Chapter 3 A Semantic Enhanced Conceptual Framework for Argumentation Based Group Decision Making

Abstract In this chapter, we will design a group argumentation support conceptual framework to facilitate automatic/semi-automatic decision making in the context of complex problems. The main elements in the framework are modelled and discussed. Particularly various argumentation schemas are reviewed and a novel decision making oriented argumentation schema is proposed. An ontological formal semantic representation of proposed argumentation schema is presented, based on which the process of decision making is given and computational decision functions are designed.

Keywords: conceptual framework for group decision making, argumentation schema, decision function.

3.1 Overview

In this chapter, we will design a group argumentation support conceptual framework to facilitate automatic/semi-automatic decision making in the context of complex problems. We are mainly concerned about how to discover and represent the various perspectives of the problem during the group argumentation and how to integrate and evaluate group experts’ view to assist decision making.

The literature review in Chapter 2 has revealed that in current approaches group argumentation and group decision making are often regarded as two separate stages. Although some approaches have been proposed to represent and evaluate argumentation for decision making purposes, there is still a lack of a comprehensive framework which can fully integrate the process of argumentation with the process of decision making. In order to design such a framework, it is necessary to identify the main elements in the group argumentation and decision making process and how they interact with each other. A new conceptual framework needs to glue those elements together to support decision making fully using the argumentation approach.

3.2 Overview of the Proposed Conceptual Framework

In (Schneider et al, 2010), a user survey has been conducted to assess the importance attached to different features in an online discussion system. The result shows the usability, integration, author context, topic, referential context and visualisation/sort/query are comparably important features in the discussion system. However, for the decision system the three phases (intelligence, design and choice) identified by Simon (Simon, 1960) are widely adopted. So it leads discovering and structuring problem domain, designing evaluation model-- mainly involving criteria and decision maker’s preference, and structuring solution to be major features of the decision system. The final outcome of decision system is to recommend the optimised solution and reasons behind it. Apart from that, the detailed solution route (how to achieve the task), remaining issues to be solved should be presented for the higher level decision support. The decision result and rationale should be
archived as a reusable knowledge asset for case-based reasoning. The main features of these two systems are illustrated as Figure 3.1.

By further analysis of features of the discussion system, some traits of the group discussion have been identified to be highly required in the decision making system. Among which, the authors’ social reputation can be obtained from their interaction by analysing the authors’ context; the possible criteria can be obtained from the topic collection by analysing the topic context and referential context; different levels of issues and ideas can be obtained from the discussion utterance and the authors’ rationale can be obtained by analysing the referential context. By integrating with the decision system, the user not only can see the original conversation but also the decision made based on these conversations where applicable. The overview concept of integrating the discussion system to the decision system is shown as Figure 3.1.

![Figure 3.1 Overview map of discussion system and decision system](image)

Based on the above discussed integration between the discussion and decision making, an argumentation based conceptual framework for group decision making is proposed shown in Figure 3.2. In this conceptual framework, decision makers are also participants of the group argumentation. The procedure of group decision making in this framework can be specified as the following steps:
Participants propose their solutions for the particular task based on their belief and knowledge;

Participants argue others’ solutions with their evidence or explanation, at the same time their proposed solutions or argumentations are argued by others from either positive or negative prospective;

The utterances of argumentation are organised by a formally defined argumentation schema, the semantics of utterance type and relation between them will be well defined which can clearly specify the rationale of the author who proposes the utterance. So the state and strength of each argumentation can be evaluated based on the semantic type and relationship of the following utterances addressing it;

The metadata manager tool is exploited to annotate the utterance with a formal concept from the underlying domain ontology in order to better expose the decision makers’ mental model of the problem space;

System elicits the criteria and group level preference about them for evaluating the decision from the group mental space (list of concept). Particularly a group level preference can be obtained by the group members’ ranking towards criteria;

Decision function will take the preference of the group members for each criteria, the strength of pros/cons argumentation and social parameter (experts’ credibility) into account to update the state of utterance and score the candidate decisions.

Recommendation system presents the decision result in the different views to facilitate the decision maker to analyse and choose the best solution or evolve the decision task to the different level.

As illustrated in the Figure 3.2, “Utterance” represents participant’s proposed raw data; “Structure Ontological Content” represents structured utterance encoded by predefined schema; “Semantic Enhanced Argumentation Content” represents structured utterance annotated by topical terms; “Mental Space” indicates full sets of semantically enhanced structured contents generated in the group argumentation. And “Argumentation Schema” is a predefined structure to organise and encode the argumentative information; “Metadata Manager” indicates an annotation approach to retrieve the topical concept from the domain ontology and add it to the argumentative information; “Identify Criteria” & “Update Social Parameter” respectively represent a process to identify the different aspect of decision task and participant’s credibility in particular domain of interest. “Decision Function” indicates a series of functions to evaluate the acceptability of arguments, calculate the strength of each argument, and score the decisions.

The following sections will describe the various elements of this conceptual Framework in detail.

### 3.3 Argumentation Schema

It has been shown that without systems of language symbols, it would be very difficult to reason or argue. These symbols should have meanings shared by the members of the group who are participants in the social action. Many studies on structuring discussion information have been published. Those proposed discussion information structures actually act as a system of language symbols for better organising the information, reasoning upon the information and even facilitating participants’ communication.

### 3.3.1 Various Argumentation Models

Toulmin’s argument model is one of the most notable argumentation models. It was proposed by Stephen Toulmin in 1958. This model is based on non-formal logic, and mainly applied in the field of law (Freeman, 1996) and public policy decision making (Tweed, 1998) etc. Generally, Toulmin’s argument model, shown in Figure 3.3, has six core parts which respectively are claim, ground, warrant, backing, modality and rebuttal. They can be defined as following:

- **Claim** – An assertion that the expert believes is true and tries to prove in the discussion.
(ii) Ground (evidence) – A fact one appeals to as a foundation for the claim, which can be recognized proposition, credible fact or experimental data.
Toulmin’s model can provide a graph-like argumentation representation, which can help users easily observe the process of reasoning and more objectively consider the discussed problem. However, Toulmin’s model is a bit hard for users to master without a certain degree of logic knowledge. In the distributed collaborative argumentation environment, it is not realistic to ask all the attendees to understand and employ all the elements. Mitroff (1982) also argues that Toulmin’s logic model is much more complex in structure and cannot directly be applied in the design of argumentation information structuring. In addition, Toulmin’s model lacks interaction value which is an essential part of the group action. For example, user cannot raise questions to any element for clarification or argue about validity of data and warrant.

The IBIS argumentation model is another well recognized one that provides symbols to model collaborative argumentation (Figure 3.4). It originally was proposed by Kunz and Rittel (Kunz et al, 1970). This model consists of four basic elements: Topic, which denotes assigned task and opens the following discussion. Issue, which means raising question or issue, is brought up and disputed because different positions are assumed. Position provides possible solution or explanation about the issue. And arguments state evidence, facts and viewpoints that either support or challenge positions. Because any elements can bring other related issue, the process of argumentation can be organised into a tree structure around issues. The IBIS argumentation model is often applied in the field of design for capturing design rationale (Medeiros, 2006) via proposing issue, offering solution/idea and arguing with evidence and fact.

The original concept of IBIS focuses on a model of problem solving by cooperation as an argumentative process. So compared with Toulmin’s model, the IBIS model is more easily accepted in a group environment to explore the domain problem space and to stimulate participants to construct the solution space. Also, in the IBIS model the relationship between the various elements can be used to aid the search for similar issues, the history of an issue and the consequence of previous decisions. However, Toulmin’s model has more explicit logic structure which is vital for argument evaluation. Particularly the modality element can directly reflect the strength of argument. The justification of claim even could be quantified by a computerized model (Xiong et al, 2008), which is highly required by decision making process.
Amgoud (2009) proposes the first general and abstract argument-based framework for decision making, in which two types of arguments are distinguished: i) epistemic arguments justifying beliefs and are themselves based only on beliefs, and ii) practical arguments justifying options and are built from both beliefs and preferences/goals. In the decision making context, options mean solution candidates which are akin to claims in the Toulmin model and positions in the IBIS model. A practical argument may highlight either a positive feature of a candidate decision, supporting thus that decision, or a negative one, attacking thus the decision; however epistemic argument only proves the certainty of information (belief) in the related practical argument. Normally, the practical argument corresponds to the option (decision candidate) and the epistemic argument corresponds to the practical argument or other epistemic arguments. To some extent, the practical argument connects the epistemic argument to the candidate option. It is more like the function of Warrant in the Toulmin’s model. The following argument snippet is a simple example (Amgoud et al, 2009):

Task: “what treatment should be employed for this patient?”
Option: “having a surgery”
Practical (pro) [“the patient may have a cancer” “when argument: having a cancer, having a surgery avoids loss of life”]
Epistemic (pro) [“the patient has colonic polyps”, and argument: “having colonic polyps may lead to cancer”]

Generally, the strength of an epistemic argument reflects the quality, such as the certainty level, of the pieces of information involved in it, whereas the strength of a practical argument reflects both the quality of knowledge used in the arguments and how important the preferences are to which the argument refers regarding the decision task. In the above example it means how important avoiding loss of life is in the context of treatment. Obviously these different argument forces will have different effect in the decision making. However how to model and elicit the argument force, and how to evaluate the relation between the decision and other discussion elements are not trivial issues. The detail will be discussed in the Section 3.5.
3.3.2 Argumentation Schema Design for Group Decision Making

In the context of argumentation based group decision making, decision makers/participants (agents) deliberate the goal of the task and propose their own solutions; they also support/attack others’ opinions with justifications or raise issues for clarifying or refining the solution. Finally, various aspects of the problem, alternatives of solutions and their rationale are exposed and thereafter the belief and desire of the agent will be updated which will facilitate to obtain better decision. Our vision is that group argumentation schema should be able to be used for exploring and structuring the problems and solution with group members’ contributions and also offer necessary extended mechanisms for decision making automation. So the ideal group argumentation schema should be better to model the process of group interaction but also can provide a decision support function.

It has been shown IBIS is good for modelling group argumentative process in the context of cooperative problem solving (Karacapilidis et al., 2000), Tolumins’ model has good reasoning value for decision evaluation (Xiong et al., 2008), and Amgoud’s argument framework has potential capability to further extend reasoning based decision evaluation. We are looking for a new group argumentation schema which can combine these two merits without loss of usability in the factual group discussion environment. In the conceptual framework shown above (Figure 3.2), the utterance is the basic unit and it can play different roles. Combining IBIS model and Amgoud’s argument framework for decision making, we can identify various roles of utterances as follows.

(i) Specifying task,
(ii) Proposing solution (Idea),
(iii) Raising issue,
(iv) Pros/cons practical argument.
(v) Pros/cons epistemic argument

The abstract schema of argumentation can be generalized as argumentation= {utterance1, link, utterance2}, the instantiation of this abstract representation can be shown as Table 3.1.

### Table 3.1 Semantics of Utterance

<table>
<thead>
<tr>
<th>Antecedent</th>
<th>Link</th>
<th>Subsequent</th>
<th>Semantic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution</td>
<td>Resolve</td>
<td>Task</td>
<td>Propose the solution to the specified Task</td>
</tr>
<tr>
<td>Practical Argument</td>
<td>Support/Challenge</td>
<td>Solution</td>
<td>in favour or against the solution with belief and preference</td>
</tr>
<tr>
<td>Issue</td>
<td>Raise_issue</td>
<td>Solution</td>
<td>Raise question regarding some aspect of solution and hope to clarify or update solution</td>
</tr>
<tr>
<td>Solution</td>
<td>Resolve</td>
<td>Issue</td>
<td>Propose the solution to the specified issue, the original solution may be updated or evolved.</td>
</tr>
<tr>
<td>Epistemic Argument</td>
<td>Support/Challenge</td>
<td>Practical Argument</td>
<td>In favour or against the practical argument with belief</td>
</tr>
<tr>
<td>Epistemic Argument</td>
<td>Support/Challenge</td>
<td>Epistemic Argument</td>
<td>In favour or against the epistemic argument with belief</td>
</tr>
</tbody>
</table>

Each utterance will include fields which are 1) expert_id, 2) utterance_id, 3) time, 4) content, 5) state, 6) target_id, 7) domain, 8) Type, 9) semantic_link, 10) score. Some fields are directly provided by system and user’s input. Among them, the field1 (expert_id) stands for the identification of utterance proposer, the field2 (utterance_id) and the field6 (target_id) are the identifications of two argument counterparts, the field4 (content) means the content of current utterance, the field7 (domain) is a topic of utterance which can be used to conceptualize participant’s mental space and also identify the criteria for evaluating decision, the field8 (Type) indicates the role of this utterance which can be selected from the concept of our predefined ontology, and the field9 (semantic_link) refers to the relationship between two argumentative utterance that can be selected from the property of our
predefined ontology. But the rest only can be obtained by analysis of other related argumentative utterance. For example, the field5 (state) and field10 (score) are calculated by system based on the following argumentation and proposer’s expertise. For solution and argument utterance, values of the state field can be “rejected”, “accepted” or “unverified”, which indicate the acceptability of information. Or they can be “unsolved”, “solved” or “unverified” for issue utterance, which indicate if there is an accepted solution to address this issue. Only “accepted” solution and argument utterance will be considered to be used for the evaluation of decision by the decision function. And only “unsolved” issue could be utilized to evolve the decision problem. Finally, the score of the solution utterance will give the ordering of decision. The algorithm of calculating the score and deciding the state will be discussed later. A new proposed argumentation schema is shown as the Figure 3.5. The basic argumentative utterance units and links between them in this schema are similar to those in the IBIS model which has been reported to have good capability to model group argumentative process. The score property of the utterance reflects the strength of the argumentation which is comparably similar to modality element in Toulmin’s model. The logic reasoning process in the Toulmin model can be achieved by the score based computation in our new schema.

![Proposed argumentation schema](image)

Figure 3.5 Proposed argumentation schema
In the group argumentation, the agent is required to input information in the form of defined argumentation schema, which will construct an argumentation tree illustrated as Figure 3.5. In following sections, we will describe how decision can be made (ordered) and evolved based on this information structure.

Figure 3.6 Group Argumentation interface

3.4 Ontology & Metadata Manager

In the above section, it has been shown that practical argument reflects the quality of knowledge used in the arguments, as well as how important the preference to which the argument refers is. In traditional multi-criteria decision making approaches such as AHP, a preference will correspond to a criterion and defined as how important this criterion will affect the decision. In most cases, preferences are predefined by decision makers before decision-making activity. In some ontology driven decision making approaches, an ontology designed by the domain expert is used to model decision makers’ preferences (Niaraki, 2009). The concepts in the ontology are mapped to criteria upon which the decision maker can express his preference to evaluate alternative solutions. For example, in (Niaraki, 2009) concepts in the road segment ontology such as “weather”, “safety”, “facilitate”, “tourist attraction” can be derived by the personal route planning system as criteria of evaluating decision. Decision makers’ preferences upon these criteria are used to decide optimized route. However in most cases we have ontology to model a domain rather than a task, so concepts in the domain may be much broader than the concepts required in a decision making task. There is still a lack of automatic mechanism to select criteria required for task-oriented decision making from a
predefined ontology. Furthermore, there is no mechanism to update ontology according to the new criteria proposed by decision maker which is out of the original predefined ontology.

In group argumentation, the group’s utterance set comprises a group’s beliefs about the particular task. If the system can extract concepts or topics that each utterance talks about, the mental space of a group in the context of decision making will be externalized including the criteria that decision maker may be concerned about in the decision making and individual’s domain of interest.

In order to annotate utterances with formally defined concepts illustrated as Figure 3.7, we need to provide a general ontology in an application domain. The difference from the traditional ontology driven decision making approach is that in the traditional ontology driven decision making approach all concepts existing in the domain ontology could be the criteria for evaluating decisions, however in our approach only concepts that occur in the utterance set are regarded as potential criteria for decision making. Furthermore, in our approach concepts occurring in the utterance set but not in the ontology may cause the update of original ontology. Comparably the criteria elicited from our approach are more relevant to the specific task, as they are generated from the task focused group discussion. In addition, the decision making in our approach is not constrained by fixed (or predefined) aspects of related domain. The update of ontology can facilitate new aspects of the problem to be proposed and recorded. As shown in the Figure 3.7, the classes formally defined in the domain ontology hierarchy are used to represent the concept of different argumentative utterance.

Using formal concepts in the ontology to annotate utterances can also provide a mechanism to represent group experts’ domains of interest and update their credibility with respect to a certain topic during group interaction which could be used to evaluate trustworthiness and strength of the argument. For example, if an expert’s (decision maker) utterance about class1 is challenged by other experts, from the group point of view his credibility about class1 will be decreased. So in the stage of evaluation of decision, this expert will take less impact on the certain perspective (class1 related) of the final decision.

![Figure 3.7 Utterance annotation illustration](image)

In group argumentation, participants use natural language to state their utterance. It is not trivial to map linguistic terms to ontological concepts due to issues of synonymy, polysemy, morphology and syntax. To address these issues, in the proposed conceptual framework (Figure 3.1 in p. 61), a metadata manager as an annotation tool is introduced, whose role is to extract meaningful terms from the utterance and map them to a formal concept defined in the ontology. Meaningful term extraction can be done automatically or manually. In the automatic method, the metadata manager can pre-
process terms in the content of the utterance with Part-Of-Speech (POS) tag and stemming and keep
the meaningful term set whose POS is noun or verb. In the manual method, the system provides an
interface for the participant to summarize their utterance using the meaningful keyword which will
indicate the main aspect of the utterance. Besides, the metadata manager is also able to search the
domain ontology repository with the term set to annotate the utterance using a semantically similar
formal concept. The purpose of annotation is for conceptualizing the utterance to better classify the
possible perspectives of the decision task and expert’s domain of interest. The implementation of
conceptual annotation is described in Chapter 5.

3.5 Agents’ Social Parameter

Indiramma (2008) argues that most current approaches in decision making have mainly addressed
computational issues, but social issues were given less attention. However in group activity, social
issues such as trust, belief, empathy and emotions are very important factors. Particularly in the
context of collective decision making, the social parameters of one decision maker will prominently
affect the degree of acceptance of his decision within the group.

Rodriguez (2006) defines social space as a set containing all humans, their domains and their
relationship to other humans. Any human is associated with a collection of domains, meaning he has
expertise in such domains. The relationships between the humans are trust relations. The purpose of
defining a domain is to allow individuals to categorize the type of trust relations they have with one
another and to categorize the type of problems contained within the problem space. In addition,
domains are related to each other by similarity. The meaning of trust relation will rely upon the
context and connected individual. In some context, trust could be a way to measure similarity (Ziegler,
2005). For example if human h₀ trusts human h₁, h₀ will believe that h₁ will make decisions which are
consistent with his value system. However in other contexts, trust acts as a way to measure
dissimilarity, as in the case that human h₀ lacks expertise which human h₁ has so he believes h₁ can
make better decision. The degree of trust that h₀ has for h₁ can be represented by conditional
probability P(A|B), formalized as:

\[
\text{Weight}_{trust}^{h₀,h₁} = P(h₁ \text{ is good } | h₀ \text{ has knowledge of } h₁)
\]  

Furthermore due to the diversity of the human’s aspects such as multi-skill and multi-facet, trust
relations could be more accurate if they are domain dependent or context specific. So the role of
domain will model the aspect of the human and problem from different facets. The statement about
the trust relation can be further claimed as human h₀ can trust human h₁ to make good decision in
domain d₀, it can be formalized as:

\[
\text{Weight}_{trust}^{h₀,(d₀),h₁} = P(h₁ \text{ is good in } d₀ | h₀ \text{ has knowledge of } h₁ \text{ in } d₀)
\]  

In group argumentation, the participant p₀ makes explicit his or her trust in participant p₁ by
supporting p₁’s claim or argument. In the opposition, the participant p₀ can also express distrust of p₁
by challenging his claim or argument. The group wide trust can be aggregated to reflect a certain
participant’s credibility. In the group argumentation, the credibility of the participant can reflect the
credibility of his utterance, which will indicate the acceptability of his opinion. Argumentation
provides an explicit way to disclose one’s favourable or unfavourable attitude to others. So it could
be exploited to construct the trust network among individuals who interact with each other in some
group activities. The group activity is not only constrained to the small and close group, it can be
extended to the activity in huge and open social community such as on-line forum and social network.
Conversely, trust network within a group will be useful to evaluate the individual’s decision. We
envision decision oriented group argumentation as an open and iterated process due to the complexity
and dynamic of the problem. So trust relations developed in the past between two agents provide the
implicit evidence that one will accept or reject the other one’s claim or argumentation at present even
if this agent does not say so explicitly. For example if participant p₀ has very high trust relation to
human p₁, it is very possible that p₀ support p₁’s claim even if p₀ does not explicitly comment on p₁’s
utterance. Therefore for the evaluation of the acceptability of agent proposed solution or argument in
the group argumentation, we not only need to consider the response of other participant but also the credibility of proponent in the group should be taken into account.

In our approach, we define the trustworthiness of the agent in the group as the agent’s credibility. The value of the agent’s credibility is up to the aggregation of other’s trustworthiness to him. For one particular group decision making activity such as one meeting session or one round focus group discussion, the initial value of the agent’s credibility is obtained from his previous performance. The value of the agent’s credibility is not a fixed value; it will be dynamically updated during the group argumentation interaction. The agent’s credibility categorized by different domain reflects this agent’s expertise in particular domain. It could be used to form expert teams by selecting the participants before the group decision making.

In our framework, the group profile can be defined as following:

\[ GP[i] = \{a_i, D_i, C_i, GR_i, (U_1 \ldots U_k) \} \]

- \( a_i \) ---- agent \( i \)
- \( D_i = (d_{i1}, d_{i2}, \ldots, d_{in}) \) ---- domain set of agent \( i \)
- \( C_i = (c_{i1}, c_{i2}, \ldots, c_{in}) \) ---- credibility set of agent \( i \) in the domain \( (d_{i1}, d_{i2}, \ldots, d_{in}) \) respectively
- \( GR_i \) ---- general reputation of agent \( i \) in the group level.
- \( U_i = (u_1 \ldots u_k) \) ---- Utterance sets proposed by agent \( i \).

Credibility of agent, in the domain \( d \) indicates in which degree agent’s belief in the domain \( d \) is true. In the group argumentation while the group members pro/con argue an agent’s claim about some domain, this agent’s credibility in this domain will be increased /decreased. The extent of increase/decrease will much depend upon the credibility held by the one who interacts with this agent, which means arguments from agents with higher credibility will more affect other agent’s credibility value in certain domain that is argued. The formula of updating credibility value of the agent, towards domain \( k \) is as follows:

\[
C_{ik} = C_{ik} + W^* \sum_{j \in \{j/\text{support}(a_j, a_i) \text{ in } \text{domain}_{ij}\}} C_{jk} - W^* \sum_{p \in \{p/\text{challenge}(a_p, a_i) \text{ in } \text{domain}_{ip}\}} C_{pk} \]  

(3-3)

\( C_{ik} \) : The credibility value of agent \( i \) in the domain \( k \)
\( a_i \) : agent \( i \)
\( W \) : Normalization Coefficient

The agent’s general reputation \( GR_i \) in the above group profile represents the average credibility value about all related domains associated with him. This value will be a substitute of the agent’s credibility in a certain domain in the case that this domain specific credibility is not available in our system. \( GR_i \) can be represented as:

\[
GR_i = \frac{ \sum_{n=0}^{D_i} C_{in} }{ |D_i| } \]  

(3-4)

In the decision making stage, the credibility of the agent will be the important factor to evaluate the acceptability of his claim. Only acceptable claims will be useful for scoring (order) the decision candidates.

### 3.6 Decision Function

In decision making, the goodness of potential action is judged by estimating, by means of several criteria, how much its possible consequences fit the preferences or the intentions of the decision maker. Due to the possible conflicts among different decision makers’ preference and knowledge, the system should have some function to achieve the groups’ consensus.

Amgoud (2009) argues that an argumentation based decision process for ordering the alternatives can be decomposed into the following steps:

1. Constructing arguments in favour/against statement (pertaining to beliefs or decision)
2. Evaluating the acceptability of arguments
(3) Evaluating the strength of each argument
(4) Determining the different conflicts among arguments
(5) Comparing decision on the basis of relevant “accepted” arguments.

Based on these steps, a decision function should be designed which can evaluate the acceptability of arguments, calculate the strength of each argument, score the decisions by their following arguments. In the context of a factual group argumentation, the acceptability of arguments should be decided by many factors. In the Walton style argument scheme (Walton, 1996), the critical questions are used to identify the acceptability of an argument. For example, critical question can be categorized as the expertise question: “How credible is expert E as an expert source?”, the field question: “Is E an expert in the field that the assertion is in” or the consistency question: “Is the assertion consistent with the testimony of other experts?” etc. Inspired by Walton’s approach, we choose the experts’ expertise and other experts’ response to be factors to evaluate the acceptability of arguments. So in our approach, the acceptability of arguments can be decided by how much credibility the speaker has in the domain in which this argument is involved, and also by how other expert respond to this argument (favour/against). This approach can assure the opinion from the highly credible proponent in a certain domain is more likely to be accepted; however the group members’ explicit comment will directly affect the acceptability of any claims. We believe this approach is a trade-off between emphasizing individual’s intelligence and considering the collective’s knowledge. Individual equality and the collective good are always thought as two goals of democracy (Held, 1984). The credibility of the agent in a certain domain will be dynamically updated based on the agent’s performance and other agent’s response to him in the group activity. The intention of others’ response to the argument can be identified as Table 3.2.

### Table 3.2 Decision oriented argumentation ACT

<table>
<thead>
<tr>
<th>Argumentation ACT</th>
<th>Intention</th>
<th>Certainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support</td>
<td>Prefer</td>
<td>High</td>
</tr>
<tr>
<td>Challenge</td>
<td>Not Prefer</td>
<td>High</td>
</tr>
<tr>
<td>Raise issue (Solved)</td>
<td>Prefer</td>
<td>Low</td>
</tr>
<tr>
<td>Raise issue (Unsolved)</td>
<td>Not Prefer</td>
<td>Low</td>
</tr>
</tbody>
</table>

As discussed above if an agent explicitly makes claim to support/challenge others’ claim without doubt, he obviously prefers to accept/reject others’ claim in a high degree. If an agent questions an others proposed solution by raising an issue, he intends to express uncertainty towards others’ claim. However if anyone can provide further solution to solve the question which can satisfy the questioner, the questioner will change his mind to accept the original claim. Otherwise, he may not accept the original claim as no one can clarify his doubt. So the function to evaluate the acceptability of arguments can be defined as follows:

\[
ACC(\text{arg}_i) = C(a_i) + \sum_{k \in \{k: \text{support}(a_{i, \text{arg}_j})\}} ACC(a_k) - \sum_{o \in \{o: \text{challenge}(a_{i, \text{arg}_j})\}} ACC(a_o) + W * \sum_{s \in \{s: \text{raise\_issue\_solved}(a_{i, \text{arg}_j})\}} C(a_s) - W * \sum_{r \in \{r: \text{raise\_issue\_unsolved}(a_{i, \text{arg}_j})\}} C(a_r)
\]

(3-5)

\[
\text{Accepted}(\text{arg}) = \begin{cases} 
\text{true} & \text{ACC(arg) > Threshold} \\
\text{false} & \text{ACC(arg) < Threshold}
\end{cases}
\]

arg; argument i
ACC(arg); acceptability value of argument i
a; agent holding argument i
C(a); credibility of agent holding argument i
W; relative coefficient
If the value of Accepted(arg) is true, the state of corresponding argument will be assigned as “accepted”, otherwise it will be “rejected”. Only accepted argument will be used to evaluate other relevant arguments or decision candidates. Along with the further argumentation, the acceptability of one argument could be changed. This kind of state change well abides with defeasible logic modus. As shown in table 3.2 the “unsolved” issue will decrease the acceptability of argument, however the “solved” issue is the opposite. If there exist one accepted solution for an issue, the state of issue will be set as “solved”, otherwise its state will be “unsolved”. The state of issue can be calculated as following formula. The true value of solved(issue,) represents “solved” state, and false value of solved(issue,) represents the “unsolved” state.

\[
Solved(issue_j) = \begin{cases} 
\text{true} & \exists j \text{is solution}(S_j) \land \text{resolve}(S_j, issue_j) \land \text{accepted}(S_j) \neq \emptyset \\
\text{false} & \text{Otherwise}
\end{cases}
\]

(3-6)

Due to the intrinsic feature of defeasible logic, only the later proposed argument can defeat or strengthen former one. In the design of the decision function, we assume most of experts in the group are rational persons. However there is still a risk that the malicious experts, who seek to win the argument, could deliberately propose some non-sensible argument, which will definitely affect the result of automatic decision evaluation. In order to minimize the impact of this potential issue, in the proposed function to evaluate acceptability of argument (Eqn. 3-5) the credibility of experts holding argument or solution is considered. So even if a malicious expert deliberately defeats one utterance, if his credibility is less than the owner of another utterance he still could not win the argument. On the other hand, the credibility evaluation mechanism (Eqn. 3-3) will dynamically update the credibility of expert based on others’ views toward his utterance. This mechanism can prevent an expert from obtaining high credibility if he often makes malicious arguments. In conclusion, the automatic evaluation of acceptability of argumentation and the recommended decisions by system will be more or less affected by malicious expert. But, to some extent the proposed mechanism and functions will minimise the impact of this issue. Particularly our approach could perform better in long term or multi-round discussion, because analysis from many rounds of interaction has better potential to compute the credibility of an expert relatively precisely.

Practical arguments, which are directly connected to the candidate decisions and highlight their positive or negative features, take a significant role to order the decision candidates. So the score of a decision will be evaluated by the aggregation of the strength of the accepted practical arguments and related raised issue. As described above, the strength of the practical arguments can be decided by the collective truth of beliefs and preferences of the relevant domain. So the function to calculate the strength of practical argument can be defined as following:

\[
\text{Strength}(\text{arg}_i) = ACC(\text{arg}_i) \ast \text{Preference(Domain(\text{arg}_i))}
\]

(3-7)

Strength(arg): the strength of argument i.
Domain(arg): The domain which argument i belongs to.

Here preference means the importance of the aspect related with the argument toward achieving task, which is equivalent to the criteria with the degree in the traditional decision making approach, particularly in the multi-criteria decision making. As to epistemic argumentation, it only proves the certainty of information (belief) in the related practical/epistemic argument. So the strength of epistemic argument is equal to the acceptability of it. Again we take above argument snippet as example:

**Practical argument:** [“the patient may have a cancer” “when having a cancer, having a surgery avoid loss of life”]

The preference expressed by this argument can be read as how important the life issue is in the treatment. It can be represented as a fuzzy figure. In the group argumentation, the preference of various domains is decided by a group wide agreement, which can be obtained by the group voting or
ranking. At the end of group argumentation, all the concepts of domains occurred in the group discussion are listed to each group member, which allow all the members to rank those concepts according to their own preference in the context of particular task. The aggregation of the group voting will represent the preference relationship to the relevant problem domain. Thereafter the group agreement to different aspects will be explicitly indicated. This is a procedure to identify the criteria for decision making shown in the above conceptual framework diagram. Compared with predefining the criteria for decision evaluation in the multi-criteria decision making, identifying the criteria from the utterances of the group members’ discussion may discover more relevant and customized aspects of problem domain based on the specified task. This method particularly fits decision making for the complex problem or cross-domain problem in which the problem cannot be easily formalized so that it is not possible to define the criteria for evaluation beforehand. Similar to the multi-criteria decision making, those preference relations to the different domain could be used to evaluate decision candidate. In the multi-criteria decision making, decision makers have to score the different aspects of the decision task based on criteria. However, in our approach the preference of criteria are used to evaluate the strength of argument. The latter will decide the order of decision candidate.

The function to score the decision candidate is quite straightforward, only needing to aggregate all the strengths of following arguments from both positive and negative aspects. The function can be defined as following:

\[ \text{Score}(\text{Dec}_i) = \sum_{\text{prefer}} \text{strength} (\text{arg}_i) - \sum_{\text{Not prefer}} \text{strength} (\text{arg}_j) \]  

(3-8)

Dec; Decision candidate i (Solution in argumentation schema)

3.7 Summary

In this chapter, a group argumentation support conceptual framework for decision making has been proposed. A new group argumentation schema with the combination of IBIS model, Toulmin’s model and Amgoud’s framework has been designed in which an argument-based framework for decision making is discussed. The factors which influence the decision making such as social parameter, criteria and decision function have been defined and modelled. The semantically enhanced utterance representation has been identified as a useful tool to externalize group experts’ mental space and preference, which is essential for building intelligence and evaluating decision in the decision making process.

This conceptual framework has drawn a big picture of implementing a group argumentation support system for decision making. The requirements of functionality block shown in Figure 3.1 have been described and the process of the system also has been indicated. In Chapter 4, an agent based software system will be designed based on the specification of this framework.