HUMAN-CENTERED META-SYNTHETIC ENGINEERING FOR KNOWLEDGE CREATIVE SYSTEM

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Abstract: Meta-synthetic Engineering and Cyberspace for workshop of Meta-synthetic Engineering (CWME) is the methodology for Open Complex Giant System (OCGS), proposed by distinguished scientist Dr H Tsien. CWME synthesizes intelligence from qualitative hypothesis to quantitative studies in terms of human-centred and human-computer cooperated manners, on a meta-level, for dealing with complexities of Knowledge Creative System (KCS). In this paper, a new architecture for constructing knowledge creative systems is proposed that follow on the theory of OCGS and human-centred meta-synthetic engineering, which synthesizes data mining and multi-agent technology, as well as domain experts and users, computers and network, relevant social components, and so on. From a broad perspective, the KCS is OCGS and presents features such as knowledge conductive and human-centred. The system design and implementation of KCS involves organizational factors and interaction of humans- humans, humans-computers, and computers - computers. As a consequence, the collective intelligence emerges from the interaction network of components in a KCS. In addition, some algorithms and tools are developed to analyze the link structure of a KCS to distil the emergent collective wisdom on some topics.

1 INTRODUCTION

An enormous proliferation of databases in almost every area of human endeavor has created a great demand for new, powerful tools for turning data into useful, task-oriented knowledge. In efforts to satisfy this need, researchers have been exploring ideas and methods developed in machine learning, pattern recognition, statistical data analysis, data visualization, neural nets, etc. These efforts have led to the emergence of a new research area, frequently called data mining and knowledge discovery (Smith1998) (Ryszard 1997).

With IT and WWW development, Data mining main topic is broader, including Association analysis, Classification, Clustering and outlier analysis, Sequential and spatial patterns, and time-series analysis, Text and Web mining, data visualization and visual data mining. For the ultimate goal of data mining is prediction, data mining is faced with the following Challenging Issues:

Identifying data source for desired knowledge (knowledge or auxiliary meta data) concerning mining purpose.

- Data collection methods (in Web, wireless, txt) concerning different types of data from different environment
- Usefulness and certainty of mining results concerning Support and confidence
- Interactive mining with different data granularities, e.g., generalized association rules
- Mining in data streaming environments about look at data only once; the amount of data is huge
- Interestingness of mining results concerning about having to know the original likelihood
- Evaluation of mining results i.e. How to measure the advantage gained, Expression of various kinds of mining results.

The above challenges in essence are to how to judge the mining results according to original problem, this is concerning with the tacit knowledge. As a general rule of thumb, explicit knowledge

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consists of anything that can be documented, archived and codified, often with the help of IT, especially KDD. While IT technology often facilitate Knowledge Discovery, for Knowledge Discovery, much harder to grasp is the concept of tacit knowledge, or the know-how contained in people's heads. Another, the purpose of KDD is applied to economic domain, business domain or others. This type system is full of uncertainty, emergence and possibility, which belong to the open complex giant system (OCGS). To process the problems high related to OCGS, it need human's imaginary and innovation to discovery the function structure of the problems in system. Machine can compute in high efficiency, but can not innovate. So complex problem solving-oriented KDD is a knowledge creative process with human-centered approaches.

The remainder of the paper is structured as follows. Section 2 describes the human-centered complex problem solving process directed by meta-synthetic engineering. Architechture of KCS oriented complex problems are discussed in Section 3. Section 4 describe the collective intelligence emergence from the KCS, and a distill tool is established. And conclusion is in Section 5.

2 HUMAN-CENTERED COOPERATIVE COMPLEX PROBLEM SOLVING

2.1 Characteristics of the Complex Problem

As one of science and technology domains, systems science takes systems as its study object from its application to the basic theory research. Early in 1990, Chinese scientist H.S. Tsien and his colleagues proposed a new discipline of science—the study of open complex giant system (OCGS) and its methodology, i.e. Meta-synthesis (meta-synthetic engineering from the qualitative to the quantitative) (Tsien1993, 2001).

Depending on the quantity and interactive complexity of the subsystems and variety of subsystems contained in the systems, system can be divided into two large groups: simple systems and giant systems. If the number of subsystems is comparatively large (e.g. a hundred), such as a manufacturing plant, it can be called a large system. No matter which it is, small or large, such a simple system can be studied, starting from the interaction of the subsystems, then directly synthesizing the dynamic function of the complete system. This can be called the direct method. At most, a large computer or a supercomputer is needed to process such a system. If there are a large variety of subsystems with hierarchical structure and complex interrelations, then the aggregate is called a complex giant system. As examples, there are the biological system, human brain system, social system, etc. what's on the higher level is systems with human beings as their main subsystems. For such, "open" and "complex" have newer and broader connotations. Here the openness can be summarized as the following (1) system and its subsystems exchange information with the outside world; (2) the subsystems acquire knowledge by learning. Moreover, the complexity of such systems can be outlined as thus: (1) between the subsystems there are many modes of communication; (2) subsystems are of many varieties; (3) the subsystems have different ways of expressing and acquiring knowledge; (4) the structure of the subsystems change with evoluti

There are typical OCGS, such as social system, economic system, environment system, military system, Internet, etc., their data usual are the study object of KDD. Problems high related to OCGS are full of possibility, uncertainty and emergency, which cannot be tackled by traditional methodology or simply putting individual techniques together. Meta-synthetic engineering is proposed to tackle complex problems fitting in the category of open complex giant system (OCGS). It advocates to present an insight of problem solving in system thinking, by the synthesis of relevant knowledge, techniques and intelligence, human and domain intelligence, collective intelligence emergence on a meta-level in analyzing, designing and implementing problem solving-oriented Knowledge Creative System (KCS).

Since 1990, basic research and application research for meta-synthetic engineering have achieved many fruit, such as intelligent system's meta-synthetic (Dai1995,2000), internet being a typical OCGS(Cao2001,2003), collective wisdom emerging from human-computer cooperated system(Cui2003a,b), human-human interactive models(Cui2004), human-centred cooperated system based on meta-synthetic on, so the structure of the system is in a state of flux. engineering design and implement (Li2003,2004, Zhang2004), social intelligence(Dai2004,Cui2005,Dai2006). This paper is based on the above research result.

2.2 The Process of Human-centred Cooperative Problem Solving on Meta-synthetic Engineering

To solve the complex problems high related to OCGS, the uncertainty must be taken into consideration. That requires high efficiency of computers and human insight into the problem, by application of meta-synthetic engineering, which can be derived from system thinking and thinking in imagery supported by data information, domain's techniques and intelligence, human intelligence, explicit and tacit knowledge. And then all kinds certain factors and uncertain factor of the problem is discovered step by step from the certain situation to the uncertainty, illustrated by Figure 1.

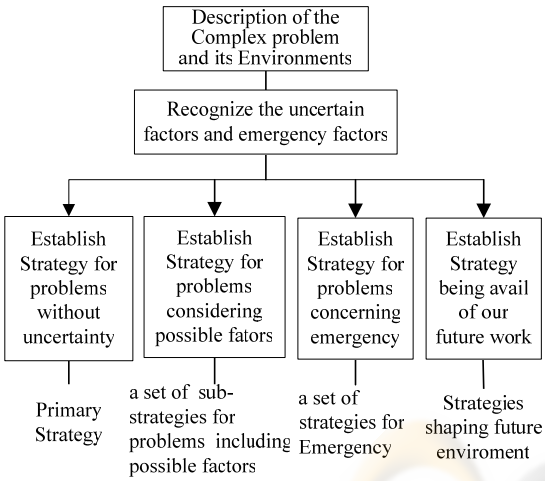

Figure 1: The framework of solving complex problem full of uncertainty.

In Figure 1, first step is to describe the problem and its environment, then explore and recognize the uncertain factors and possible factors. And then the respective strategies can be established, including strategy for problem without uncertainty, strategy for problem considering possible factors, strategy for problem concerning emergency and strategy being avail of our future. With this framework, the concrete steps following the human thinking are established in Figure 2. There, the first is to describe the complex problem by human's idea and analysis of problem, find the principal part and factors in certain hypothesis. Secondly, focus and keys of problem are found by experts with effective interactions and organizations, and then build the analysis structure of problem. Further, the imagination of problem development is built to recognize the key scene, select driven factors and simulate the imagination of problem without uncertainty. Then consider kinds of uncertainty situations and generate strategies respectively by evaluated evaluations standards.

The process is full of uncertainty, thinking dynamics and thinking creativity. Many tasks are involved such as problem analysis, dynamic situation assessment, data information processing, problem modelling and simulation, tactics generation. All these should follow the human dynamic thinking. This makes open interactive environment very essential in every step. Thus it is human centred.

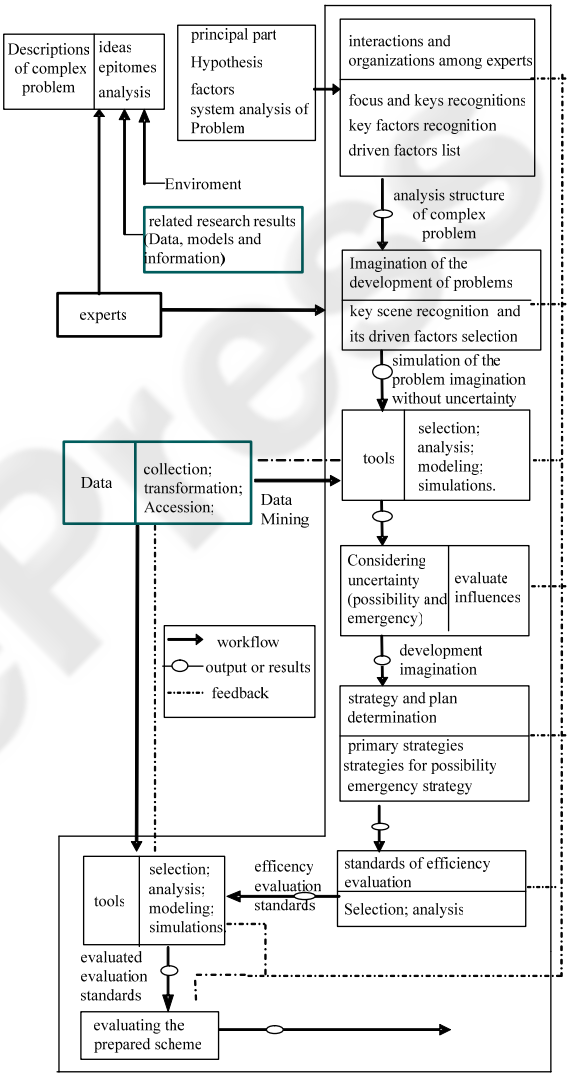

Figure 2: The process solving complex problem based on meta-synthetic engineering.

3 ARCHITECTURE OF KCS ORIENTED COMPLEX PROBLEMS

3.1 KCS Inputs and Outputs

Data and information of the problem, knowledge in human mind and in computer, and the natural rules of human's thought constitute the KCS inputs. On the other hand, the research on KCS-problem solving techniques based on Meta-synthetic engineering generates KCS outputs. As illustrated in figure3, this consists of knowledge in human and computer after problem solving, constructs, models, methods, instantiations, problem analysis open environment, situation assessment open environment, problem modelling and simulation open environment.

The constructs are semantic elements that conceptualize problems within a domain and their solutions by means of interactions among experts, embody experts' explicit and tacit knowledge, and require tools such as data mining, KDD, and techniques of dialogue in deep thought to implement. Models constitute a set of statements that describe the relationships between constructs. This needs methods such as multi-agent distributed computing to be implemented. Instantiations are final artefacts, limited in their scope and developed on the basis of constructs, models and methods. In KCS research, instantiations can precede the complete definition of constructs, models and methods, by having experts rely on their intuition and experience.

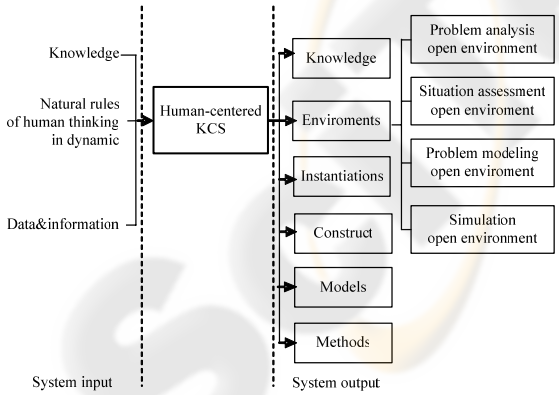

Figure 3: KCS inputs and outputs.

3.2 The Abstract Multi-agent Models for KCS

To implement the above human-centred IIS, agent technology is very suitable. This section describes the design and implementation of agent-based human-centred KCS.

The KCS are distributed and should be established on top of Internet/intranet network. In this system, first, agent refers to man/expert and computer in the network. Thus the abstract KCS open model is designed to solving problems on the basis of meta-synthetic engineering, as illustrated in figure 4.

Here, humans and computers form a social unit. In order to solve a problem, all social units constitute a network-based intelligent information system. There are collective wisdom emerging from www society, information, data, knowledge interactions and organizations among social units. According to system components, there are three type interactions and organizations: man-man interaction and organization, man-computer interaction and organization, and machine-machine interaction and organization, which create a knowledge creative environment.

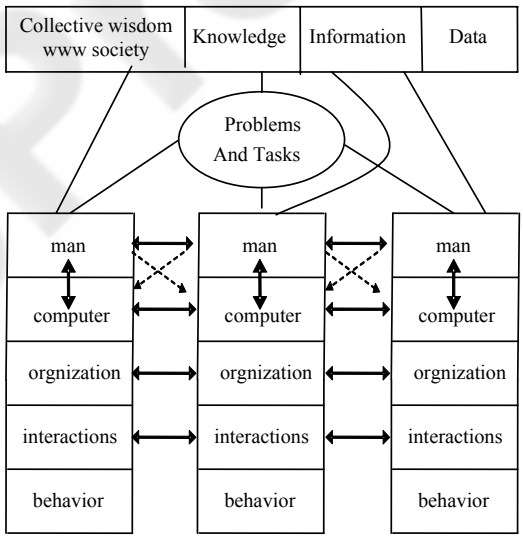

Figure 4: KCS multi-agents models on meta-synthesis.

The first involves the human knowledge (explicit knowledge and tacit knowledge, particularly tacit knowledge, i.e. creative thinking). In implementing computing tasks, man's thinking should be the core of the computing tasks. Such a Knowledge Creative system provides interactive techniques and organizational mechanism for generating the space of knowing what is in man's head. The second type

concerns human-centred data supporting techniques. In order to ensure the thinking to be feasible or reasonable, KCS provides open and human-computer-interacted data support techniques. The third type involves distributed computing by computer and the human-centred data supporting techniques, where agent technology can play roles. Figure5 introduces some details in KCS models.

3.3 Knowledge Creative Environments

3.3.1 Computer-computer Interaction and Human-centred Data Support Techniques

Human-centred KCS allow great flexibility to evaluate and improve a program based on experience in the field. They can testify user's dynamic thinking about a problem. Users can change the parameter values, construct new models, adjust the model's structure, allow greater flexibility to evaluate and improve a program. This type of data support technology includes open interactive modelling in system thinking, open interactive visualization, and their open interactive environments of problem analysis, situation analysis & situation assessment, modelling and simulation.

In particular, to support this flexibility of human-centred cooperative problem solving (Wooldridge 1995, 1996), agent technology is a feasible tool to design and implement computer-computer interactions and open interactive human-centred data supporting.

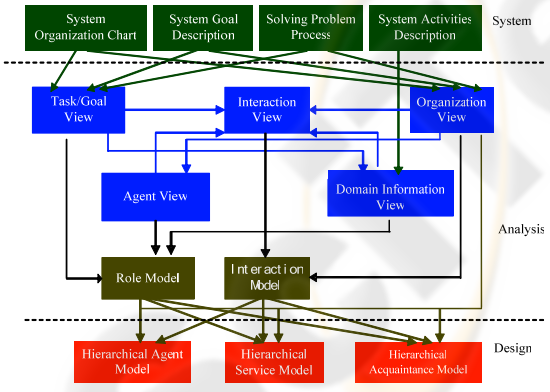

Figure 5: KCS MESSIA design framework.

To this end, KCS is designed by the method of MESSIA (Li2003a,b), which combine the GAIA (Wooldridge 1999,2000)and MESSAGE (Evans 2001), illustrated in Fig. 5. In system description period, IIS consists of system organization chart, system goal description, solving problem process and system activities description. IIS system analysis needs to define agent role model and interaction model from the following five views: task/goal view, interaction view, organization view, and agent view. IIS system is further designed in terms of hierarchical structures, which consist of hierarchical agent model, hierarchical service model, and hierarchical acquaintance model.

3.3.2 Man-man Interaction and Organization

KCS provides interaction and organization mechanisms for human-human to generate knowledge (Robinson1998, Dick2003). Knowledge is generated through interactions among groups. As a result, KCS evolves over interactions.

Metal models, defensive routines and leaps of abstraction (Argyris1978,1992) have a great effect on knowledge creativity. According to the theory of learning organization proposed by Senge et al (Senge1990), the discussion and dialogue joined with system thinking, self-reflection in and on action, and balance between inquiry and advocacy can overcome the obstacles in effective interaction, emerge the experience of the member, change the metal model on his own initiative, convert the knowledge from the tacit to the explicit, from the explicit to deeper explicit, from the explicit to the tacit, from the tacit to deeper tacit(Nokita1995), and emerge the collective wisdom from the global organization of the group.

To have effective interactions among individuals, it is necessary to apply some approaches such as system thinking, self-reflection, balancing inquiry and advocacy to implement self-reflective openness discussion and dialogue for balancing inquiry and advocacy in man-man interactions (Bohm1998). KCS should study the mechanism and techniques for the effective interactions.

For knowledge creativity, it also requires learning organization. Learning organization is fused into the coherent body of interactions. KCS is a global organization.

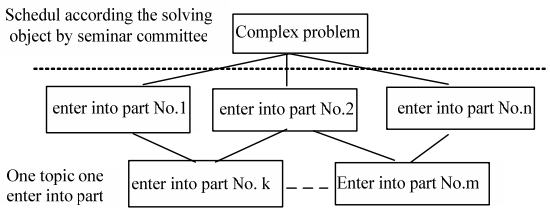

Figure 6: Learning organization mechanism in KCS.

In KCS, the problem solving process is segmented into several sessions according to the problem. Sessions may be parallel or sequential. In each session, there are chairman and experts by means of learning organization mechanism. Figure 6 illustrates learning organizations.

4 COLLECTIVE INTELLIGENCE EMERGENCES

4.1 The Network of KCS

Although the process of interactions among generalized experts is very difficult to predict at a "local" level, it results in a network of KCS replete with response or being responded.

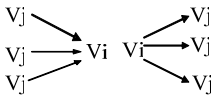

Figure 7: Response and responded relations among discussions.

Illustrated in figure7, the network of KCS is established according to the inter-response embedded in the discourse content, where the discourse of expert one time is regarded as a node V with opinion attributes $A_i(\sigma)$, $i = 0,1,2,\ldots,N_1$. $A_0(\sigma)$ denotes the quality attribute of an opinion, $A_1(\sigma)$ denotes the response quality of an opinion, other attributes are concerning with the opinion content by means of natural language processing. Among these nodes, there are edges E with attributes $H_j, j = 0,1,\ldots,N_2$ representing the response embodied in discussion. Let $S=\{S_k, k=0,1,2,\ldots,M\}$ denote the generalized experts. S_0 denotes the especial expert orienting on some certain topic---which represent the authority opinions emerging from www, the others represent human. Thus, the attributed directed dynamic graph of KCS is built as the following.

$$G=\left\{\begin{matrix}(V, A_i(\sigma), i=0,1,\ldots,N_1)(E, H_j, j=0,1,\ldots,N_2) \\ S_k, k=0,1,\ldots,M \qquad\qquad t\end{matrix}\right\} \quad (1)$$

Where, V, A, E, H represent quantitatively the evolution of the structure of KCS driven by the interactions among S along with time t.

4.2 Analysis of the Link Structure

In the paper (Wooldridge and Jennings, 1996), there is a structure analogy between KCS and www, and a set of algorithmic tools are developed for understanding and distilling the emergence of the collective wisdom on the problem from the network structures. The algorithm is overviewed here.

With hypothesis that opinion quality attribute A_0 and the opinion response quality A_1 exhibit what could be called a mutually reinforcing relationship, i.e. positive feedback, the algorithm is established. This positive feedback is break by an iterative method in following.

$$\begin{aligned} A_0(V_i) &= \sum_{V_j \to V_i} A_1(V_j) \\ A_1(V_i) &= \sum_{V_i \to V_j} A_0(V_j) \end{aligned} \quad (2)$$

The updating operations are performed for all discourse of each one at every time, and the process is repeated (normalizing the attribute value after iteration). The discourses with the larger authoritative attribute value are recorded, which are the emergent representations of the emergent intellective communities in the global level. For example, in figure 8, the redder node has the more authorities with larger authority value.

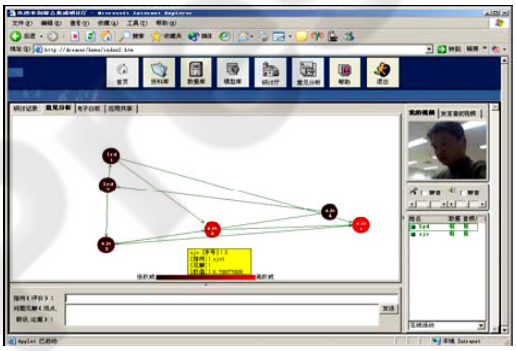

Figure 8: The distill results by analyze Analysis of the link structure, the redder node the more authority.

5 CONCLUSION AND GREAT APPLICATION

With the viewpoint of meta-synthetic engineering, this paper analyzed the human-centred cooperative problem solving process, and proposed a new framework for understanding, analyzing, designing and implementing multi-agent-based Knowledge Creative System.

This KCS generates the models, methods, instantiations, knowledge in both human and computer, and the open interactive environments for human thinking, analyzing, modelling and simulating. These open interactive environments require effective Interactions and organization for man-man, man-computer, and computer-computer in

KCS. Further, interactions lead to the network of KCS which the collective intelligence emerge from in the system whole level. Moreover, an effective distil tool is developed.

Since 1999, human centred metasynthetic engineering of KCS is implemented and applied in solving problem high related to economic system, environment system and military system. Our further work is on human-centred data and information processing.

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