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Decision Model for Complex Group Argumentation

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HIGHLIGHTS:

1. Proposing a novel decision model for group argumentation under complexities
2. Resolving twofold complexity in our model: the complexities derived from problem and group
3. Evaluating our model towards the practice of supplier selection
4. Exploring theoretical and practical development of using classic metasynthesis for complex system designs

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ABSTRACT

This paper describes a decision model used for group argumentation when decisions contain twofold complexities: problem itself and people. Related studies have been well documented in literature, but group mechanism was still limited in consideration of two aspects: (1) complexities of problem and people and (2) interaction manners of opinions derived from people. In this paper, we develop a mechanism called Complex group argumentation (CGA) framework for group decision-making (GDM). This solution employs the classic methodology of system designs: the qualitative-to-quantitative metasynthesis, and contains two core processes: complexity resolving and group argumentations. In the practical side, we evaluate performance of CGA framework in the context of supplier selection (SS). The results show our approach can fulfill requirements of practical SS, in the meantime possesses the abilities for coping with disadvantages in real-world complex GDM. The results of this paper shall be beneficial to inspire studies of group argumentation in academics, and also provides proposals of mechanisms for development of group support systems in industrial community.

Keywords: decision making; group argumentation; complexity; supply chain

1. INTRODUCTION

The DM methodology is under the paradigm of actions including ranking, sorting, and choosing among a number of prepared alternatives for best achieving predefined objectives. When the objectives are specified as multiple dimensions, DM known as multiple criteria decision making (MCDM) (Wallenius et al. 2008). DM process is greatly involved by human factors, leading to sub-fields as individual and group DM. Keeney (2013) defined group decisions as "decisions where a group of two or more individuals must collectively select an alternative from a set of two or more alternatives that best satisfies the group's objects, and no individual has veto power". Group consists of a number of individuals with correlative talents committed to a common purpose, specific goal, and a similar working approach as well as evenly distributed accountability among members. However, it is a nature that individuals are inclined to best satisfy their own objectives other than the objectives of any other individual or the groups. Keck et al. (2014)'s experiment shows that groups are more likely to make ambiguity-neutral decision than individuals. An important problem in GDM is to integrate multifarious opinions, thus requiring the process of group argumentation.

Supplier selection (SS) is a typical scenario of MCDM. Its strategic success is usually due to multiple individuals involved in processes. Ho et al. (2011) suggested that stakeholders from both internal and external companies should be concerned, in order for leading to an unbiased consideration of conflicting opinions. Chai and Ngai (2015) required that stakeholders should be qualified, who possess enough competence and sufficient influence on supply chain, and particularly a twofold consideration of the horizontal and vertical dimensions. When stakeholders being group members, this paper are particularly interested in the understandings of two core issues: (1) how to determine the qualified stakeholders as the group member for evaluating supplier process; and (2) in the case of involving multiple even conflicting opinions of stakeholders, how to support argumentation or negotiation among individuals through a system approach. Essentially, they can be boiled down to two core challenges in practical GDM, as firstly complexities of problem itself, as well as complexities of group.

Group consensus in SS is significantly important, but mechanism of group argumentation under complexities still remains. Our interests in this paper are concern about needs in practice of strategies of group argumentation, and are to propose workable conceptual designs. The contributions of this paper are summarized here. We propose a novel conceptual model called Complex group argumentation (CGA) framework. Two core units in this model are examined: (1) twofold complexities-resolving approaches: problem *decomposition* and group *screening*, and (2) group argumentation process and model. We recommend and use a classical methodology, the qualitative-to-quantitative metasynthesis (Qian et al. 1990; Qian, 1991) for system designs. The ability of this methodology is in handling complex systems which well fits our faced situation: group process under complexities. This methodology had been proved its effectiveness in building Chinese system framework "hall for workshop of meta-synthetic engineering (HWME)" (Gu and Tang, 2005; Dai and Cao, 2002), but was not implemented aboard. We consider that our framework is conceptually novelty for academics. The established group models could be beneficial for both practitioners and academics, and expected to be widely adaption and discussion for further studies.

The rest of this paper is organized as follows. Section 2 provides a literature review on decision and group argumentation. Section 3 elaborates resolving mechanisms of twofold complexities, being the preliminary of our framework. Section 4 presents the conceptual model of CGA framework. In Section 5, we develop group argumentation model and system process designs within our framework. Section 6 evaluates our design and development in the SS content. Section 7 concludes this paper.

2. Literature Review on Group Decision and Argumentation

2.1 Group Decision Making

Early landmark solutions in GDM might be Arrow (1951) and Keeney (1976). They attempted to examine possibilities of aggregating individuals' preferences into an ordinal (by Arrow) or cardinal (by Keeney) preference function of group which can fulfill preset conditions. Dias and Sarabando (2012) developed a formulation to control the possibility of an individual over the group. The formulations are more like a non-dictatorship condition under Arrow and Keeney's solutions. Individual's judgments are usually made according to different logics and partitions. Predd et al. (2008) thus developed a method to aggregate probabilistic forecasts from incoherent and abstaining group members. Schilling et al. (2007) captured the alignment of group members quantitatively using a before/after preference measurement design. In case of that group members argued against the set the utility and values of DM, yet had to agree on a decision, Rios and Rios Insua (2009) proposed to partition the set of non-dominated alternatives, and particularly negotiating over these alternatives using a guaranteeing Pareto optimality. Huang et al. (2013) extended the intuitive additive weighting (AW) method for individual preference aggregation and referring to the dissimilarity of preference levels. Keeney (2013) adopted a set of DM assumptions and indicated that group expected utility can be a weighted sum of individual expected utilities. This general GDM model allows that individuals have different objectives, frames, and perspectives regarding the same problem.

2.2 Group Argumentation

In literature, argumentation theory was initially examined by Dung (1995). It suggests that an argumentation system provides both a set of arguments and the manner they interact with respect to the corresponding agent. Since then group argumentation was usually examined in term of theoretical construction and Expert/Intelligence System. In theory side, firstly, Sillince (1996) proposed a design of argumentation and contract models for strategic organizational decision. It considered semi-autonomous groups and proposed an interaction paradigm including argumentation domain, the grammars, and the procedures. Karacapilidis et al. (1997) showed a framework which supports rational and efficient decision, when agents being members of a group therein. Ei-Shinnawy, and Vinze (1998) argued that group composition in GDM had no impact on either group polarization or persuasive arguments. Zhang et al. (2005) considered the nature of decision task, and provided an approach for generation and identification of these tasks in an organization. Atkinson and Bench-Capon (2007) provided a practical reasoning approach based on presumptive justifications of action through the instantiation of an argument scheme. Coste-Marquis et al. (2007) further generated a framework on the merging of Dung's argumentation system. Mercier (2011) considered the expert reasoning of the argumentative theory in a psychological viewpoint.

In system side, secondly, Ramesh and Whinston (1994) argued that group argumentation process in decision support system (DSS) consists of three formalisms as representation, gaming, and coordination, meanwhile proposed a framework of argumentative reasoning facilitation systems (ARFS). De Moor and Aakhus (2006) extended traditional IS modeling approaches for a Language-action Perspective (LAP), and developed a LAP-based diagnostic method to support argumentation. Vetschera (2007) examined the preferences embedded in electronic negotiation support systems for exactly reflecting the behavior of negotiators and negotiation outcomes, with an empirical manner. Navarro et al. (2013) developed a real-time argumentation framework for agreement process in an open multi-agent system. Recio-Garcia et al. (2013) developed a DSS considering decision makers' social factors, personality and trust in the argumentation process.

We discuss the current literature here. + a paragraph to response the reviewer #1.

2.3 Supplier selection under three-track DM

Supplier selection (SS) plays a crucial role in sourcing strategies because of its overall influences. The interest of this issue is in great increasing over past several years. Under MCDM paradigm, popular literature survey like Ho et al. (2010), Chai et al. (2013), and Govindan, et al. (2013) were done in terms of technique employments, criteria establishments, structural decisions and sustainable developments. We can boil them down to three tracks: structural level, semi-structural level, and non-structural level. Simon (1955, 1962) pioneers to suggest in general non-structural form of decision-making (DM) that against structural forms. In this dichotomy manner, he commented that non-structural problems are never emerged and thus no past experience can be learned or utilized for resolving. Related problem structures or conditions are usually so complex that requiring human intelligence such as intuitive observations or creative thinking.

How group argumentation process comes from the three-track decision making (DM). Specifically, structural level requires well-organized decision tasks (Zigurs and Buckland, 1998), highly structured information, and clear criteria for evaluation. Typical studies include Awasthi et al. (2010), Bai and Sarkis (2010), and Li and Zabinsky (2011). Semi-structure level concerns criteria establishment (e.g., Ho et al. 2011), relations among criteria (e.g., Chai and Liu, 2014), and company strategic orientations (e.g., Shen and Yu, 2009). Finally, non-structural level covers organizational and psychological factors of decision processes. It pays more attentions on enterprise completive strategies (e.g., Gunasekaran and Ngai, 2005), psychological needs and information system (IS) adoption (e.g., Au et al. 2008), supply chain risks (e.g., Kull and Talluri, 2008), company policy (e.g., Zhang and Chen, 2013), and the auction process (e.g., Chaturvedi et al. 2014; Jin et al. 2014). The structural level DM attempts to learn past experiences, techniques, and methods, via motivated or integrated usages, because of highly organized information and clear evaluation principles. DM in semi-structural and non-structural levels require both quantitative and qualitative analyses, frequently communication and discussion, and supporting manners such as voting or scoring. This process is known as group argumentation process (Espinasse et al. 1997; Bui et al. 1997) or group negotiation process (Raiffa, 1982; Ehtamo, et al. 1999; Wang and Zionts, 2008), has been advanced and employed toward supplier selection in literature (e.g., Cakravastia and Takahashi, 2004; Dudek and Stadtler, 2005; Choudhury et al. 2006).

3. TWOFOLD COMPLEXITIES RESOLVING IN GDM

3.1 Decision problem decomposition

Decision problems can be treated as an action for achieving some targets (Bui et al. 1997). For a simple problem, people could easily recognize their properties like decision principle, available resources, alternatives (i.e. decision objects), or actions (i.e. decision schemes). But under complex circumstance, well description and definition of problem is an initial process. Being aware of internal structure, we recommend a problem decomposition process aiming for establishing multiple decision tasks with a tree-like structure. The decomposition extent is the successful establishment of well-organized decision tasks (Zigurs and Buckland, 1998). Six important properties related to a task should be clear recognized, they are the target, the criteria, the alternatives, the group, the resources, and the uncertainties. We show its details in Table 1.

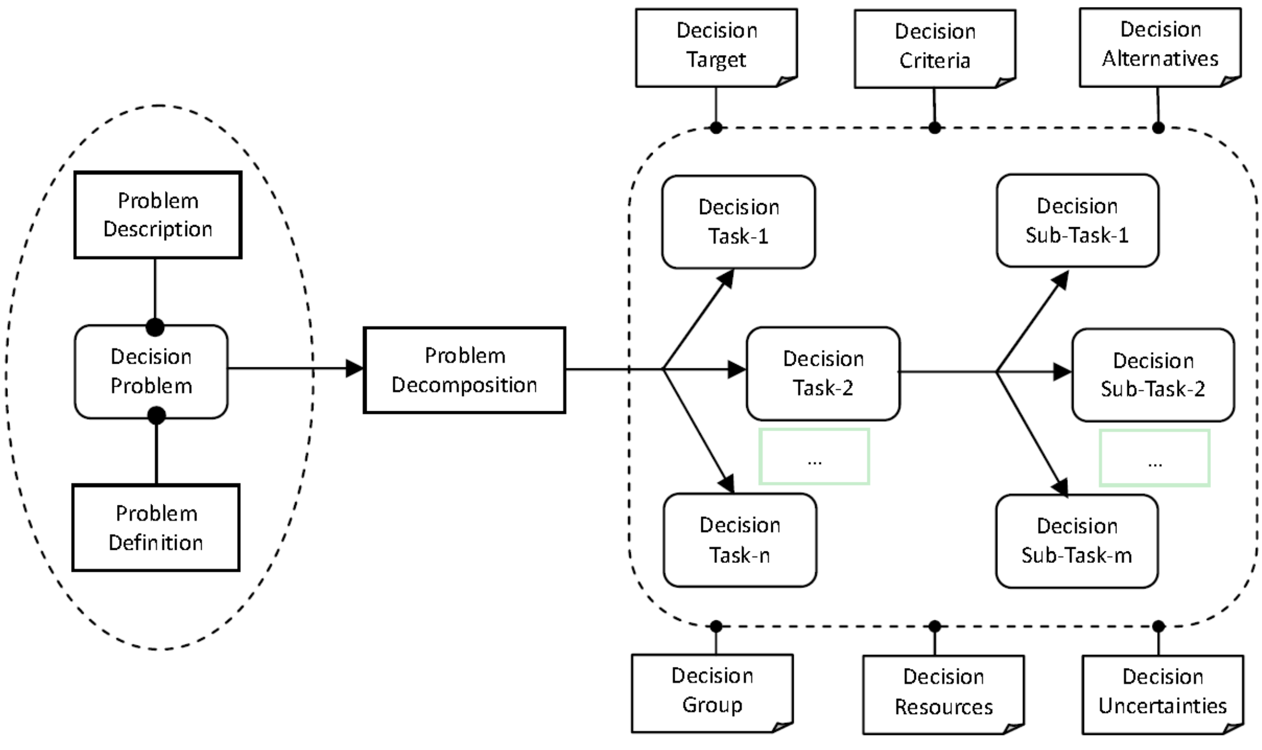
Table 1
The properties of decision tasks

Property items	Descriptions	SS for example
Decision Target	The expected outcomes; the sign of accomplishing the decision	Ranking, sorting, choose the suitable suppliers
Decision Criteria	All necessary dimensions used for evaluating alternatives	Evaluation criteria like prices, quality of service, transportation, etc.
Decision Alternatives	Alternatives that is provided for decision	Suppliers as candidates for ranking, sorting, and choice
Decision Group	A number of people assembled as a group for making decisions	Group members may be domain experts, managers, and organizers.
Decision Resources	The existing information that is used for problem-solving	A collection of alternative suppliers, such as a supply base (Chaturvedi et al. 2014; Wan and Beil, 2014)

Decomposing problem is a complex process. Rosch (1978) pioneers to propose two hierarchy decomposition principles including cognitive economy and perceived world structure. It suggested four converging operations to establish the vertical dimension of categories as common attributes, motor movements, similarity in shapes, and identifiability of averaged shapes (Rosch, 1978; Mervis and Rosch, 1981). It provided basic heuristic rules in a philosophical perspective. However, the hierarchy decomposition at the philosophy level is too limit to meet requirements of faced complexities in decision process.

As comments of Baucells and Sarin (2003) additionally, “decision analysis has a strong tradition of breaking down complex problems into simple parts and then combining the information collected on these parts to reach a decision”. We advocates three principles for general tree-like problem decomposition. (1) Standard Consistency. Decomposed standard of sub-task should be compatible with that of ‘parent’ task. (2) Low Coupling. In same layer of the decomposition tree, the sub-tasks should be mutual independence as much as possible. By reducing the connections among sub-tasks, the low coupling is benefit for independent problem-solving. In addition, it could improve the decision efficiency through parallel processing. (3) Appropriate Granularity. How many sub-tasks should be decomposed? Or say, what’s the granularity of task decomposition? Despite the answer can be flexible depending on the nature of problems, two measurements should be taken into account: (a) the six properties regarding each decomposed decision task need to be clarified and easy to be identified as much as possible; (b) in the tree-like structure, the decomposed task (i.e. the parent node) should utilize decision resource coming from its decomposing tasks (i.e. the child nodes) as much as possible. Detailed decomposition process is illustrated in Figure 1.

Figure 1
Decision task properties decomposition



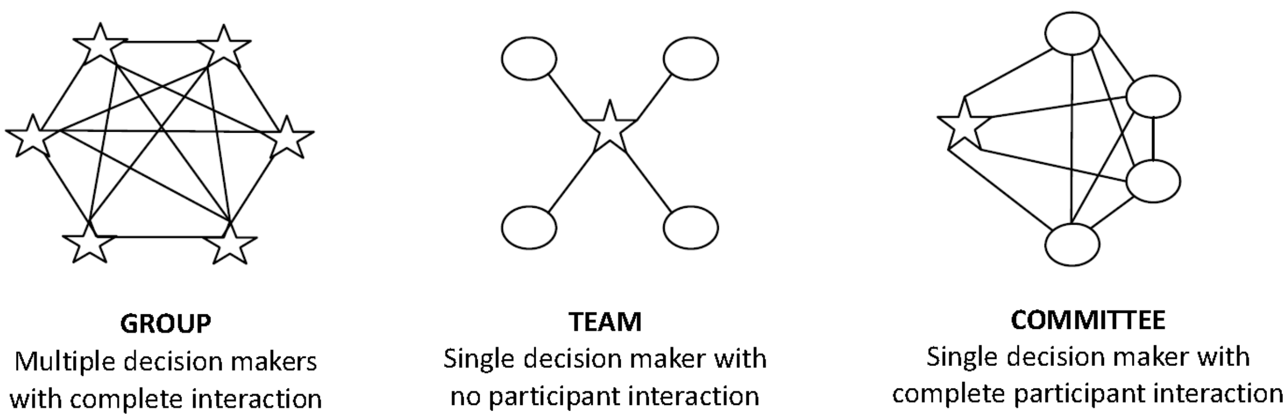
3.2 Decision group screening

Group value embodies in the consistency of mental and behavior of group members. The consistency depends on the degree of standardization and particularity of group standard. Decision group screening is to select the qualified and necessary personnel for a particular decision task in order to improving the quality of decision outcomes. Generally, group screening techniques will be diversified depending on different nature of decision tasks. In practice, taking the project bidding of a hydropower station construction as an example, people are regulated that the member evaluation committee must come from at least three mutual independent personnel as construction crew, supervision crew, and audit crew. Another example can be found in human resource management field. The people of performance appraisal regulate group members according to specific requirement of decision task, such as the 360 degree performance appraisal technique requires the decision group of at least constituted by five elements including the objects themselves who are receiving the performance appraisal, and the necessary personnel who are from the higher authority, the peer authority, the lower authority, and the outside of the organization (Atkins and Wood, 2002). In addition, group screening is the key procedure for R&D project selection (Sun et al. 2008), facilitation location problem (Ishizaka and Nemery, 2013), and employee performance evaluation (Jiang et al. 2000).

Stakeholders in SS usually refer to a large number of people and a complex organizational structure. Generally, company's stakeholders are from two parts: the internal crew of company from the departments of manufacturing, finance, and marketing, and the external crew of company including national or local government, policy makers, environmental supervisors, and general community or pubic (Ho et al. 2011). Chai and Ngai (2015) suggested that stakeholders should be primarily qualified as possessing competence and sufficient influence on supply chain DM. It thus considers two dimensions of stakeholder's sources: (1) the horizontal dimension including company managerial or operational crews like core directors, stockholders, department managers, procurement personnel, and external domain experts, and (2) the vertical dimension including the nodes of the supply chain like distributors, customers, terminal salespersons, and client relations managers. Therefore, it is rational and necessary to investigate how to determine suitable stakeholders to involve in SS process. However, most existing studies just define the concept of group as a kind of individual aggregated entity which neglects the individual properties and behaviors (Chai, Liu, & Ngai, 2013).

Marakas (1999) defined multi-person decision to be an activity conducted by a collective entity composed of two or more individuals and characterized in terms of both the properties of the collective entity and of its individual members. This definition determines the unique characteristics of each of three main multi-person decision structures as shown in Figure 2. The group structure is classified as a collaborative mode, whereas both the Team and Committee structures are classified as non-collaborative mode. The differences between Team and Committee are the manner of opinion interactions. By this approach, these people involved in decision process can be resolving via associating with a specific decision structure.

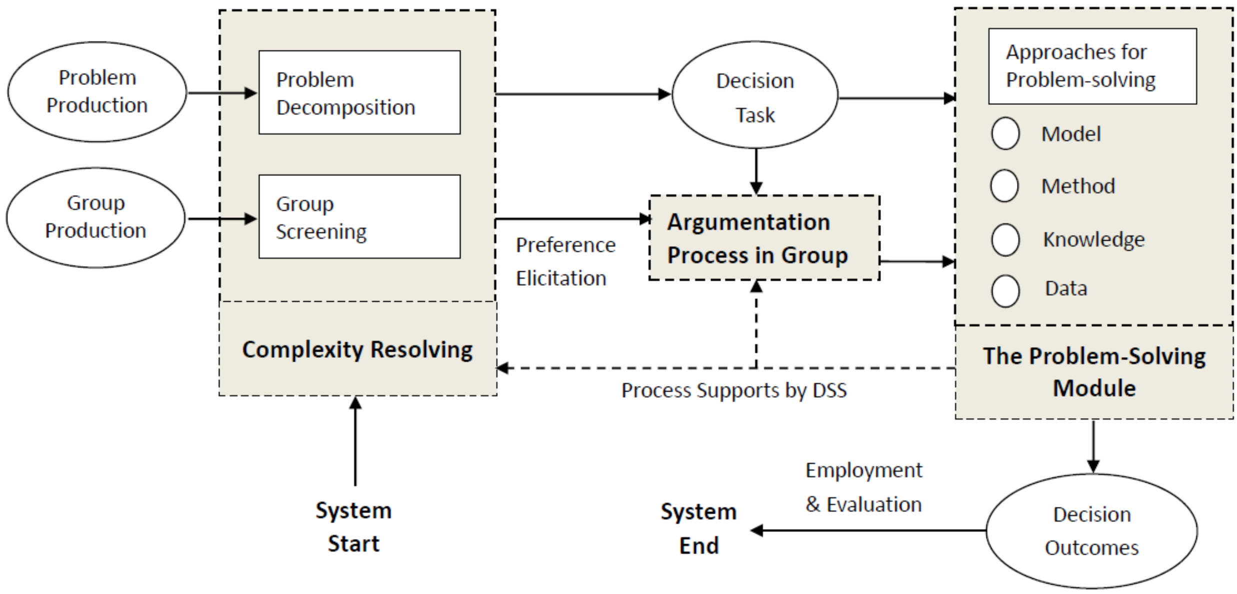
Figure 2
The basic multi-person structures in DM



4. Complex Group Argumentation Framework

In this section, we propose a complex group argumentation (CGA) framework. This framework consists of the following key units: (1) the resolving of two kinds of complexities, (2) the group argumentation process; (3) the problem-solving module. The framework is illustrated in Figure 3.

Figure 3
The framework of complex group argumentation approach



Complex decision problems like multi-perspective strategic suppler evaluation (Chai and Ngai, 2015) are hard to be resolved by IS directly. Reorganizing and analyzing practical problem is a necessary for establishing multiple well-defined and refined decision tasks through applicable problem decomposition. Second, practical decision problems usually involve multiple persons who are participated in decision processes through different roles. The group members could be organized with different structure, and under complex relationship. DSSs have to apply mechanisms to screen qualified people for particular decision task. A unit in our framework is twofold complexity resolving as complex problem decomposition and complex group screening which are detailed in Section 4.

The decomposition process results multiple well-defined decision tasks, meanwhile screening process reduces complexity of group and produces the applicable decision group for certain decision tasks. The responsibility of decision group is to use the expertise and knowledge which are boiled down to decision preference (also called judgments, evaluations, opinions, etc.). But for the inherent difference and conflicting in individual's perspectives, we thus need the group argumentation process for the applied and valuable outcomes of group preference, a process of opinion convergence from the individuals to the group, which are detailed in Section 5.

5. Group Argumentation Process

5.1 Complex system and design methodology

Group argumentation refers multiple persons with multiple perspectives. The design of group argumentation is rational to consider methodologies of complex systems. Three research schools exists as follows (1) Complex adaptation system of America represented by Santa Fe Institute (SFI) (http://santafe.edu/); (2) Dissipative structure theory and self-organizing systems of Europe (Prigogine & Nicolis, 1977), and (3) Open complex giant system (OCGS) theory of China (Qian et al. 1990; Qian, 1991). The former two lay on the perspective of mathematical modeling and quantitative simulation, whereas the last one caters the system qualitative and quantitative analysis. The representative scholar Tsien Hsue-Shen (2012) (also known as Qian Xue-Sen) of the Chinese school, suggested that to construct OCGS should follow the methodology of "the metasynthesis from qualitative analysis to quantitative analysis", and hence proposed the system framework of "hall for workshop of meta-synthetic engineering (HWME)".

Metasynthesis in essence is an approach to integrate expert systems, all sorts of data and information, and computation intelligence together (Gu and Tang, 2005; Tang, 2007). HWME is a giant intelligent decision and problem-solving system, in which human and machine are integrated, through using metasynthesis (Dai and Cao, 2002). Several key issues were reported like the architecture of HWME (Cao and Dai, 2002), the method of synthesizing the divergent thinking of group members (Gu, 2001), the method of effective organizing discussion information (Hu, 2002), and real-world case studies (e.g. Qian and Dai, 2007). This metasynthesis is effective methodology for studying the model of OCGS (Cao et al. 2009), and is also an advanced form of group decision support system (GDSS). In this paper, we attempt to figure out such process of group argumentation with SS applications using this metasynthesis methodology. We targets to meet the core requirement in DM process: the convergence and consistency of multiple perspectives of group members.

The metasynthesis process needs feedback timely in hierarchical layer. It inspires evaluators' experiments or conjectures for interaction and discussion of information. The core idea of metasynthesis is illustrated in Figure 4. Individuals are initially invited to open a discussion. Individual brings their knowledge and experiences, and deeps the understanding to present problems. In this stage, the opinion is qualitative, and likely to be empirical, ambiguous, and biased. These understandings are a preliminary of cognition process, and the start of the metasynthesis process. In decision process, individuals with different professional fields are able to negotiate with others in the form of GROUP, TEAM, and COMMITTEE (see Figure 2). An iterative manner will be followed in this interaction. In each iteration, it may emerge new information, targets, hypothesis, models, parameters, experiences, feedbacks, and results. After several iterations, related definitions, theorems, formulas, equations, and variables will be clarified gradually, and quantified partially or completely. "If these can be further coded into computerized languages and systems, we are ready to convert the originally qualitative understanding to semi-quantitative and finally, up to full quantitative knowledge and systems about the underlying problem and problem solving method" (Cao et al. 2009). Until now, it completes a qualitative-to-quantitative process due to cognitive interaction. In the sense, metasynthesis can be regarded as a working mechanism of cognitive process (Gonzalez et al., 2003). Figure 5 illustrates this process in detail. In the paper, we develop the metasynthesis-suited group argumentation model (see Section 5.2) and system process (see Section 5.3) under our CGA framework.

Figure 4
The methodology of qualitative-to-quantitative metasynthesis

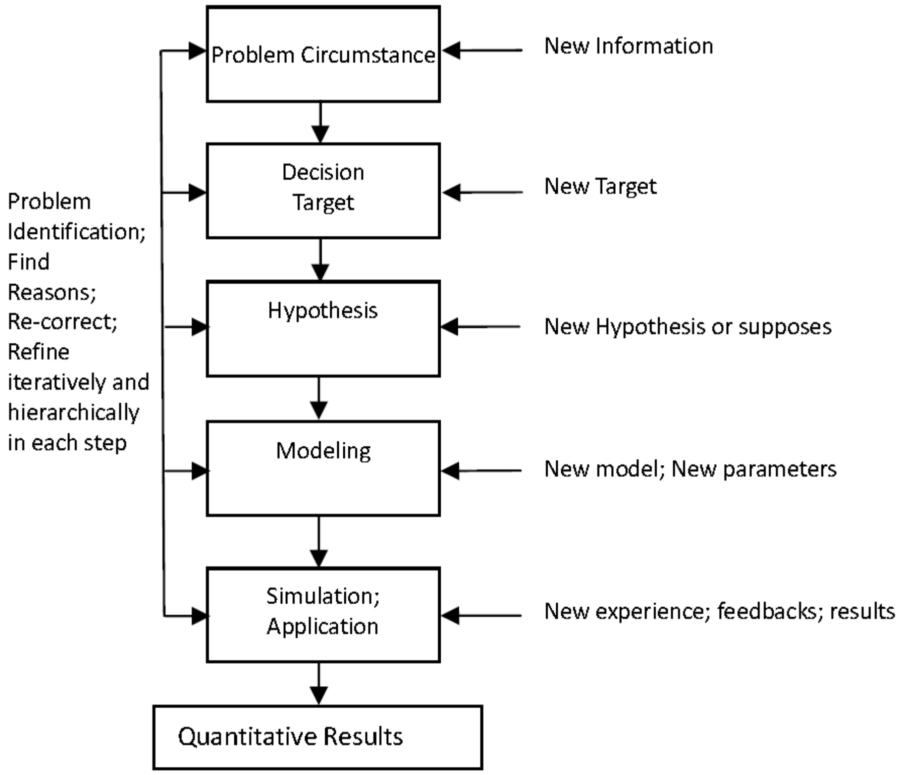
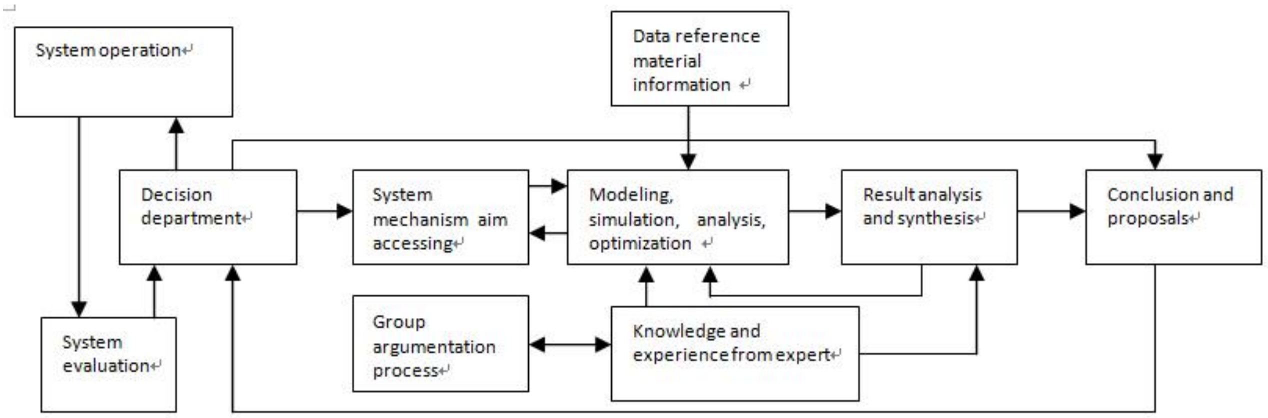


Figure 5
System problem-solving process based on Metasynthesis

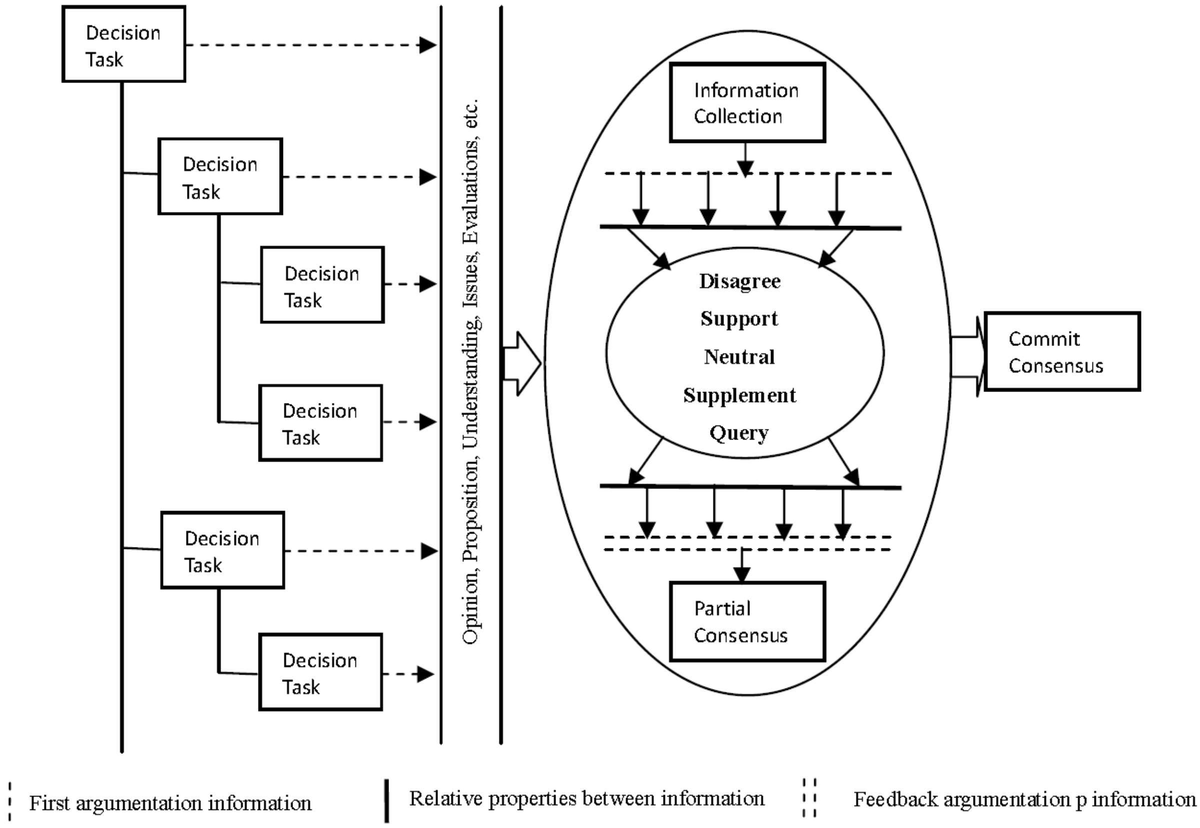


5.2 Group argumentation conceptual model

Metasynthesis working mechanism provides the supports to group argumentation. Following hierarchical decomposition in problems, domain experts provide their opinions, propositions, understandings, issues, and judgments, according to individuals' knowledge and expertise. The IS received these qualitative or semi-quantitative inputs being the preliminary stage in metasynthesis process. Through information collection, system sorts the first argumentation information via relative properties among information. The relative properties are defined as the following five types: disagree, support, neutral, supplement, and query. The system feedback the workshop information and commits the partial consensus through sufficient discussion, debate, and negotiation of opinions.

After multiple iterations and qualitative-to-quantitative argumentations, the system finally outputs several overall consensuses. Figure 6 illustrates the details of designed group argumentation conceptual model. This is a refined model since our primary model initially reported in Chai and Liu (2010).

Figure 6
Complex group argumentation conceptual model

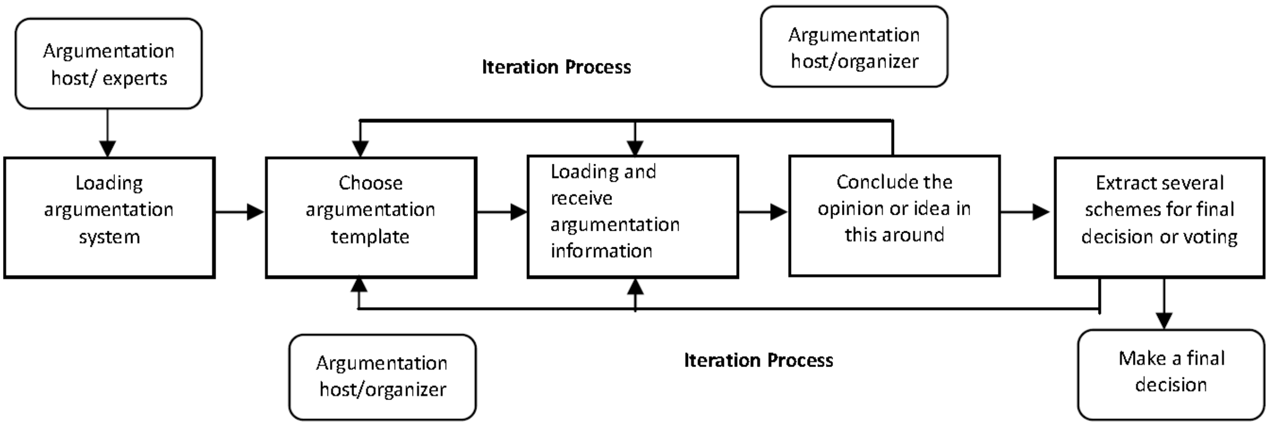


5.3 Group argumentation system process

The IS argumentation process can be online or offline according to web environments. Considering different influence of group members, the process can be classified as free argumentation, leading argumentation, and cooperative argumentation. Based on the field and the scale in argumentation, we have group argumentation, point-to-point argumentation, cooperative argumentation on one side, and debate-like confront discuss. Therefore, the process designs in IS argumentation process ought to depend on demands and characters of faced problem itself, and comprehensively consider various argumentation modes mentioned above. In this section, we present a proposal of a general IS group argumentation process as shown in Figure 7.

This process is a multi-hieratical, iterative raised process including two sub-processes: the argumentation process and the voting process. (1) The argumentation process: The iteration of the argumentation process which is controlled by organizers could generate a preferred idea following certain argumentation principle. The idea from the latter iteration is more specific and clear than that from the former iteration. The obtained idea of this iteration shall integrate more new ideas due to the experts' consideration and new situations, which is used to prepare the next round of argumentation. The whole process builds a progressive increase mode of information and knowledge, until getting a rational scheme or plan for voting. (2) The voting process: The organizer convenes argumentation participants to process the voting following certain voting principle. This voting also needs multiple times until the satisfactory results.

Figure 7
General group argumentation decision process



The designed process refines the metasynthetic problem-solving process into three independent stages.

Stage 1: This stage is to establish complex task and to propose empirical hypothesis. Domain experts here are required to study decision tasks and form the qualitative judgments based on their knowledge, experience, and intelligence. The expert system is necessary to be integrated in GDSS, generally contains the modules as follows: client management, conference preparation, workshop room, conference management, web information mining, profile or resource management system and so on.

Stage 2: This stage is to establish data and information structure, index system and model system, and conduct systematical simulation and experiment to qualitative judgments of Stage 1. Domain experts in this stage shall make quantitative judgments to experimental hypothesis through evaluation of the index system. The experiment assumption or all known parameters will be considered by experts in the system simulation and experiment process, and strengthen the quantitative cognition via iterating this qualitative-to-quantitative process. The GDSS thus should involve basic functions as model management, method management, knowledge management, and data management.

Stage 3: This stage is to conduct analyze and metasynthetic by domain experts based on some results of simulation and experiment in stage 2. This stage is from experimental judgment rising to quantitative results. Once it is not satisfied in the quantitative results, the model and parameters are allowed to be modified promptly. The adjustment process will be repeated until achieving a satisfactory result through human-machine interactions, repeating comparisons, and successive approximation. In the case that the tentative results fail to incorporate certain experimental judgments, new cognitions or knowledge shall be generated in the next iteration. New experiment results shall be proposed because such loop mechanism can guarantee a satisfactory result.

6. MODEL EVALUATIONS TOWARDS SUPPLIER SELECTION

The present CGA framework are expected to be adapted for general group decision problems such as great engineering project management, company's strategic decision, human resource management and performance evaluation, and operation management. Considering sourcing problems faced by a manufacturer who outsources the manufacturing of a product, while a collection of companies are the candidates yet a few of them shall be selected as formal suppliers. SS usually refers different departments, multiple criteria for evaluation, and multiple decision makers with non-identical perspective. To our framework, we described the key extensions versus pervious designs. The CGA model shall be implemented in GDSS to support key decision processes, including flexible applications of decision models and algorithms, aggregation of individuals' opinions, and achievement of whole procedures.

The CGA implementation in SS will be discussed from two aspects. On the one hand, we conduct a requirement analysis with respect to the characteristics of practical GDM, and evaluate our approach as shown in Table 2. On the other hand, we investigate disadvantages in practice, and discuss the coping manners via processes designs and model establishments. Table 3 illustrates the details.

Table 2
Evaluations on characteristics of GDM scenarios

1.	**Complexity in decision problem**
	Description: Generation and identification of decision tasks are one of key stages in GDM. In practice, the problem structure could be complex. In SS, a manufacturing product needs different components to intermesh together. Procurement of these components via evaluated suppliers shall be complex which is required to be resolved.
	Evaluation: Problem decomposition mechanism in our framework is used for clarifying the properties of decision tasks. The solution is in the form of a tree-style structure. Outcomes of each node provide the feedback to its parent node, and serving as important decision resources.
2.	**Complexity in decision group**
	Description: Complexity exists in decision group in terms of the complex organizational structure. In SS, it refers multiple internal and external stakeholders like managers, engineers, sales, even personnel from public or community (Chai and Ngai, 2015).
	Evaluation: Screening of decision group provides the manner of resolving group organization with different types as Group, Team, or Committee (see Section 4.2). The mechanism is designed to match proper persons to a decision task, according to their expertise.
3.	**Usage of decision resource**
	Description: A qualified decision process should be adoption of comprehensive and valuable resources in an effective manner. In SS, these resources could involve analysis data, information of suppliers and manufacturers, or specialized knowledge.
	Evaluation: Our designed processes take in account different criteria under a MCDM paradigm. The task decomposition and metasynthesis process aggregate multiple sources. The hierarchical tree-like structure is an effective mechanism for resource re-adoption. Through decomposition from "problem" to "task", the experience feedback is used to optimize company operations or workflows. In addition, the feedback mechanism could help people to recognize advantages or disadvantages of the decomposition path of problem.

Table 3
Evaluations on disadvantages of GDM scenarios

1.	**How to handle Information Distortion in practical GDM?**
	Description: The quality of suppliers may evaluated by stakeholders with different norms. It

	may lead to higher or lower judgments beyond the fact. Other evaluators may not grasp actual situations, or involving the bias or prejudice in GDM due to any interested relation. All these could lead to “decision information distortion” that will count against a reliable decision.
	Evaluation: Generally speaking, personal prejudice cannot be completely avoided. Yet, the bias or prejudices are expected to be reduced to the most extent. Our approach is able to construct the suitable decision group as well as removing unqualified persons. The manners include (1) well setting of parameters in group selection stages, (2) well setting of the weight of decision makers and evaluation criteria.
2.	**How to avoid the formation of “non-formal organization” and reduce their effect?**
	Description: Non-formal organization means a kind of people group without formal organization structure. Members in this group aggregated together based on personal emotion or relative benefit; pursue the opinion consistency in evaluation, therefore expecting to produce greater impact to decision outcomes. The consistency opinions of these members are usually with bias and show negative influence against a multi-perspective fair outcome of GDM. The form of non-formal organization will be adverse for impartial evaluations. For example, in order to pursue benefit of the groupuscule, the group skullduggery may be incurred in non-formal organization (Schilling, Oeser, and Schaub, 2007).
	Evaluation: The mechanism in our CGA model address this challenge well. First, group argumentation process enable people represent their preference independently, and maintain such independence of opinions in IS. It hinders the formation of “non-formal organization” in the aspect of opinion representation. Second, problem has been decomposed into a series of tasks with a tree-like structure. The individual is assigned to one or several tasks based on their expertise, yet without information about other group members. The overall structure of task decomposition is just mastered by a few personal like system organizers or authorized managers. In this way, group members are hard to form an influential non-formal organization.
3.	**How to handle the issue of “Central Tendency”?**
	Description: “Central tendency” means that evaluator’s opinions trend to be identical with others and lose sight of existing difference in performance. It goes against reliable DM outcomes.
	Evaluation: Our mechanism is able to address this challenge well. First, the group argumentation is designed as a closed and single-blind process. It is built on the match between decision tasks and a selected group of people. Individuals are hard to review others’ opinions. Second, the argumentation mechanism identifies five modes of opinion interaction, including Disagree, Support, Neutral, Supplement, and Query (see Section 5.2). The proportion of “support” and “supplement” can be controlled. It thus reduces negative influence of “central tendency”. Third, considering the nature of group members in screening, individuals from different interested group could not tend to agree with other decision peers.
4.	**How to handle the issue of “Halo Effect”?**
	Description: “Halo effect” means under MCDM setting, when providing a very positive evaluation on an alternative (say, supplier) concerning a criterion, this evaluator tends to perform a series of positive evaluations under other criteria with a non-rational “halo effect” of this alternative. It leads to a higher evaluation beyond the fact, and of course goes against a reliable outcome.
	Evaluation: Our mechanism reduces negative effect of “halo effect” because of the follows. First, group argumentation set weights on evaluation criteria, which could balance the final decisions objectively. Second, the settings on criteria and weights shall be discussed and interacted in argumentation system. The more subjective, reliable and reasonable condition setting for suppliers can be expected.

7. CONCLUSION

Many methodologies has been used for SS in literature including mathematical modeling, DM techniques hybridization, and criteria establishment. But the studies on group mechanisms with solutions of coping with environmental complexities still remains. The CGA framework proposed in this study concerns about twofold complexities derived from inherent problem factor and human factor. We recommend to use two steps: problem decomposition and group screening. This two-step process is integrated in the framework via the classic system design methodology: the qualitative-to-quantitative metasynthesis. We thus build a group argumentation process which is new to the literature. We evaluate the performance of our approach and discuss its characteristics for fulfilling practical requirements and its coping modes against various disadvantages in real-world GDM.

Group argumentation process in CGA framework is an operation mechanism for opinion interaction. Using metasynthesis, we redesign it including the conceptual model and the system process. Our evaluation shows its effectiveness for fulfilling requirements of SS in practice, and indicates the abilities for coping with disadvantages of complex GDM in the real world. In the perspective of IS, this group process can be frequently called by other decision process, once committing the consensus of diverse opinions are needed. For instance, the case may include (a) the argumentation for clarifying the properties of decision task such as targets, criteria, alternatives, groups, resources, or uncertainties; (b) the argumentation for establishing tree-like structure in task decomposition; and (c) the argumentation for problem-solving schemes.

The metasynthesis was deemed as a classic solution for system design under complexities. Its effectiveness was proved in developing the framework of “hall for workshop of metasynthetic engineering (HWME)”. But for some reasons, its studies were confined to the Chinese school and lack of comprehensive implementations abroad. Our group process in this paper is abided by its methodology of metasynthesis engineering design. We believe that it illustrates a significant value for GDM in theory and for supplier selection in practice.

Most of solutions of group mechanism in literature were considered under the paradigm of MCDM (Interested readers please refer to recent literature survey by Ho et al. (2010) and Chai et a. (2013)). In all these previous solutions, opinions of decision group are represented through various decision (information) table, and integrated using manners of information fusion such as averaging operator. In this paper, we in essence suggested an IS approach for fusion of group information in decision process, particularly in the scenario of supplier selection. To our knowledge, this study is the pioneer work in developing group mechanism of supplier selection using Chinese School’s metasynthesis methodology.

The limitation of this study is clarified here. This work provides a conceptual model and system process. Although we deem that this framework is conceptual novelty for academics, it is the lack of the feedback of IS implementations in the real world. In this sense, we would like to publish it and expect more feedbacks from industrial community. Implementations adopting the present approach is expected. And one could adapt our argumentation model for system prototyping, or to accommodate more extensive DM areas.

Group mechanism is likely to be a very promising directions in term of DM in theory part, Supplier Selection (SS) in application part, and in Expert and intelligent systems (EIS) in system part. We will no doubt see more studies on group-related application studies. Group mechanism for supplier selection out of MCDM paradigm is still new to the literature and thus is firstly worth for more investigation in the future. Secondly, the corresponding Expert and Intelligent System that could implemented the well-established group mechanism is a must. Finally, we believe that the studies on metasynthesis methodology for system designs are still limited and is worth for more attentions by academics and system developers.

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