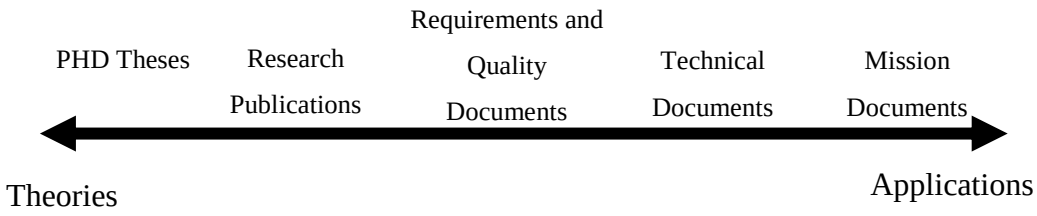

Figure 9 – A knowledge text-based repository of a domain

The methods and systems used for enunciating ideas and their realizations in a given language tend to enable a shared set of protocols for communicating either knowledge of science or the business application. Scientists report in their natural and/or specialist language, and throughout the evolution of their research. Terminology used gets adapted, hence created at times, to the novelty of their work. Thus at times new terms are coined. Such has been used as a communication instrument to report research and intent behind any other type of research reporting to permit for the knowledge to flow and adapt amid knowledge workers.

This research was about understanding and identifying how scientific knowledge is converted into the knowledge of a business application. We have used a model for the conversion of scientific research into a business enterprise, thus the flow and adaptation (together leading to the diffusion) of specialist knowledge from research documents onto commercial documents. We focused only on such conversion of research documents to commercial documents. A field project (for the PhD research 2003 – 2007) within the context of a spin off enterprise (SME, Small to Medium Enterprise) was conducted. Our hypothesis was to attempt and identify through comparative and diachronic studies how research documents (science: theories, assumptions, *fundamental knowledge: i.e. higher education institution*) feed onto commercial (business: models, practices, *applied knowledge: i.e. spin-off of higher*

education institution) documents. Whilst covering the organizational structures supporting the flow of knowledge and its adaptation within the same domain of application (s) of science, through the observational study. Collectively and in general, we considered to what extent an SME is to create dynamics of innovation, by expanding on Nonaka et al's (1995) *knowledge conversion model*. Considering the diffusion of knowledge as a parameter based on evidence in terms of attempts to manage knowledge, in contrast to the creation of knowledge, per se. We have selected a specialist domain of investigation for our research and as our pool of text-based data, that on satellite technology, though for which knowledge is continuously evolving due to the undiscovered nature of space environment, as of yet. Such is narrowed to LEO (Low Earth Orbit) satellites manufacturing organization, alike those developed and managed by SSTL, Surrey Satellite Technology, in which a field project was conduced. Hence, we have carried an introspective study using *Case Methodology* (Yin 1993, 1994) and guided at times by *Grounded Theory* principles (Glaser, 1978). The latter being a positivist approach towards creation of knowledge, as it is believed that knowledge is created from experiences, because reality or truth are argued to be knowable. Accompanied by use of methods for corpus linguistics being focused on the specialist language in use, and guided by the generally agreed statement, that frequency of lexis is a correlate of its acceptability (Quirk et al, 1985).

We have a corpus comprising,

- 80 SSTL / Surrey Space Centre "domain expert" selected publications (No. of words: 405252)
- 206 publications titles, SSTL / Surrey Space Centre (No. of words: 31441)
- Select set of PHD thesis titles and abstracts, SSTL / Surrey Space Centre (No. of words: 5495)
- Texts from Swedish Space Corporation's *Satellite Technology News*, 1997-2004
- BSI (British Standard Institute) Standards Notification, EN 13701:2001, *British and European Standard, "Space Technology Terminology*". UK Participation: Technical Committee ACE/68, "Space systems and operations". (No. of words: 31441)

- BMP, Best Manufacturing Practice Database, comprises texts related to satellite technology and development. (No. of words: 908266) BMP is a partnership among the US Office of Naval Research's BMP Program, the Department of Commerce's Bureau of Industry and Security, and the University of Maryland's Engineering Research Centre.

In order to assess our corpus-based approach for studying the flow and adaptation of knowledge we have equally pursued a case study. As a basis for us to examine whether a SME behaves in an innovative manner, for example, by adapting new knowledge. New knowledge is created and adapted, which in turn could be manifested by the use of a set of specialist terminology.

To be able to investigate the gap in knowledge diffusion within SSTL, we did an observational study, and a study of language used in satellite engineering in general. Both studies have an empirical basis. Diffusion of knowledge within organizations, may take different forms and mediums. In this research, knowledge diffusion is regarded as a two tier process. Involving the flow of knowledge (displacement of belief) and its adaptation (replacement of belief), we looked at:

- Employee to employee knowledge diffusion (online, synchronous feedback): Through the questionnaire survey (and face to face interviews).

- Employee to organization knowledge diffusion (offline, asynchronous feedback): Partial coverage through the questionnaire survey, but analysis of knowledge diffusion is mainly driven by results from the lexical analysis (single words and compound terms) of the collated sets of documents. Those are of research (i.e. higher education institution, specialist research groups) and commercial (i.e. spin-offs of higher education institution, domain specific enterprise) nature and source.

A bimodal research method was followed. Inclusive of:
- Observational study: questionnaire and interview based

- Historical study: analysis of text repositories. Involving extraction and modelling of specialist terminology collated from: public domain publications (i.e. NASA, BSI, and BMP), specialist domain publications (i.e. Surrey Space Centre and SSTL).

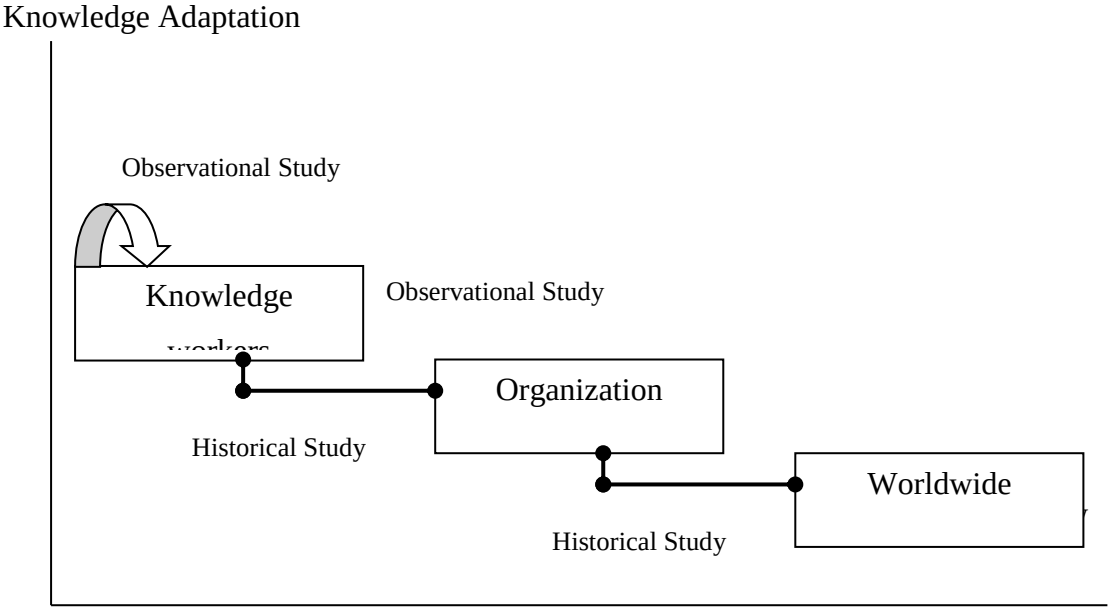

Figure 10: A methodology for examining knowledge flow and adaptation

Figure 10, represents a relational view of the methodology, integrated within the possible set of agents for knowledge diffusion. Whereby knowledge is assumed to flow among or across from knowledge workers, to the organization, then to worldwide (horizontally), but the adaptation phase comes into place once knowledge is personalised and applied (vertically). However, such methodology was implemented in the specialist nature of the domain of investigation.

Table 1 below shows how knowledge bottlenecks have been looked upon during the flow and adaptation of knowledge amid agents involved in its diffusion. Through the observational study and the historical study, behaviour between agents was modelled using the techniques prescribed below.

Agent A	Agent B	Artefact	Technique
Person	Person	Opinion, practice, know-how, organizational structures	Questionnaire-based study
Person	Organization	PhD Dissertations, Research Publications, technical reports	Text Analysis
Organization	organization	Specialist documents (i.e. technical documents, technology-specific documents, missions documents)	Text Analysis
Organization	Worldwide	Specialist documents (i.e. technical documents, technology-specific documents, missions documents)	Text Analysis

Table 1: Knowledge diffusion in the environment of a small organizatio

6. Contributions & Primary Conclusions

Through such research studies the following contributions were made,

- We have developed a method for a systematic study of knowledge management within a small to medium enterprise. Especially those focused in high technology ventures.
- The method developed includes questionnaire surveys, face-to-face meetings, and corpus-based analysis.
- We worked with knowledge creating crew, in particular a space technology organization. Subsequently, we have found out that perceptions about blockage in diffusion of knowledge, was to be different at various levels of the knowledge creating crew. Specifically knowledge engineers (middle management) insisted that there were bottlenecks of knowledge diffusion within the organization (i.e. due to lack of management support, location of sources of knowledge).
- Attempt was made to see whether documents could facilitate diffusion of knowledge (i.e. research to commercial teams). Such that these documents are accessible by different members of the knowledge creating crew (ranging from

researchers to marketing people, and from administration to engineers; for instance).

- We have expanded Nonaka's et al (1995) knowledge conversion model (largely based on intuition and for knowledge creation), to a model on knowledge diffusion based on empirical evidence (for flow and adaptation of knowledge).

Starting this research with a subjective method of questionnaire analysis, we have moved to a more objective method of corpus analysis to extend Nonaka et al's (1995) *knowledge conversion model*, and away from such model's basis of formulation that tended to be intuitive and along the lines of essentially subjective case study analysis. Figure 1 portrays how Nonaka et al's (1995) *knowledge conversion model* was expanded, to include consideration and contribution for how knowledge flows and is adapted within research and commercial documents, within the context of a small to medium enterprise, and based on empirical evidence. Hence, a bimodal (observational and historical) research study was conducted, and diffusion of knowledge that is text-based had been portrayed. Attempting to seek whether small to medium enterprises do create dynamics of innovation, in the context of the case study pursued, such is possible. Spinning the use of lexis (thus knowledge associated) within such research documents to and from commercial (applications) documents would provide proof for technological diversity within the product and service line offerings, based on diffusion of specialist knowledge. Such was manifested in an empirical way from results of the observational study (both pilot and intranet-based: sharing of knowledge) and text-based study (analysis of specialist language: transfer of knowledge).

The observational study helped us deduce that text-based knowledge diffusion may be the solution to alleviating knowledge bottlenecks as a hypothesis. Thus, it led us to conduct the historical (due to diachronic nature of text) type of study. We looked at written text in the form of both research-driven papers and commercially-driven papers. We attempted to show a connection between the two forms of reporting scientific research and commercial research per se, thus diffusion of knowledge. Suggesting that research papers have an effect on applications driven papers, by having attempted to demonstrate that there is a cohesion where commercial interests

are existent, and, indeed, a distinction at the level of choosing and adapting a set of lexis by the knowledge workers of the domain, on a par with the practice followed within an organization. Such choice is representative of the knowledge of the technology within the domain of the application. However being grounded to intent behind such commercial activity, once the transition from research type of documents to commercial type of documents is compromised. This is related to the terminology of the domain that is diffused and utilized by knowledge workers of specialist domains. The choice of lexis may as well be analyzed through cross-citation of authors contributing to a specific domain of a technology, which could be compounded further if the domain is multidisciplinary. Though such may provide the basic framework by which knowledge diffuses, for instance from research documents to commercial documents. Whereas appearance of specialist terminology in patent documents may be looked upon as an intermediate stage in the transfer of knowledge from research labs and centres to commercial organizations and ventures. The observational study has paved the way for us to model and investigate how knowledge may flow, including supporting technologies and organizational structures (i.e. management, practices, rules and so forth). Whilst the historical study, may be regarded as a facilitator towards modeling text-based adaptation of specialist knowledge, AUTOCART provided the framework for the aforementioned empirical and text-based study carried.

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