Systemics and Informatics World Network
Volume 13 ▪ December 2012 ▪ pp. 93-100
sai: siwn.0013.2012.067

ISSN 2044-7272 (print)
ISSN 2051-5634 (online)

Semantic Enhanced Argumentation Based Group Decision Making for Complex Problems

Haibo Jia

Chapter 7 Discussion

Abstract: In this chapter, a further systematic qualitative evaluation is conducted to compare the proposed approach with existing work using an empirical feature metrics. Firstly, based on the requirement of decision making support the required feature metric are identified; secondly, under the guidance of the feature metric the proposed approach and others' approach are thoroughly analysed and a features table for all the approaches are developed; thirdly evaluate the proposed approach by the comparison with others and draw a conclusion to present the advantage and weakness of our approach.

Keywords: comparison based evaluation.

7.1 Introduction

In Chapter 2, the argumentation based theory and practices in the context of group decision making have been reviewed. Thereafter, a semantic enhanced group argumentation for decision making support framework is proposed and prototype system is developed. The system has been tested in a small organised group discussion and result shows the usability and proposed functionalities are well accepted by the group of users.

In this chapter, the further qualitative evaluation is conducted to compare our approach with existing works using a feature metric. Firstly, based on the requirement of decision making support the required feature metric are identified; secondly, analyse our approach and other's approach under the guidance of the feature metric and develop a feature table for all the approaches; thirdly evaluate our approach by the comparison with others and draw a conclusion to present the advantage and weakness of our approach.

7.2 Comparison

7.2.1 Aspects To Compare

By the comparison of our proposed approach with others' approaches, an evaluation of our approach in the qualitative level can be conducted. In order to identify the aspects to compare, it is necessary to analyse the required feature metric of argumentation based group decision support system. The feature metric in our research is a list of features which have been explicitly or implicitly identified as useful factors for the group decision making support in the context of the group argumentation. In this sense, these features should support the group decision making process and also fit the requirement of group argumentation.

Intelligence, design, choice have been identified as the three most important phases for decision making in the previous research. Many decision support systems have been developed to support some or all those phases. In the context of group argumentation, the intelligence is mainly created by the information from group members' utterances or referred from integrated knowledge base by group members, which include opinion, fact, data, ground, premise and question etc. The well-

defined argumentation model can better structure the groups' utterance, which can facilitate the system to identify and analyse the group's intelligence. Besides that, the quality of intelligence is much upon the trustworthiness of the information. So any mechanism or tools for evaluating or indicating the potential trustworthiness of the utterance could be very helpful. Generally design involves the development of alternative approaches and models solving the problem, and choice consists of analysing and evaluating the alternative and choosing one for implementation. For decision making in the group argumentation, design often means a process model which develops an approach to process group intelligence, evaluate the trustworthiness of information and the strength of different type of argument, identify the group's preference; and choice means a decision model which can integrate the strength of different type of argument with the group's preference to make optimisation. Based on the analysis of Simon's theory in the context of group argumentation, some features can be identified as necessary supporting function for group decision making as following:

(i) Well defined group argumentation model;
(ii) Capability of integrating with knowledge base;
(iii) Mechanism to identify the credibility of the argument;
(iv) Mechanism to identifying the group's preference;
(v) Formally defined decision model;

In the new decision making support paradigm proposed by Courtney (2001), the decision process is not simply regarded as making better choice based on the intelligence, preference and goals. Courtney argues the better decision making should develop and synthesis the different perspectives of the problem and iterate the process of problem solving while the mental model is updated. This new view of decision making emphasizes the iteration process of recognizing the problem, proposing action, analysing action and discovering the new problem. Similar to this view, one of our motivations in this research is that semantic enhanced group argumentation can facilitate the decision support system to decompose task and solution which will lead to the iteration of the decision process and discover more underlying problems behind the decision candidate. So in the context of group argumentation based decision making support, the system should provide tools to identify the perspectives of the decision problem and iterate the argumentation process from the rough level to the detail level. At the same time, in order to facilitate the decision maker to better identify and understand some hidden perspectives of the problem, the high level solution and problem should be decomposed in some way. General speaking, iteration mechanism, capability to identifying the perspective of problem, and solution & problem decomposition should be important features of argumentation based group decision making support. Based on the analysis of Courtney's claims, another group of features can be identified as useful decision supporting functions:

(i) Mechanism to support the iteration of decision making process;
(ii) Mechanism to explicitly decompose the decision problem and proposed solution.

In our point of view, the process of decision making and rationale behind decision is a valuable knowledge asset generated by the group via interactive argumentation. It will be an add-on benefit if this knowledge asset can be partially reused in other decision processes with similar decision problems or the knowledge can be shared in different group discussion. So the potential capability of rationale reuse and semantic support are considered as two extra features to evaluate the systems.

7.2.2 Comparison with Related Work

Based on the feature metric proposed in the above section, the related works are further reviewed from different perspectives. The feature table for different approaches is listed as Table 7.1. All these approaches or systems are claimed to support decision making in the group argumentation setting, though they are applied in the different application domain. Among which, Zeno system (Gordon, 1997) is designed for the mediation systems; HERMES (Karacapilidis, 2000) is an advanced Group Decision Support System for cooperative and non-cooperative argumentative discourse; Xiong's approach (Xiong,2008) aims to build group level consensus for group argumentation; Win-win approach (Bose, 1995) is designed for collaborative negotiation and decision making for software requirement capturing; Meta-synthesis (Liu, 2007)) is an approach for solving complex giant

problems in which a group argumentation tool are used to help experts to achieve the convergent thinking from divergent thinking; Sugimoto's approach (Sugimoto, 1998)) is for creative concept formation during the group discussion. The detail comparisons of those approaches based on the features illustrated in Table 7.1 is specified as following:

Table 7.1 Feature Comparison Table of different approaches

Features / Approaches	**Argumentation Model**	**Preference**	**Authority of argument**	**Decision mechanism**	**KB integration**
Our approach	IBIS + Toulmin + Amgoud's framework	Group Voting (criteria level)	Dynamic expert credibility	Labelling function	None
Zeno System (Gordon, 1997)	IBIS + Toulmin	argument (position level)	None	Labelling function	None
HERMES system (Karacapilidis, 2000)	IBIS+ Toulmin	argument (position level)	None	Labelling function	Yes
Xiong's approach (Xiong,2008)	Toulmin	Modality value of argument	Pre-defined expert authority	Consensus building	None
Araujo's Approach (Araujo, 1995)	IBIS	Group voting	None	Using AHP Decision model	None
Win-win approach (Bose, 1995)	Winwin Spiral Model	None	None	Labelling function	None
Meta-synthesis (Liu, 2007)	None	None	None	simulation & evaluation	None
Sugimoto's Approach (Sugimoto, 1998)	None	None	None	No explicit support	Yes

Table 7.1 Feature Comparison Table of different approaches (cont'd)

Features / Approaches	**Iteration mechanism**	**visualization**	**Semantic support**	**problem & solution decomposition**	**Rationale level reuse**
Our approach	Iteration by unsolved issue	Argumentation space & decision space (tree structure)	Content level + argumentation level	Yes	possible
Zeno System	None	Argumentation space (tree structure)	Argumentation level	None	None
HERMES system	None	Argumentation space (Tree structure)	Argumentation level	None	None
Xiong's approach	None	None	Argumentation level	None	None

Araujo's approach	None	Argumentation space (Tree structure)	Argumentation level	None	None
Win-win approach	None	None	Argumentation level	None	None
Meta-synthesis	Iteration by simulation	Argumentation Space (metric space map)	Content level	Yes	None
Sugimoto's approach	None	Argumentation space (metric space map)	Content level	No	None

(i) Argumentation Model

In the group argumentation system, Toulmin's model and IBIS model are the most widely adopted models. In the related work listed in Table 7.1, Xiong's approach use Toulmin's model; Araujo's approach apply IBIS model; zeno system and HERME system use the combination of Toulmin's model and IBIS model; Win-win approach exploit the Winwin spiral model; Meta-synthesis and sugimoto's approach use free style dialog without any argumentation model.

Comparably the elements defined in the IBIS model are more suitable for the group interaction, so it is more easily accepted in a group environment to explore the domain problem space, stimulate participants to construct solution space. However, Toulmin's model has more explicit logic structure which is vital for argument comparison and evaluation. In contrast, Toulmin's model lacks the capability for the group interaction so that it is hard to be adopted in the practical group argumentation setting. Although in Xiong's approach author claims Toulmin's model is used in the group argumentation, the discussion is constrained by one-round argumentation due to the limitation of its argumentation model. The IBIS model as a discussion structure is used in the Araujo's approach. However due to the limitation of logic structure representation, the system cannot offer direct support for decision making. So in this approach the group argumentation is only introduced as a tool to explore the problem space and generate the possible solution, and decision making is another separate process using AHP decision model and experts' input.

The WinWin spiral model used in WinWin approach defines the domain independent conceptual elements that form the agreed upon ontology of decisions for collaboration and negotiation. This ontology can be utilized to capture decision rationale and support decision maintenance in the WinWin collaboration framework in order to achieve a mutually satisfactory agreement for all stakeholders of the project. However because this model is not dedicated to the argumentation system, there are some limitation for user to make argumentation towards other options. For example the option for the issue can have adoption or rejection reasons, but the validity of these reasons cannot be further argued by the groups.

In the Zeno system and HERMES system, the combination of the IBIS model and Toulmin's model ensure the group decision support system can better cover the aspect of collaborative interaction and logic representation. The comparison of different positions is defined as "constraint" element in the new model, which can be further argued by the participants. So the preference of the pro and cons argument can be compared to evaluate the truth of conclusion. To some extent it is like the "modality" element in Toulmin's model showing the probability of the claim being true. The systems have demoed this new combination model is not only suitable for the group interaction but also possible for automatic decision making via analysing and comparing the related argument.

In Meta-Synthesis and Sugimoto's approach, no argumentation model is defined. The participants only propose their ideas using conceptual terms, and system cluster those terms and produce the group consensus or discover new related concepts from knowledge base to stimulate the

participants to further thinking about the problems. Due to lack of argumentation model, these kinds of approach can only be used in the brain storming stage rather than full cycle of decision support.

In our approach, Amgoud's abstract argument-based framework for decision making is used to complement the above combination model. In the new model argumentation are further distinguished by the practical argument and epistemic argument. Different arguments have different approaches to evaluate and compare. Epistemic arguments justify beliefs and are themselves based only on beliefs; and practical arguments justify options and are built from both beliefs and preferences/goals. The distinction of various type of argument can help the system better analyse the quality of the argument. Besides that, in our approach the "issue" element can be linked to the any "solution" element which can facilitate the system to decompose the solution into different aspects.

(ii) Preference Model

In the different related approaches, different mechanisms to capture the preference model are presented. In Xiong's approach, the preference is represented by the speakers' degree of force to support or challenge a claim. When the speaker makes argument, he must explicitly indicate the force of his argument. In Zeno and HERMES system, the preference represents the order of different positions. This is proposed by participants and can be argued by others. The potential risk of this kind of approach is to cause endless recursive argument for the preference. In Araujo's approach, the preference is modelled by both weight of criteria and weight of positions regarding the criteria. Participants can gain or update preference from the group argumentation; group voting is used to rank the weight of criteria and positions; but the criteria are predefined based on the goal of decision.

In our approach, the preference is represented as the importance of the criteria. Based on the semantic annotation of the utterance content, the system can automatically identify topic list of the argumentation which is regarded as the potential criteria list. The criteria list can be ranked by the group voting to get group level preference. Different from other approaches, in our approach the criteria are generated automatically by the system based on argumentation context and the participants only need to express their preference on them. It will reduce the participant's cognition load.

(iii) Authority of Argument

In most of related approaches, the authority of the arguments is treated equally. They assume all the participants are rationale agents and their utterance have the same credibility. In Xiong's approach, the authority credibility of expert is manually assigned so that different experts' arguments have different impact on the decision problem. In our approach, the expert's credibility is modelled as a vector of pairs --<domain, value> rather than an individual value used in Xiong's approach. This credibility model can distinguish the experts' expertise in different domain of interest. The domain of the expert's credibility is identified by the topical term of his proposed utterances. The value of the expert's credibility is computed by the type of semantic relation of others' argument to him. So the authority of argument can attribute to content level and structure level semantic offered by our model.

In our view, in the group discussion the different arguments may address the different aspects of the problem. So an overall authority credibility of expert may be not sufficient to express the credibility of the experts' argument in the particular domain. on other hand, our approach can dynamically update the agent's credibility by analysing his interaction with others. For long term and large scale discussion activities, this dynamic updating function can more precisely and simultaneously capture the agent's credibility based on the acceptability of the group.

(iv) Decision Mechanism

In Araujo's approach, the AHP decision model is used to evaluate the solution choice. However, the decision model is not fully integrated with the argumentation process. So the argumentative utterance

cannot directly be used to construct the AHP model. In Xiong's approach, decision is made by the consensus building via simply aggregating the strength of expert's claim.

In Sugimoto's approach and meta-synthesis approach, there is no proposed explicit decision mechanism. In these systems, group argumentation only acts as a brain-storming tool to help expert to recognise the problem but not for decision and evaluation. The decision making process may resort to other tool such as simulation, experiment etc.

In our approach, the labelling functions are exploited to compute the state of the solution choice and argumentation. Based on the semantic of the argumentative role and their interlink relationship, different heuristic decision functions can be designed based on various proof standards to qualify the solution choice. It will give decision makers an indicator to make their decisions. Similarly Winwin approach, Zeno and HERMES system also apply labelling function to identify the state of the elements in the argumentation model. However, in those systems the discussion space is updated simultaneously so that the parties can immediately see whether their positions are currently "wining" or "losing", given the argument which have been made so far. It can motivate them to propose better argument in favour of their positions in Zeno and HERMES; or determine and coordinate the decision making activities in the WinWin process. But on other hand, the frequently modifying the state of all argumentation elements by the propagation of the effect of any updating will bring big computation load to the system. In our approach, the labelling function is only executed once in the decision making stage after the stage of group argumentation finish. The major reason is the preferences of all the criteria are generated by group voting after group argumentation, which is required in the labelling function.

(v) Knowledge Base Integration

In some approaches, the domain knowledge base is integrated with the process of group argumentation. In HERMES system, the fact or evidence in the knowledge base is used by participants to support their arguments. In Sugimoto's approach, the system seamlessly integrates the knowledge base with the group discussion environment. A concept match algorithm is used to discover the related concepts from knowledge base to expand the existing discussion space.

In our approach because we aim to develop a domain independent framework, there is no any dedicated knowledge base integrated with the system. However, a cross domain knowledge base, DBpedia, is used to annotate the content of utterance which is the underlying foundation of the semantic support.

(vi) Iteration Mechanism

In the most reviewed approaches, the discussion session is regarded as a closed process; no one can explicitly indicate the unsolved issue for the next discussed session which is not a rare case for the complex decision problem. In Win-win approach, the unsolved issue is only regarded as the indicator to update the state of the Win Condition (claim) rather than to giving clue for other discussion session. In meta-synthesis approach, the simulation method is used to further analyse the experts' proposed options which could discover underlying issues for further discussion.

In our approach, the "issue" element can have the state "unsolved" if there is no any accepted solution. The "unsolved" issue is an explicit indicator for the decision makers to further decide possible decision problem and iterate the argumentation process to the next decision session.

(vii) Visualization

Most of related approaches including our approach use tree structure to record the content of utterance. It shows that the tree structure is the most ideal structure to represent the collaborative argumentation and the state of argument.

Due to lack of direct interaction between the participants, in the Meta-Synthesis and Sugimoto's approach metric space map is used to visualize the participants' ideas. This visualization approach is more suitable for clustering related information to reflect the groups' convergent thinking.

(viii) Semantic Support

In the reviewed approaches, the semantic support is constrained in the argumentation level or content level. For example, in Zeno system the role of argumentation is defined as different categories. It can be seen as the argumentation level semantic support, by which system can provide computation service for decision making labelling function. Differently in sugimoto's approach, content level semantic support is used in the system, in which semantic related concepts extracted from knowledge base by information retrieval technology are used to expand participant proposed concept term. So it facilitates the participant to discover some underlying relationship between proposed concepts via content based semantic expansion.

In our approach, both argumentation level and content level semantic support are provided. The argumentation schema is formally represented using the semantic web standard language and the utterance content is annotated by the formal concept extracted from DBpedia. These two levels semantic support can facilitate the system to query the argumentation collection by the semantic way (concept match and pattern match) and even share the decision rationale in the similar context.

(ix) Problem & Solution Decomposition

In our approach, solution can be decomposed by answering its underlying problem. Similarly the problem can be decomposed by raising new questions regarding the proposed solution underlying the problem. This solution decomposition ensures the decision maker not only can see the top level solution options but also see the implementation of solutions in detail. And the problem decomposition can better present the problem space in different granularity to the participants.

In other approaches, the top level solution options can only be argued rather than questioned. So there is no mechanism which can decompose the solution to present the solution route and decompose the problem to construct problem space.

(x) Rationale Level Reuse

Due to above mentioned comprehensive semantic support in our approach, the group argumentation record in one decision making process can be used as enriched knowledge asset. In which, the decision rationale can be reused in other similar context. For example, if a solution option in the current decision process A is similar to another solution option in the past decision process B, the argument underlying the solution option in the decision process B is possible to be retrieved in the decision process A by the system for reusing the decision rationale. Due to time and resource limitations, we are not able to setup long term and multiple rounds discussion sessions to validate this function. However, we have theoretically demonstrated the implementation of rationale reuse using a simple faked example in section 4.3.2.

For other approaches, they only have partial semantic support (content or argumentation). So it is difficult to share decision rationale in the different decision process.

7.3 Summary

In this chapter, based on the analysis of different views for decision making support and the requirement of group argumentation, a feature metrics for evaluating the group argumentation based decision making support system is developed. Under the guidance of these features, a qualitative comparison based evaluation for different related approaches is conducted.

Compared with other related approaches, our approach shares some common features with other approaches such as labelling decision function, argumentation model etc. However, our approach also

has some unique characteristics in the feature metric, such as rationale level reuse capability, iteration mechanism, solution & problem decomposition mechanism and dynamic expert credibility update. Besides that, the argumentation model and semantic support mechanism in our approach are more comprehensive than others. On the other hand, some approaches integrate the knowledge base into the argumentation platform for the agents to construct their arguments and some can simultaneously update the state of argument to present whether their positions are currently “wining” or “losing” during the group argumentation, which has been proved very useful. In our approach, there is no such support function.