Game Theory in Business Collaboration

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Abstract

Game Theory has been studied in several areas such as Mathematics and Economics and it helps to choose a better strategy to maximise their profit or improve their quality. However, it does not have many studies about applying game theory to business collaboration. In this paper, we take negotiation of access control policy between organizations as one of the business collaboration challenges and apply game theory creatively on Business Collaboration aspect for decision making in terms of improving performance.

The approach of this project would be making our assumption about the business collaboration first and then analyse the game theory characteristics. Then, we compare the business challenge to the game theory characteristics to form the result.

The outcome of this project would be a match result which mapped a classified business collaboration problem model with a game theory model.

1 Introduction

Nowadays, a simple business process involves multiple business partners – customers, dealers, sales representative and logistic company. On the other hand, businesses are increasingly outsourcing key operations and interacting with ever extending nets of partners. Since different players' decisions can have an effect on selecting the optimal solution, the solution selecting process becomes complicated.

A Business Collaboration is a set of roles interacting through a set of choreographed Business Processes. Due to lack of trust, policy of access is required for ensure security between organisations. The access control policy of a single organisation or service is defined in terms of roles and their privileges. Given a request to access a resource or perform an operation, the service enforces the policy by analysing the credentials of the requester and deciding if the requester is authorised to perform the actions in the request B2B integration is basically about the secured coordination of information among businesses and their information systems. It promises to dramatically transform the way business is conducted among organisations. Negotiation of common access to a set of resources reflects the sharing preferences of the parties involved. Such negotiations typically seek agreement on a set of access properties.

Game Theory has been an important theory in several areas such as Mathematics, Economics and Philosophy because Game theoretic concepts apply whenever the actions of any individuals, groups, firms are interdependent. Also, it helps them to choose a better strategy to maximise their payoffs in terms of quality or profit. In terms of business collaboration, we could apply game theory to model the business collaboration situation such that we can find out a better strategy for decision making.

Therefore, the aim of this project is to investigate how Game Theory can be applied to Business Collaboration aspect for decision making in terms of maximising profit or improving performance.

In this workshop paper it is constructed as followings: in Section 2 and 3 are some related research about game theory and business collaboration; Section 4 discusses the methodology how we solved the problem; Section 5 presents the analysis outcomes of the research and Section 6 recommends the future work for this project. Finally, Section 7 concludes the paper.

2 Business Collaboration

A Business Collaboration is a set of roles interacting through a set of choreographed Business

Transactions by exchanging Business Documents. A Business Collaboration is defined by the parties in the collaboration; it can be simple or complex, it can include expected and unexpected actions and the collaboration can allow for other than e-Business options. It is about the capability to transition to human interactions or decisions that may be important to e-Business activity, e.g. a phone call. A business activity consists of regular collaborative work among participants to achieve a business objective. An activity structure is a digital schema-based representation that describes the properties of a business activity and that semantically relates it to the people, artifacts, tools, and events involved in carrying out the business activity. There are also relationships between interacting activity structures.

2.1 Business Collaboration Overview

The first dimension is collaboration aspects which place emphasis on the different behaviors of an enterprise in business collaboration**:**

- Before seeking partners to cooperate with an enterprise will first need to capture its private behavior in the internal business process aspect. (Swaminathan and Tayur, 2002)
- Based on its internal behavior the enterprise can then specify its capabilities in its externally visible behavior in the participant public behavior aspect. (Decker, 2006)
- Enterprise negotiates with other parties to establish cooperation. (Orriens *et al*, 2006; Orriens, 2006)

2.2 Business Collaboration Characteristics

The business collaboration characteristics are:

- Long-time execution.
- Heterogeneous and autonomous business process communication among multiple business participants. (Axelsson *et al*, 2002)
- cross-organisational asynchronous business interaction. (Joines *et al*, 2001)
- Complex business-oriented transactional semantics.
- Cross-organisational transaction policy coordination.

Also, it has to be consistency which is the core requirement of collaboration. Consistency also needs support from other business transaction requirements, such as atomicity, isolation and time constraint to guarantee the consistency in individual organization as well as the whole business collaboration. (Sun, 2007)

2.3 Challenges in Business Collaboration

Trust is one of the major challenges in business collaboration. Many studies have shown that the impediment to online payment is the lack of trust in E-business. (Yang *et al*, 2006)

Current standards in business collaboration design, due to their pre-defined and inflexible nature, are precluded from accommodating business dynamics. The challenge is thus to provide a solution in which business collaboration development can be done in a flexible and adaptive manner. (Fensel, 2001)

Buyers will need to maintain established long-term relationships with preferred suppliers. Therefore, a variety of business models are likely to continue to be viable in the marketplace. (Sun, 2007)

The models where the principal faces hidden action. These types of models are known as moral hazard models. Consider a small firm selling specialized medical equipment via a sales force, which currently consists of a single salesman. The salesman (agent) represents the firm owner (principal) to the clients. The total amount of sales, and hence, the firm's revenues, depend on the efforts of the salesman. If the salesman does not work hard, the sales volumes from the new contracts are low, or potential customers are lost to competitors. Thus, the firm owner would like to design a contract and offer it to the salesman with the goal of providing an incentive to the salesman to work hard, such that both parties will mutually benefit. This situation is an example of the principal-agent problem. (Axelsson *et al*, 2002)

All of the papers contain a clear discussion about the business collaboration behavior, characteristics and challenges. However, there is no relevant work solving the problem with game theory.

3 Game Theory

A mathematical theory, developed by J. von Neumann (1903-57) and O. Morgenstern (1902-77) in 1944, concerned with predicting the outcome of games of strategy.

3.1 Game Theory characteristics

The Algorithm Game Theory (Nisan *et al*, 2007) talk about the usefulness of game theory in situations arising on the Internet. This is the foundation reading for the project because it covers most of the Game Theory terminologies.

It identifies some main terms:

Player: Any participant in a game who has a nontrivial set of strategies and selects among the strategies based on payoffs.

Payoffs: In any game, payoffs are numbers which represent the motivations of players. In all cases, the payoffs must reflect the motivations of the particular player.

Strategy: A strategy defines a set of moves or actions a player will follow in a given game. A strategy must be complete, defining an action in every contingency, including those that may not be attainable in equilibrium. For example, a strategy for the game of checkers would define a player's move at every possible position attainable during a game. Such moves may be random, in the case of mixed strategies. (Webb, 2007)

Game: A situation in which a conflict arises between two or more players.

Nash Equilibrium: Nash equilibrium is a set of strategies which represents mutual best responses to the other strategies. In other words, if every player is playing their part of Nash equilibrium, no player has an incentive to unilaterally change his or her strategy. Considering only situations where players play a single strategy without randomizing a game can have any number of Nash equilibria. (Stengel, 2008)

Complete Information: game is one of complete information if all factors of the game are common knowledge. Specifically, each player is aware of all other players, the timing of the game, and the set of strategies and payoffs for each player.

Sequential: A sequential game is one in which players make decisions following a certain predefined order, and in which at least some players can observe the moves of players who preceded them. If no players observe the moves of previous players, then the game is simultaneous.

Zero Sum: All outcomes involve a sum of all player's payoffs of 0.

Cooperative: A cooperative game is one in which players are able to make enforceable contracts. Hence, it is not defined as games in which players actually do cooperate, but as games in which any cooperation is enforceable by an outside party.

Repeated: When players interact by playing a similar stage game numerous times, the game is called a repeated game.

Coordination Game: It is a class of games with multiple pure strategy Nash equilibria in which players choose the same or corresponding strategies.

Also, Game theory is believed to give an optimal decision in order to gain maximum profit in terms of business. Perng (Perng *et al*, 2007) made an argument that Game Theory reveals an attractive profit increase for formwork subcontractors joining a coalition.

3.2 Game Theory Models

In Andrea's research, (Schalk, 2003) it stated that Game theory assumes that a player evaluates various outcomes in terms of the utility derived from them. There are two key points in a co-operative game:

- What is the payoff for each coalition?
- What payoff each player in the coalition should get?

The benefits acquired by the different members of the various coalitions are different. Consistent with the definition of co-operative games, if the profit gained by a co-operating player exceeds that which would be gained when acting independently, that player will certainly seek to establish a coalition. The method adopted for allocating benefits and costs among the members will affect the willingness of various members to remain active in the coalition. The allocation problem may be solved in a variety of ways, but an allocation rule that prescribes, somehow, a solution for the allocation problem should satisfy desirable criteria such as efficiency, fairness and others. (Schalk, 2003)

On the other hand, Mahesh Nagarajan and Greys Sosic also made a strong argument about applications of cooperative game theory to supply chain management. Special emphasis is placed on two important aspects of cooperative games: profit allocation and stability. (Nagarajan and Sosic, 2006)

3.3 Game Theory in Business Application

Hu, Yu and Huang have discussed the applications of both Nash equilibrium of dynamic game and bargaining game theory to Collaboration

Planning Model respectively. The possibility and feasibility of attaining the goal of win-win and the conditions required are discussed for the co-operative enterprises of upstream and down-stream in Supply Chain Management. The simulation results verified the effectiveness of the model and algorithm. (Zhu *et al*, 2005) Moreover, the collaboration planning model is established by negotiation instead of automated negotiation.

Again, Mahesh Nagarajan, Greys Sosic also did a research with Supply Chain. They described the construction of the set of feasible outcomes in commonly seen supply chain models, and then used cooperative bargaining models to find allocations of the profit pie between supply chain partners. A few models including negotiation model were analyzed and surveyed, and included suppliers selling to competing retailers, and assemblers negotiating with component manufacturers selling complementary components. Then they discussed the issue of coalition formation among supply chain partners. (Nagarajan and Sosic, 2006) However, they did not consider a repeated game which extended their model to an arbitrary number of players and a repeated game.

Ken Binmori and Nir Vulkan (1997) pointed out that:

- For some protocols, the system itself can choose equilibrium in an unproblematic manner.
- When the choice of an equilibrium selection norm would itself give rise to bargaining problems among the players, the equilibrium refinement theories of game theory can be given new life. Therefore, they have a non controversial means of interpreting the counterfactuals involved when observing that optimizing players stay on the equilibrium path in a game.
- Where analytic approaches fail, algorithmic methods for computing fix points corresponding to equilibria can be realistically employed.

4 Methodology

Before the analysis, we have made some assumptions:

- Each decision maker ("PLAYER“) has available to him two or more well-specified choices or sequences of choices.
- Every possible combination of plays available to the players leads to a well-defined end-state that terminates the game.
- A specified payoff for each player is associated with each end-state.
- Each decision maker does not have perfect knowledge of the game and of his opposition; that is, he does not know in full detail the rules of the game as well as the payoffs of all other players.
- All decision makers are rational; that is, each player, given two alternatives, will select the one that yields him the greater payoff.

First, we used the characteristics from section 2.1 to analyse the negotiation of access control policy situation.

We have 7 classification criteria.

- Players: How many players will be in this negotiation policy game? The answer could be zero, two or more than two.
- Strategy: In a game each player chooses from a set of possible actions, known as strategies. In this situation would be accepting the policy or denying the policy.
- Nash Equilibrium: It has a mutual best response to the other strategies.
- Sequential: One player performs her/his actions after another is a sequential game.
- Complete information: If it is a sequential game and every player knows the strategies chosen by the players who preceded them.
- Zero Sum: One gain is the loss of the others.
- Repeated: players play the game numerous times.

After we went through all these questions, we found out the game type of business collaboration challenge.

Then, we compare to the analysis for the games of Game Theory. (See Table 1)

Game	Players	Strategies per player	Sequential	Complete information	Zero sum
Cake cutting	infinite	infinite	No	Yes	Yes
Coordination game	*N*	variable	No	No	No
Diner's dilemma	*N*	2	No	No	No
El Farol bar	*N*	2	No	No	No
Guess 2/3 of the average	*N*	infinite	No	No	Yes
Minority Game	*N*	2	No	No	No
Peace war game	*N*	variable	Yes	No	No
Pirate game	*N*	infinite	Yes	Yes	Yes
Screening game	*N*	variable	Yes	No	No
Signaling game	*N*	variable	Yes	No	No

Table 1. Game Model Analysis

5 Result

After the analysis, we have the result that negotiation of access control policy is a non-cooperative, n-person game with incomplete information.

First of all, it could be many different organisations request for the access of the specific service. Therefore, it is a n-person game which can have many requester to play this negotiation game at the same time. Then, in our assumption, we said they do not have full knowledge about the game which is an incomplete information. Since all requests are sent as individual, it is a non-cooperative game. We found that the once the negotiation is done, they may negotiation again in the future such that it is a sequential game.

Next, we compared it with our game model analysis. It turns out there are a close match with coordination game.

6 Future Work

We believe that using the strategy from Game Theory to solve the business collaboration challenge could bring a significant improvement. The future work would be investigating the strategy for coordination game and then model it in a mathematical fashion such that we can use formula to produce experiment.

7 Conclusion

Game theory helps us model, analyse, and understand the behaviour of multiple self-interested agents who interact while making their decisions.

Most business situations can be modeled by a "game," since in any business interaction involving two or more participants the payoffs of each participant depend on the other participants' actions.

This paper has given an overview of game theory and business collaboration.

Also, it analysed some game models in game theory and lastly we defined the access control policy is classified as a non-cooperative, n-person game with incomplete information and it has the same characteristics as coordination game.

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