A Discussion Information-Structuring Model Based on the Toulmin Formalism

Caiquan Xiong[1,2]，Ying Pan[1]，Dehua Li[1]
(1、Institute for Pattern Recognition and Artificial Intelligence, Huazhong University of Science and Technology, Wuhan 430074, China；
2、School of Computer Science, Hubei University of Technology, Wuhan 430068, China)
E-mail:x_cquan@163.com

Abstract

In the course of discussion, the group will produce a lot of discussion information, in which the consensus is hided. This paper proposes a discussion information-structuring model for consensus building. The model divided a statement into several parts such as premise, warrant, modality, claim etc., according to the Toulmin argument formalism. "Modelity" is designed as a quantitative scale that reflects the expert's attitude to the claim, while premise and warrant are used to provide demonstration for the expert views. We can reach a consensus by computing the value of modality. The model is a comprehensive description of the discussion information, and can effectively manage the discussion information and do consensus building.

1. Introduction

One of the most important components in the hall for workshop of meta-synthetic engineering is group discussion platform[1]. An effective group discussion platform can not only support experts in their discussion online or offline, but also effectively manage the discussion information and do consensus building[2]. Discussion information includes the basic information of experts and topics of the discussion, and the experts' argumentation generated dynamically during the group discussion. The experts' argumentation is the most important information because experts' claim and group consensus are hidden in it. Experts put forward their own claims or show their attitude (e.g. backing, rebuttal, and query) to the previous claims. To verify their claims, win other experts' support and trust and inspire group thought, experts also need to introduce many grounds and warrants for their argumentation. Then the discussion information not only includes a large amount of data but also is complex in structure. In order for computer to deal with the discussion information effectively, it is necessary to analyze the structure of the discussion information and define a discussion information-structuring model in logic.

Many researches of discussion information structuring have been published. A notable model is Toulmin logic model [3], proposed by Stephen Toulmin in 1958, who was a British philosopher. The model is based on non-formal logic, and mainly is applied in the public policy decision making. However, Toulmin logic model is much more complex in structure and can not directly applied in the design of argumentation information structuring [4]. Bui and Bodart [5] proposed an argumentation structure called ARBAS, in which discussion information is divided into nine parts such as viewer, object, action, resource, intonation, position, justification, proposed move and time stamp etc. But the ARBAS have not been verified in factual group argumentation support system (ASS). Issue-Based Information System (IBIS), which was proposed by Kunz and Rittel [6] in 1970, divides the discussion information into several parts including issues, alternatives, positions and constraints, and have been applied to the HERMES system. Sillince and Saeedi [8, 9] yet proposed other argumentation information computing models. However, those models emphasize particularly on the logical expression for single argumentation of single topic, and dose not concern with multiple discussion information structuring and consensus building from many experts' argumentation. The hall for workshop of meta-synthetic engineering is a method for solving complex problems and involves many topics and sub-topics. All the claims associated with each topic should be synthesized individually to make the final decision.

E-FORENSICS 2008, January 21-23, Adelaide, Australia

DOI 10.4108/wkdd.2008.2670

It is seen that the discussion information not only includes experts' argumentation but also other information such as experts, topics and claims. It is not feasible to directly apply the Toulmin or IBIS model to structure the discussion information in the hall.

Tan J F [10] and other some researchers proposed another discussion information-structuring model called "discussion tree". They thought the argumentation is the most important part in the discussion information, which are experts' statements for the topic or comments on other experts' claims. So a tree is constructed to describe it, in which the root is the decision task and other nodes are argumentation. The directed arcs among nodes are semantic relationships that denote the expert argues for, argues against or queries for one argumentation. According to the discussion tree, they also defined the data structure including argumentation ID, argumentation person, argumentation topic, argumentation details, argumentation ID that is commented, the semantic relationship between currently argumentation and comment object, decision task number, discussion style etc. But the model has four limitations below: (1) due to large amount of argumentation, it is difficult to determine the previous argumentation that the expert argumentations aim to; (2) the standardization of semantic relationships is not enough to express one-to-many relationship between argumentations in the database; (3) it does not draw out claim during the structured processing of argumentation; (4) it has no discussion of consensus building based on the structure model of argumentation.

We think that experts' argumentation aims at claim instead of previous argumentation. A graphical view of the group discussion will indicate the relationship between expert and claim, and the experts' attitude to a claim. Furthermore, the relationship can be quantitatively processed to do consensus building. This paper proposed a discussion information-structuring model for group consensus emerging in the hall for workshop of meta-synthetic engineering. It is based on a simplified Toulmin formalism, and divides the experts' argumentation into several parts including premise, warrant, modality and claim. "Modelity" is designed as a quantitative scale that reflects the expert's attitude to the claim, while premise and warrant are used to provide demonstration for the expert views. We can reach a consensus by computing the value of modality. The model is a comprehensive description of the discussion information, and can effectively manage the discussion information and do consensus building.

2. Toulmin Argument structure

Toulmin argument structures, suggested in Figure 1, have six component parts, including claim, ground, warrant, backing, modality and rebuttal. They are defined as follows.

1) Claim—An assertion that the expert tries to prove to be true in discussion. It usually is an affirmative statement.

2) Grounds (for the claim)—This is the foundation of the expert's claim, such as provable or recognized proposition, credible fact and experimental data.

3) Warrant—This is the expert's reasoning for connecting the grounds to the claim.

4) Backing—Further facts or reasoning that are used to support or justify the warrant.

5) Modality—A strong leap from ground and warrant to the claim, showing the probability of the claim being true.

6) Rebuttal—This holds back the reasoning warrant to claim and weakens the modality of the claim.

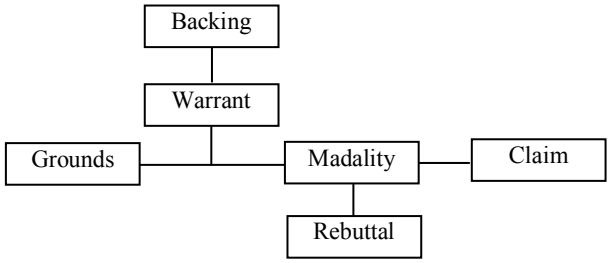

Figure1. **Toulmin Argument Structure**

However, the actual situation of discussion is more complex than the description in Toulmin argument structure. In Toulmin, only the warrant component is supported by the backing, which means when the audience questions your warrant, you need to provide further backing statements. But in actual case, the backing itself also needs to be supported by other backing statements. And in other case, not only the warrant but also the ground needs backing, but in Toulmin, the ground is defined as a recognized component without proving.

The rebuttal also needs to be supported by the ground and the warrant when it argues against claim. They are hierarchical in structure. Moreover, the counterclaim in Toulmin needs ground, warrant, backing, modality and rebuttal too. So Toulmin argument structure gradually evolves to a complex scheme in nonformalism, as shown in Figure 2. Obviously, it is not feasible to directly apply the Toulmin model to structure the discussion information.

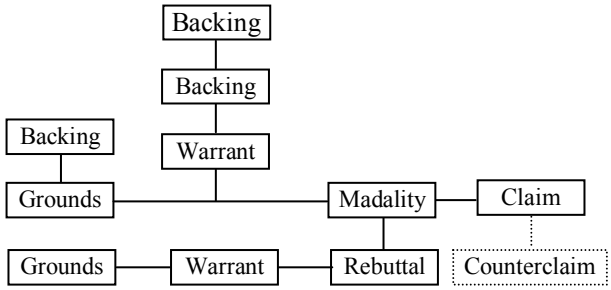

Figure2. **Extended Toulmin Argument Structure**

Recently, most of the work is to simplify Toulmin argument structure. Mitroff and Hamalainen [5] presented a Premise–Warrant–Claim model, and took it as the logic basis of political decision, in which the premise refer to the ground in Toulmin, In the work of Ramesh and Whinston, a Claims–Arguments–Proposals model, and three formulas (i.e. Representation, Coordination, Games) corresponding with formal logic and a dialog grammar were presented. However, those simplified Toulmin argument structures are not feasible to be applied in the design of discussion information structuring because they lack the important component—"modality". The modality plays an important role in connecting all experts' statements to the claim, and reflects the experts' attitude to the claim, in which the integration of all experts' attitudes is the consensus.

3. Discussion information-structuring model

3.1. Analysis of discussion information structure

The purpose of the design of discussion information structure is to divide the experts' argumentation into several parts that can be saved in the database, so we can query and analyze the argumentation information using the technology of database. Furthermore, a favorable design of discussion information structure can do consensus building from discussion information.

Toulmin formalism is composed of several components, and all components can be implemented by database technology. So a discussion information structure based on Toulmin formalism is practical for us. However, because of too many components of backing, rebuttal and counterclaim, the extended Toulmin argument structure is so complex that the database design criterion is undermined. On the other side, the Mitroff's Premise–Warrant–Claim model is too simply to reflect factual situation because of lacking of modality.

In this paper, we present a Premise–Warrant-Modality–Claim model, which incorporates above two models and easy to be implemented in the hall for workshop of meta-synthetic engineering. It is defined as follows.

(1) The core of our Premise–Warrant-Modality–Claim model is the modality and the claim. The other two components, the premise and the warrant, are preserved. The claim is the object of experts' argumentation, and the modality reflects the expert's attitude to the claim. The premise and the warrant are complementary statements to the expert's attitude.

(2) The backing supports not only the premise but also the warrant. It also consists of a premise and a warrant. Whatsoever, the backing is work for the claim in the end. So we can look the backing as the warrant of the claim.

(3) The rebuttal consists of a premise and a warrant. It is a statement that wakens the modality of the claim to be a minus value. So we can process the rebuttal in the same way as backing.

In this way, the backing and the rebuttal can be processed conformably in the Premise–Warrant-Modality–Claim model.

The hall for workshop of meta-synthetic engineering is a method for solving complex problems, and then the discussion platform also is a complex information system. The discussion information includes not only the basic information of experts and topic of the discussion but also the experts' argumentation. Figure 3 shows the conceptual structure of discussion information using a simply ER model. As shown in Figure 3, the argumentation connects the expert and the claim.

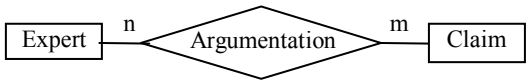

Figure3. **Discussion Information Conceptual Model**

For the implementation of the discussion information conceptual model using database technology, we define some tables in database as follows.

Argumentation Table (expert's ID, claim ID, response style, premise, warrant, modality, time stamp).

The response style includes Propose, Backing, Rebuttal and Query. And the modality is a quantitative scale (from +10 to -10) of the response style, according to Lowe in 1985 [13]. The modality is divided into eleven scales upon the degree of support, from the most to the least (i.e. from backing to rebuttal). The values of modality are a decreasing arithmetic

progression from +10 to -10, such as (10，8，6，4，2，0，-2，-4，-6，-8，-10).

Expert Table (expert's ID, expert's name, expert's credit).

Claim Table (claim ID, the topic of the claim, the expert of the claim, claim details, claim concern value, claim authority value, claim consensus value).

3.2 Group consensus emergence

The *Argumentation Table* is the most important part in the discussion information conceptual model. It reflects the relationship between expert and claim, namely the expert's attitude to the claim. Each argumentation can be expressed by the reflection relationship between expert and claim. The reflection relationship can be looked as the modality of the Toulmin formalism. Other components give grounds of the expert's attitude to increase the credibility of the other experts. By summing all the values of modality of the claim, we can assess the degree of support to the claim, and the group consensus is built.

We also define a conceptual view called consensus building graph to describe the reflection relationship.

Definition: Let E be a set of experts, then for $m(m \geq 2)$ experts, we have $E=\{e_1,e_2,...,e_m\}$. Let A be a set of expert credibility, then $A=\{\alpha_1,\alpha_2,... \alpha_m\}$, here α_i is the credibility of the expert e_i. Let C be a set of claims, then $C=\{c_1,c_2,...,c_n\}(n \geq 2)$. The consensus building graph (CBG) has three components and is expressed as follows:

$$CBG=(E,C,R)$$

Here, R is an ordered pair set,

$$R=\begin{pmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{pmatrix},$$

the $r_{ij}=<e_i, c_j>$ is the multiple subset of Cartesian product $E\times C$, representing the attitude of expert e_i to the claim c_j. The weight of r_{ij} is $w(r_{ij})=\alpha_i\times v_{ij}$, here α_i is the credibility of the expert e_i, and v_{ij} is the value of modality of expert e_i to the claim c_j. Then the r_{ij} is a weighted directed arc.

The scale of CBG dynamically increases. The first argumentation forms the first expert node and the first claim node. Whenever the expert proposes a claim, we think he supports to his claim at the same time. So the first directed arc would be drawn between the first expert node and the first claim node. And with the discussion proceeding, more new claims and response of expert to claim are produced, so more directed arcs are drawn. The out-degree of an expert node shows the expert's activity to speak, and the in-degree of a claim node shows the degree of concern to the claim. A consensus building graph is indicated in Figure 4.

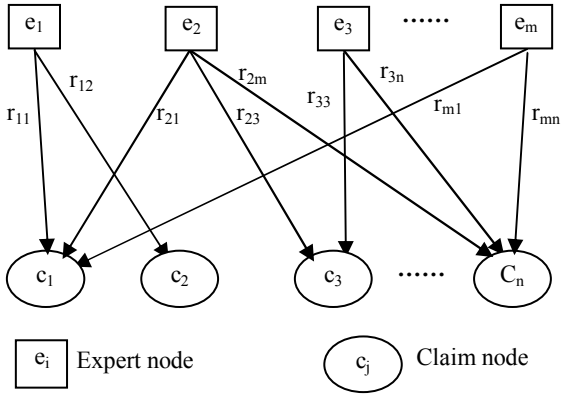

Figure4. **Consensus Building Graph (CBG)**

From the consensus building graph, we can compute following indexes.

(1) The degree of concern to the claim is the in-degree of the claim node c_j:

$$Concern(c_j)=\sum_j ID(c_j).$$

(2) The authority of claim is the credibility of expert who proposes the claim:

$$Weight(c_j)=\alpha_i$$

(3) The consensus value of claim is the sum of the in-degree arcs' weight of the claim node c_j:

$$Consensus(c_j)=\sum_i W(r_{ij})=\sum_i \alpha_i\times v_{ij}$$

Then a claim consensus vector can be obtained based on the consensus value of claim:

$$\left[\sum_{i=1}^{n}\alpha_i\times v_{i1},\sum_{i=1}^{n}\alpha_i\times v_{i2},\cdots,\sum_{i=1}^{n}\alpha_i\times v_{im}\right]$$

We can use Structured Query Language (SQL) to do aggregation computation in argumentation table to attain the values of above indexes. The results are saved in the claim table. We also set threshold value for *consensus(c_j), weight(cj)* and *concern(cj)* according to the request of discussion, and get the valuable claims. The *consensus(c_j)* is the preference guidance in consensus building because it incorporates the authority credibility of expert and the modality value of expert to claim.

4. An example of consensus building using Premise–Warrant-Modality–Claim model

We design a group discussion support system based on above consensus building model. The system is based on the browser/server structure. Every expert

logs on the system to enter the virtual discussion hall, according to the username and password given in the conference notice. The interface of discussion hall is divided into several areas, including the list of expert area, the argumentation details area, argumentation structuring area and consensus building area. Except the argumentation structuring area requires input by handwork, the reminder areas can be generated automatically.

A simulation experiment was done in the initial formed group discussion support system. The test involved five experts, whose credibility values respectively were {0.20, 0.20, 0.10, 0.40, 0.10}. The topic of discussion was *the city's education development planning in "11th-Five-Year Plan"*. The group of experts proposed four claims in half an hour of discussion, shown in following.

1) Claim c_1 proposed by expert e_1: The ratio of education expenditure to the city financial expenditure should be increased.

2) Claim c_2 proposed by expert e_2: We should focus on the development of vocational education.

3) Claim c_3 proposed by expert e_4: The expenditure of compulsory education should be expanded.

4) Claim c_4 proposed by expert e_1: We should actively develop the private education.

The experts' argumentation was structured to save in the argumentation table. If there is no premise or warrant in the argumentation, the values of their columns will be NULL. The argumentation details during discussion have not been given in this paper due to the space limitations of the article. The CBG of the test are indicated in Figure 5.

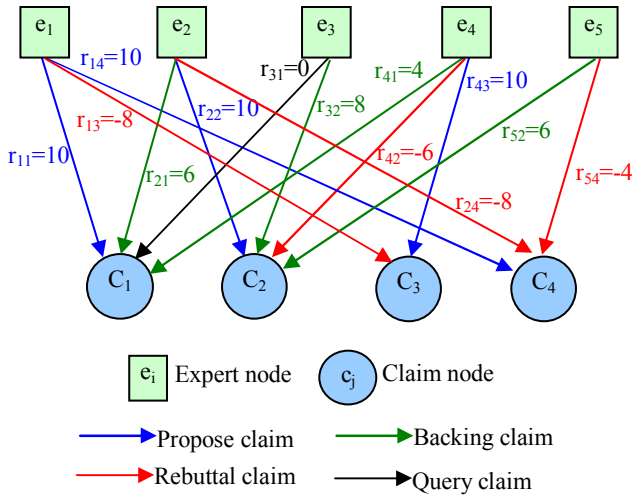

Figure5. **An example of CBG**

Every claim, whether it was proposed initially or was responded by experts, would be evaluated a value of modality in the argumentation structured area. In this test, after experts finishing the discussion, the final claim table is shown in Table 1.

Table1. **The computed concern value, authority value and consensus value of claims**

Claim	Concern value	Authority value	Consensus value
C_1	4	0.20	0.2*10+0.2*6+0.1*0+0.4*4 =4.8
C_2	4	0.20	0.2*10+0.1*8+0.4*(-6)+0.1*6 =1.0
C_3	2	0.40	0.2*(-8)+ 0.4*10=2.4
C_4	3	0.20	0.2*10+0.2*(-8)+0.1*(-4) =0.0

The analysis result of the test indicated that c_1 and c_2 were more concerned than other claims, c_3 had the maximum authority value, c_1 and c_3 had larger consensus value. According to the rule of max-consensus value, c_1 and c_3 well be the consensus of the discussion.

The results show that it is efficient to structure the experts' argumentation and to save it in the database using Premise–Warrant-Modality–Claim model, and we can reach a group consensus by the consensus building graph (CBG).

5. Summary

The organization and management of argumentation information is very important in the group discussion platform of the hall for workshop of meta-synthetic engineering. For one side, the argumentation information should be preserved as a part of conference documents, which provide reference in the future. The other side is the group consensus is hidden in the experts' argumentation. In order to save the argumentation information in the database, the argumentation information requires to be structured. So we can get a consensus from the structured argumentation information by database technology. In this paper, we have proposed a discussion information-structuring model, Premise–Warrant–Modality–Claim, based on Toulmin formalism. The model is a comprehensive description of the discussion information and is good in structure. We can store and manage the argumentation information using database technology in the model. Furthermore, to implement the modality component of Toulmin formalism, we also have proposed a new algorithm called group consensus graph (CBG), which reflects the experts' attitude to the claim and is effective to get group consensus. The CBG has been applied successful in the

discussion platform of military strategy meta-synthetic engineering hall, and has positive results.

There are also some limitations in our research. Firstly, a lots of argumentation information are generated during the face-to-face discussion, so we need faster speed to input the experts' argumentation. It is a challenge for us. Secondly, there isn't enough mature intelligence technology to process natural language, and then the structuring of experts' argumentation is done manually. The third one is that the consensus building mainly relies on the components of claim and modality, however, in fact, the premise and warrant are all important components in inspiring group thought, and contain lots of useful information. How to get some useful information from them is our future direction.

References

[1] Qian X S, Yu J Y, Dai R W, A new discipline of science: The study of open complex giant system and its methodology, *Chinese Journal of Systems Engineering & Electronics*, 1993, 4(2): 2-12.

[2] TANG X J, LIU Y J, Group Argumentation and Its Analysis on a Highlighted Social Event- Practice of Qualitative Meta-synthesis, *Systems Engineering-Theory&Practice*, 2007, 3: 42-49.

[3] Toulmin S E, *The Uses of Argument*, New York: Cambridge University, 1958.

[4] Mitroff I I, Mason R O, Barabba V P, Policy as argumenta logic for ill-structured decision problems, *Management Science*, 1982, 12(28): 1391–1404.

[5] Bui T X, Bodart F, et al., ARBAS: a formal language to support argumentation in network-based organizations, *Journal of Management Information Systems*, 1997, 14(3): 223– 238.

[6] Kunz W, Rittel W J H, Issues as elements of information systems (Technical Report 131), Berkeley, CA: University of California, 1970.

[7] Gordon T, Karacapilidis N, The zeno argumentation framework, Proceedings of the 6th Int, *Conference on AI and Law (ICAIL'97)*, Melbourne, Australia, ACM Press, New York, 1997: 10–18.

[8] Sillince J A A, Saeedi M H. Incorporating rhetorical and plausible reasoning in an electronic conferencing system, *Knowledge Based Systems*, 1999, 12: 113– 127.

[9] Sillince J A A, Saeedi M H, Computer-mediated communication: problems and potentials of argumentation support systems, *Decision Support Systems*, 1999, 26(4): 287– 306.

[10] Tan J F, Zhang P Z, Huang L N, A Group Argumentation Information-Structuring Model in Hall for Workshop of Metasynthetic Engineering, *Systems Engineering - Theory & Practice*, 2005, 1: 86-92, 99.

[11] Hamalainen M, Hashim S, Holsapple C W, Suh Y, Whinston A B, Structured discourse for scientific collaboration: a framework for scientific collaboration based on structured discourse analysis, *Journal of Organizational Computing*, 1992, 1(2): 1–26.

[12] Ramesh R, Whinston A B, Claims, arguments, and decisions: formalisms for representation, gaming and coordination, *Information Systems Research*, 1994, 3(5): 294–325.

[13] Lowe D G, Co-operative structuring of information: The representation of reasoning and debate, *International Journal of Man-Machine Studies*, 1985(23): 97-111.