SOME DEVELOPMENTS IN THE STUDIES OF META-SYNTHESIS SYSTEM APPROACH*

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Abstract

In the early 1990s, Professor Qian Xuesen (Tsien HsueShen) and his colleagues proposed the Metasynthesis system approach for solving the open complex giant system problems. The method emphasizes the synthesis of collected information and knowledge of various kinds of experts, and combining quantitative methods with qualitative knowledge. Later it is evolved into Hall of Workshop for Meta-Synthetic Engineering (HWMSE) which emphasizes to make use of breaking advances in information technologies. Then continuous endeavors have been taken to put those ideas into practice. With tremendous advances in networking and distributed computing technologies, past difficulties in implementation are disappearing together with further understandings of HWMSE and fruitful results achieved in similar or relevant research fields in recent years in China. In this paper some of those development are introduced, together with some parallel research work abroad.

Keywords: Meta-synthesis approach, complex system modeling, decision support systems

1. Introduction

Difficulties confronted in modeling complex systems, such as socioeconomic system, environment system, etc. drove people to rethink the analytical and reductive approaches and explore creative approaches along a system rethinking trend since 1970s (Tomlinson & Kiss, 1984). Relevant system approaches have been proposed, such as Ackoff's interactive planning, Checkland's soft system methodologies (SSM), Mason and Mitroff's strategic assumption surfacing and testing (SAST), etc. Those endeavors reflect the limitations of analytical thinking dealing with human and organizational elements, especially those more "softer" information which had long been neglected during quantitative modeling for unstructured messy problems. Then attentions are paid to oriental philosophy. Pressman (1992) compared both western and eastern system methodologies. Oriental researchers also explore their own methodologies to deal with system complexities, such that the Chinese group led by Chinese

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systems scientist Professor Qian, Xuesen proposed a meta-synthesis system approach toward the open complex giant system based on their classification of system. In this paper, we first review the system classification by Professor Qian, the meta-synthesis approach (MSA) from the qualitative to the quantitative, Hall of Workshop for Meta-Synthetic Engineering (HWMSE), and current application areas of MSA and HWMSE research in China. Then we address the basic research foci in MSA research, i.e. integration and synthesis, which had also been concerned by systems researchers abroad. Some of their research achievements are listed, which to demonstrate the trend of MSA research. Finally some research work of a major project on MSA and HWMSE in China are addressed.

2. Brief Introduction to the Meta -Synthesis Approach

Since 1980s, Professor Qian and his colleagues paid impressive attention to system movement and gave their own thinking about system studies. They started from the basic concept "system" in system sciences and gave their classification about system considering the quantity and interactive complexity of the subsystems within one system, where open complex giant system reflects the most complex and difficult handled system, in 1990.

2.1 Open Complex Giant Systems

The open complex giant system (OCGS) is depicted as one kind of system, where the quantity of subsystems is extremely large; the subsystems have hierarchical structure and complex interrelations within them; finally their energy, material and information exchange are open to outside, self-adaptive and evolutionary. Some examples of OCGS have been analyzed, such as biological system, human brain system, somatic system, geographical system and social system. The research of OCGS problems covers broad disciplines, such as biology, noetic science, medical science, geoscience, astronomy and social sciences. Applying traditional reductionism for exact science does not work well with OCGS problems. So Professor Qian and his colleagues propose the meta-synthesis from the qualitative to the quantitative for OCGS problems (Qian, Yu & Dai, 1993).

2.2 Meta-Synthesis Approach from the Qualitative to the Quantitative

Meta-synthesis approach from the qualitative to the quantitative, or simply as meta-synthesis approach (MSA) is specially designed for solving OCGS problems. The approach has been exacted, generalized and abstracted from practical studies, especially from three complex giant systems, social system, human body system and geographical system. Among those studies and practices, scientific theory is usually combined with empirical knowledge and expert judgment. Firstly, empirical hypotheses (judgment) are proposed, as qualitative knowledge, whose accuracy has to be tested based on models built from empirical data and relevant materials. Through quantitative computation and repeated collation, conclusion is finally reached. The compendious expression about MSA is "confident hypothesis, rigorous validation", i.e. quantitative knowledge arises from qualitative understanding. The approach emphasizes to synthesize the collected data,

information, models and knowledge of various kinds of experts, and to unite scientific theories of various disciplines, human experiences and knowledge. Later MSA is evolved into Hall of Workshop for Meta-Synthetic Engineering (HWMSE), which emphasizes to make use of breaking advances in information technologies to facilitate expert argumentation for a comprehensive modeling about complex problems.

2.3 Hall for Work Shop of Meta-Synthetic Engineering (HWSME)

In 1992 Professor Qian's group proposed the idea for constructing the Hall for Workshop of Meta-Synthetic Engineering as a test bed for MSA for OCGS problems (Wang, et al. 1996). The formulation of idea of HWMSE assimilates both theoretical and practical knowledge, such as seminars, meta-synthesis from qualitative to quantitative approach, C^3I system and war gaming in military sciences, information technology, artificial intelligence, virtual reality, systematology, and other new advanced technologies. It aims to exceed the traditional decision support system (DSS), which is mainly based on computer, by a man-machine hybrid system where people play main role to give judgment for strategic planning and decision analysis. There are three systems in HWMSE, machine system, experts system and knowledge system, where machine system does not only limit to a traditional DSS but refers to a networked system, such as the Internet. Experts system put people as the principal role in HWMSE, and machine system helps people work. For strategic and critical problems, experts are selected based on those information such as background, age, knowledge and experiences stored in experts system. Knowledge system not only consist present knowledge stored by machine and experts systems, but also new knowledge produced within the Hall. Both the experts system and machine system are carrier of knowledge in knowledge system. Then the Hall not only has abilities in collecting, storing, transferring, analyzing and synthesizing information and knowledge, but also abilities for creating new knowledge. A generic framework of HWMSE where are activities taken is shown as in Figure 1, where activities and relations also belong to research in epistemology.

2.4 Meta-Synthesis Methodology (MSM)

MSA can also be referred as a methodology. More than 10-year research by practice in several projects on socioeconomic problem, military system, etc. enabled rapid progress on MSA studies in recent years along with the tremendous achievements in networking technologies and more concerns in complexity research. Currently, more focus is on how to implement the meta-synthesis of three levels, information, knowledge and wisdom. Yu and Tu (2002) give a comprehensive introduction about MSM together with a case in macro economy decision analysis. Actually, the evolution of meta-synthesis absorbs ideas from meta-analysis methods; while the former emphasize the synthesis from different disciplines (Qian, 2001). Generally, there are three phases during MSA toward complex problems, (a) qualitative meta-synthesis; (b) qualitative and quantitative combined meta-synthesis, and (c) meta-synthesis from the qualitative to the

quantitative. During the practice, a lot of methods, tools, and models, which are support resources in HWMSE, will be applied for a variety of complex system problems. A typical case of applying MSM for strategic planning and system design is referred as overall-design group, such as that in aerospace programs. Next we list some MSA research and practices areas in China.

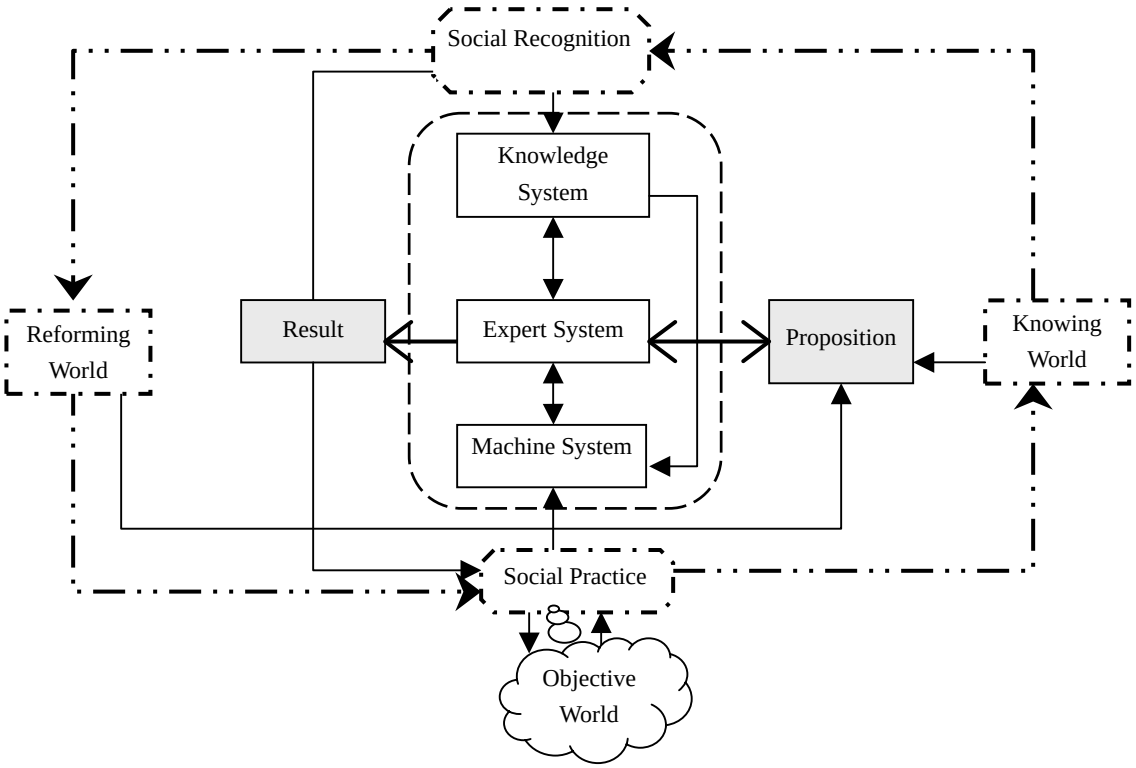


Figure 1. Generic framework of hall for workshop of Meta-synthetic engineering

2.5 Applications of MSM

There are a lot of applications of MSM, most of them started from system engineering practices. Here list some principal application fields or projects.

(1) Social System Engineering: Development Strategy (national, regional) (Qian, 2001)

(2) Economic System Engineering

- Forecasting, pre-warning and monitoring of national macro economy (Yu & Tu, 2002);
- Synthesis research about the financial subsidy, price and salary in China (Qian, Yu & Dai, 1993);
- Man-machine meta-synthetic system for macro economic decision making (major project supported by Natural Science Foundation of China, 1999-2003) (NSFC, 2001)

(3) Military System

- Defense system analysis (Wang, et al. 1996) (Chapter 6)
- HWMSE for space-military system (HWMSESMS) (Qi, Li & Chang, 1999);

(4) Earth and Environment System
- Research on sustainable development and coordination between population, economy development, environment and ecology (Yu & Yuan, 2002; Gu, 1998)
- Development of oil field (Chen & Wang, 2002)

(5) Information and Intelligent System
- Pattern recognition of handwritten Chinese characters (Xiao, Wang & Dai, 2000)
- Information sharing system for sustainable development of China (see http://www.sdinfo.net.cn/)

(6) Evaluation and Consultation
- Science and Technology Consulting System(http://www.gctech.com.cn/anli/anli.htm)
- Evaluation for major projects (Yang & Du, 2002; Hu & Li, 1998)

(7) Others (Gan, Chen & Wang, 2001; Hu, 2002)

In recent years, more and more concerns have been giving to meta-synthesis research in China and those hot areas are mainly around OCGS problems, such as geographical system, social and economic complex problems, and information system for complex system. That is also along the international trends on similar research, even which may not be titled as meta-synthesis. Next section we address some typical relevant research by international peers before a further introduction about our current NSFC major project.

3. Relevant Meta-Synthesis Research Abroad

Only a few references about meta-synthesis could be observed as Professor Qian proposed meta-synthesis methodology 13 years ago; while more emerges within recent five years. Those relevant research fields cover similar complex problems stated above, such as
- Geographical System focused on Global Change and Environmental Problem
- Social problem
- Physical systems
- Health care and education.

A lot of examples can be found in Gu & Tang (2002). Here we list some projects or relevant fields:

3.1 Some Scientific Programs on Meta-Synthesis

(1) Synthesis of Science (Japan, 1997-2002)

One of "Research for the Future Program" supported by Japan Society for the Promotion of Science (JSPS), the project "Synthesis of Science" aims at overcoming the problems resulting from the territorialization of engineering knowledge, which is a big factor counterproductive to the optimization of product design, manufacturing, maintenance, renewal and safety. Such excessive territorialization also leads to increased social costs, system vulnerability, and environmental deterioration. Synthesis, on the other hand, requires the formation of a comprehensive system of knowledge applicable across all domains. A total of more than 2 billion yen research funds have been inputted. A methodology of collaborative synthesis is explored from the view of artificial intelligence, mainly by ontology engineering so as to systemize knowledge for synthesis. The main application is on the design and production of industrial product (Kitamura, et al., 2002);

(2) ENSEMBLE Project for Emergency Management (European Commission, 2000-)

Supported by the European Commission DEG-RES nuclear program since 2000, the ENSEMBLE project focuses on methods to reconcile disparate national forecasts of medium and long-range atmosphere dispersion. This project addresses the problem of achieving a common coherent strategy across European national emergency management in correspondence to modeling long-term transport of debris emitted from nuclear accidents, especially when national long-range dispersion forecasts differ from one another during an accidental atmospheric release of radioactive material. It aims to develop new decision-making "ENSEMBLE" procedures and web-based software tools for real-time reconciliation and harmonization of dispersion forecasts from meteorological and emergency centers across Europe during an accident. A web site has been set up for this project (ensemble.ei.jrc.it) and achievements had been reported in an international workshop on complex system modeling held in Vienna in July of 2002 (Bartbnicki, et al. 2002).

(3) Analytic Techniques for Qualitative Metasynthesis (USA, 2000-2005)

Funded by National Institute for Nursing Research, National Institutes of Health (NIH) in USA, the project “analytic techniques for qualitative metasynthesis” aims to change the situation of relative absence of efforts to integrate the findings from qualitative research in health field, whose findings contain information on the subtleties and complexities of human responses to disease and its treatment that is essential to the construction of developmentally and culturally sensitive instruments to appraise health conditions and appropriate interventions to improve them. The short-term goal of the project is to develop the analytic and interpretive techniques to conduct qualitative metasynthesis projects and provide to researchers and practitioners with useful form of those findings to matter. The long-term goal is to enhance the utilization of qualitative findings as a basis for research and practice. The specific focus in this research is on women with HIV/AIDS since a sufficient number of qualitative studies exist to warrant metasynthesis and it is a field of great significance to women's health and nursing practice (Sandelowsk & Barroso, 2000).

Actually, the project still focus on research reviews and synthesis, where applied meta-analysis method, which had been helpful to Professor Qian’s thinking on the meta-synthesis from the qualitative to the quantitative. The development of research synthesis is similar to the MSA development. At first people used the qualitative approach, i.e. traditional narrative reviews, then a quantitative approach, meta-analysis, was proposed. ***Meta-analysis*** is a statistical method of research integration, which can quantitatively integrate and analyze the findings from all the empirical studies relevant to an issue and amenable to quantitative aggregation. Meta-analysis has several advantages over traditional narrative review. It not only shows the direction of the effect of treatment, but also quantifies the effect and identifies the moderator variables. In a meta-analysis, findings from different studies are expressed in terms of a common metric

called the effect size. However meta-analysis gives more weight to studies with multiple results while ignores studies for which the effect size cannot be computed. To overcome the limitations of both methods, Slavin (1986) proposed the method of "best-evidence synthesis" which theoretically draws the strengths from both methods. It does not prescribe a rigid set of criteria for selecting the empirical studies; the statistical analysis is supplemented with a rich literature review, which explains any discrepancies observed, and summarizes the results, which cannot be quantified. The fourth kind of research synthesis is interpretive synthesis, including such as "reciprocal translational synthesis", "refutational synthesis" and "lines of argument synthesis". The main idea of such kind of methods assumes that synthesis of qualitative research should be interpretive rather than aggregative. They consider the findings of individual studies. The purpose of these methods is not to generate predictive theories, but to facilitate more understanding of the phenomenon, context or culture under consideration. Finally Suri (2000) argues that each of those four methods has their own strengths and weakness, so she suggests that a *comprehensive research synthesis* should include quantitative as well as qualitative research findings. The process of synthesizing research should be inductive and interpretive rather than a rigid set of procedures and techniques.

Above are some projects which are relevant to meta-synthesis research. Lots of relevant research had been undertaken in fields like artificial intelligence, decision support systems, systems engineering, etc. In Russia, there is even a MetaSynthesis corporation for consulting. They have used a methodology of conceptual analysis and design of organizational control system, which permits to analyze the complex objects from different views and to synthesize procedures for getting the solutions reduced to new strategies.

3.2 Other Relevant Research or Methods on Synthesis and Integration

(1) Synthesis of Distributed Expert System (DES)

Distributed expert system (DES) is an important research in artificial intelligence. It is one of technologies in distributed artificial intelligence (DAI) systems. Zhang & Zhang (1999) fulfilled systematic research work on synthesis of distributed expert system (DES), and systematically summarized the potential synthesis cases, methodologies and strategies of synthesis of solution in DES. Four potential synthesis cases in DES: conflict synthesis case, inclusion synthesis case, overlap synthesis case and disjoint synthesis case are identified, and four types of DES: homogeneous DES, partially homogeneous DES, partially heterogeneous DES and heterogeneous DES, are defined. The necessary conditions of synthesis strategies in different synthesis cases are recognized. They gave the measurements for synthesis strategies, and proposed two methods for designing synthesis strategies in DESs: analysis method and induction method.

(2) Integration in Probability Risk Assessment (PRA)

Proposed by NASA in the 1950s probability risk assessment (PRA) is a set of methods, also as a methodology for assessing the safety of

large complex systems, such as space programs and nuclear power stations. In the earlier time the study on the safety of those systems was based on the qualitative analysis of possible risk factors, such as fault mode and effects analysis (FMEA), hazard analysis (HA). Later, quantitative analysis methods are applied, such as fault tree analysis (FTA). Both quantitative and qualitative analysis methods are included in PRA, which is an integration of FMEA, FTA and other techniques to assess the potential for failure and to help find ways to reduce risk (NASA, 2000). PRA has well applied to nuclear safety analysis and got a lot of achievements. While due to poor performance of PRA in the estimation of risks for the Apollo Space Program, NASA stopped using PRA in 1960s until the accident of Space Shuttle 'Challenge' in 1986. We think PRA reflects the essential ideas of MSA. In PRA, the analysis is based on the data, information, knowledge and models. Finally, expert's opinions will be collected (NASA, 1995; Zhao, 2000). The important reason of applying meta-synthesis in risk assessment for space program is that the real test data are not enough or even not available for statistical risk analysis. As usual, only a few of real data can be acquired from space program tests, then some substitute data, e.g. data in whole system tests under incomplete conditions, data in subsystems tests, or even from other similar space programs (the previous programs or references from similar tests in other countries), will be in use. However, sometimes those data are still not enough for analysis. Then mathematical models or simulation are applied to produce some data. If conclusion is still not well reached, a group of experts are asked to estimate the risks. European Space Agency (ESA) had applied the expert's judgment in risk assessment for their space programs (ESA, 1991).

(3) Knowledge Management System toward a Sustainable Society

In the end of 1980s, a Japanese system scientist Professor Y. Sawaragi and his students proposed the *Shinayakana* systems approach (Sawaragi, Nakayama & Nakamori, 1988). During the development of a decision support system or complex problem solving, three *I*'s, interactive, intelligent and interdisciplinary, are required. Interactive means human-computer interaction. Intelligent means knowledge required. Interdisciplinary asks solving the problem with different experts from multiple disciplines. In regard to researcher's attitudes, three *H*'s are recommended: honesty in modeling the reality, humanity in designing support systems, and harmony within the research group (Nakamori, 1989). In the middle of 1990s, one of Professor Sawaragi's students Professor Nakamori and his colleagues engaged in applying *Shinayakana* approach to constructing the environment framework model, which provides integrated knowledge on environment problems in the form of matrix system (Nakamori, Kusube & Morita, 1996). Model integration is emphasized. It is assumed that a lot of models developed by researchers who located in different sites, then a system is necessary to be developed to integrate models via network (Nakamori & Sawaragi, 2000). Also they thought to integrate knowledge and information since mathematical models were not enough to solve the global environmental problem. They paid attention to the knowledge and the integration on utilization of the

knowledge and judgment of experts in relevant fields. Later Professor Nakamori proposed the ***i*-system** (Figure 2) which can be called as a knowledge-creating system as he moved to school of knowledge science, Japan Advanced Institute of Science and Technology and began to combine Nonaka's knowledge-creating theory with system sciences (Nakamori, 2000). The *i*-system integrates statistical data and individual's fragmentary knowledge, and then creates new knowledge; therefore the system enables a process to convert tacit knowledge into explicit knowledge. It has five subsystems: intelligence, imagination, involvement, integration and intervention. Here we think *i*-system is a meta-synthetic engineering system, which includes knowledge system, machine system and expert system. Now, *i*-system has been applying to the environment system in Ishikawa and environment business, where it can be referred as a *meta-synthesis* environment system.

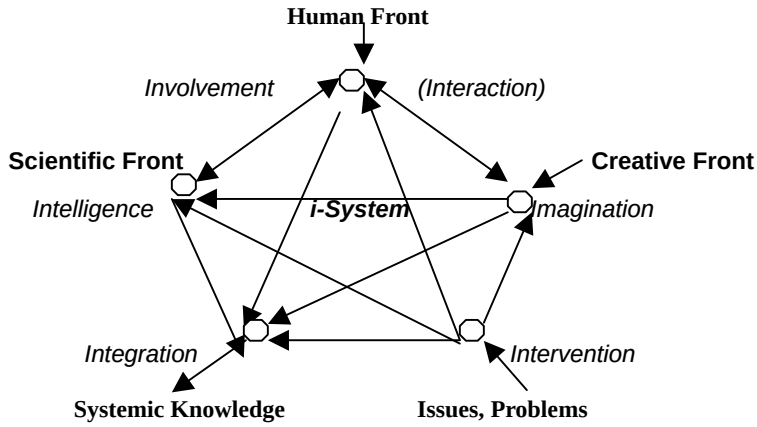


Figure 2. The framework of *i*-system

Tremendous advances in information technologies drive a trend of integration and synthesis and have been resulted so many achievements. On the other side, deep thinking in systems provides a framework of meta-synthesis. Next we address our undergoing NSFC project on a demo of HWMSE for macro economy decision making.

4. Introductions of NSFC Major Project on Meta-Synthesis Approach

In 1999, Natural Science Foundation of China (NSFC) approved a 4-year major project engaging to implement a pilot HWMSE prototype for macroeconomic decision making under a budget of 5 million *yuan*, the largest investment for individual project by NSFC. Around 50 researchers from 14 nationwide research institutes or universities are involved after several rounds of peer and expert reviews. Those people are separated into 5 groups or subprojects: Group 1. HWMSE platform; Group 2. macroeconomic modeling; Group 3. meta-synthesis method and macroeconomic method research; Group 4. knowledge discovery, data-mining and cognitive process analysis of macroeconomic decision making; Group 0: overall system design, to facilitate coordination

of those 4 groups' work and communications between NSFC and this project (NSFC, 2001).

During the project application period, the leading investigators of the projects proposed two questions for Group 3 people. 1) How to integrate experts' opinions especially when those opinions are so different and conflicted during debates? Referred as *opinion synthesis issue*; 2) How to integrate current operable models and to construct new models for unknown problems? Referred as *model integration issue*. Next studies on above-mentioned two issues by Group 3 are introduced.

4.1 Model Integration

Modeling is a pervasive activity which manifests itself in nearly every discipline. Different people develop various models for various problems or systems. Effective decision support calls for integration of different models about different components so as to construct a comprehensive scenario about a larger system. The potential significance of research findings in model management extends well beyond the sphere of operations research and management sciences or any other patent model-based fields (Krishnan & Chari, 2000). Model integration is regarded as an extension of model management; while the former extends the scope of the latter, especially in practice as a result of increasing complexities which had been continually perplexed people along the socioeconomic and environmental development.

Tang (2001) reviewed the model integration research and summarized three approaches, top-down, bottom-up (or distributed), and systemic approach, toward implementation of model integration. By top-down approach, a comprehensive model about the concerned problem should be clarified so as to decompose the problem efficiently. Top-down architecture reflects a centralized mechanism to divide-and-conquer for problem-solving. A generic, common sense framework is pertinent for the concerned problem during the implementing model integration. Ontological engineering contributes much. Bottom-up approach reflects *distributed* and *decentralize*d activities during implementing model integration and management. Such kind of approach overcomes the limitations in model resources for integration and expands the scope of integration activities, especially when it is hard to acquire a standard architecture for integration. However, applying bottom-up approach still needs some higher-level framework. The third approach to model integration is systems thinking towards the concerned problem itself, i.e. systemic approach, which calls for more attentions beyond technology issues, especially for practical problem solving. Bhargava & Krishnan (1993) indicate 4 issues worth deep thinking: a) *cognitive issues*; b) *language issues*; c) *system issues*; and d) *empirical issues*. Issues a) and d) have been largely ignored by current concerns of the theoretical methods about model integration, while referred by systemic approach. The resolution of those kinds of issues had been realized not quickly achieved; instead, a learning process is usually involved. Those three approaches reflect the evolutions of perspective towards model integration, from process-oriented to problem-oriented, and from analytical thinking to synthetic thinking. More and more social and organizational factors have been considered in modeling process.

Collaboration, especially dealing with those subjective factors has been gradually becoming an important focus during integration. Thus model integration is based on results of opinion synthesis.

The integrated modeling environments (IME) facilitate the process of model integration. DecisionNet and DOME (Distributed Object-based Modeling and Evaluation) are two typical examples. As a typical example for bottom-up approach, DecisionNet is a collection of decision analytical tools, aims to improve the usability, interoperability and reusability of decision technologies by exploiting these strengths of Web technologies. Initially its application is on combat simulation, and now moves to electronic commerce (Bhargava, Krishnan & Muller, 1997). Advances in software engineering and distributed artificial intelligence and the quick development of Internet technology invigorate model integration research. In our project, an agent-based framework of macro-economic models integration which is similar to DecisionNet (Hu & Wang, 2001).

Research on opinion synthesis issue is mainly around two areas. One is the synthesis method; the other is the approach to synthesizing process. Above has addressed some synthesis research. Here we only give achievements on meta-synthesis system reconstruction.

4.2 Meta-Synthesis System Reconstruction

Professor Klir proposed reconstructability analysis (RA) in 1976. The purpose of RA is to deal with the various problems that emerge from the relationship between systems perceived as whole and their various subsystems. RA is thus connected with the issues of wholeness. Identification and reconstruction are two principal problems in RA. Identification concerns with a given structure whose elements are viewed as subsystems of an unknown overall system. It aims to make meaningful inferences about the overall system from information in the subsystem and possibly some additional background information. Reconstruction deals with a given overall system and aims to break the system into subsystems as small as possible, which are adequate to reconstruct the overall system with an acceptable degree of approximation, solely from the information contained in the subsystems. Shu (2001) combines this analysis with metasynthesis and proposed *meta-synthesis reconstructabilty analysis*, which can integrate the data, information, models and knowledge; and is applied to forecasting the growth rate of GDP in China. It is shown that the precision of forecasting is improved as considering the knowledge from experts.

4.3 Computerized Support for Synthesis Process

The process of synthesis of different perspectives mainly refers to process of synthesis of data, information, models, knowledge, and even wisdom. The working process of synthesis of perspectives is usually undertaken via a serious of group activities, mainly for communications, collaborations and conclusion or consensus. Figure 3 illustrates a

kind of organizations of those activities. Within such a synthesis process, new knowledge may be created for resolution of issues based on group work.

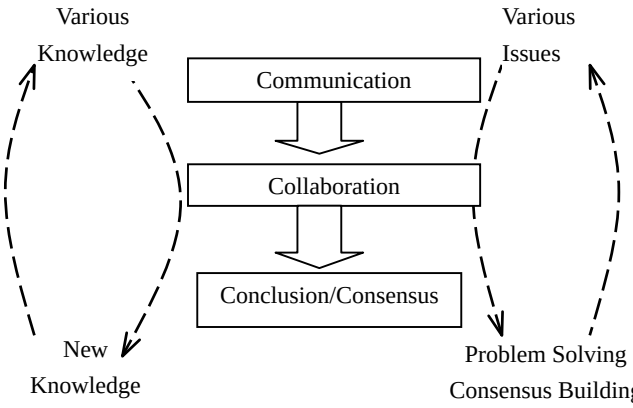


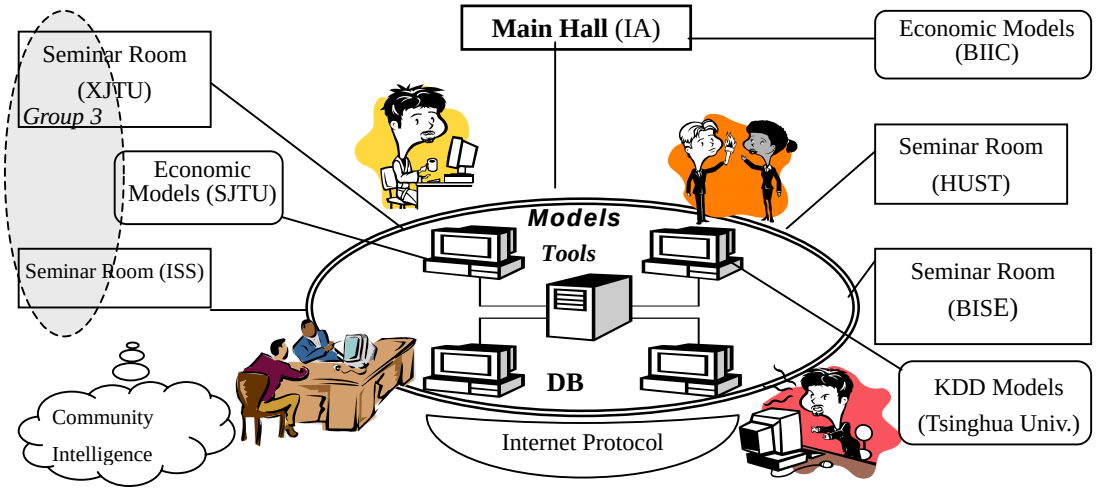
Figure 3. C^3 type process

Computerized tools are mainly around those three C's. To achieve the ideas of HWMSE, more attentions are given to computerized support for group activities, especially for group thinking, group argumentation, and group decision. Several environments support those group activities are developed, such as *Electronic Common Brain* (Cheng & Zhang, 2001) and *Group Argumentation Environment* (Tang & Liu, 2002).

After 2-year research and development, lots of achievements had been reached according to the original working plan submitted to NSFC. Several models for macro economy had been developed and tested. Methods for synthesizing experts' opinions, such as Delphi, analytical hierarchy process (AHP), etc. are also programmed into modules. At a mid-term summary meeting in the end of 2001, it was found that at least 4 meta-synthetic halls had been developed. Factually, the construction of Hall is the principal task for Group 1. Due to respective research focus, other groups also develop some simple halls to demonstrate the process from qualitative meta-synthesis to quantitative meta-synthesis, such as method group (Group 3) and KDD group (Group 4), and most of those halls support brainstorming, Delphi, and AHP. Then a crucial problem cannot be avoided, how to integrate all ready work into a whole for the sponsor. Different views have been existing toward this problem since the start of the project. That is why no detailed overall design of integration proposed from the start. Systemic thinking and WSR approach had been given towards the issue (Tang & Gu, 2002). Here are some brief ideas.

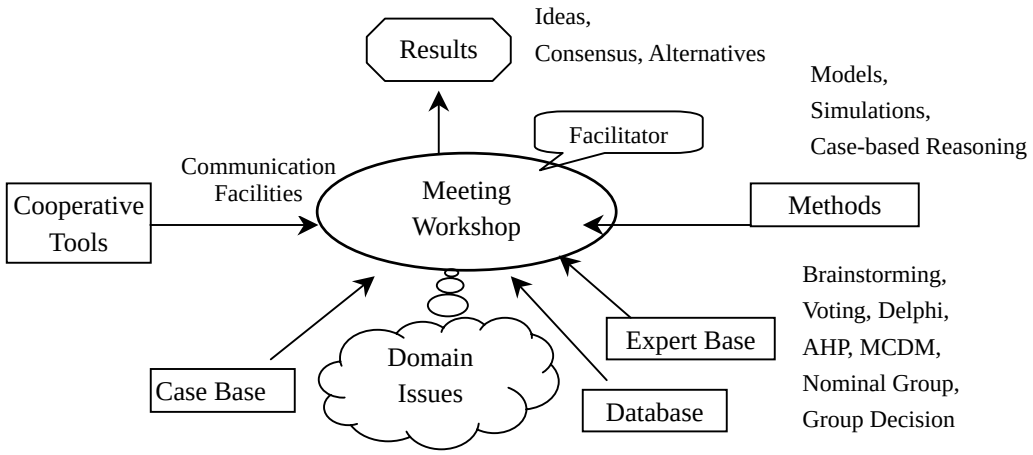
4.4 Framework for HWMSE in the Major Project

Figure 4 displays our proposed framework for HWMSE in this project. Such a framework adopts ideas from Decision Net. HWMSE is for a process from qualitative understanding to quantitative knowing which includes both analysis and synthesis technologies.



BIIC: Beijing Institute of Information and Control; BISE: Beijing Institute of Systems Engineering; HUST: Huazhong University of Science and Technology; IA: Institute of Automation; ISS: Institute of Systems Science; SJTU: Shanghai Jiaotong University; XJTU: Xi'an Jiaotong University.

Figure 4. A framework for HWMSE



MCDM: multiple criteria decision making

Figure 5. A meeting template in HWMSE

According to current achievements from all members of the project, there will be at least 5 discussion spaces to the end of project. Just like most convention centers in reality, a web-based convention center (Hall) specific for various workshops can be constructed. Group 1's platform is the main hall or master room of the 'building'. Other platforms are general rooms for workshop. Macro economy models can be stored in either main server where to run those platforms or those independent and distributed servers. As opinions synthesis tools support

different meeting styles and each discussion room has special tools, administrators of each discussion room will recommend appropriate rooms for meeting organizers. Sometimes, organizers select one room while meeting template is not available, there are two solutions based on current situations. One is to move to available rooms; another is to remote use of tools or templates in other rooms or other independent servers. Ideally, users do not know where those resources exist, only organizers set up a virtual room with necessary resources for problem discussion.

Figure 4's framework is applied to the integration of their exploring results in Group 3 people. The template of a meeting utilizing HWMSE resources for macro economy problem is shown in Figure 5. Various models can be regarded as resources for experts during discussion and debates within the Hall.

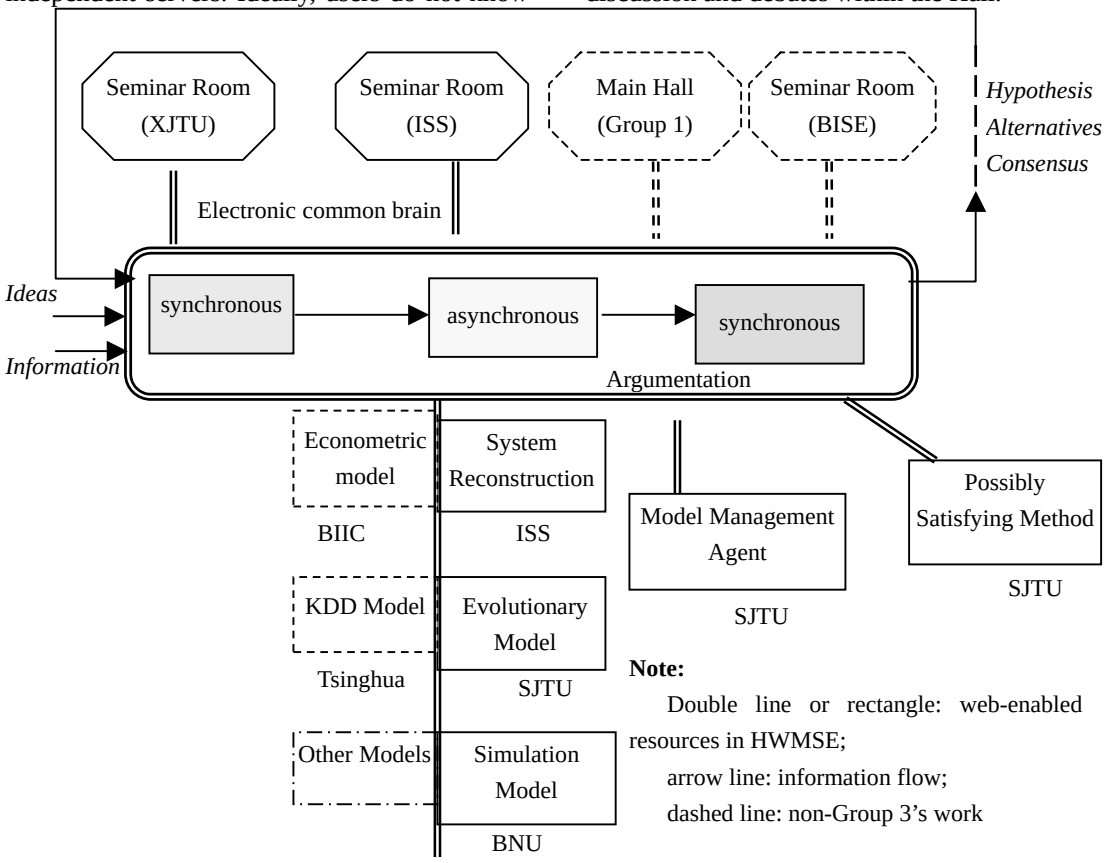


Figure 6. A working process in HWMSE

To deal with unknown problems, expert meetings will be organized. Expert base will provide basic background for meeting organizers, who usually serve as facilitators during the meeting. All participants make full use of resources such as communications facilities, cooperative tools, models and methods to support relevant activities during the argumentation process, such as review all topics, propose own arguments, call accessible models

to analyze interested arguments, etc. If for a convergent decision process, voting, Delphi, AHP, etc. may be used to achieve some consensus toward concerned issues. If for divergent thinking process, brainstorming template is applied for idea generation. Figure 6 depicts a possible working process in HWMSE.

5. Concluding Remarks

Along with the meta-synthesis system approach proposed in 1990, system research in China goes further and wider. Due to the complexity of open complex giant system, only traditional reductionism methods could not meet the requirement for problem solving, which has also been acquired along the system rethinking trend. With the revolutions in information technology and entering knowledge-based economy era, meta-synthesis approach is becoming more and more a necessity towards knowledge creation and technology innovation for complex issues, which had been exhibited among the recent scientific programs or fields addressed in this paper.

This paper presents main ideas of Group 3 of NSFC major project on demonstrating HWMSE for macro economy decision making. We focus on basic solutions towards main issues and methods supported for whole system design and implementation in this major project. Main issues include model integration and opinion and knowledge synthesis. And agent-based technology is applied for distributed model integration. To achieve the ideas of HWMSE, more attentions are given to computerized support for group activities, especially for group thinking, group argumentation and group decision. Several environments support those group activities are developed, such as *Electronic Common Brain* and *Group Argumentation Environment*, which serve as distributed discussion rooms within the Hall. Various models can be regarded as resources for experts during discussion and debates within the Hall.

Obviously, our current on-going work only exposes some strength of HWMSE support for complex problem solving. However, what had been reported also shows the great potentials for further intensive research on meta-synthesis approach. More commonly, MSA is regarded to deal with unstructured messy problems. Even DSS aims for unstructured problems, HWMSE can fulfill all functions of DSS while more emphasis on knowledge creation and creative activities based on wisdom and intuition. Lot of explorations need to be undertaken.

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