Chapter 1
Introduction

ABSTRACT

The situations to which game theory has actually been applied reflect its selective usefulness for problems and solutions of an individualistic and competitive nature, building in the values of the status quo. The main principal area of application has been economics. In economics, game theory has been used in studying competition for markets, advertising, planning under uncertainty, and so forth. Recently, game theory has also been applied to many other fields, such as law, ethics, sociology, biology, and of course, computer science. In all these applications, a close study of the formulation of the problem in the game theory perspective shows a strong inclination to work from existing values, to consider only currently contending parties and options, and in other ways, to exclude significant redefinitions of the problems at hand. This introductory chapter explores these and forms a basis for the rest of the book.

INTRODUCTION

Network Design is one of the most active research areas in computer science involving researchers from system architecture, networks, algorithm development, optimization technique, artificial intelligence and information theory. Generally, network design includes problems ranging from allocation of network resources, analysis and effects of competitive and/or cooperative agents, network protocols, network dynamics, performance optimization, to network traffic and topology control. In addition, many new network design paradigms such as sensor, ad hoc network management and smart grid networking add rich new flavors to existing problems. Usually, networks are a complicated mix of applications, protocols, device and link technologies, traffic flows, and routing algorithms. There may be tens of thousands of feasible configurations, each with different performance attributes and costs. Therefore, network design is challenging, requiring designers to balance user performance expectations with network-resource costs, capacities, capabilities, and use levels (Bragg, 2000).

Many systems that can be modeled using network design approach appear in various fields such as informatics, social science, economics, ecology, biology and engineering. If these systems can be modeled as complex network systems, a network design method that finds a desired network structure can become one of strong tools in large-scale system designs. With conventional network design methods, new network design

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methods have been proposed (Mizuno, Okamoto, Koakutsu & Hirata 2012).

Optimization approach is one of the most important methods in network design. Therefore, a lot of research has been conducted to find an optimal solution for network control problems. In traditional optimization processes, one is quite often faced by a situation where more than one selfish agent is involved in decision making. Different agents might typically have different objectives. To get the optimal solution on the network design, multiple objective optimization techniques are necessary by taking into account complex interactions among network components. However, due to the model complexity among conflicting network performance criteria, it is practically unable to implement realistic network models. Recent results show a strong relation between network design and game theory. Game theory, an alternative name is interactive decision theory, is the study of mathematical models of conflict and cooperation between intelligent rational decision makers. It is a branch of applied mathematics as well as of applied science.

As the name of the theory suggests, game theory was first used to describe and model how human populations behave. Some scholars believe that they can actually predict how actual human populations will behave when confronted with situations analogous to the game being studied. Due to this reason, the essence of a game is the interdependence of player strategies. Therefore, game theory is thought as a science of strategy. It attempts to determine mathematically and logically the actions that *players* should take to secure the best outcomes for themselves in a wide array of *games* (Crossman, n.d.).

Usually, a game is a formal description of a strategic situation, and game theory is the study of decision-making where several players must make choices that potentially affect the interests of the other players. Game theory was originally an economic and mathematical theory that predicted that human interaction had the characteristics of a game, including strategies, winners and losers, rewards and punishment, profits and cost, behavior of firms, markets, and consumers. The use of the game theory has since expanded in the social sciences and has been applied to political, sociological, and psychological behaviors as well. Recent advances in game theory have succeeded in describing and prescribing appropriate strategies in several situations of conflict and cooperation. But the theory is far from complete, and in many ways the design of successful strategy remains an art (Dixit, & Nalebuff, n.d.).

The basic ideas of game theory have appeared in various forms throughout history and in numerous sources, including the Bible, the Talmud, the writings of Charles Darwin, Brouwer's fixed-point theorem and so on. In game theory, the basic assumption is that the decision makers pursue some well defined objectives and take into account their knowledge or expectations of the other decision makers' behavior (Han, Niyato, Saad, Başar, & Hjørungnes 2011).

HISTORY OF GAME THEORY

Early discussions of games occurred long before the rise of modern, mathematical game theory. One reason why game is an exciting activity for humans is that it couples intellectual activity with direct competition; better thinking and learning generally results in winning more games. Thus, humans can test out and refine their intellectual skills by playing games against opponents, and evaluate their progress based on the results of the competition. During the first five centuries A.D., one problem discussed in the Babylonian Talmud is the so called marriage contract problem. Nowadays, it is recognized that the Talmud anticipates the modern theory of cooperative games ("Game theory," n.d.).