**Presentation Report**

**On**

**Game Theory In Networking**



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**ABSTRACT**

**Game theory** is a discipline aiming to model situations in which decision makers have to make specific actions that have mutual – possibly conflicting consequences in which the action of one component has impact on that of any other component . Game theory techniques have widely been applied to various engineering design problems. In the context of wireless networks, game theory may be used as a tool for forming cooperation schemes among entities such as nodes, terminals or network providers. Game theory has been applied to networking , in most cases to solve routing and resource allocation problems in a competitive environment. The behaviour of a given wireless device may affect the communication capabilities of a neighbouring device, notably because the radio communication channel is usually shared in wireless networks . Situations of this kind can be modelled by making use of game theory. Applications of game theory in wireless networking presents it in a layered perspective, emphasizing on which fields game theory could be effectively applied. This describe how various interactions in wireless networks can be modeled as a game and how game-theoretic solutions may effectively predict/simulate realistic user behaviour in competitive or cooperative scenarios. This similarity leads to a strong mapping between traditional game theory components and elements of a network in understanding the complex interactions between nodes in this highly dynamic and distributed environment.

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**1.INTRODUCTION**

**1.1 Game theory** is a mathematical method for predicting human behavior in strategic, multi-player situations. Game theory assumes that each player forms rational beliefs about what other players (associates) in the game will do and then chooses a response to those strategies that maximizes its own payoffs[2]. Under the assumption of rationality, game theory assumes that play will be at (or will converge to) an equilibrium.

**Rationality:** In the language of Game Theory rationality implies that each player tries to maximize his/her payoff irrespective to what other players are doing[2][4]. In essence each player has to decide a set of moves which are in accordance with the rules of the game and which maximize his/her rewards.

Game Theory can be classified in two branches

1. *Non co-operative game theory :*In this case the players work independently without assuming anything about what other players are doing[3].
2. *Co-operative game theory:* Here players may co-operate with one another.

Game Theory has found applications in Economic, Evolutionary Biology, Sociology, Political Science etc, now Its finding applications in Computer Science.

Components of game:

A game has the following

1. Set of players                            D = { Pi   | 1 <= i  <= n}
2. Set of rules                                R
3. Set of Strategies                        Si for each player Pi
4. Set of Outcomes.                      O
5. Pay off                                       ui (o)  for each player i and for each outcome o *e* O

**1.2 Example** 1{*Coin Matching Game*}

*Coin Matching Game :* Two players choose independently either Head or Tail and report it to a central authority[6]. If both choose the same side of the coin , player 1 wins, otherwise 2 wins.

A game has the following :-

1**.  Set of Players**.                 
  Coin Matching Game form the set of players i.e. P={P1,P2}

2.  **Set of Rules**:           R   
   Each player can choose either Head or Tail. He has to act independently and made his selection only once. Player 1 wins if both selections are the same othrwise player 2 wins. These form the Rule set R for the *Coin Matching Game*.

3. **Set Strategies**:            Si for each player Pi   
    For example in Matching coins S1 = { H, T}  and S2 = {H,T}  are the strategies of the two players. Which means each of them can choose either Head or Tail.

4.  **Set of Outcomes**:       O   
     In matching Coins its {Loss, Win} for both players. This is a function of the strategy profile selected.

In our example S1 x S2 = {(H,H),(H,T),(T,H),(T,T)} is the strategy profile.

5**.  Pay off**  : ui (o)   for each player i and for each outcome o *e* O   
 In general its different for different players.   
Let the payoffs in  *Coin Matching Game* be,

u1(Win)  = 100   
u1(Loss) = 0 similar for u2

**1.3 Solving and analyzing the games**

**1.3.1 Iterated Dominance**

Once the game is expressed in strategic form, it is usually interesting to *solve* it. Solving a game means predicting the strategy of each player, considering the information the game offers and assuming that the players are rational[1][7]. There are several possible ways to solve a game; the simplest one consists in relying on *strict dominance*.

Strategy S **strictly dominates** a strategy T if every possible outcome when S is chosen is better than the corresponding outcome when T is chosen.

**Dominance Principle**

Rational players never choose strictly dominated strategies.

*Idea:* Solve the game by eliminating strictly dominated strategies!

iterated removal

**Example** packet forwarding game in network layer[1].

**Limitation :**

Removal of strictly dominates strategies does not always work.Consider a game :

|  |  |  |  |
| --- | --- | --- | --- |
|  | A | B | D |
| A | 12 | -1 | 0 |
| C | 5 | 2 | 3 |
| D | -16 | 0 | -1 |

Rows=Player1 set of strategies{A,C,D}

Columns = Player2 set of strategies{A,B,D}

NEITHER PLAYER HAS DOMINATED STRATEGIES HERE!

**1.3.2 Weakely dominance**:

B weakely dominates A : There is atleast one set of opponent’s action for which B is superior and all other sets of opponent’s action gives B atleast the same payoff as A.

One can perform an elimination based on iterated weak dominance, which results in a strategic profile .

**1.3.3 Mixed strategies:**

Each player associates a probability distribution over its set of strategies

Payoffs are computed as expectations.

We should players choose prob. distribution that cannot be exploited by other player i.e. payoff should be equal independent of the choice of strategy of other player.

**1.3.4 Nash theorem:**

An outcome o\* of a game is a NEP (Nash equilibrium point) if no player can unilaterally change its strategy and increase its payoff.

Every two person game has *at least one* equilibrium in either pure or mixed strategies.

2.**GAME THEORY IN NETWORKING**

Game theory techniques have widely been applied to various engineering design problems. In the context of wireless networks, game theory may be used as a tool for forming cooperation schemes among entities such as nodes, terminals or network providers[8].

This describe how various interactions in wireless networks can be modeled as a game and how game-theoretic solutions may effectively predict/simulate realistic user behaviour in competitive or cooperative scenarios.

* 1. **LAYERED PERSPECTIVE**

2.1.1 **PHYSICAL LAYER:**

From a physical layer perspective, performance is generally a function of the estimated **signal-to-interference and-noise ratio** (SINR) that players/nodes receive, a physical layer interactive decision making process occurs.In this frame, game theory can be applied to allocation problems concerning resources such as power or spectrum[6]. Here we formulate a non-cooperative frequency control FDMA system Simplified version of this model is jamming game[1]. It’s a zero sum game with mix strategy Nash equilibrium.

* + 1. **DATA LINK LAYER:**

Game theory applications regarding the data link layer involve the medium access control problem. In these games, selfish users seek to maximize their utility by obtaining an unfair share of access to the channel. Multiple Access Game[1], introduces the problem of medium access. Suppose that there are two players *p*1 and *p*2 who want to access a shared communication channel to send some packets to their receivers *re*1 and *re*2. We assume that each player hasone packet to send in each time step and he can decide to access the channel to transmit it or to wait. Assume that *p*1, *p*2, *re*1 and *re*2 are in the power range of each other, hence their transmissions mutually interfere.

2.1.3 **NETWORK LAYER:**

It does establishment of routes and the forwarding of packets along those routes. Game theory may be applied to aid a node in determining which the optimal route is or deciding whether it should forward a received packet or not.

In the game called the Forwarder’s Dilemma[1][7],we assume that there exist two devices as players, *p*1 and *p*2. Each of them wants to send a packet to his destination6, *dst*1 and *dst*2 respectively, in each time step using the other player as a forwarder.

If player *p*1 forwards the packet of *p*2, it costs player *p*1 a fixed *cost* 0 *< C <<* 1, which represents the energy and computation. Each player is tempted to drop the packet he should forward, as this would save some of his resources; but if the other player reasons in the same way, then the packet that the first player wanted to send will also be dropped. They could, however, do better by mutually forwarding each other’s packet. Hence the dilemma.

2.1.4 **TRANSPORT LAYER:**

At the transport layer, game-theoretic models have been mainly developed to analyze the effectiveness of congestion control . Congestion avoidance control refers to controlling the load of the network by restricting the admission of new user’s sessions and resolving the unwanted overload situations. Admission control takes place each time a new session request is received and decides whether it should be allocated resources or be rejected due to lack of resources. Its basic goal in cellular networks is to control the admission of new sessions within the network with the goal of maintaining the load of the network within some boundaries.

Example :

1.Provider v/s Provider:

In this kind of games the networks constitute the players.

As individual players in the game, the access networks

will try to choose the request that best fits their characteristics[8].

2.Customer v/s Provider:The main goal of such schemes is to maximize not only the QoS offered to customers, but also the provider’s gain, therefore balancing the interests of both parties[8].

**2.2 Challenges in the use of game theory**

The use of game theory in wireless networks unfortunately comes with a set of challenges, the most important of which are the following ones:

**2.2.1 Assumption of rationality**

Game theory is founded on the hypothesis that each player plays rationally and thus seeks his best interest in a rational manner. When dealing with nodes or terminals however this behavior cannot be always

guaranteed.

**2.2.2 Assumption of willingness to cooperate**

In cooperative games it is assumed that players will collaborate in order to maximize their profits. A significant problem is that players sometimes choose to behave selfishly or even cheat in order to optimize their own profit. For this reason, in certain occasions, incentive mechanisms for cooperation, as well as disincentives against cheating need to be formulated.

**2.2.3** **Not guaranteed existence of equilibrium**

In game-theoretic formulations an analysis is often required to check if they reach a nash equilibrium. Even if an equilibrium is reached however, the existence of multiple equilibria is not always excluded. In such case the most efficient and stable one has to be sought.

**2.3 CONCLUSION**

In this we have attempted to demonstrate how game theory can be applied to networking. Following a layered perspective, it has been explained how to capture networking problems in game-theoretic formulations, emphasizing on which game type best suits each application field and on how the corresponding utility function may be constructed.

The purpose of this was to familiarize with computer science through the basics of both non-cooperative and cooperative game theory . We believe that game theory also has a strong role to play in the development and analysis of protocols.

Game theory is a concept and a fascinating tool which we can integrate to our own study of real life situation.

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