

# TOWARDS META-SYNTHETIC SUPPORT TO UNSTRUCTURED PROBLEM SOLVING \*

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## **Abstract**

Decision Support System (DSS) aims to provide effective support for solving unstructured, ill-structured or wicked problems as its initial emergence in the late 1960s. The ever-lasting complexity which exists in social world brings a great deal of uncertainties in human activities, mainly for decision makers who are in morass of overwhelming flow of data, information and knowledge but still lacks effective knowledge support. And “people problems” are key reasons of unimplemented goals of DSS instead of technology-related problems, and sometimes increase uncertainties to decision making process. Due to much complexities in those problems, Chinese system scientist Qian Xuesen (Tsien HsueShen) proposed meta-synthesis method to tackle with open complex giant system (OCGS) from the view of systems in the early 1990s. Here, we regarded problems relevant to OCGS are ill-structured or wicked problems. The essential idea of meta-synthesis approach (MSA) can be simplified as “confident hypothesis, rigorous validation”, i.e. quantitative knowledge arises from qualitative understanding. Later MSA is evolved into Hall of Workshop for Meta-Synthetic Engineering (HWMSE) which emphasizes to utilize breaking advances in information technologies.

In this paper, we adopt a new paradigm of decision making in a DSS context, which emphasizes the synthesis of perspectives towards problems description and analysis, and actually reflects meta-synthetic support for decision making. Moreover, the HWMSE is a test bed of meta-synthetic support for ill-structured problem solving. Then a simple demonstration on building meta-synthetic support tools for weapon system comprehensive evaluation is given. Those tools mainly fall into two categories: analytical tools for qualitative-quantitative meta-synthesis and argumentation tools for qualitative meta-synthesis. Further research endeavors are also indicated.

**Keywords:** meta-synthesis, decision support systems, system analysis and demonstration

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## **1. Introduction**

Decision Support System (DSS) aims to provide effective support for solving unstructured, ill-structured or wicked problems as its initial emergence in the late 1960s. Currently DSS serves as a great umbrella which covers a lot of terms or products, such as intelligent DSS, group support system (GSS), groupware, computer supported collaborative work (CSCW), knowledge-

based support system, etc. The ever-lasting complexity which exists in social world brings a great deal of uncertainties into human activities, mainly for decision makers who are in morass of overwhelming flow of data, information and knowledge from an increasing number of support tools but still lacks effective knowledge support. In 2002, the major journal, Decision Support Systems, published a special issue, “DSS: directions for the next decade” edited by Carlsson and Turban (2002).

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In witness of “an unparalleled digital revolution”, the special issue studied the problems of those unimplemented goals of DSS and indicated directions for the next decade. Among those problems, “people problems”, which may refer to human’s limited capacity in cognition, subjective prejudice and world views, and belief in experts, are key reasons instead of technology-related problems. Then those human problems can bring or increase uncertainties to decision making process. Even we suppose those uncertainties can enable a structured problem into ill or unstructured problem, or a tame problem into wicked problem.

That is why DSS studies have never faded and new approaches or methodologies are always in the light of research, especially to deal with those people problems. In parallel to many western schools in approaches and methodologies for unstructured problem solving (Tomlinson & Kiss 1984; Flood & Jackson, 1991; Rosenhead & Mingers, 2001), eastern inquiry modes are studied and new system approaches have also been forwarded based on comparisons between western and eastern system thoughts by oriental system scientists. Meta-synthesis approach (MSA) is one of those approaches proposed by a Chinese system scientist Qian Xuesen (Tsien HsueShen) to tackle with open complex giant system (OCGS) from the view of systems in the early 1990s (Qian, Yu & Dai 1990; Qian, 2001). Here, we regarded OCGS problems are ill-structured or wicked problems. The essential idea of MSA can be simplified as “confident hypothesis, rigorous validation”, i.e. quantitative knowledge arises from qualitative understanding, which reflects the process of knowing and doing in epistemology. The approach expects to unite organically the expert group, data, all sorts of information, and the computer technology, and to unite scientific theory of various disciplines and human experience and knowledge, for both proposing hypothesis and quantitative validating. Later it is evolved into Hall of Workshop for Meta-Synthetic Engineering (HWMSE) which emphasizes to make full use of breaking advances in information technologies (Wang, 1996).

In this paper, some DSS trends are briefly reviewed. A new paradigm proposed by Courtney for DSS is discussed to reveal that the synthesis of perspectives towards problems description and analysis in the paradigm is actually oriented to meta-synthetic support

for decision making, based on “decision-making is becoming more *pluralistic* and less hierarchical, determined not so much by position in the organizational hierarchy but much by the *argumentative* and *evidential* values”. HWMSE is a test bed of meta-synthetic support for ill-structured problem solving. Then a simple demonstration on building meta-synthetic support tools for weapon system demonstration and comprehensive evaluation is given. Those tools mainly fall into two categories: analytical tools for qualitative-quantitative meta-synthesis and argumentation tools for qualitative meta-synthesis. Further research endeavors are also indicated.

## 2. Meta-synthetic Support along the DSS Trends

### 2.1 A Glimpse on DSS Developments

Shim et al. (2002) reviewed the agenda by Keen (1987) “for the next decade of DSS” and also looked ahead to the year 2007. There are also other prospects about DSS in the future. Here, some DSS trends based on the original DSS data-model-interface framework briefly listed in Table 1.

**Table 1** A Glimpse of DSS Development

<i>DSS Components</i>	<i>Development Highlight</i>
Data System	Data warehouses, OLAP, data mining, web-based DSS
Model System	Optimization-based; Modeling paradigms;
Interface / Technology	Visualization, Personalized/Customized Application, Intelligent Agents,
Knowledge System	Intelligent Systems; knowledge management; knowledge creation;
Decision-making models	Simon’s Model; Multiple Criteria Decision Analysis Problem structuring methods System approaches

Actually e-commerce, supply chain or business applications are versatile support products for relevant decision making. Here we do not try to cover all relevant

topics but just try to review DSS from its basic components. Knowledge component was not among the original framework of DSS; while the adoption of concepts of experts system into DSS for qualitative-quantitative aid brings knowledge system as a basic component as DSS. Currently, knowledge-intensive support can be sensed anywhere for decision-making. Knowledge system is no longer a simple component but serves as ubiquitous intelligent aids to decision making.

However, another large category of DSS is not listed in Table 1. That category is relevant to group work instead of individual work. Groupware, group DSS, CSCW, computer mediated communication system (CMC), etc. fall into this category. Those tools are mainly supports for communication, collaboration and consensus building of group activities. Actually, group support systems (GSS) replaced GDSS since the mid of 1990s because of more emphases on communications and information sharing among group work. Most products with knowledge management brands also belong to this category. While there is another category of support tools for group work, i.e. for argumentation and sensing-making for problem structuring. Lots of tools had already been explored, such as Dialog Mapping (gIbIS based, QuestMap) (Conklin et al. 2001), Decision Explorer and Group Explorer based on Strategic Options Development and Analysis (SODA) (Eden & Ackermann, 2001), Augmented Informative Discussion Environment (AIDE) (Mase, Sumi & Nishimoto, 1998). Those tools are all based on specific metal models about group thinking or decision making, which indicates that research on metal models and cognitive models about decision making or problem structuring approaches play very basic roles in DSS research.

The trend of GSS reflects that decision-making is becoming “more *pluralistic* and less hierarchical, determined not so much by position in the organizational hierarchy but much by the *argumentative* and *evidential* value”, which is also supported by new decision paradigm for DSS proposed by Courtney (2001).

## 2.2 New Decision Paradigm for DSS

The salient feature of Courtney’s paradigm as shown in Figure 1, in comparison to traditional decision models in a DSS context, is the development of multiple perspectives during problem formulation phases, where technical (T), organizational (O) and personal (P) perspectives are suggested by Mitroff and Linstone(1993). Ethical and aesthetic factors are also in consideration.

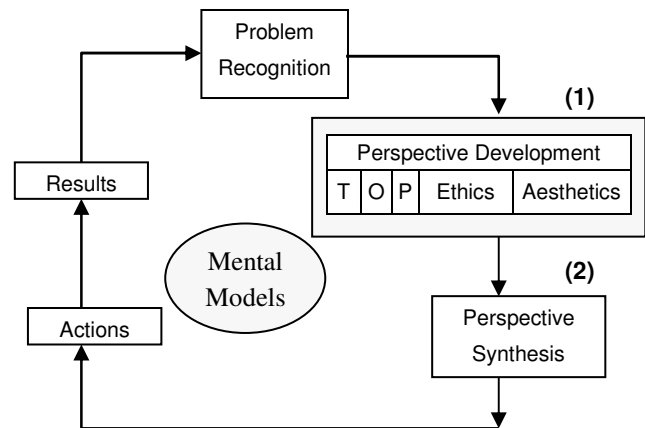


Figure 1. Decision Paradigm for DSS (Courtney 2001)

Here, besides ethical and aesthetical perspectives for decision making process, TOP perspectives are not enough to cover other necessary perspectives, such as situational or contextual perspectives. Linstone and Zhu (2000) had compared between TOP approach and *Wu-li Shi-li Ren-li* system approach. We argue that such a correspondence does not reflect the essence of *Ren-li* aspect which actually covers organizational, personal, situational/contextual, and even ethical and aesthetical perspectives.

From problem recognition to taking actions, the procedure on perspective development and synthesis can also be understood as divergence and convergence of individual/group thinking during problem structuring process. From problem recognition to developing a variety of perspectives as indicated as (1) in Figure 1 is divergent thinking process for idea generation and creative perspectives toward unstructured issues, and then transfer to synthesis of perspectives as indicated as (2) in Figure 1 is convergent thinking for acquiring alternatives for final choices or actions. Such a transition

between divergent and convergent thinking mode is defined by the mental model about decision making process. Here (1) and (2) together with mental models are regarded as meta-synthesis approach toward unstructured problem solving.

### 2.3 Meta-Synthetic Support for Unstructured Problem Solving

The essential ideas about meta-synthesis approach is “confident hypothesis and rigorous validation”. Here we do not discuss more about history of MSA and HWMSE. For more details, please read Qian, Yu & Dai (1990), Wang (1996) and Qian (2001). For the trends about meta-synthesis approach, see Gu & Tang (2002).

There are three kinds of meta-synthesis, i) qualitative meta-synthesis; ii) qualitative-quantitative meta-synthesis; and iii) meta-synthesis from qualitative knowledge (hypotheses) to quantitative validation. The divergence and convergence process in Courtney’s paradigm could apply to three kinds of meta-synthesis. Each kind of meta-synthesis can be supported by various tools or methods. The results of divergence-convergence process may be qualitative hypothesis where after divergent idea generation, some basic points or concepts will be acquired to develop scenarios or perspectives for further studies; or may be final validated knowledge. HWMSE can provide whole support for such a problem structuring and solving process. For unknown or new issues, new knowledge is often needed for a practical solution. And creative solutions often refer to wisdom. Then HWMSE is expected to enable knowledge creation and wisdom emergence.

On the other side, a Japanese professor Ikujiro Nonaka proposed the theory about organizational knowledge creation where he emphasized the role of a right “*ba*” during knowledge creation process (Nonaka & Takeuchi, 1995). *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*, which means to create a boundary of new interaction (Nonaka & Nishiguchi, 2001).

Based on basic ideas of HWMSE, we think HWMSE is also a *ba* for knowledge creation and wisdom emergence for creative solutions of unstructured complex issues. Table 2 lists some functions of HWMSE which may be achieved in the four different *Ba*’s during the knowledge conversion process proposed by Nonaka.

**Table 2.** Activities in HWMSE based on *Ba*

<b>Activities</b>	<b><i>Ba</i></b>
Idea generation; confident hypothesis; wisdom emergence	Originating <i>Ba</i>
Concept formulation, knowledge creating	Dialoguing <i>Ba</i>
Rigorous validation	Exercising <i>Ba</i>
Meta-synthesis from qualitative knowledge to quantitative understanding	Systematizing <i>Ba</i>

Therefore, the work to develop supporting tools in HWMSE is to explore tools or methods to fulfill those tasks or activities listed in Table 2. Next section introduces our endeavours in developing supporting tools in HWMSE for specific application.

### 3. A Simple Example

The case is on building meta-synthesis support tools for weapon system demonstration and comprehensive evaluation. Generally, weapon system evaluation includes menace analysis, function analysis, effectiveness analysis, cost analysis, venture analysis, etc. in consideration of its evolutionary life cycle from planning to a conceptual design, from a prototype to a real product, from deployment to retirement. Due to complexities in calculation and model composition and integration in the field of naval weapon system evaluation, application of DSS for naval weapon system evaluation is a very natural idea for domain people. There had a lot of such kind of work. In our case, those tools developed to support comprehensive evaluation and system demonstration of weapon system mainly fall into two categories: argumentation tools for qualitative meta-synthesis and analytical tools for qualitative-quantitative meta-synthesis.

### 3.1 Group Argumentation for Idea Generation

It is a web-based computerized environment tool, group argumentation template (GAE), which supports divergent thinking. There are two principal modules, electronic brainstorming module and affinity diagramming module. Registered users can initiate or participate any sessions held in GAE. Like most e-chats tools, GAE list all participants' utterances as plain texts. Moreover, all collective information, mainly utterances and keywords by each participant who attends the same session of one topic are processed by dual-scaling method and results are visualized at a 2-dimension space for better understanding (Figure 2). During the divergent process, experts express their opinions freely while simultaneously affected by others' ideas, and then are expected to acquire new understandings about the weapon development strategy beyond their original views. Such interactions create a "ba" for problem solving.

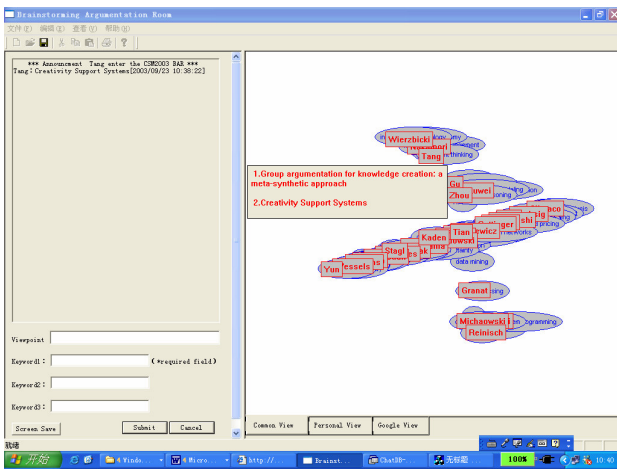


Figure 2. Common Viewer for Group Discussion

The visualized map is helpful to expose some structures of the issue under exploration, and then stimulate users' further thinking or formulate some new concepts. There are three kinds of viewer for experts. Common viewer serves as a blackboard during seminar session and displayed the clusters of keywords and names of experts who had expressed ideas as shown in Figure 2. Personal viewer serves as a personal notebook which recorded the utterances by all experts as shown in Figure 3. Search viewer provides engines to access

external information about the discussed topics.

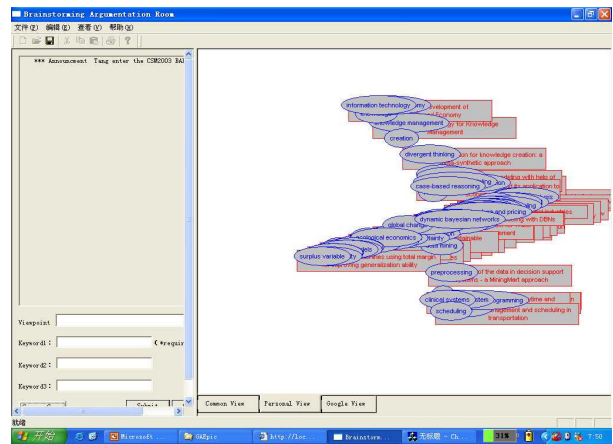


Figure 3. Personal Viewer for Group Discussion

Besides, the map can be transformed into an affinity diagram, i.e. to apply KJ method automatically, instead implemented manually applied in most brainstorming tools. Such a way allows the perspectives or view groups emerge naturally, rather than according to preordained categories (Tang & Liu, 2002). GAE is mainly for idea generation and could be used to propose qualitative hypothesis.

### 3.2 Analytical Supported Tools for Weapon System Evaluation

As hypotheses are proposed (in our case, the alternatives about weapon system are given), various analyses will be undertaken based on the current decision maker's attitudes towards risk and different ways of using resources. Mainly, three indicators will be analyzed, i.e. system effectiveness, cost and risk of weapon system development. Figure 4 shows the visualization of the working states of a weapon system during system effectiveness analysis.

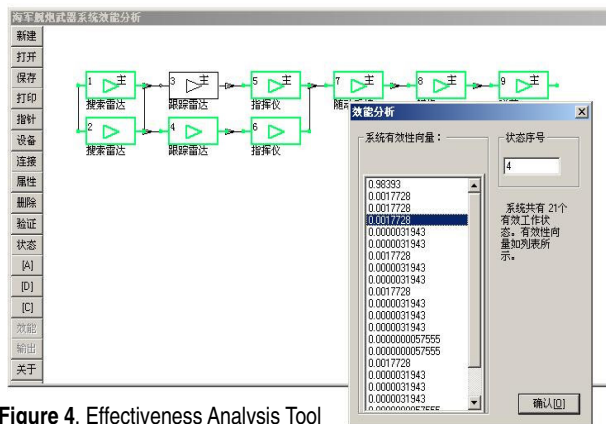


Figure 4. Effectiveness Analysis Tool

The effectiveness analysis tool is a general tool, which enables users to define a weapon system. Then the tool automatically outputs the set of operating states of the defined weapon system and calculates the system effectiveness indicator based on ADC (availability, dependability and capacity) method.

Risk analysis tool as shown in Figure 5 is based on VERT (venture evaluation and review technique) which can give probabilistic risks on cost, time and effectiveness about a weapon system development project.

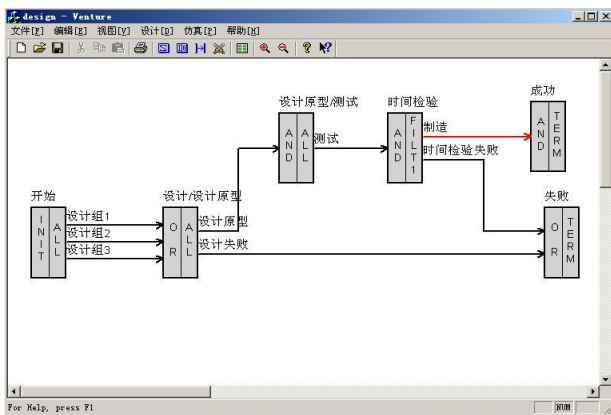


Figure 5. Venture Analysis Tool based on VERT

Those tools implemented by Web technology can enhance the accessibility of the tools by a wider community. Thus those specific tools are not only for professional analysts, but for training and learning as well. Anyone who can access Internet can try those tools. Besides, visual modeling is implemented which enables users to genuinely design a weapon system interactively and freely. For details, see Tang & Zhang (2003).

All those tools are based on browser/server framework. During the weapon system design process, users can acquire relevant data about the equipments of the designed weapon system from the data supplier running on the data server. As the weapon system is verified, model server can calculate the system effectiveness upon request.

Tools for comprehensive evaluation, such as AHP and nominal group technique (NGT) are developed to help to check those alternatives or ideas from the experts and give quantitative results for strategic choices.

## 4. Concluding Remarks

In this paper, we discuss DSS trend and Courtney's decision paradigm in a DSS context which emphasizes the synthesis of perspectives towards problems structuring process, which actually reflects meta-synthetic support for decision making. As a test bed of MSA, HWMSE can also serve as a *ba* for knowledge creation and wisdom emergence. A simple demonstration on building meta-synthesis support tools for weapon system comprehensive evaluation is given.

Meta-synthesis approach aims to knowledge creation and wisdom emergence which is essential for creative solutions of unstructured complex issues. Our research is just started in aim of supporting the creation of 'ba' for knowledge emergence. It is necessary to study the cognitive process about group argumentation, group thinking and decision making, to study man-machine (people-Web) environment for group knowledge creation. Moreover, mechanism of group formulation for knowledge creation needs to be studied.

By review of DSS development, it is found that Simon's decision making framework has always been referred while early technologies work had already been discarded due to continuous revolutions in information technologies. Problem structuring approaches including those soft OR and system approaches belong to the theoretical part of DSS studies and are worth more concerns.

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