GAME THEORY BASED NETWORK SELECTION IN 4G

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ABSTRACT *:* **Most of the existing complex networks, such as the Internet, are operated and built by thousands of large and small entities (autonomous agents), which collaborate to process and deliver end to end flows originating from and terminating at any of them. The distributed nature of the Internet implies a lack of coordination among its users. Instead, each user attempts to obtain maximum performance according to his own parameters and objectives. Methods from game theory and mathematical economics have been proven to be a powerful modeling tool, which can be applied to understand, control, and efficiently design such dynamic, complex networks. Game theory provides a good starting point for computer scientists in their endeavor to understand selfish rational behavior in complex networks with many agents (players) [1] Such scenarios are readily modeled using techniques from game theory, where players with potentially conflicting goals participate in a common setting with well prescribed interactions.**

Key words: Game Theory, Network Selection, 4G, WiMax, Quality Points.

INTRODUCTION

Game theory is a mathematical tool used in understanding and modeling competitive situations which imply the interaction of rational decision makers with mutual and possibly conflicting interests. It was originally adopted in economics, in order to model the competition between companies.

Nowadays game theory is widely applied to other areas, such as: biology, sociology, politics, computer science, and engineering. Game theory has been adopted in the telecommunication environment, especially in wireless sensor networks, cognitive radio networks, and adhoc networks. Game theory is used as a tool for studying, modeling, and analyzing the interactions between individuals strategically. In the wireless environment, game theory has been used in order to solve many distributed power control, resource management and allocation, and dynamic pricing related problems [2]

RELATED WORKS

Game theoretic approaches have been introduced as a useful tool to handle those tricky network attacks. In this paper, author review the existing game theory based solutions for network security problems, classifying their application scenarios under two categories, attack defense analysis and security measurement.[3] When programs compete for resources such as personnel, time, funding, and priority, they are weighed against other programs, such as Lean initiatives, Six Sigma, etc. The consequence of this comparative selection tends to favor the program that can show the quickest return on investment.[2] While the Quality of Service (QoS) offered to users may be enhanced through innovative protocols and new technologies, future trends should take into account the efficiency of resource allocation and network/terminal cooperation as well.

Modeling 4G based scenario of game theory:

Game theory is the study of a mathematical model of conflict and cooperation between intelligent rational decision makers [5]. The critical components of a game are:

A. A well-defined set of two or more players.

B. A set of actions or strategies for each player.

C. A set of payoff functions for each player for each possible strategy.

Author will consider the following game which has similarity with the model of but also has differences which will become evident later in this section [6] **G** = {N, K, Pi}
N = the set of players (here three access networks: WCDMA denoted by 1, WLAN denoted by 2 and WiMAX denoted by 3).

K = the set of strategies (Service requests that access networks choose to serve with the aim of achieving the highest payoff).here author consider three types of service requests: streaming video denoted by 1, internet surfing denoted by 2 and voice call denoted by 3.
Pi = the payoff for each player i for choosing a strategy from the set of strategies K [6].

Individual Access Networks:

According to a Game theoretical model [5], the players of the game are the individual access networks (here WCDMA, WLAN, WiMAX) each of which competes to win a service request. Here author have positioned these networks along X, Yand Z axis respectively As shown in fig 1

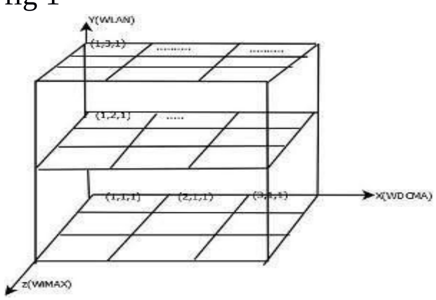

Fig 1. Individual Access Network

Strategies of Access Network:

In a Game theoretical model each player can choose a strategy from a set of strategies. In network selection game the strategies are the service requests. At a particular time each player makes choice of a strategy with the aim of achieving highest payoff. Here each access network makes choice of a service request with this aim. Therefore there are varying combinations of these strategies which give the strategy space coordinates Figure 1 Strategy Space [1].

The strategy space coordinate (1, 1, 2) means that WCDMA network has chosen strategy 1(streaming video),WLAN has chosen strategy 1 too and WiMAX has chosen strategy 3(Voice call). In general three competing access networks along 3 coordinate axis together with varying combinations of their chosen strategies make up the strategy space [5].

Calculating the payoff:

To calculate the payoffs of each competing access network. The payoffs will not only depend on the choice of strategy of the access networks but also on other factors which are denoted by A to E in this paper. Each factor will have an associated conditional a particular time which is denoted by an integer for clarity and demonstration purpose [2].

These factors or inputs are identified as following:

A. The type of service: streaming video (1), internet surfing (2), voice call (3).
B.User preference: Cost (1), Quality (2).
C.Traffic state and signal strength of the network: bad (1), medium (2), good(3).
D.Speed of the user: High speed (1), Low speed (2), Stable (3).
E.Drainage rate of battery in each mode: (1),(2), (3), (4), (5), (6).

The fifth input factor will now be clarified. This factor is kept dynamic in this work. In case of the fifth factor (factor E), input condition 1 means that in a three mode (WCDMA, WLAN, WiMAX) enabled mobile device in the 4th generation communication networks, WCDMA is draining battery power at the least rate, WLAN is draining the battery power at a worse rate than WCDMA and WiMAX is draining the battery power at the worst rate among the three modes. Therefore the conditions are given as following:

means that WCDMA>WLAN>WiMAX
means that WCDMA>WiMAX>WLAN
means that WLAN>WCDMA>WiMAX
means that WLAN>WiMAX>WCDMA
means that WiMAX>WCDMA>WLAN
means that WiMAX>WLAN>WCDMA

Assignment of Quality Points:

Inclusion of quality points shows that, a measure like 'quality points' can be used to account for the relative advantage of one access network over another in a particular condition [4].

An illustration of Assigning Quality Points:

A. Quality point based on type of service

A1. When factor A=1 (Streaming Video) Game theory is the study of a mathematical model of conflict and cooperation between intelligent rational decision makers [5].

Quality Point for three networks are

Q1(WCDMA),factor A=1=3

Q2(WLAN),factor A=1=5

Q3(WiMAX),factor A=1=6

A2. When factor A=2(internet surfing) Quality Point for three networks are

Q1(WCDMA),factor A=2=3

Q2(WLAN),factor A=2=4

Q3(WiMAX),factor A=2=4

A3. When factor A=3(VoiceCall) Quality Point for three networks are

Q1(WCDMA),factor A=3=7

Q2(WLAN),factor A=3=4

Q3(WiMAX),factor A=3=4

B. Quality point based on user preference

B1.When factor B=1(Cost i.e. the user prefers cost to quality) Quality Point for three networks are

Q1(WCDMA),factor B=1=3

Q2(WLAN),factor B=1=7

Q3(WiMAX),factor B=1=4

B2.When factor B=2(Quality ie. The user prefers cost to quality) Quality Point for three networks are

Q1(WCDMA),factor B=2=3

Q2(WLAN),factor B=2=5

Q3(WiMAX),factor B=2=6

Weighting Coefficients:

Author considered five factors (A to E) which affect the payoff of the three competing access networks. But it should also be noticed that these factors do not affect the payoff in the same way, some factors have greater impact while others have less impact, and in other words some factors are more important for network selection decision while others are less important for network selection decision.

Therefore, author suggest a system of weighting to account for the varying effects of these factors or inputs. For example author assign the following weighting coefficients (which can be an integer number) to the five factors (A to E) [2]:

WA=Weighting Coefficient for factor A

WB=Weighting Coefficient for factor B

WC=Weighting Coefficient for factor C

WD=Weighting Coefficient for factor D

WE=Weighting Coefficient for factor E

The Network Selection Decision

The total payoff of each network is the weighted sum of quality points it receives from each factor depending on the specific condition of the factor. Therefore, author introduce the following "payoff equation" which gives the payoff of the competing access networks: [3]

Pi=WAQAi+WBQBi+WCQCi+WDQDi+ WEQEi (1)

In (1), Pi is the payoff of player i, to are weighting coefficients for factor A to E respectively and is the Quality point that player i obtains from factor depending on a specific condition (denoted by a number as shown previously), to bear the similar meaning (for example, the Quality point that player i obtains from factor E depending on a specific condition). [5]

Equation (1) for 3 players can be written separately as:

P1=WAQA1+WBQB1+WCQC1+WDQ D1+WEQE1--(2)

P2=WAQA2+WBQB2+WCQC2+WDQ D2+WEQE2--(3)

P3=WAQA3+WBQB3+WCQC3+WDQ D3+WEQE3--(4)

Equation for Calculating payoff of the networks:

Using Equation(2),(3) and (4)wen can get the payoffs for each network and the network with the highest payoff will serve a particular service request of the user in case two or more networks (players) make choice of the same service request (strategy) at the same time.

Flowchart for Network Selection Process:

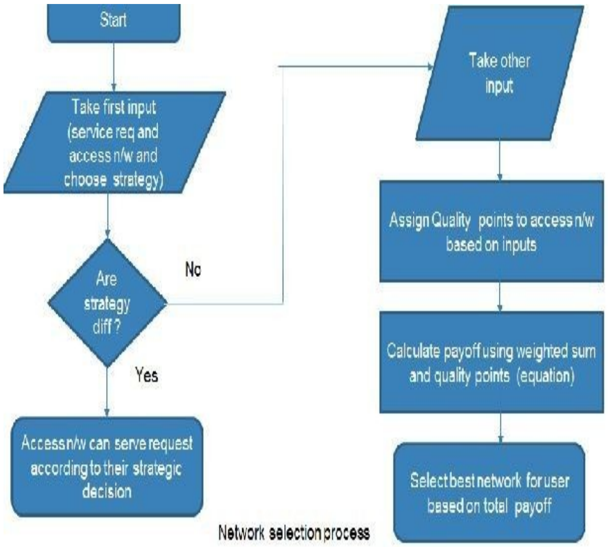

Fig 2

COMPARISION OF DIFFERENT APPLICATIONS OF GAME THEORY

The network selection problem can be a very complex problem, and various game theoretic approaches that try to solve the network selection problem are proposed in the literature. Different game models are used to model the problem as non- cooperative or cooperative game between users and/or networks.Table 1 illustrates a classification of the existing approaches into three broad categories based on the interaction between players: users vs. users (non-cooperative and cooperative, networks vs. users (non-cooperative and cooperative, and networks vs. networks (non-cooperative and cooperative. In Game Theory based Network Selection paper they have presents an overview of the network selection decision problem and challenges, a comprehensive classification of related game theoretic approaches and a discussion on the application of game theory to the network selection problem faced by the next generation of 4G wireless networks [1] In Game Theory for Network Security paper author has the existing game-theory based solutions for network security problems, classifying their application scenarios under two categories, attack-defense analysis and security measurement. Presents a brief view of the game models in those solutions and summarize them into two categories, cooperative game models and non-cooperative game models with the latter category [2]. In Game Theory in Strategy Development of Reliability and Risk Management paper author has focused primarily on the two person game, illustrating with simple mathematics and notation, in the hopes of providing the reader with a tool that can be extended and applied to numerous problems where rational conflict is the dominant factor consisting of subcategories [3].

Tiitle	Game Theory-Based Network Selection:Solutions and Challenges	Game Theory for Network Security	Game Theory in Strategy Development of Reliability and Risk Management	4G Converged Environm ent: Modeling Network Selection as a Game
Algorithms	Multi-criteria decision making algorithms	Decision making algorithm s	polynomial-time algorithms	Decision making algorithms
Game Theory Mod	Cooperative/Non cooperative	yes	yes	yes
Network Selection Principle	Evolution/Auction Game	Evolution	Evolution	Both
Application	Good Response Time and Delivery	Good	Good	Good

Comput at ional Comple xity	More	Less	Less	More
Routing And Security	Less	Good	Good	Good
Network Security	Less	Good	Good	Good

Table-1

CONCLUSION AND FUTURE WORK:

The users want to get the best value services/network for the money they pay. As game theory is often used to study this interaction between rational decision makers, it makes it applicable in the area of network selection strategies. In spite of their limitations, game theoretic approaches have shown that they are both powerful tools for solving networks security problems and that new game theoretic approaches should be a pool of research directions on network security.As author review above, there are only a couple models addressing three or more players interaction with focus on multiple defenders [6]. Therefore, building game models involving three or more players for more network security application scenarios and addressing application problems in which multiple attackers can launch attacks in a non-competitive way is one of the future research directions [5].

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