International Journal of Scientific & Engineering Research, Volume 4, Issue 8, August 2013
ISSN 2229-5518

Harnessing Organizational Knowledge Engineering for Expert System Development by deploying ART Artificial Neural Networks Algorithm

CHRIS M. JAYACHANDRAN M.C.A., M.Sc (Psy)., DWAP., CUSCS., CLSS(BB).,
IT Consultant & Assistant Professor
Department of Computer Applications (M.C.A), Loyola College (Autonomous),
Chennai – 600 034, Tamil Nadu. Email Id: chrisjayachandran@yahoo.com

Abstract— Application of ART Neural Network Algorithm in organizational knowledge engineering for expert system development is one of its kinds Research Work. This pioneering effort is the fusion of domains such as Knowledge Management and Engineering, Artificial Neural Networks, and Expert Systems. This Research Work is the modular fine-tuning in the existing knowledge engineering pedagogies for Expert System development, by stepping over specific shortcomings that are held to be systemic in the Expert system development life-cycle. This paper proposes the 'sure-to-yield-results' Plasticity-stability feature of ART Neural Networks in organizational knowledge engineering for expert system development.

Index Terms— Knowledge Assets, Organizational Knowledge Engineering, Knowledge Walkouts, Tacit Knowledge, Knowledge Artifacts, Knowledge Maps, Organizational Memory, ART Algorithm – Plasticity and Stability, Knowledge Engineering

1 INTRODUCTION

Bloomberg Businessweek headquartered in New York evaluated the market value of Facebook at $2 Billion by end of 2006; which got spiked to $15 billion by the end of 2007 when Facebook gave way for private investment from companies such as Google, Microsoft, and Digital Sky Technologies. At end of March 2012, Facebook's advertising revenue alone grossed at $872 million.[1] During the Initial Public Offering on 18th May 2012, Facebook was estimated at a whopping $104 bllion.[2] After sustaining in its performance at the NASDAQ, as on 4th February 2013, Facebook's market value was $ 60,896,105,201[3], which well exceeds the $60 billion mark, a mammoth hike from $2 billion at the end of 2006 to $60 billion towards the end of 2012; in just 6 years' span. It is not a rocket-science to understand what Facebook is all about. It is simply a Social Networking Tool; but has become interwoven in at least 527 Million Individuals' daily life [1], besides being evaluated at whopping market capitalization as given in the preceding lines.

In this digital-era, where does an organization cash-in from? What is the single most important 'factor of production' as opposed to the classic adage: Man, Money, Machines, and Materials? How do organizations such as 3M (http://www.3m.com/) founded in 1902 could still be empowered to embrace a net income of $4.3 billion during the Financial Year 2011-2012, and GE (http://www.ge.com/) founded in 1892 could chip-in a net income of $17.406 billion? After extensive research corporations and organizations across the globe have had their ticks at one quintessential element that answers the foregoing question: Knowledge. Facebook has its locus on Knowledge – Knowledge to connect several hundred millions of users across the globe every day – Knowledge to make it dawn on companies and service providers to advertise for their product and services through Facebook so that several millions of users could be reached with optimized advertisement expenditure. So has been the case with Netscape Communication Corporation that introduced the world's first commercial and popular Web Browser – Netscape Navigator. When Netscape Communications Corporation opted for Initial Public Offering (IPO), the market valued this $17 million company at $3 billion at the Close Of Business on the first day of trading. The market did not value the company on the basis of its buildings and computers but on the basis of its Knowledge Assets: its invention of the commercial web browser, innovative projects, patented technology, and due to technological prowess of its founder Mr. Marc Andeersen [4].

Thus, it becomes evident that Knowledge Assets drive organizations to a whole new level in the globalized economic conditions, where there is head-on competition among them. It is the Knowledge Assets that provide a strategic leverage to organizations. Corporations that have been established before centuries could still march on with enticing profit-figures only due to their ability to germinate Knowledge Assets within them and to solely channelize such Knowledge Assets towards sustaining, growing and expanding their business ventures. As it dawns on many organizations which may be corporations or service providers – that Knowledge is the only competitive asset they have, more of their energies and resources are being directed towards Collaborative Knowledge Harvesting across the enterprise, so that decisions are made swiftly, and wisely by taking stock of the precedents. It is just not sufficing to have Knowledge Assets, but there must be a provision for Organizational Knowledge Engineering, and a possible scenario of tapping the most from the precedents so that no time is wasted either

in repeating the same grave-mistake or in searching for the Knowledge to pursue the right course of action(s) at all times; by virtue of an Expert System across the organization, not confined by geographical or technological boundaries.

2 *TYPES* OF KNOLEDGE*[5]*

Knowledge Type	Description
Domain knowledge	Domain knowledge is valid knowledge for a specified domain. Specialists and experts develop their own domain knowledge and use it for problem solving.
Meta knowledge	Meta knowledge can be defined as knowledge about knowledge.
Commonsense knowledge	Commonsense knowledge is a general purpose knowledge expected to be present in every normal human being. Commonsense ideas tend to relate to events within human experience
Heuristic knowledge	Heuristic is a specific rule-of-thumb or argument derived from experience
Explicit knowledge	Explicit knowledge can be easily expressed in words / numbers and shared in the form of data, scientific formulae, product specifications, manuals, and universal principles. It is more formal and systematic.
Tacit knowledge	Tacit knowledge is the knowledge stored in subconscious mind of experts and not easy to document. It is highly personal and hard to formalize, and hence difficult to represent formally in system. Subjective insights, intuitions, emotions, mental models, values and actions are examples of tacit knowledge

2.1 Signifance of Tacit Knowledge

Tacit Knowledge has been proven to be mobile and dynamic through knowledge Walkouts. Knowledge Walkout refers to a scenario when a seasoned employee of a particular department or function leaves the organization and joins with a business rival. In this case, that business rival will, as a logical sequence, be benefitted through the ingrained experience of the newly inducted resource (employee). Besides being mobile and dynamic, Tacit Knowledge can have considerable impact on the over-all organizational performance. The most valuable knowledge, skills, and competencies in business reside tacitly between the ears of the employees. As easily as these elements accompany employees home every night, they can also be lured into a competitor's business. Tacit knowledge can rarely be fully articulated, yet it can be easily manifested through application, integration, and collaboration. It can maximize its productive application for both leading, and adapting to turbulent business environments.

2.2 Comparing Tacit Knowledge and Explicit Knowledge[4]

Category	Tacit Knowledge	Explicit Knowledge
Nature	Personal, Context-specific	Can be codified and explicated
Formalization	Difficult to formalize, record, encode, or articulate	Can be codified and transmitted in a systematic and formal language
Development Process	Developed through a process of trial and error encountered in practice	Developed through explication of tacit understanding and interpretation of information
Location	Stored in the minds of people	Stored in documents, databases, Web Pages, emails, etc
Conversion Processes	Converted to explicit through externalization that is often driven by metaphors and analogies	Not required
IT Support	Hard to manage, share, or support with IT	Well supported by the existing IT
Medium needed	Needs a rich communication medium	Can be transferred through conventional electronic channels

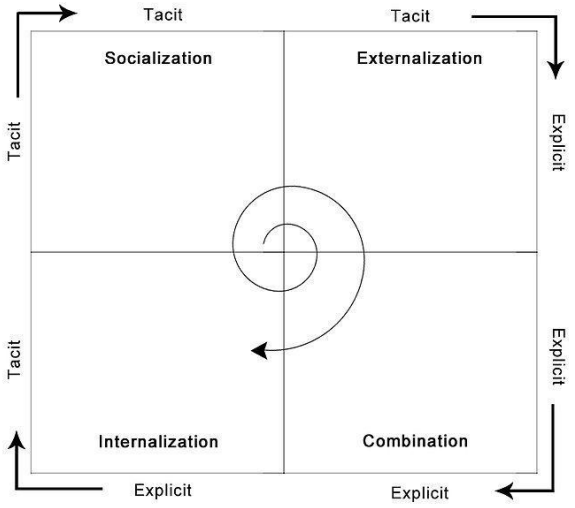
2.3 Benefits of Tacit Knowledge

An organization is being bestowed with the following benefits from Tacit Knowledge:

- Competitive Advantage
- Increased ROI
- Increased Employee Productivity
- Increased Effectiveness
- Improved Collaboration
- Faster Innovation

2.4 Tacit Knowledge to Explicit Knowledge Conversion[7]

- Socialization
- Externalization
- Combination



- Internalization

3 Knowledge Assets

Knowledge Assets consist of guidelines, set within business context, enlivened by stories and quotes from experience, and linked to people and documents for further investigation. The role of knowledge assets in knowledge management is to provide the means by which one team or person can transfer their knowledge to many teams or people, separated in time and distance. A Knowledge Asset is an explicit managed resource which supports organizational decision-making and action. It contains synthesized, validated and organized knowledge.[8]

4 Knowledge Artifacts

It is a common practice that people, spontaneously and often implicitly; identify structures that make their cooperation and problem solving activities more effective. When these structures are sufficiently worked out and put at work, they are usually materialized in artifacts in various dimensions such as conceptual, linguistic and/or modeling tools, whose structure is strictly shared by the members of a well defined community. Knowledge artifacts incorporate the core competences as well as the experiences of actors who are professionals skilled in possibly different disciplines, each of them characterized by a specific professional language.[9]

A knowledge artifact is any object that conveys or holds *usable* representations of knowledge. As any object, Knowledge Artifacts can be transferred, shared, and preserved. Moreover, *usability* of a Knowledge Artifact is interpreted as its ability to be put into action by a human actor in an organizational context. They are *primarily* used to *objectify* how people within an organization and community organize their "memories" and the involved "knowledge" and how people are able to put it into use to make proper and timely decisions.[10]

5 Knowledge Map

A Knowledge map is a navigational aid that enables a user to hone in rapidly on the desired concept, and then follow links to relevant knowledge sources (information or people).[6]

The organizational knowledge map is an outcome of synthesis within the organization and portrays the sources, flows, constraints, and sinks of knowledge within an organization. An organizational knowledge map highlights the following:

a) Location, ownership, validity, timeliness, domain, sensitivity, access rights, storage medium, use statistics, medium and channels of common organizational data, information and knowledge pools or sources.
b) Organizational documents, files, systems, policies, directories, competencies, relationships, authorities
c) Boundary objects, knowledge artifacts, stories, heuristics, patterns, events, practices, activities
d) Explicit

6 Organizational Memory

Stein and Zwass (1995) define Organizational Memory as the means whereby knowledge from the past is brought to bear on present activities resulting in higher or lower levels of organizational effectiveness. It integrates information across the organizational boundaries and to control current activities and thus avoid past mistakes. Generic functions of Organizational Memory are perception, acquisition, abstraction, recording, storage, retrieval, interpretation, and transmission of organizational knowledge.[11]

7 Adaptive resonance theory (ART) Neural Networks

Adaptive resonance theory (ART) networks (Carpenter and Grossberg 1988) are most useful for pattern clustering, classification (e.g., signal classification), and recognition. They can also perform pattern association with some modifications. These networks can work on binary or analog-valued input. The adaptive resonance theory suggests a solution to the stability-plasticity dilemma during the designing of learning systems. The dilemma asks: "How can a learning system be

designed to remain adaptive in response to significant events and yet remain stable in response to irrelevant events?" It would be easy either to learn new patterns (learning plasticity) or retain the knowledge of previously learned patterns (learning stability).

One of the key features in attaining learning plasticity and stability is the use of pattern resonance.

An ART Network uses resonance of a pattern in the output layer, with a pattern in the input layer, to establish a good hetero-associative pattern match. A resonating network has two main layers. The first layer receives and holds the input pattern. The second layer responds with a pattern classification or association to the input pattern (the recognition layer) and verifies that by sending a return pattern to the first layer (the comparison layer). If this return pattern is correct (similar to the input pattern), then there is a match. If the return pattern is substantially different from the input pattern, then the two layers will resonate by communicating back and forth, seeking a match. If a novel input pattern fails to match stored patterns within the tolerance level (imposed by the so-called vigilance parameter), a new stored pattern will be formed.

8 KNOWLEDGE ENGINEERING

Knowledge Engineering is an Engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise. It is the knowledge acquisition for expert system development, and used to describe the reduction of a large body of knowledge to a precise set of facts and rules.[13] It typically involves a special form of interaction between the expert-system builder, called the *'Knowledge Engineer'* and one or more human experts in some problem area. The Knowledge Engineer 'extracts' from the human experts their procedures, strategies, and rules of thumb for problem solving, and builds this knowledge into the expert system.[14]

8.1 Expert System

An expert system refers to a computer system which exhibits the human expert's intelligence. An expert system handles real-world problems requiring the expert's involvement, uses a computer model of expert knowledge and expert reasoning. [15] Expert systems are knowledge-based systems which contain expert knowledge and can provide an expertise, similar to the one provided by an expert in a restricted application area. For example, an expert system for diagnosis of cars has a knowledge base containing rules for checking a car and finding faulty elements, as it would be done by a specialized engineer.[12]

8.2 Five Stages of Expert System Development

a) Knowledge Acquisition

b) Knowledge Validation

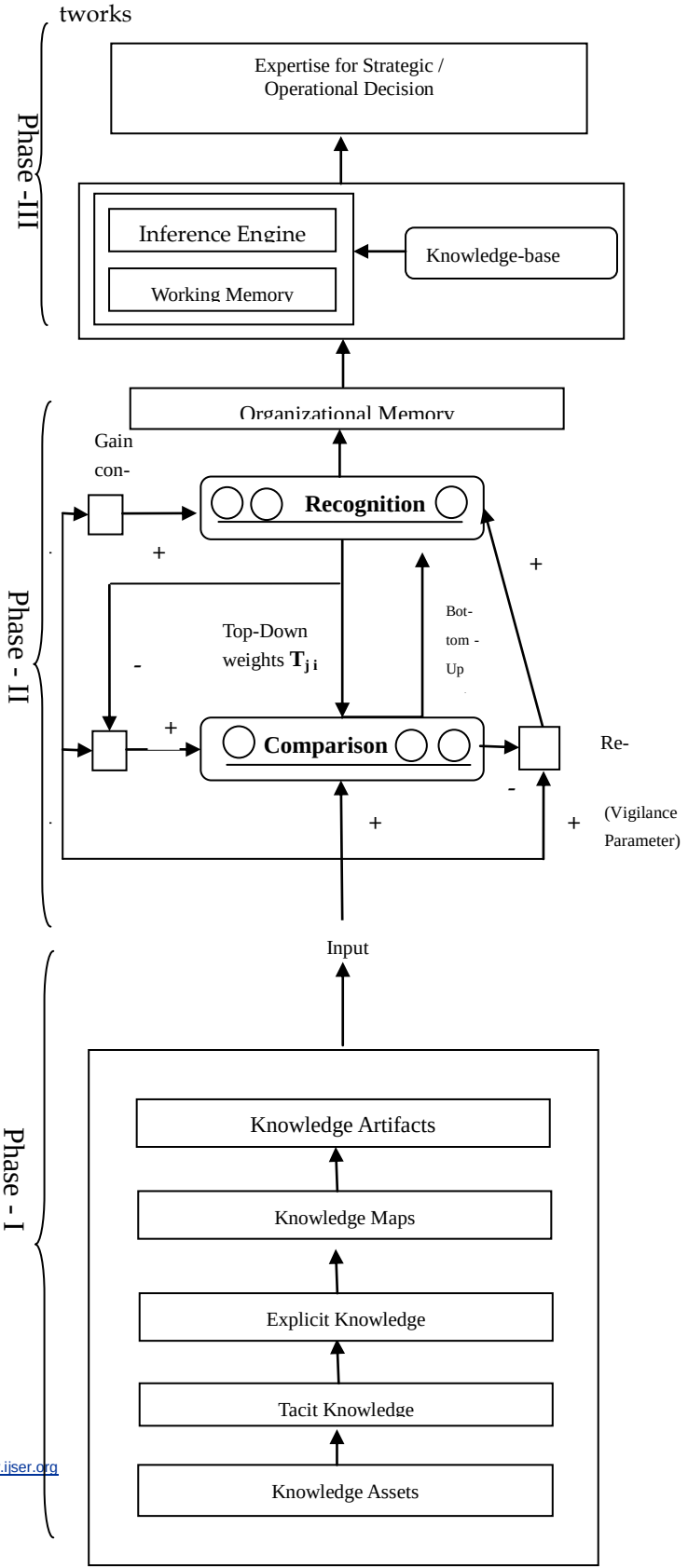
c) Knowledge Representation

d) Inference Engine

e) Explanation and Justification

9 DEPLOYMENT

The proposed solution in organizational knowledge engineering for expert system development steps-over all the impediments pertinent in a typical expert system life-cycle. This is achieved through the deployment of ART Neural tworks



algorithm.

All the foregoing limitations / drawbacks are being overcome by virtue of deploying ART Neural Networks which falls under unsupervised learning neural networks. It is far more superior to many other types of neural networks, addressing the Stability-plasticity dilemma excellently.
The crux of the proposed solution centers on the very fact that organizational knowledge engineering is pursued in such a manner that it is highly productive, and fault-tolerant. Productive in a sense that it encodes the experience (tacit knowledge) of the seasoned employees, and finally makes it available organizational-wide usage perpetually. As such, organizations stand to get benefitted as the intangible competitive asset – the knowledge – is being captured, codified and made available even after the seasoned / veterans of an organization leave the organization on natural grounds or for much better opportunities elsewhere (knowledge walk-outs). The significant value-proposition of this proposed solution banks on the fact it virtually eliminates or minimizes the need for knowledge engineers, and domain experts for contemplating and succeeding in developing an expert system.

9.1 Phase – I

The Phase I concentrates on in-taking all the knowledge assets of an organization in order that tacit knowledge ingrained in the minds of the employees is being made to be explicit knowledge. Nonaka's spiral process is being employed to convert the tacit knowledge into explicit knowledge.[7]. Once, the ingrained experience in any operational or strategic transaction or during the course of executing any project; is being converted into digitized explicit knowledge, knowledge maps are being constructed so as to result in knowledge artifact. But each knowledge artifact need not play an indispensable role, which well deserves to be part of the organizational memory paving the way for the development of the expert system through Phase III. Thus, the validity of each knowledge artifact towards to the merit of storing it in the organizational memory is being authenticated by the deployment of ART-2 Neural Networks in the Phase II.

9.2 Phase – II

ART Neural Network has a two-layered architecture as depicted in the above-given diagram. The input into the ART is the knowledge artifact which refer to a unwritten decision resulting in the organizational benefit as taken by an executive of the organization, way in which an exceptional / uncertain situation was being managed, critical decision taken, factors that favored the accomplishments of the determined corporate-goals or otherwise, resolutions to be pursued to arrest a particular business-case, and the like. Such a knowledge artifact will be received from the Phase I and will be fed in the ART Neural Network.

ART Algorithm

Weight Initialization

The ART net consists of two layers: the input and the output layers. The connection weight B_{ij} (t) (called a bottom-up weight) points from unit *i* in the input layer to unit *j* in the output layer at time *t*. The connection weight T_{ij} (*t*) (called a top-down weight) points from unit *j* in the output layer to unit *i* in the input layer at time *t*. These weights define the stored pattern associated with output unit *j*:

$$T_{ij}(0) = 1$$
$$B_{ij}(0) < L / (L - 1+m)$$

where *m* is the number of input units, and L > 1 (L is a constant; typically L=2).

Calculation of Activation

The activation levels of the input units are determined by the input pattern.
The activation level of an output unit is calculated by the following procedure:

1. $$I_j = \sum B_{ji} X_i$$

   and
   $$O_j = F_w(I_j)$$

where O_j is the activation level of output unit *j*, X_i is the activation level of input unit *i*, and F_w is a winner-take-all function such that

$$F_w(I_j) = \begin{cases} 1 & I_j = \max_i \{I_j\} \\ 0 & \text{Else} \end{cases}$$

2. Vigilance test: Suppose output unit *j* is the winner neuron. If
   $$(\sum_i T_{ij} X_i) / (\sum_i X_i) > \sigma$$

where X_i is the activation level of input unit *i*, and σ is a vigilance parameter,
$0 \le \sigma \le 1$, then update weights; else set $O_j = 0$, disable the output unit *j*,
go to step 1, and repeat. If all committed output units (specifying stored patterns)
are disabled, then a new output unit is allocated and its weights are initialized as
stated.
Weight Training

$$T_{ij}(t+1) = T_{ij}(t) X_i$$

$$B_{ji}(t+1) = \frac{L\, T_{ij}(t) X_i}{L - 1 + \sum_k T_{kj}(t) X_k}$$

By applying the above-furnished ART Algorithm with winner take-all strategy, a relevant knowledge artifact is learnt by the neural network by being stable to irrelevant knowledge
artifacts which the organization might not leverage with.

Such irrelevant knowledge artifact need not necessary be associated with an output vector which eventually reaches the organizational memory. In the recognition phase, the network finds the output neuron whose bottom-up weight vector (**B**) is closest to the input vector (**X**) in terms of their dot product.

$$\mathbf{B} \cdot \mathbf{X}$$

This is essentially the winner-take-all strategy. In other words, after each knowledge artifact is being compared with their likely output vector, competing with each other knowledge artifact's match with the output vectors in the Recognition layer; the knowledge artifact having a close match will emerge as the winner. Only a winner, the knowledge artifact, when output by the ART Neural Networks, enters the organizational memory reservoir. This process exactly mimics the tasks of a knowledge engineer trying to extract the tacit knowledge from a domain expert. As the number and method is kept sophisticated for interviewing the domain expert, the knowledge engineer stands to extract effective tacit knowledge. Similarly the more knowledge artifacts which are relevant for gaining competitive advantage to an organization, the ART Neural Network gains plasticity; and the more irrelevant, and knowledge artifact manifesting generic form of knowledge without competitive benefits, the ART Neural Network remains stable. In this way the Stability-Plasticity problem in organizational knowledge engineering for expert system development is being dealt with flawlessly.

9.3 Phase – III

The working memory, here in the Phase III, would embody information about a specific instance of a strategic / operational transaction along the line of where an organization is competing with the corporate-rivals. Say for example, organizational memory may have a pertinent knowledge artifact concerning selecting an OEM manufacturer in Taiwan for kick-starting the sale of cost-effective Android-powered smart phones. But in the working memory, there would be details about the rivals that are already into such product offering; along with information like product mix, product demographics, product pricing etc. The knowledge base contains a slew of rules for entering into Android smart phone branding, and merchandizing. This would also represent knowledge about the gamut of smart phone industry. The inference engine is the corner-stone of the expert system development. This symbolizes a problem solving model capitalizing the rules in the knowledge base and the situation-specific knowledge in the working memory to solve a problem. In the above discussed example, to freeze from whom to source the OEM for making a maiden-entry into the Android-powered smart phone merchandizing after a great deal of product-positioning. If a unique knowledge artifact fails to match stored patterns within the tolerance level (imposed by the so-called vigilance parameter), a new stored pattern will be formed. Tolerance level can have its enclaves based on the organization's corporate statistics such as the type market the organization has been into, (monopoly, oligopoly, perfect competition, etc) demographics, price-points, competitor's strategies, customer-base / customer loyalty, and the like.

10 Conclusion

The proposed solution apparently overcomes the inherent drawbacks in the prevailing expert system development and deployment. The scope of the proposed solutions spans to versatile industries and numerals verticals within each industry. The viability of the proposed solution is such that the monetization strategies are within attainable ceilings.

References

[1] http://www.socialbakers.com/blog/563-5-best-facebook-statistics-from-ipo-filing-amendment-charts

[2] http://www.businessweek.com/articles/2012-05-18/nine-things-you-should-know-about-facebooks-ipo

[3] http://www.nasdaq.com/symbol/fb

[4] Amrit Tiwana, Second Edition, "The knowledge Management Toolkit orchestrating IT, Strategy, and Knowledge Platforms"Pearson Education Inc. ISBN 978-81-317-0635-0 Page 34, 44, 72-73, 90

[5] Eds. Sajja & Akerkar , "Advanced Knowledge Based Systems:Model, Applications & Research (Eds. Sajja & Akerkar)" TMRF e-Book Vol. 1, pp 1 – 11, 2010

[6] http://www.gartner.com/it-glossary/k-map-knowledge-map/

[7] http://eprints.kingston.ac.uk/2291/1/Gourlay%202004%20SECI.pdf

[8] Shih-Wei Chou and Mong-Young He, Department of Information Management, National Kaohsuing First University of Science and Technology, Taiwan "Knoledge Management: the distinctive roles of Knowledge Assets in facilitating Knowledge Creation" – Shih-Wei Chou and Mong-Young He, – Journal of Information Science, Vol.30 2nd November 2004, Pages 146-164.

[9] Stefania Bandini, Ettore Colombo, Gianluca Colombo, Fabio Sartori, Carla Simone, "The Role of Knowledge Artifacts in Innovation Management: the Case of a Chemical Compound Designer CoP" - University of Milano-Bicocca via Bicocca degli Arcimboldi 8 - 20126 Milan (ITALY)

[10] Federico Cabitza1, Carla Simone and Marcello Sarini - Comunicazione Dipartimento di Informatica, Sistemistica e, "Knowledge Artifacts as "Bridges between Theory and Practice: The Clinical Pathway Case". Università degli Studi di Milano-Bicocca, Italy, {cabitza, simone}@disco.unimib.it 2 Dipartimento di Psicologia.

[11] "Actualizing Organizational Memory with Information Systems", - Pennsylvania State University, -Fairleigh Dickinson University, Teaneck, New Jersey 07666 - Information Systems Research, 6, 2, 1995, 85-117

[12] N. Kasabov, 1996, "Foundations of Neural Networks, Fuzzy Systems, and Knowledge Engineering", MIT Press

[13] Feigenbaum, E.A. (1980). "Knowledge Engineering: the Applied Side of Artificial Intelligence." Report STAN-CS-80-812. Department of Computer Science, Stanford University.

[14] Donald A. Waterman,"A Guide to Expert Systems" –Addision Wesley Longman, Page5, ISBN 0-201-52636-0

[15] LiMin Fu, Edition 2003, "Neural Networks in Computer Inte ligence" –Tata McGraw-Hill, ISBN 0-07-053282-6