The 33rd Annual Conference of the Japanese Society for Artificial Intelligence, 2019

A Team Negotiation Strategy that Considers Team Interdependencies

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ABSTRACT

In automated negotiation, team negotiation is poised as one of the most important negotiation techniques. A team is a group where multiple interdependent agents participate in negotiations as a negotiating party during the course of negotiations. Existing team negotiation strategies did not consider the change in decisions due to the interdependencies within the team. In this paper, we propose a team negotiation strategy that considers the interdependencies within the same team. Towards this end, in the proposed negotiation strategy, we first set the parameters that represent the interdependencies that exist within the team in both directions. Thereafter, a voting process is performed in each direction. By weighting the degree of dependency of each team member, a change in agent decision due to its dependency relationships is measured. A comparative experiment with the existing team negotiation strategies showed the efficiency of the proposed strategy.

1. Introduction

Numerous researches on automated negotiation agents have been done in multiagent research fields [1, 2]. Negotiation has emerged as an important social activity wherein different people with different targets seek to reach an agreement in order to satisfy each other's interests and is indispensable in the real world where various goals exist. Therefore, automated negotiation is attracting attention as it can bring the benefits of negotiation in order to solve real life problems. In this regard, it is thought that it can be applied to route change interference and scheduling system in e-commerce system and transportation system [1, 2, 3]. One of the most important automated negotiation techniques is team negotiation [4, 5]. A team is a group where multiple interdependent agents participate in negotiations as a negotiating party during negotiations. There are numerous negotiation scenarios between multiple groups in the real world such as negotiations between a couple and a real estate agent, a negotiation between a friend and a travel agency.

In these scenarios, the team in the negotiation participates in the negotiation as a single party, but cannot be regarded as one agent. This is because they may have internal conflicting preferences when making team decisions. Even if one of the team members is unlikely to accept the proposal from the negotiating partner, this proposal may be compromised and accepted when another member accepts it. In this way, since all the team members have individual preference information and are affected by the decision of other agents, linear preference information cannot be expressed as one agent. Therefore, it is important to negotiate with the dependency amongst the team members.

However, the existing team negotiation approaches did not consider interdependencies within the team during negotiation [4, 5]. As teams are interdependent by nature in team negotiations, interdependencies must be considered during these negotiations. For example, when an agent in a team accepts the opponent's proposal, the agent that depends on that agent becomes more likely to accept the same opponent's proposal by the degree of dependency. In this context, it becomes necessary to evaluate these changes in decisions due to dependencies within the team.

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In this paper, we propose a team negotiation strategy that considers the dependency relationships within this team. The proposed negotiation strategy, bidirectionally sets the parameters that express these dependency relationships that exist within the team. By setting bidirectional dependencies within the team, it becomes possible to express unilateral dependencies. In each mechanism, when the voting process is performed, by weighting the dependency degree of each team member, change of agent decision according to the dependency relation is expressed.

2. Proposed Team Negotiation Strategy

First, we define interdependencies within the team as follows. Let parameter $w(a, b)$ define Agent A 's dependency on Agent B, and each team member sets parameters to all other team members according to its dependency relationships. This is defined as the degree of dependency from agent A to agent B. When there are N team members, the dependency $W(a)$ that Agent A receives can be defined by Equation (1).

$$W(a) = \Sigma\, w(i, a) \tag{1}$$

Where $w(i, a)$ is the degree of dependency that Agent A receives from Agent i. For example, when there are three team members, their interdependencies can be represented as shown in Figure 1.

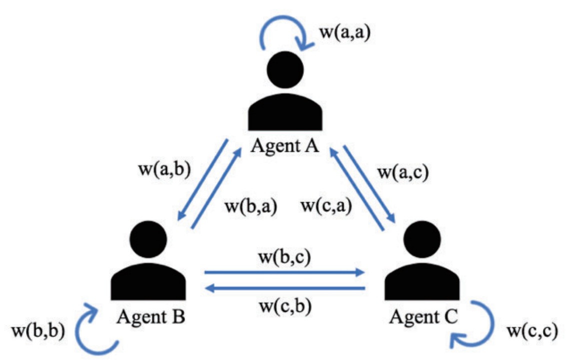

Figure 1: Dependency relationships amongst three team members

As shown in Figure 1, we can see that the dependencies between Agent A and Agent B, Agent B and Agent C, Agent A and Agent C can be defined from both directions. By this, it can also be defined in a state that depends unilaterally.

Members with a high degree of dependency who receive it can be regarded as members with high decision and speaking rights within the team because other members are strongly influenced by their opinion. Therefore, members with high dependence are members of high importance within the team, and if the utility value of members with high importance is high, other members can easily compromise. Conversely, members with low importance depend heavily on other members, so they depend on the utility values of other members. Since the importance value in the team at this time has a difference in importance depending on the members, the weighted sum by importance rather than the sum of the utility values of simple team members is the utility value of the team. For example, utility values of members with high importance are simply added with a simple summation, but other members are influenced by the dependency within the team, and the utility value increases. Therefore, it is necessary to calculate the increment of the utility value due to the dependency relationship. Therefore, when the utility value of Agent A is assumed to be $u(a)$, the utility value of the team can be defined by Equation (2).

$$U = \Sigma\, u(i)\, W(i) \qquad (2)$$

Where $u(i)$ is the utility value obtained by Agent i. $W(i)$ is the importance level of Agent i and can be regarded as the decision power that Agent i has in the team. In this research, we propose a novel team negotiation strategy that maximizes the utility value U of the whole team.

2.1 Accept/Reject Opponents' Offer

The Accept mechanism for a team determines whether to accept the proposed bid from the negotiating partner. Towards this end, all team members need to vote regarding the proposed bid by the opponent. Let $s(a)$ be the acceptance function employed by Agent A in order to assess the proposed bid. $s(a)$ is a function that returns 1 when Agent A chooses acceptance, and 0 if not. Here, the acceptance function is defined by Equation (3).

$$f = \Sigma\, s(i)\, W(i) \qquad (3)$$

Where $s(i)$ represents s is a variable that returns 0 or 1 as to whether or not the Agent i accepted. $W(i)$ is the importance level of Agent i. In other words, it is synonymous with $W(i)$ in the team judged to be accepted when Agent i accepted. Therefore, when voting is done, it is necessary to obtain the importance degree of the accepted member as the voting right and the acceptance function as the sum of the importance degree. As a result of voting in this way, accept as a team if the acceptance function exceeds half the size of the team. Since the acceptance function is the sum of the importance of the received members in the team, when it exceeds half the size of the team, members who exceed the majority in the team accepted the other party's bid. Therefore, accept the proposal of the negotiating partner as a team's decision. Otherwise, the team starts the offer proposal mechanism.

2.2 Offer Proposal

The Offer mechanism decides and transmits the bid to be proposed to the negotiating partner as a team. The proposed approach employs a voting mechanism that selects widely accepted candidates such as Borda count [6]. Submit the bid that each team member wishes to propose within the team. After that, each team member evaluates all the submitted bids by using its own utility function. Let the utility value obtained when Agent A accept Agent B's proposed Bid is $u'_{A(b)}$. Agent A has a dependence on agent B for $w(a, b)$, and it is necessary to weight it when evaluating it depending on the degree of dependency. The utility value $u_{A(b)}$ for Agent B's proposed Bid for Agent A is as follows. Next, we evaluate and rank all the bids submitted within the team by Equation (4).

$$u_{A(b)} = u'_{A(b)}\, \{1.0 + w\,(a, b)\} \qquad (4)$$

Where $u'_{A(b)}$ is the utility value when accepting B's proposed. Also, $w(i, a)$ is the degree of dependency that Agent A receives from Agent i. Assign the score from the set [0, |A| - 1] to the submitted bid along with its ranking. | A | is the total number of bids submitted. All team members make this ranking, and the highest score bid is sent to the negotiating partner as the team's proposed bid.

3. Experiment And Discussion

In this experiment, we use GENIUS which is a general-purpose negotiation platform as evaluation environment [7]. GENIUS is an open source software, aimed at negotiation simulation and the development of automated negotiation agents. Since GENIUS supports Java API that is necessary for agent development, development becomes easy with basic knowledge of Java programming. We set the experiment setting as follows. The Automated Negotiating Agents Competition (ANAC), an international competition of automated negotiation agents, employs this simulator, where several researches on automated negotiation agents are actively conducted. In addition, the negotiation problems used in the past ANAC competition have been prepared as a standard, and they support the development of an effective negotiation strategies in various negotiation problems. We set the experiment setting as follows.

- We set up 3 team members and use 3 agents of Atlas 3, Caduceus, PonPokoAgent.
- We also used Farma as a negotiating partner. All the agents used for the experiments received high ranking results at ANAC competitions.
- We used two parts, partydomain and Domain 8, implemented in GENIUS as a negotiation domain.
- Negotiating with setting the maximum time of negotiations to 180 turns, the agents negotiated 10 times for each team member's permutation. That is, 3! × 10 = 60 automated negotiations were made in one negotiation domain.
- We set the following two interdependencies in the team.

	Agent A	Agent B	Agent C
Agent A	0.5	0.2	0.3
Agent B	0.3	0.6	0.1
Agent C	0.2	0.1	0.7

Table 1: Dependency within the team

	Agent A	Agent B	Agent C
Agent A	0.6	0.2	0.2
Agent B	0.3	0.5	0.2
Agent C	0.3	0.3	0.4

Table 2: Dependency within the team

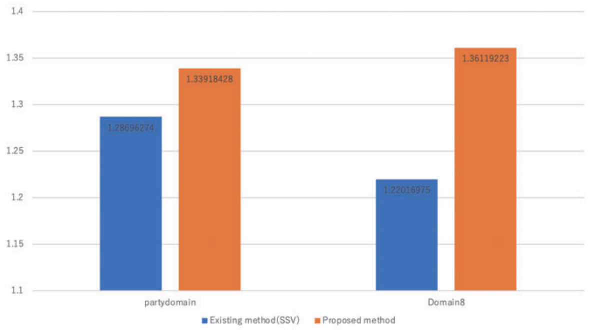

Figure 2: Average negotiation result (Table1)

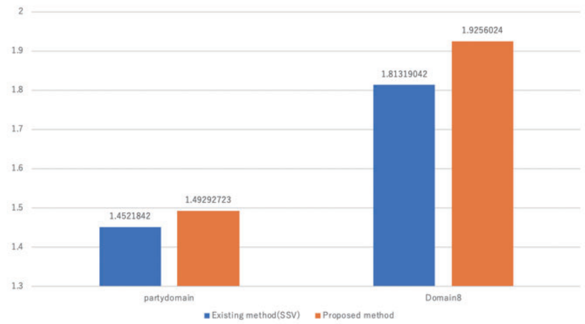

Figure 3: Average negotiation result (Table2)

The results of the experiment are shown in Figure 2 and Figure 3. As demonstrated in Figure 2, the results show that the score increases by about 0.05 for partydomain and about 0.14 for Domain 8. Since the number of team members is three, the increase in score per person is increased by about 1.8% for party domain and about 4.7% for Domain 8. As demonstrated in Figure 3, the results show that the score increases by about 0.04 for partydomain and about 0.11 for Domain 8. Since the number of team members is three, the increase in score per person is increased by about 1.3% for party domain and about 3.7% for Domain 8. Table 3 shows the results of examining the number of agreement proposal candidates in order to investigate the difference in increment by the negotiation domain.

Domain Name	Issues	Total Bid
partydomain	6	3072
Domain8	8	6561

Table 3: Comparison of size of negotiation space

From Table 3, when comparing partydomain and Domain 8, the total number of bids is larger in Domain 8. As the total number of Bids increases, the options of the proposed Bid spread, so the probability of agreeing on the same agreement decreases and the difference in the agreement proposal based on the strategy is largely reflected. From Figure 2, Figure 3 and Table 3, it can be seen that the utility value of the team is increasing as the total number of agreement proposals is larger. Therefore, as the total number of agreement proposals increases, the difference between the utility values of existing teams and the proposed method teams increases, so it can be concluded that the proposed method adapts to the utility value of the team that changes according to the dependency relationship.

4. Conclusions And Future Work

In this paper, we proposed a novel negotiation strategy that considers the interdependencies within the team in team negotiation scenarios. Towards this end, the proposed strategy implements appropriate considerations by setting the parameters that represent the interdependencies within the team, and then, using these parameters to weigh the relationship in each direction. A comparative experiment with the existing team negotiation strategies demonstrated the efficiency of the proposed strategy. As for future research, planned to investigate how to quantify the parameters that represent the interdependencies in actual negotiation problems. In addition, it become very difficult to simulate the actual negotiation scenarios unless there is a method to formulate appropriately from these scenarios. As another research direction, we also plan to study the change in the dependency score due to the change in the negotiating partner. As the negotiation partner changes, the result changes accordingly, so we plan to investigate how the agreement proposals change with the proposed approach.

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