The study of quantitative analysis for solving conflict problems among intelligent agents

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Abstract

In the environment of conflict, each agent represents an expert. In achieving a solution to a global problem, each agent has its own local goal to be fulfilled. As each agent is given control over its own actions, its own local goals and its own utility functions, it will naturally pursue its own interests. This situation of conflict must be resolved before a satisfactory solution to a problem can be presented. Therefore, this research describes how to represent each agent's view and expand the ideas of mathematic techniques to Conflict Agents and give a brief evaluation of each technique in its theory.

Keywords : *Conflict resolution, DAI, agent.*

1. Introduction

Rosenschein and Genesereth [4] noted that most DAI researchers accepted the situation of complete cooperation, known as the 'benevolent

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agent assumption'. This assumption is not a realistic one as agents may have conflicting views.

Conflicting views do exist because if an agent is given control over its own actions, its own local goals and its own utility functions, it will naturally pursue its own interests. When working on a shared goal each agent would like its priorities to be given most consideration. Unfortunately many of the agent's priorities (arising from their own personal goals) will not be coherent with fellow agents' thus leading to a situation of conflict.

Differing goals/interests is just one major source of conflict. Other reasons for its occurrence include incorrect or incomplete local knowledge, criteria for the evaluation of priorities and solutions, and also the contention for resources.

Due to information exchange among the conflict participants, conflict resolution occurs. Either through direct negotiation between the agents or through a third party known as the 'mediator' [8], [11], conflict resolution can be achieved. Improved robustness and balance in the integrated solution can be provided by using this communication process to resolve conflict. Therefore Conflict Resolution is a very important procedure required for the coordination of systems made up of intelligent, autonomous, interacting agents.

2. The views of agents

Before using mathematic techniques to solve the problem of conflict and take the decision among the conflict agents, this research describes how to represent each agent's view.

2.1 *Linear programming*

If different linear equations are represented as different agents' views, then this research can get an area which is formed by the intersection of these different equations. In this area, according to the need, the decision making can be obtained. First look at the simplest of cases, that being when the problem has just two dimensions. In this situation the different linear equations can be visualised on a diagram, Figure 1 representing the views of three agents, denoted A-C, in the two dimensions x and y.

The problem of course can be extended to N dimensions but once N becomes greater than three it is impossible to visualise on paper. In this situation, since the agents' views are represented by linear equations in N dimensions, therefore the linear equations should each consist of N

variables. If there are M agents and M is greater than N, i.e., there are M equations and N variables and $M > N$ then there will be two situations. One is if these linear equations which represent different agents' view still intersect by chance, then the best solution will happen on the extreme points in the feasible solution area. The other is if these linear equations do not intersect (and this situation happens quite often), then the feasible solution area will not be formed and the decision maker has to make a decision by using some other techniques. However, if $M < N$ then this case in mathematics will result in infinite solutions. Besides the above situations, if the views of agents cannot be represented by linear equations i.e. they are non-linear, and then in this case it is more complicated.

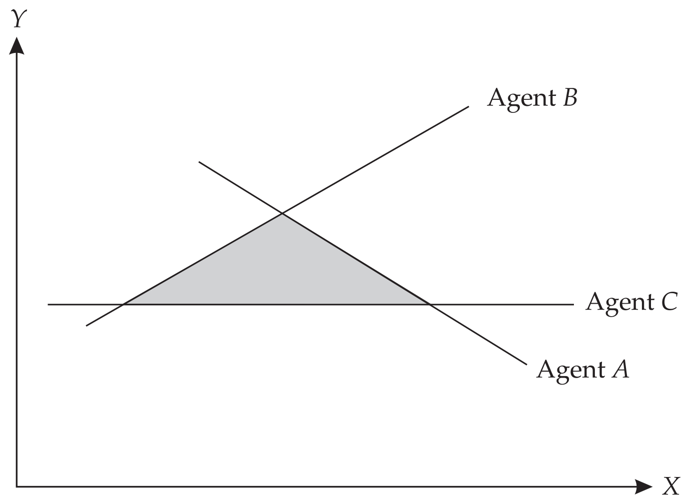

Figure 1
Linear programming diagram

2.2 *Bar charts*

The height of each bar can be used to represent the value of a decision variable, denoted x, of each agent, and take the median value of each bar to be a point, and then connect these points to draw a line. This line is a tendency line for a particular decision variable x. This research can use the tendency line to be a criterion when this research takes the value of the decision variable. If the value of the decision variable is far from the tendency line then this research may decide not to take this value. Of course there is possibility that this value of the decision variable is correct, In this case it is related to the field of the decision risk. This research will ignore the decision risk in discussing the field.

Figure 2 shows this idea. The x-axis represents the agents and y-axis represents the value of one particular decision variable, denoted x.

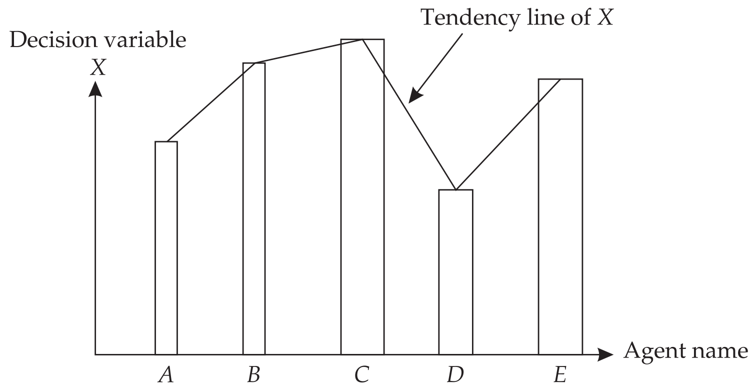

Figure 2
Bar chart 1

Using the same technique this research can obtain the tendency line of another decision variable; denoted y. Figure 3 represents this.

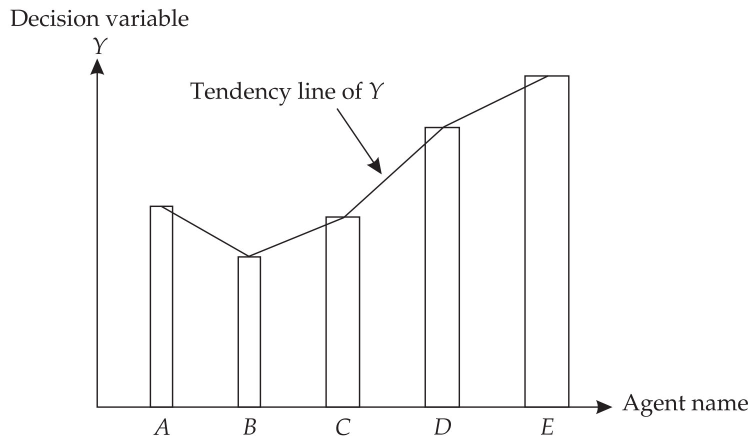

Figure 3
Bar chart 2

2.3 *Scattergrams*

The scatter diagram can be used to represent the views of agents. Different agents' views can be represented as points in an N dimensional space. Here this research takes the simplest case, i.e. two dimensions x and y. Figure 4 represents the views of many agents in the two dimensions. From the scatter diagram this research can obtain a cluster area which contains most agents' views, this area can be said to be the best decision making area. Again there is possibility for decision risk, i.e. the outliers may have the correct value. This is ignored in this field of discussion. There is another kind of possibility, that if two clusters contain the same number of agents' views, then in this situation this research has to put further constraints to obtain the best decision making area.

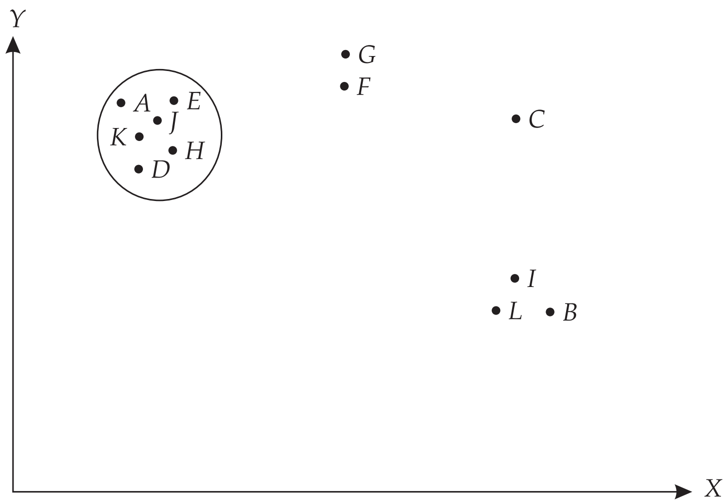

Figure 4
Scatter diagram

3. Assumptions

The mathematic methods that this research is going to use are based on the following assumptions:

1. For the reason of simplicity, in the framework this research will only use finite agents to represent the situation of Conflict Resolution. Agents express their own opinions in a given problem because these opinions may conflict with each other, therefore this research need another agent,

it is called the Conflict Resolution agent, denoted C, to resolve the conflict. A Conflict Resolution agent can be regarded as an arbitrator. Under a total goal it has to decide which agent's view is more suitable for the goal. In order to give a more clear description about the agents' ideas, in the following assumptions this research will use three agents to represent the term 'finite agents'. They are denoted by agent A, agent B and agent C. Agent C is a Conflict Resolution agent.

2. Agent A and agent B share the same corporate database but have their own knowledge bases. The reason for this assumption is that if agent A and agent B do not share the same corporate database, say agent A can access more secret data than agent B, then agent A will make a more correct decision for a given problem than agent B does. The corporate database here means it is an open database for everybody to access it equally without any restriction.

3. Both agent A and agent B are thought to be of the same importance in the organization. The reason is that if agent A is more important than agent B then when they pass their opinions to agent C, for example, agent A's value for a given problem is 0.4, while agent B's value is 0.6. Because $0.6 > 0.4$ then if this research's decision rule is to take the greater value to be a decision variable value, then agent C should believe agent B's suggestion. However, if agent A is more important than agent B in the organization, i.e. to say agent A is more experienced than agent B, then agent C should believe agent A's suggestion. In this case it is difficult for agent C to make a decision, which is why this research made this assumption. Figure 5 shows this kind of idea.

4. Agent A and agent B must be independent of each other. If they are not independent then their decision-making will affect each other. Otherwise agent A has to decide its value of decision variable by looking at agent B's value. Therefore agent A and agent B will have different constraint equations. In this case it will make the Conflict Resolution process more complicated.

5. The role of agent A and agent B is to provide the value of decision variables. Each agent provides at least a set of values of decision variables. If one of a set of decision variables is missing then this research regard its value as zero.

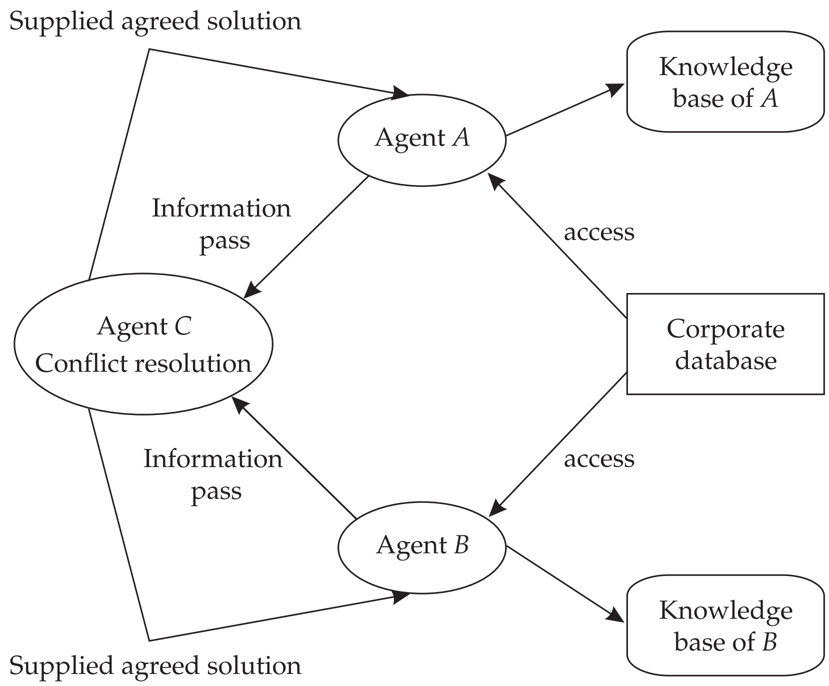

Figure 5
Framework diagram

Under these assumptions, agent C has a goal function which is a linear function consisting of decision variables. These decision variables are provided by agent A and agent B. The general form is as follows:

$$f(x) = c_1x_1 + c_2x_2 + \ldots + c_nx_n$$

where $x_1, x_2, \ldots, x_n$ are the decision variables and $c_1, c_2, \ldots, c_n$ are the coefficients.

4. Mathematic techniques to conflict resolution

Below are some mathematic techniques that this research refers to the work of Keating [7] to expand and use to solve the problem of conflict and take the decision among the conflict agents.

4.1 *Linear programming*

According to assumption 4 and 5, an example of this method is described as follows: An example of this method is described as follows, in the operation of a manufacturing firm; the objective of the firm is to maximize the total profit. In this case, $x_1, x_2, \ldots, x_n$ may represent quantities of different products to be produced and $c_1, c_2, \ldots, c_n$, are the unit profits that each of the different products can bring to the firm.

Each agent can be regarded as a department such as sales department, accounting department etc. So agent A is a sales department. Its view is to seek the maximal profit and to produce the quantities x_1 for the product 1, quantities x_2 for the product 2, and quantities x_3 for the product 3. However from the view of agent B which is an accounting department, to seek the maximal profit is to produce quantities y_1 for the product 1, quantities y_2 for the product 2, and quantities y_3 for the product 3. Because c_1, c_2 and c_3 are fixed, the maximal profit is dependent on the provided decision variables, i.e. (x_1, x_2, x_3) and (y_1, y_2, y_3).

Now there are two sets of different goal values, one is $f_A(x) = c_{1A}x_1 + c_{2A}x_2 + c_{3A}x_3$, the other is $f_B(y) = c_{1B}y_1 + c_{2B}y_2 + c_{nB}y_n$ i.e. there is conflict in the quantity of each product. Therefore another agent, denoted C, is needed to perform conflict resolution. The approach agent C takes is to compare the values of $f_A(x)$ and $f_B(y)$ then take the greater value. Say $f_A(x) > f_B(y)$, therefore the maximal profit of this manufacturing firm is $c_1x_1 + c_2x_2 + c_3x_3$. This Conflict Resolution strategy is applicable where equations represent profit, but when equations represent cost it should take the smaller value. The Linear Programming concept is citation from [1].

4.2 *Classical statistics*

This section will introduce basic statistical methods of describing information. These basic statistical methods are also based on the same framework, i.e. agent A and agent B provide the values of decision variables to agent C and then agent C uses the following methods to make the Conflict Resolution.

1. *Median*: the middle measurement after the values of agents' decision variables have been arranged in order of magnitude. If the total number of the values of agents' decision variables is an even number, then the median is half of the sum of the two middle values. For example, if there are the following values of decision variables already arranged in ascending order (see the Table 1)

Table 1
Table of Values 1

Agent	A	B	C	D	E	F
Value	1	5	10	14	17	21

Median $= (10 + 14)/2 = 12$.

2. *Mean*: the measure of central location. It is computed by summing up all of the values of agents' decision variables, then dividing by the total number of agents:

$$\bar{X} = \frac{\sum_{i=1}^{N} X_i}{N}.$$

For example, from the following Table 2.

The mean $= \dfrac{(30 + 24 + 29 + 32)}{5} = 30.4$.

Table 2
Table of Values 2

Agent	A	B	C	D	E
Value	30.0	24.0	37.0	29.0	32.0

3. *Range*: in dealing with distributed problems it is usual for each agent to have a set of constraints corresponding to its recommendations. These constraints are the lower and upper limits that an agent will accept. Therefore range can be calculated by the difference between the largest and smallest constraints of all the agents. The range is very easy to compute. However, when extreme values are included in the sample, it may give a false impression of the variation. For example, from Table 3 this research can get the range value 24.0 by $43.0 - 19.0$.

Table 3
Table of Constraints

Agent	A	B	C	D	E
lower	22.0	19.0	25.0	20.0	23.0
upper	39.0	29.0	43.0	38.0	34.0

4. *Mean deviation*: the sum of the absolute difference of the value of each individual agent's decision variable with the mean divided by the number of agents:

$$\frac{\sum_{i=1}^{N} |X_i - \bar{X}|}{N}.$$

For example, in the Table 2.

Mean deviation

$$= \frac{|30 - 30.4| + |24 - 30.4| + |37 - 30.4| + |29 - 30.4| + |32 - 30.4|}{5}$$

$$= 3.28.$$

5. *Variance and standard deviation*: the difference of the value of each individual agent's decision variable with the mean is squared before they are summed up and divided by the number of agents, so that we obtain a measure of variation called variance:

$$\text{Variance} = \frac{\sum_{i=1}^{N} (X_i - \bar{X})}{N}.$$

The square root of variance is called standard deviation (S.D.):

$$\text{S.D} = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \bar{X})^2}{N}}.$$

For example, in the Table 2

$$\text{S.D.} = \frac{\begin{pmatrix} (30 - 30.4)^2 + (24 - 30.4)^2 \\ +(37 - 30.4)^2 + (29 - 30.4)^2 + (32 - 30.4)^2 \end{pmatrix}}{5} = 4.22.$$

A large standard deviation means that the values are widely spread whereas a small standard deviation denotes that the agent's values are closer together. The concept of Statistics is citation from [13].

4.3 *Fuzzy Mathematics*

In previous discussions of configuration this research uses three agents to tackle problems, i.e. agent A and agent B pass their opinions to agent C, and then agent C makes the decision. However, in the real world people can have many opinions about a particular issue i.e. agent A may have many values for one thing passing to agent C, so does agent

B. This situation is similar to a fuzzy mathematical model. Therefore in this section this research will use fuzzy concepts to tackle this kind of problems. In a fuzzy set the most important concept is grade of membership. Its definition is as follows:

Suppose $\bar{A}$ is a fuzzy set of a domain U then the so-called grade of membership function of $\bar{A}$ is to satisfy

$$u\bar{A} :\to [0,1]$$

$$u \to u\bar{A}(u)\,.$$

Where $u\bar{A}$ is called the grade of membership function of $\bar{A}$, $u\bar{A}(u)$ means the grade of element $u \in U$.

The following example explains the relationship of grade of membership function and fuzzy set. The concept of Fuzzy Mathematics is citation from [14].

Example. Assume $U = [0, 100]$, it means some set of age. A and B represent "old" and "young" individually, their grade of membership functions are as follows:

$$u\bar{A}(x) = 0\,, \qquad 0 \le x \le 50$$

$$u\bar{A}(x) = \left[1 + \left(\frac{x-50}{5}\right)^{-2}\right]^{-1}, \qquad 50 < x \le 100$$

$$u\bar{B}(x) = 1\,, \qquad 0 \le x \le 25$$

$$u\bar{B}(x) = \left[1 + \left(\frac{x-25}{5}\right)^{2}\right], \qquad 25 < x \le 100\,.$$

If $x = 60$ then $u\widetilde{A}(60) = 0.80$, $u\widetilde{B}(60) = 0.02$, i.e. the grade of 60 years old belonging to "old" is 0.80, the grade of 60 years old belonging to "young" is 0.02, therefore 60 years old is thought to be elder.

After learning the definition of the grade of membership function and its application, this research can use "Maximize the grade of membership rule" to make a decision. However, first of all if different situations have different grades of membership functions, so in some situations this research can use statistical methods to get the grade of membership function. Here this research takes an example of normal distribution function $f(x)$ to be the grade of membership function.

Where $f(x) = \exp\left[-\left(\frac{x-\bar{x}}{\partial}\right)^2\right]$.

Maximize the grade of membership rule

Given agent C (Conflict Resolution agent) has a goal and the grade of membership function of its goal is seen below, which is a normal distribution function.

i.e.

$$u\widetilde{C}(x) = \exp\left[-\left(\frac{x-\bar{x}}{\partial}\right)^2\right].$$

Agent A and agent B provide different strategies to agent C in order to pursue the goal. Agent A may have many values of decision variables $x_1, x_2, \ldots, x_n$ about its strategy passing to agent C, so does agent B. Therefore according to the "Maximize the grade of membership rule", the best solution for agent C to take is to compare the grade of membership functions of agent A and agent B, and then take the greater one. For example, if $u\widetilde{A}(x) > u\widetilde{B}(x)$ then this research should take agent A's suggestion.

Where $u\widetilde{A}(x) = \exp\left[-\left(\frac{x-\bar{x}}{\partial}\right)^2\right]$, $u\widetilde{B}(x) = \exp\left[-\left(\frac{x-\bar{x}}{\partial}\right)^2\right]$ and x is the goal value this research wants to pursue. The mean $\bar{x}$ and the variance ∂ in $u\widetilde{A}(x)$ are different from the mean $\bar{x}$ and the variance ∂ in $u\widetilde{B}(x)$, because the values of agent A's decision variables are different from agent B's [9]. The method of how to get the mean and the variance has been discussed in Section 4.2.

4.4 *Game theory*

Within game theory, agent A and agent B are competitive with each other i.e., they provide the solutions of decision variables for agent C, then let agent C select one solution between them.

When agent A and agent B calculate their solution values, they can take a cooperative method to exchange their own knowledge or they can calculate the solution values individually. The role of agent C is to resolve the conflict between agent A and agent B according to the decision rules. Therefore agent C has to set up a decision table (Table 4) according to the rules of game theory and find out which solution is suitable to take.

Table 4
Decision table

	B		
A		B_1	B_2
	$A1$	3	2
	$A2$	-1	0

Assume the values in the following matrix represent the different results of agent A's and agent B's alternatives

Seen from agent A's point of view, the following conclusions are reached:

1. When agent A offers the first alternative to agent C, agent A will expect agent B to choose the second alternative, since the loss for B will be 2 and it is the minimum loss among all B's alternatives.
2. When agent A offers the second alternative, agent A will expect agent B to choose the first alternative, since the loss for agent B will -1 (B gains 1) and it is the minimum loss among all agent B's alternatives.
3. Between the two alternatives, agent A will reason that if he offers the first alternative to agent C, he will at least be sure to gain 2 from agent B. This approach is called the maximin strategy.

Seen from agent B's point of view, the following conclusions are reached:

1. When agent B provides the first alternative for agent C, agent B will expect agent A to choose the first alternative, since 3 will be the maximum gain agent A can expect.
2. When agent B provides the second alternative for agent C, agent B will expect agent A to choose the first alternative, since 2 is the maximum gain agent A can expect.
3. Comparing the maximum gains that agent A will get with respect to his choices, agent B will provide the second alternative for agent C. In that way agent A can gain only 2, which is the minimum among the two. For agent B, this is the minimax strategy.

In the above example, agent A will offer the first alternative to agent C and agent B will provide the second alternative. Agent A's maximin strategy coincides with agent B's minimax strategy, when the saddle point is reached.

4.5 *Network approach*

Network is another approach to represent the more complicated relationship of agents. Every node can be regarded as an agent in a network. The root node is the Conflict Resolution agent and the other nodes can be viewed as potential sub-Conflict Resolution-agents. Nodes are linked by arcs; each arc has an associated label which can be regarded as the value of agents' decision variable.

In Figure 6 there are seven nodes, denoted A, B, C, D, E, F, and G to represent seven different agents in an organization. Agent C is a Conflict Resolution agent which has a total goal to seek. The goal may be to seek minimal cost or maximal benefit for the organization. Agent A, B, D, E, F and G are potential Conflict Resolution agents. Agent A and agent B are the first level of agent C and agent D, E, F, and G are the second level of agent C.

Assume agent A will pass three decision variables (x, y, z) to agent C but the x' value is unknown. It is dependent on the other decision variables y and z which can be obtained from agent D and agent E. That is agent D and agent E pass two decision variables y and z to agent A individually and then agent A according to the values of y and z to decide its x' value and then agent A passes the obtained value to agent C. In this situation agent D can not directly pass its decision variable y to agent C because agent C needs the third decision variable x which is generated by agent D' decision variable y and agent E' decision variable z, to make a decision but agent D can only provide the decision variables y. Therefore agent D has to go through agent A to do so.

The role of agent A is to receive the decision variables from agent D and Agent E, then use these decision variables to obtain the value of another decision variable, and then pass these values to agent C. That is why this research says it is a potential Conflict Resolution. The similar situation can be applied for agent B, E and so on.

In this case the length of each arc represents the value of the decision variable. There are two methods which can use to choose the arcs. One is the minimal spanning tree, the other is maximal flow. Which method to be chosen is dependent on the goal. If the manager wants to seek the minimal cost to the organization then he uses the minimal spanning tree method, if he wants to seek the maximal benefit to the organization then the manager uses the maximum flow method.

The minimal spanning tree model is used to minimize the total length (distance) of branches connecting all the nodes (agents) of the network. The solution forms a spanning tree connecting all nodes of the network. Its algorithm is a greedy algorithm. Any node is connected to the one closest to it. Then, the unconnected node with the shortest distance to a connected node is connected to the tree. After $n-1$ steps, all nodes will be connected by a tree.

The objective of the maximal flow model is to maximize the total amount of flow from a source node to a sink (destination) node in a given period of time. Its algorithm is based on repeatedly finding paths from source to sink and moving maximal flow along these paths [10].

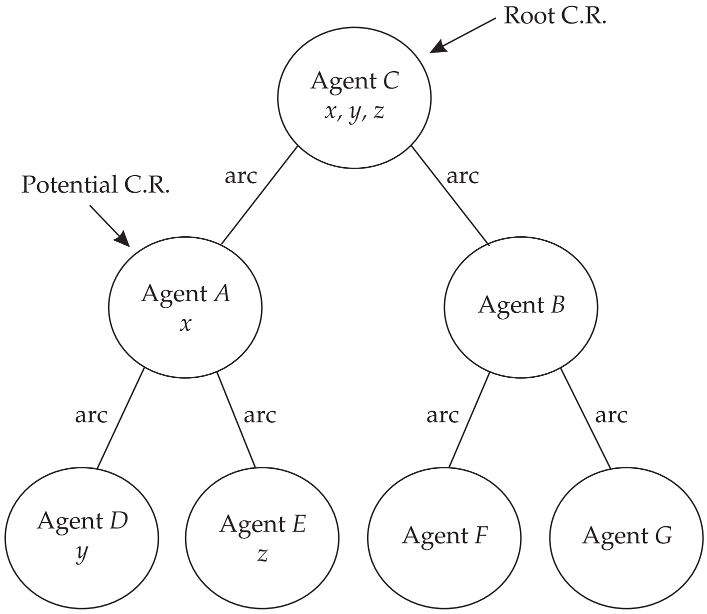

Figure 6
Network diagram

5. Evaluations

There is a brief evaluation of mathematic techniques mentioned in the previous section.

5.1 *Linear programming*

There are five advantages should be addressed.

1. *Simplicity*. Linear Programming is based on the equation theory and only uses one power equation. Basically the equation concept is very simple, therefore the representation of Linear Programming is easy.

2. *Clarity*. The goal equation has already expressed the decision variables and their relationship to each other so it is easy to know the relationship of decision variables through the equation.

3. *Extendibility*. Agents can be extended to N agents in width. That is, agent C can resolve not only the conflict between agent A and agent B but also the conflict among the other agents in the same time. Figure 7 represents this idea.

4. *Hierarchy*. It is similar to extendibility. Agents can be extended to N levels in depth. Every agent in each level has a subgoal which can also be described by Linear Programming. Every agent can be regarded as a Conflict Resolution agent whose function is similar to agent C's. Figure 8 shows this idea.

5. *Soundness*. It is based on a sound quantitative theory. Because quantitative theories themselves are very clear and definite, if a model can be described by quantitative theories then it is provable.

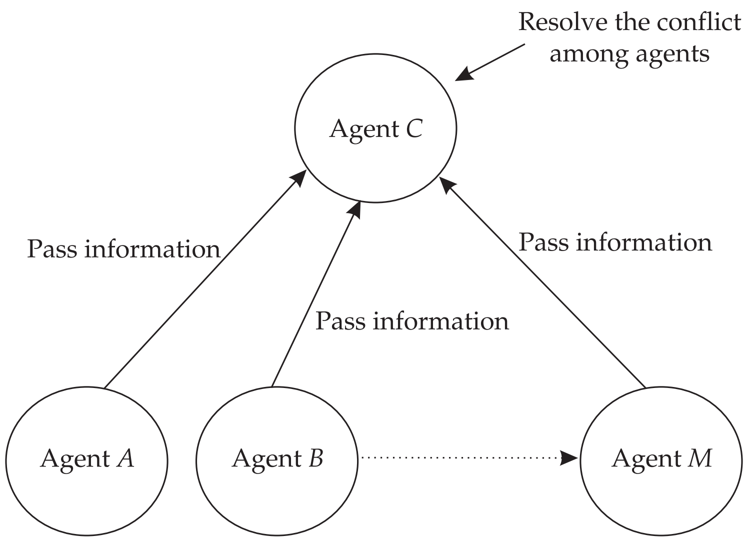

Figure 7
Extendibility diagram

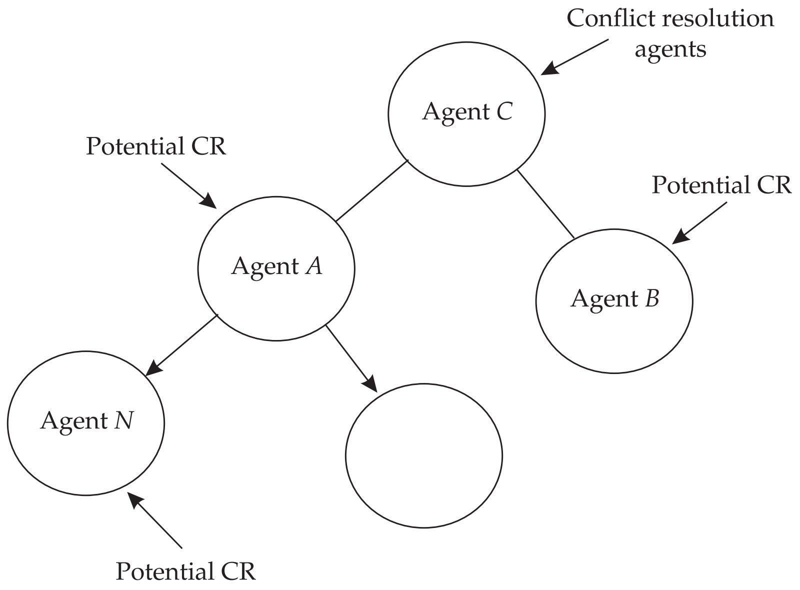

Figure 8
Hierarchy diagram

The disadvantages of Linear Programming include the following two points:

1. Constraint equations are difficult to find as a result of decision variables in practice, might not be independent of each other.
2. Linear Programming can not cover the uncertainty problems. For example, if an agent passes a value of decision variable to agent C, the possibility of 'the value is 8' is 0.8 then it is not possible to represent the possibility of 0.8 by using the goal function of Linear Programming [6], [12].

5.2 *Statistical method*

Statistical Method is based on two assumptions, one is that data is objectively observable and the other is that data has a patterned distribution. Normally if Statistical Method is used as a decision tool, it is not easy to prove that the collected data which the decision maker is based on conforms to those two assumptions. Another disadvantage is that Statistical Method is insufficient to describe subjective judgments which are why there exist the concepts of decision theories and fuzzy sets. The last point is that Statistical Method is basically a kind of data analysis method rather than a decision making method. It only provides the result of data analysis to the decision maker, so in the end the decision maker still needs a decision method to make the decision [13].

5.3 *Fuzzy mathematics*

In the real world, there exist many fuzzy phenomena such as "I eat too much", "That house is very beautiful", "A little girl" etc., therefore fuzzy sets are created to deal with these kinds of fuzzy phenomena. Also, because fuzzy sets are capable of handling non-crisp set information (subjective judgments) therefore fuzzy sets are very powerful tools in the real world to analyse things and make decisions. However, a good grade of membership function in a fuzzy set is difficult to be found and justified because grade of membership functions are generally not objective, moreover, subjective judgments are involved in the design of grade of membership functions. Thus if this research wants to describe fuzzy phenomena this research should change the ideas of the characteristic function in the classic sets, i.e., expand the value $\{0,1\}$ of characteristic function in classic sets into $[0,1]$ in fuzzy sets [9].

5.4 *Game theory*

There are at least two advantages for Game Theory.

1. Game Theory itself is based on the assumption that the decision maker would make a reasonable decision. This assumption should exist in any kind of decision-making theory.
2. Game Theory is a model of decision orientation of considering partial man-made factors. The theory itself has hidden non-controllable factors which could affect the decision-making. The disadvantages of Game Theory are described as follows. The non-controllable and uncertain factors which Game Theory considers normally, can not give a reasonable and exact description, therefore this model basically does not have the exact and provable characters of mathematical models. This point is not matched with the objective rule of decision-making. In addition, the obtained solution from Game Theory is a reasonable solution but not necessarily the best solution [2].

5.5 *Network approach*

The application of Network Approach is in very widely used, such as in connecting various cities with cable television, telephones, computer terminals, traffic flow through certain city streets, flow of information through a telecommunication system, flow of oil, gas, water, or other fluid through a pipeline and flow of electricity through a transmission network etc. [10], [3]. If Network Approach is applied to the framework of this research, then each node in Network Approach is considered as an agent and assumed to be contributive to final decision making.

The advantages of Network Approach are as follows:

1. It is very easy to describe the agents' relationship of each other. No matter how complicated the agents' relationship is, it can still be connected by using arcs.
2. Network Approach itself is based on the graphical theory and has the mathematical base, therefore the theories in Network Approach such as minimal spanning tree or maximal flow etc. can be proven correct by using mathematical methods.

However, Network Approach also has disadvantages:

1. It is difficult to describe subjective data and quantity (value) data,
2. Network Approach itself is a graphical representation method of a decision problem rather than a decision method. It only provides the result of data analysis to the decision maker, so in the end the decision maker still needs a decision method to make the decision [5].

6. Future work

This research supposes each agent itself can provide the values of the decision variables to the CR agent but in fact how does it get the values of its decision variables? This research used the mathematical technique to solve the problem. By using the mathematical technique this research can only obtain the optimum solution and a few feasible solutions. In fact in the feasible region there are many feasible solutions but it is very difficult for people to find all the feasible solutions. Therefore for future work should be toward letting each agent have the ability to calculate the values of the decision variables by itself. This could be achieved by designing a program for each agent to calculate all feasible solutions under the condition of its individual constraint and the corporate constraint.

7. Conclusions

Briefly, these mathematic techniques are important in the resolution of conflict in DAI. Although at the moment there are only five different mathematic techniques used to describe Conflict Resolution in DAI, and considered their advantages and disadvantages of each technique, they are prototypes in order to design decision rule databases including some techniques of Conflict Resolution that the CR agent can use to make decisions in the future. Thus they can provide the necessary infrastructure into which additional mathematical models could subsequently be accommodated.

Therefore the future work should be carried out with the CR agent's expertise of AI being developed. In doing so, the Conflict Resolution agent will have the intelligence to make the decisions as to which decision rule to use in a given situation.

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