Comprehending Meta-synthesis System Approach in Terms of DSS, Soft OR and Knowledge Creation

Xijin Tang
Institute of Systems Science, Academy of Mathematics and Systems Science
Chinese Academy of Sciences, Beijing 100190, PRCHINA
xjtang@iss.ac.cn

***Abstract*—**Proposed by Chinese system scientists in 1990, meta-synthesis approach is a system methodology to tackle complex system problems. Till today, this approach still lacks well understanding at home and abroad which then blocks its development. This paper addresses MSA by DSS, soft OR methods or the relevant computerized support so as to explain the working philosophy of the approach and provide help to apply the approach to practical problem solving or the construction of its practicing platform, i.e. Hall for Workshop of Meta-synthetic Engineering (HWMSE) by adopting available methods or developing new technologies. The latter part briefly addresses two technologies, CorMap and iView, which conduct a computing way to support qualitative meta-synthesis for hypothesis generation for further verification and validation. Four typical applications are given.

***Keywords*—**Meta-synthesis, decision support systems, problem structuring methods, knowledge creation, CorMap, iView

I. INTRODUCTION

Proposed by the Chinese system scientists Qian, Yu and Dai in 1990, the meta-synthesis system approach (MSA) is a system methodology to tackle open complex giant system (OCGS) problems with which reductionism methods have difficulties to deal [1]. "From confident *qualitative hypothesis* to rigorous *quantitative validation*" serves as a simplified working philosophy of MSA. In 1992 Qian proposed a concept - Hall of Workshop for Meta-Synthetic Engineering (HWMSE) as a platform to apply MSA [2]. The concept of HWMSE reflects the emphasis of utilizing the breaking advances in information technologies (IT) to harness the *collective knowledge* and *creativity* of diverse technical groups of experts by synthesizing data, information, quantitative models, knowledge and experiences into an interdisciplinary problem-solving process which undergoes from proposing hypothesis to quantitative validating. At that time, email, newsgroup or those Web 1.0 technologies just started to spread worldwide.

Seemingly an advanced approach to complex systems problems, MSA had not been well understood or even doubted by Chinese system researchers even from its start, especially as some HWMSE demonstrations exhibited just the integration of some rather updated IT or software engineering practice instead of systems engineering practice. Changes take place after continuous studies in recent 15 years in mainland China with more concerns in complexity research in the 21st century as new understandings achieved in many domains are catalysts. International scholars started to pay attention to MSA. In this paper, decision support systems (DSS), soft operational research (OR) methods for complex problem solving from different disciplines and relevant computerized supports are briefly reviewed to explain the working philosophy of MSA. Such an endeavor infers to integrate those relevant technologies into the development of particular effective technologies for HWMSE to show the power of MSA. Two supporting technologies for qualitative meta-synthesis, CorMap and iView, are briefly addressed. As results of integration of multiple algorithms, both technologies conduct a computing way for idea or assumptions generation for further validation, a contrast to those defined ways of Soft OR methods.

II. DECISION-MAKING, SOFT OR AND DSS PARADIGM

In this section, some typical frameworks or approaches proposed for different objectives are briefly addressed to show their relevance to MSA and its practicing platform, HWMSE Those include two decision-making models for DSS development (Simon's 3-phase model and Courtney's framework), one Soft OR method (Wisdom process). A simple summary is given to show their attributions to MSA.

A. Simon's Decision Making Model and DSS

Simon once distinguished 2 extreme situations regarding structuredness of decision problems, the programmed and the nonprogrammed. The latter are novel with poor structures and then difficult to be solved directly using a simple computer program without human's intervention. In late 1960s, DSS was proposed initially as a computer system to support semi-structured or unstructured problems during a general *intelligence-design-choice* decision making process defined by Simon where the 1st action *intelligence* normally refers to information collection. Later *implementation* was added as the 4th phase. Till now, DSS is regarded as a big umbrella to include many computerized tools or systems to support different tasks during diverse decision making processes. The trend of DSS may be sensed by tracking the achievements about the fundamental components of a DSS, i.e. data, model, knowledge and interface. In comparison with those much progress of the 4 components of DSS, the development of decision making models are unparalleled with the digital revolution. Actually among those problems faced along DSS development, "people problems", which may refer to human's limited capacity in cognition, subjective prejudice and world views, and belief in experts, are key problems instead of those technology-related problems [3]. The diversity of those human

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problems brings or increases uncertainties which may enable a structured problem into ill or unstructured problem.

Among the variety brands of DSS, there is another large category for group work, such as groupware, group DSS (GDSS), computer supported cooperative work (CSCW), computer mediated communication (CMC) system and even some knowledge management tools, which support group activities for communication, collaboration and consensus building, and may also be referred as the collaborationware. The emergence of the Internet enables unprecedented opportunities for group work. Emails, instant messaging, chat rooms, blogs, wikis, etc. bring more information, while also lead to information overload. Simon differentiated rationality as substantive rationality and procedural rationality, and "opposed procedural rationality - the rationality that takes into account the limitations of the decision maker in terms of information, cognitive capacity and attention - to substantive rationality, which is not limited to satisfying, but rather aims at fully optimized solutions" [4]. Since the mid of 1990s, group support system (GSS) has become popular than GDSS as more foci go to the group working process instead of only the final results of group decision-making, a reflection of emphasis of the procedural rationality, or support for argumentation and sense-making during problem structuring. Those support tools are based on different problem structuring methods.

B. Soft OR or Problem Structuring Methods

The limitations of traditional OR methods were started to be noticed since 1960s which brought system rethinking tide along 1970s; a variety of soft system approaches to deal with unstructured problems especially those complex societal problems emerged since 1980s [5, 6]. Those approaches are called soft OR or problem structuring methods (PSMs), which then provide rationales of DSS development [7, 8]. Lots of relevant tools had been explored, such as QuestMap (IBIS based, now as Compendium) for dialogue mapping approach to deal with social complexity [9], Decision Explorer and Group Explorer based on strategic options development and analysis (SODA) [10], etc. There is a trend to apply multiple methods on strategic decision making and then bring new approaches. Wisdom is one of them.

Proposed by scholars at University of Lancaster, Wisdom process (as shown in Fig. 1) facilitates session includes brainstorming, cognitive mapping and dialogue mapping along the strategic problem solving process [7]. The cognitive mapping phase provides a macro view of the problem discussed by the group and the dialog mapping phase helps the group develop consistent micro views.

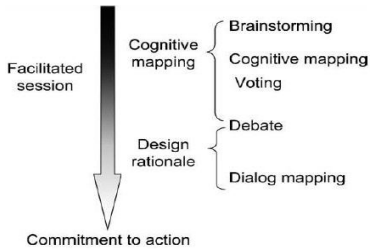

Figure 1. The Wisdom process [7]

As a matter of course, PSMs or those relevant tools reflect specific cognitive or mental models about group thinking or decision making. Recently computerized support to facilitate, expand, or enhance one's ability to work with one or more kinds of knowledge, from which to make some senses, distill insights or gain knowing, etc. has been drawn more attentions, especially as Web 2.0 becomes a popular term and is expected for better job of harnessing the vast collective intelligence potentially available. Ref. [11] reported a study using Collaboratorium, same as QuestMap. The researchers argue that current open-source/peer-production (OSPP) technology is not capable of collaborative deliberation, since the coverage of a topic is created bottom-up and then generally unsystematic. That kind of technology is more time-based, while collaborative deliberation requires logic-based postings. Such a study again tells the differences between two categories of support tools for group work addressed in Ref. [8]. Those methods or relevant tools based on soft OR methods or IBIS-methodology for collaborative work help to gain structures of the unstructured problems while sacrifice freedom of wild thinking and then may lead to loss of novel ideas, the typical disadvantages of consensus built top-down.

As the diversity of PSMs cannot be explained well by Simon's normal 3-phase model, Courtney proposed an improved one [12].

C. Courtney's DSS Framework

In comparison to traditional decision-making models in a DSS context, the salient feature of the Courtney's framework (Fig. 2) lies the step of developing multiple perspectives during problem formulation phases, where besides the technical (T), organizational (O) and personal (P) perspectives [13], two others, ethical and aesthetic perspectives are required to be considered.

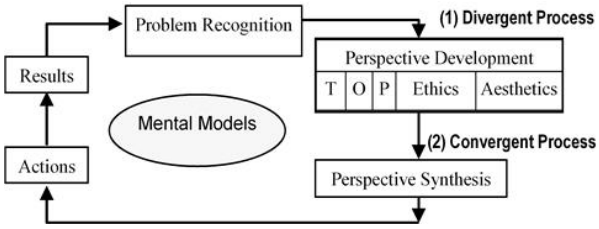

Figure 2. Decision Framework for DSS by Courtney [13] with annotations by Tang [8]

Before "actions", the procedure on "perspective development" and "synthesis" may be understood as divergence and convergence of individual/group thinking. From "problem recognition" to "perspective development" indicated as (1) in Fig. 2 is a divergent thinking process for idea generation and creative perspectives toward unstructured issues. The transfer to "perspective synthesis" as indicated as (2) is a convergent process for acquiring alternatives for choices or actions. The mental models may be regarded as PSMs or cognitive models of decision making. As such a process is for collective problem solving, the mental models may refer to collective mental models. The transition from divergent to convergent process is defined by the mental model(s). Both (1) and (2) together with mental models may be regarded as one

kind of working process of MSA toward unstructured problem solving.

D. A Brief Summary

The term of "wicked" problems instead of unstructured problems are more popular in social sciences [14]. Actually Rittel proposed IBIS (issue-based information system) to enable groups to decompose problems into questions, ideas and arguments to better deal with wicked problems. Such a term has also been referred by the Advanced Concept Group (ACG) founded at the Sandia National Lab after the 911 crisis. The mission of ACG is to "harness the collective knowledge and creativity of a diverse group to solve perceived future problems of importance to the national security". A report on a summer experiment on computer-mediated group brainstorming at Sandia showed those ACG scientists undertook serious experiments on the best way to solve wicked problems [15]. Table I is a brief summary of reviews in this session. HWMSE is regarded as an advanced state of DSS while humans are elements of HWMSE and play primary roles even as machine systems (traditional DSS) provide intensive support.

TABLE I. PROBLEMS, DISCIPLINES AND PARADIGMS FOR PROBLEM SOLVING

Terms for problems	***Disciplines***	***Problem solving frameworks/ methodologies***	***Support tools***
Unstructured problems	Management science; OR	Simon's decision-making model; PSM,	DSS, GSS, etc.
Wicked problems	Social sciences,	Courtney's framework; IBIS, Soft OR, etc.	DSS, GSS, etc.
Open complex giant systems	Systems science	Meta-synthesis system approach	HWMSE

III. MORE ABOUT META-SYNTHESIS SYSTEM APPROACH AND HWMSE

As more in-depth research on MSA was carried out, explicit explanations of MSA, such as three types of meta-synthesis, using the case of policy making on macroeconomic problems were given for the 1st time [16].

A. A Working Process of MSA

The three types of meta-synthesis denote qualitative meta-synthesis, qualitative-quantitative meta-synthesis and meta-synthesis from qualitative understanding to quantitative validation, which actually indicates a working process of MSA to complex problem solving. Ref [17] discussed how to achieve three types of meta-synthesis by a synchronous-asynchronous-synchronous process while each type of meta-synthesis can be achieved at the respective phase. Activities held in Synchronous Stage I denote to achieve qualitative meta-synthesis, i.e. perspective development or hypothesis generation for meta-synthetic system modeling. Divergent group thinking is the main theme at that stage. Methods oriented to acquire constructs or ideas toward the concerned problems are considered as qualitative meta-synthesis methods. Thus PSM can fulfill qualitative meta-synthesis. Those methods or the technologies such as IBIS define normative frameworks followed by the users. The output (such as ideas, options) are given directly by users; no further computational analysis is conducted toward those logic-based deliberation process.

The aforementioned problem structuring and relevant tools help to apply MSA and the construction of HWMSE. Next we try to understand HWMSE from creativity or knowledge creation and its computerized support.

B. HWMSE - a Knowledge Creating Ba

Meta-synthetic engineering aims to take the advantages of both the *human expert system* in qualitative intelligence and the *machine system* in quantitative intelligence to generate more (new) validated knowledge stored in the *knowledge system*. Human's primary role is emphasized in the problem solving process, where resolutions about unstructured problems are captured via a series of structured approximation. For unknown or new issues, we always call for new ideas which may come from human's imaginary thinking, intuition and insight. Supported by creativity software, sparkling ideas may drop into one's mind. Creative solutions are often related with wisdom. Then HWMSE is expected to enable knowledge creation and wisdom emergence. Ref [18] studied the knowledge creation in macroeconomic problem solved in HWMSE.

Japanese Professor Ikujiro Nonaka proposed the theory about organizational knowledge creation where a right *ba* (a Japanese word) is emphasized [19]. *Ba* is defined as a platform where knowledge is created, shared and exploited; the most important aspect of *ba* is *interaction*. The knowledge-creating process is also the process of creating *ba* [20]. Considering the basic ideas of HWMSE, we suppose HWMSE is an exact *ba* for idea generation and wisdom emergence for creative solutions to the complex issues [8]. Table 2 lists some functions of HWMSE which may be achieved via the 4 different *ba*'s.

TABLE II. ACTIVITIES IN HWMSE BASED ON KNOWLEDGE-CREATING BA [8]

Activities	***Ba***	***Methods and resources***	***Support tools***
Idea generation; confident hypothesizing; wisdom emergence	Originating Ba	Brainstorming, PSM	BBS, socialware, communityware, creativityware
Concept formulation, knowledge creating, scenario generation	Dialoguing Ba	PSM, KJ method, Delphi method, etc.	Creativityware, groupware, collaborationware, communityware, consensusware,
Rigorous validation (qualitative-quantitative meta-synthesis)	Systemati-zing Ba	Domain modeling methods, analytical methods	Modelware, groupware
Meta-synthesis from qualitative understanding to quantitative validation	Exercising Ba	Consensus methods (nominal group technique, AHP, MCDM, voting, etc.)	Modelware, consensusware, collaborationware

(AHP: analytical hierarchy process; MCDM: multi-criteria decision making)

The 1st column of Table II lists the activities related to different types of meta-synthesis; those activities may be carried out at different *ba*'s to enable knowledge conversion by using the methods or resources listed in Column 3. Possible supporting tools which can be elements of HWMSE are given in Column 4. Then to develop those supporting tools and enable their integration to fulfill those tasks or activities as

listed in Column 1 is a practical way to construct a HWMSE. Support for community or group work is a necessity. The technologies of HWMSE are integration or one kind of consensus of a variety of technologies for different tasks with different frameworks applied to the problem solving process.

A variety of explanations about human's creativity exist while creativityware is usually developed based on the cognitive or social nature of creativity. Some extend their basis to knowledge creation model, such as SECI model, which actually indicates a qualitative meta-synthetic framework to develop the supporting tools. Shneiderman abstracted 4 activities, *collect, relate, create* and *donate* for a framework of creativity and proposed 8 specific tasks, searching, visualizing, consulting, thinking, exploring, composing, reviewing and disseminating expected to be fulfilled by creativity software to accomplish those 4 activities [21]. Those tasks may also be applicable to Simon's *intelligence-design-choice* decision making process. Next 2 technologies CorMap and iView for qualitative meta-synthesis are briefly addressed. Each applies different computing mechanism to fulfill some of the tasks stated by Shneiderman toward the ideas created bottom-up.

IV. CorMap and iView: Qualitative Meta-synthesis Supporting Technologies

Both CorMap analysis and iView analysis aim to support qualitative meta-synthesis for confident hypothesizing. The structure meta-data for both technologies is <*topic, userID, text, keywords, time*>. Such metadata indicate the corresponding *userID* submits one piece of *text* (e.g. one comment, one blog, the title of a paper, a reply to one question) with a set of *keywords* under the *topic* at the point of *time*. By word segmentation and filtered feature keywords used in text summarization, or human's processing, ideas and opinions can be transferred into the structured representation. The keywords for a blog may denote the labels or tags of that blog. The keywords are articulated as attributes of the *userID* or the *text*.

A. Basic ideas of CorMap and iView Technologies

Figure 3 show the essential analytics of both technologies. The details are addressed in Ref. [22-23].

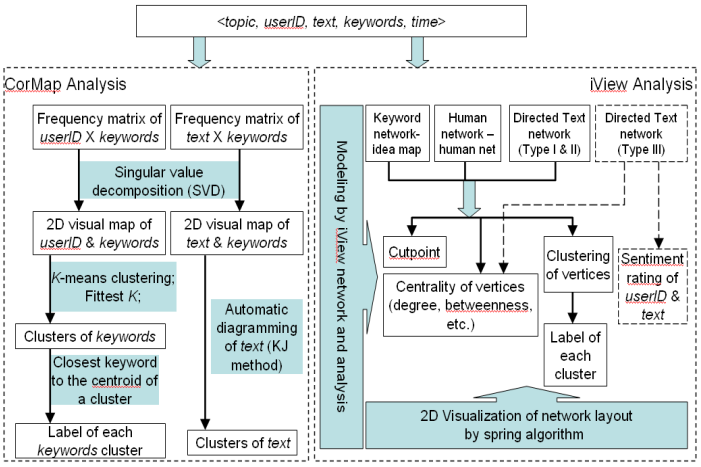

Figure 3. The analytics of CorMap and iView

The CorMap analysis denotes a technology of exploratory analysis of textual data. By conducting a series of algorithms, CorMap analysis actually helps to expose the group thinking structure from one perspective. Such kind of analysis can be applied to any combination of the concerned participants and may help to "drill down" into those community thoughts and detect some existing or emerging micro community. If applied to an individual user, CorMap analysis may help to unravel personal thinking structure.

The iView analysis exposes the group or individual thinking structure from another perspective. The central concept of iView analysis is the iView network which denotes 3 kinds of networks, *keyword network*, *human network* and *text network*. In a keyword network for iView analysis, the link between the vertices (keywords) denotes the co-occurrence of keywords among all *texts*. Such a network is referred as an *idea map* contributed by all participants. This topological network is a weighted undirected network where the weight of edge denotes the frequency of co-keywords. In a human network, the link between vertices denotes keyword-sharing between participants. The strength between two participants indicates the number of different keywords or the total frequencies of all the keywords they share. All three types of text networks are directed networks. The directed link from text *j* to text *i* in Type I text network indicates text *j* cites keyword(s) which originally appear(s) in text *i*. In the text network Type II, the link denotes to cite the closest text including the concerned keyword. In the text network Type III, the semantic meaning of link expands to a variety of attitudes, e.g. oppose, support, etc. instead of the citation of keywords in both Type I & II text networks, then the meta-data needs to include 2 more elements, i.e *attitude* and *reference*. Text network may help to show how the ideas grow and spread. Different algorithms are applied to the text network Type III due to the different semantic meanings of the link, which will be addressed separately. As a matter of fact, the iView network may be regarded as the different projections of a tripartite (text, users and keywords) network. After the projection, we get 1-mode network and apply graph theory method and social network analysis (SNA) methods to network analysis.

B. Features of CorMap and iView Analysis

Either CorMap or iView analysis shows different perspectives toward the same set of data based on different mechanisms with the same aim to acquire constructs of the problems from those textual data for one topic. Both analytical technologies share common features:

- Conduct a variety of transformations or modeling of original textural data sets to expose the hidden structure;
- Visualizing analyzing process to facilitate human's understanding and human-machine interaction. Each step leaves rooms for analysts' direct manipulations.
- Applying a series of algorithms or methods to achieve different goals during a problem structuring process: 1) give a rough imagine of the issue; 2) draw a scenario of the issue using clustering analysis to detect the structure; meanwhile, an optimal clustering is achieved; 3) extract concepts from clusters of ideas. Thus, a

category of concepts instead of a mess of diverse ideas is acquired step by step.

Both technologies can be applied to support qualitative meta-synthesis to wicked problem solving. Due to different mechanisms of each technology, one may perform more effective to human's understanding at one time. It is the analyst to make appropriate use of each technology during the discovery process.

C. *Applications*

Both technologies are under a gradual development as exploited to a variety of mining for complex problem solving.

Group thinking process mining. A group argumentation environment (GAE) has been developed to support sense-making and procedural rationality during group thinking process [8, 24-25]. Fig. 4 shows the iView's keyword network interface about a group meeting on GDP growth using a practical expert discussion system for energy strategic planning unit of Stat Grid in China. The pop-up box shows a list of the betweenness of each keyword. The top 3 keywords of highest betweenness are "investement", "export" and "enterprises".

Conference mining and on-line conferencing ba (OLCB). Results of conference mining may help to expose the main topics of the conferences, interest-sharing community and helpful for paper review assignment to overcome limited rationality. Ref. [26] showed how to understand the topics of knowledge science based on KSS serial symposia. Ref. [27] illustrated the mining to a famous scientific forum in mainland China. The results are helpful to the forum organizers to get governmental support continuously. Furthermore, to push such results to participants may stimulate more active participation, friends-making, etc. The concept of OLCB is then proposed and practiced at the international serial workshops on Meta-synthesis and Complex Systems since 2006 [28]. Fig. 5 shows the keyword network of iView analysis of MCS'2007. Ref. [29] discussed that OLCB is a kind of HWMSE.

Expert knowledge mining. A TCM Master Miner has been developed to expose the common grounds of diagnosis and treatment among the selected traditional Chinese medicine experts to help find the schools of TCM people [23].

Community mind mining. Ref.[30] depicts a successful application of both technologies, especially CorMap to social risk cognition before the Beijing Olympic Games. The CorMap as shown in Fig.6 exposes that social risk cognition between group of age 30-49 and group of age 25-29 group is close, while there is a gap of social risk cognition between group of age above 50 and group of age below 24. Similar results of cognition difference regarding the professions are also explored by CorMap analysis. The application exhibits the potentials of both technologies for social psychological study.

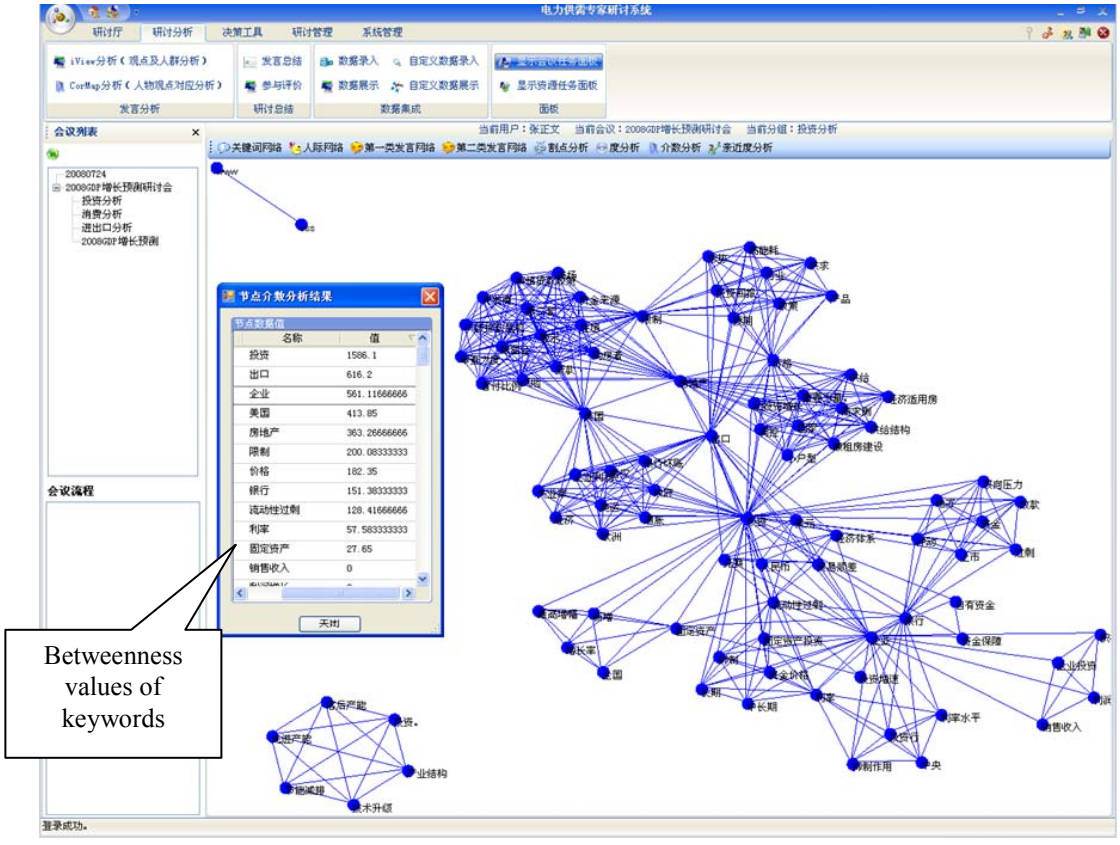

Figure 4. The iView's idea map and analysis about a group meeting on GDP growth with the Expert Discussing System of State Grid

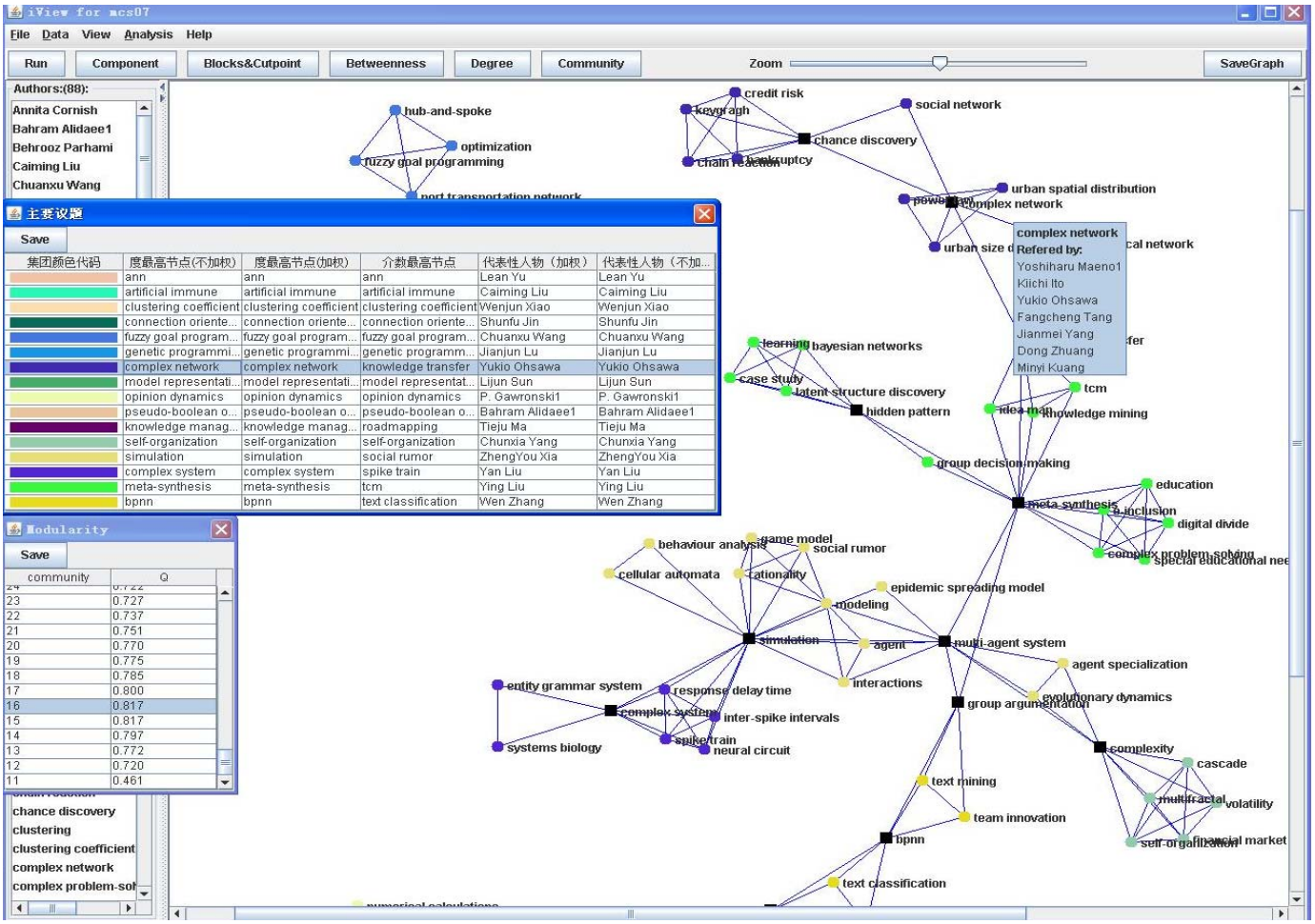

Figure 5. The iView's idea map of MCS'2007 (Black square node: cutpoint) [29]

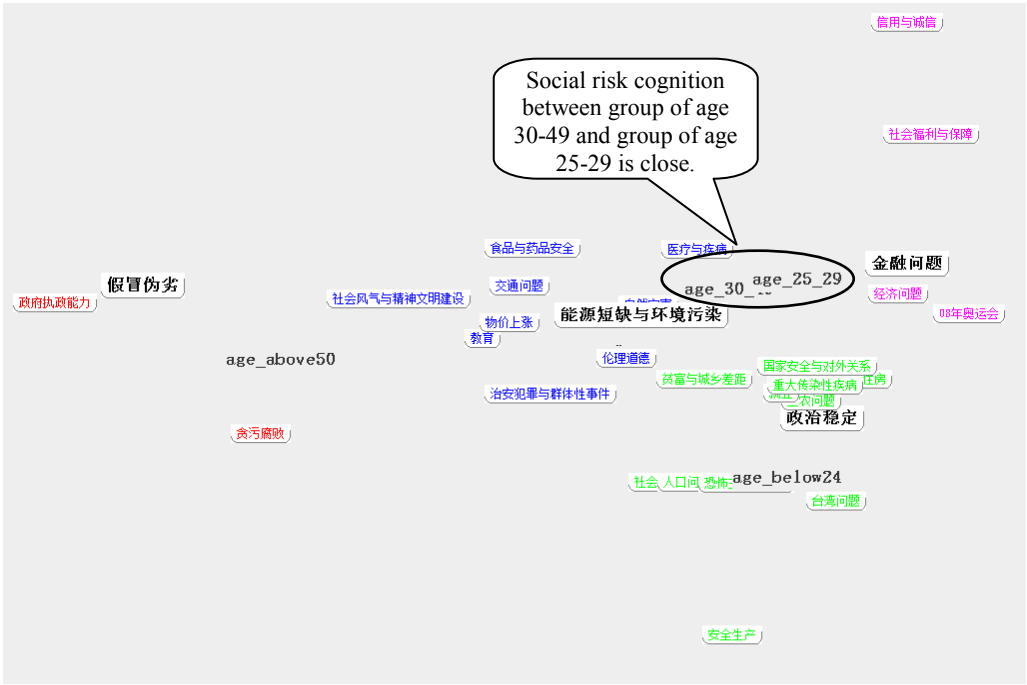

Figure 6. CorMap of the people at different ages and their word association about social risks (4 clusters of words while all words are of 30 categories) [30]

V. CONCLUDING REMARKS

Perplexed opinions toward MSA and HWMSE have been getting along with MSA studies since its existence, especially the focus of many demonstrations of HWMSE is software engineering oriented and lack of explaining how the relevant three component systems interact with each other logically. Too many details about machine system distort the understandings of the capabilities of HWMSE and hinder the exhibition of the power of collective intelligence to complex problem solving using MSA and HWMSE. In this paper, the meanings of MSA and HWMSE are explained by diverse paradigms relevant to unstructured or wicked problem solving and computerized creativity support. Moreover, the lengthy descriptions of those paradigms also reflect the MSA research itself is practice of MSA, which is an interdisciplinary job. From management science to systems thinking, from problem structuring to knowledge creation, from DSS to knowledge creating *Ba,* we try to show the fundamentals of MSA under diverse contexts for better understanding. Technologies for HWMSE are a consensus of emergence of a variety of support for different tasks during problems-solving process based on different paradigms.

The digital revolution greatly decrease the distance between people. In recent years, technologies to facilitate group work, especially those open-source/peer-production technologies (e.g. chat rooms, wikis and blogs, etc.) enable an unprecedented explosion of information sharing which may also be regarded as one kind of information overload. The community brainstorming sessions are of eruption with vast amount of wide ideas or topics created bottom-up even unsystematic. Then PSM or IBIS methodology serve as design rationale to develop technologies for logic-based collaborative deliberation. Such kind of technologies heavily rely on the defined framework which somewhat hinder wider application.

The supporting technologies for qualitative meta-synthesis CorMap and iView take another way. Both conduct exploratory analysis toward those topics or ideas created bottom-up by textual computing and enable facilitation of human-machine interaction by visualizing the analytical process in accord to human cognitive process, which reflects the thinking of those "people problems" instead of avoid of them in pursuit of advanced technologies. Four kinds of application are briefly addressed. Both technologies may be helpful to acquire useful information, such as options, which then may be as the start point during a collaborative deliberation facilitated by the Web 2.0 tools.

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