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ANALYSIS OF GAME THEORY AND RELEVANCE IN ENGINEERING

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Abstract— In this paper, we appraise some of the literature in which different applications to engineering problems are investigated from a game-theoretic approach. The review is far from comprehensive and the single purpose of this paper is to provide an approximate updated information on this topic. As well, we try all over the paper to bring to light what game theory could put in to the study of engineering problems. A broad nontechnical coverage of many of the developments in game theory is given together with some comments on important open problems and where some of the developments may take place. The purpose here is to present a broad picture of the many areas of study and application that have come into existence. The use of deep techniques flourishes best when it stays in touch with application. There is a vital symbolic relationship between theory and practice. The rapid speed of development of game theory calls for an appreciation of both the many realities of divergence, synchronization and teamwork and the abstract exploration of all of them.

Index Terms— Game theory, application, wireless communication,network,water resourses, transportation, stochastic

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1 INTRODUCTION

Game theory has been a prey of its own successes. It is now definitely inherent as a method of analysis as an important tool in economics, political science, law, social psychology and other disciplines Never the less, they do not mention engineering, except computer science, as one of the application fields of game theory. Since then, the applications of game theory to engineering (including computer science) have often appeared in the literature because many of their problems have a suitable structure and characteristics such that game theory may play a relevant role in their analysis and solutions. However, engineering is a very broad discipline, which can be divided into several branches depending on the type of problems studied / worked. Likewise, we are able to find a great variety of topics within each branch of engineering. Although there are many different problems in number.

engineering, some of these are more suited to applying game theory than others. This outline attempts to specify the possible guidelines of expansion and to suggest where some of the challenges lie ahead. A broad sketch of many of the current areas of specialization is given with no attempt at an in-depth discourse on the creation of subs specializations. The stress is on what we may want and expect for the future, keeping in view the difference between need and viability. In specific, game theory can be useful in situations related to management, design and the business of an engineering scheme.

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Primarily, we have the design of the scheme in which the various essentials putting together the plans are defined, including their scientific distinctiveness and how they interrelate with each other in order to attain the goals of that scheme. Secondly, we have the financial part, in which the expenses and profit are taken into consideration in order to All tables and figures will be processed as images. You need to embed the images in the paper itself. Please don't send the images as separate files.

support the system, including in this part, how the costs and benefits are distributed when more than one negotiator is a part. And, third, we have the completion or initiation of the system. Here, it is evident that game theory can play an considerable part in the second part, particularly when many parties are involved as one of the usual contents within game theory is cost/benefit sharing. In this case, game theory can help all stake holders included to reach an agreement to begin a favorable engineering organization, primarily when there is a divergence of interests. Still game theory is also useful in the seek of the engineering system as it can offer detail learning and solutions as to how the various components should correlate with each other so as to develop a better example of the system. So, technical issues offer many situations for applying game theory.

We can distinguish the applications into two ways. The first way would involve papers devoted to game-theoretic study of real engineering problems, while the second way would consist of papers committed to game-theoretic study of conceptual engineering systems. So, the first group could be considered a part of Game Practice, where as the second group could be assumed to be more hypothetical. However, in both ways the objects are frequently as follows,

1)Doing analysis for a better perceptive of the problem in order to give some in depth view as to how to handle it; (2)

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Finding new (hypothetical) games with motivating properties; 3) Finding answers to the query of how to share out the cost/benefit amongst the agencies concerned in the scheme and (4) evolving solutions to the question of how to devise the communication among the elements of the system in order to obtain an better show of the system. In a certain sense, the first two aims could be taken more theoretical while the other two are more realistic.

The paper is organized as follows. Section. 2 includes, the game-theoretic way to problems in electronics engineering, mainly to communications networks Sec. 3, includes some examples of uses of game-theory in civil engineering. These applications begin for true circumstances and are related to the question of allocating funds to the engineering system. In this case, most of the applications are devoted to game-theoretic investigation of conceptual technical systems. The utility of game theory is explained through live and real cases.

2 Applications to Electronics Engineering

In recent years, Electronics engineering has extensively used game theory in a wide field for its application. Some explanations for this can be found in Mac Kenzie and Wicker [2001a]. Electronics engineering includes the design and study of computer systems and telecommunications.

Instead of relating only the cost/benefit sharing/allocation, this branch of technology has more extensively used focusing on the design of how the elements of the subsequent system interrelate with each other, so as to increase its efficiency and performance.

Billera et al. [1978] examined using games the problem of finding the internal billing rates for long-distance telephone calls that are made through Wide Area Telecommunication Service. Using cooperative games the problem of benefits allocation in the global Flight Telephone was studied by Van den Nouwe and et al. [1996]. After this we will study some uses of game theory to wireless communication and computer systems which is also known as routing and congestion.

Wireless communications are communications from a distance without a material connection, Due to this there is a cost cutting in the mechanism. But the complexity faced in this circumstances is the limitation of radio electrical field. The current development of wireless communication systems is being described by huge user demands in terms of the quality awareness about the performance of the service. This needs the design of network and its actual execution to be very efficient one. It also needs the optimal usage of available resources and minimization of error creating elements in parallel process. This may be achieved through the progress and maintenance of Radio Resource Management techniques. The elements which actually come into picture for providing an optimal performance of a wireless communication system are transmission power control, modulation and coding schemes and channel allocation. Methods for organizing these elements are vital for defining RRM policies. In order to deal with these problems from game theory, in the literature on this topic, effective functions determining some significant feature for the measured players in the structure are defined. As well many credentials on this topic are tending from a non cooperative perception, which involves a good opening to use cooperative games as an substitute way of finding new ideas and insights. Some papers on power control using non cooperative games are Ji and Huang [1998], Goodman and Mandayam [2000], MacKenzie and Wicker [2001a, 2001b], Alpcan et al. [2002], Perez-Palomar et al. [2003], Sung and Wong [2003], Altman and Altman [2003], Candogan et al. [2010] and Bacci and Luise [2010]. Likewise, Goz´alvez et al. [2008], Lucas-Esta˜n et al. [2008, 2012b] and Niyato and Hossain [2006] use bankruptcy techniques for designing channel allocation schemes scheme, i.e., the players are the different technologies or networks.

In communication and computer systems there are Other two interesting topics , congestion
and routing in networks. Congestion games are non cooperative games which were first introduced in Rosenthal [1973]. These games react to circumstances in which there are a set of assets, R, and a set of players who have to prefer some resources from R, and the payoff associated to each resource depends on the number of players that have chosen it. This kind of situations arises very often in communication and computer problems, for example in channel allocation, spectrum sharing, power control, routing traffic, task allocation, or bandwidth allocation. Some recent papers on overcrowding games applications to spectrum sharing are Liu and Wu [2008] and Liu et al. [2009]. Routing games respond to the problem of how to route traffic in a communication network when the agent involved are self-centered and there is no central influence, an example of such networks being Internet. These games are also non cooperative and one of the main topics is the analysis of equilibrium inefficiency and the so-called price of anarchy (Koutsopias and Papadimitriou, 1999).

we would like to state few exciting works. Altman et al. [2006] is a review on game theory applications to telecommunications. These are mainly focused on non cooperative games.

Boche et al. [2009] is a special issue dedicated to applications of game theory to (wireless) communications. It has a mention about the limited resources in wireless communications are spectrum, space, power, and time. Game theory is used to analyze spectrum sharing, resource allocation, power control, transmit strategies, and network etiquette in wireless multiuser networks. The interest in these methods is increased significantly during the last 10 years in the networking and signal processing communities. With the same Saad et al. [2009] is a well-thought out tutorial on coalitional game theory for communication networks which includes some motivating and illustrative applications. These three works include many references which can be useful for the reader interested in this topic roughly speaking, multi-agent systems consist of multiple cooperating agents which are considered intelligent, autonomous, with a non complete information about the underlying problem and decentralized. Under this definition we can find many different problems depending on the type of agents for eg. software agents, robots, human beings, firms, etc.. Multi-agent systems have turned out to be a powerful tool for solving complex problems in a distributed way. In this sense, each agent is designed or considered in such a way that it is not able to solve the problem or control the system by itself because of resource limitations or other difficulties. This field has become one of the most important in computer science and is considered a part of distributed artificial intelligence. In this environment it seems clear that game theory can play an important role and we can find many game-theoretic papers in this field. An excellent book on multi-agent systems is by Shoham and Leyton-Brown [2009] which deals with the different foundations of multi-agent systems including game theory. An interesting situation arises when the agents in a system have to coordinate their actions in order to improve their individual aims.

Marden et al. [2009] stated uses of their game-theoretic model to the sensor operated problem and to the self-motivated sensor coverage problem. Last but not the least with the role of game theory in multi-agent systems, some papers on public learning, opinion dynamics, and near-potential games that have been shown to have strong connection to cooperative control are Lobel et al. [2009], Nedic et al. [2010], Acemoglu and Ozdaglar [2011], and Candogan et al. [2011a, 2011b].

A very different application of game theory , is the consistency of complex systems, in particular to electronic devices in electrical and electronics engineering. The consistency of a system is defined as the probability that the system will function satisfactorily. Usually, a system consists of different components and each influence in the performance of the system, therefore if we consider that each component is a player, then we could use game theory to measure the responsibility of each component in the good or bad performance of the system. For example, in Ramamurthy [1990] and Freixas and Puente [2002] we can observe how game theory is applied for analyzing the reliability of a system. Likewise, Moretti and Patrone [2008] highlight the use of the Shapley value in reliability theory. Finally to conclude this section we mention mechanism design which, in words of Garg et al. [2008a], can be viewed as reverse engineering of games or equivalently as the art of designing the rules of a game to achieve a specific desired
outcome.

3. Applications to Civil Engineering

We focus on concise of the type of problems incorporated in the area of civil engineering. Civil engineering includes, the drawing and structure of civic and classified infrastructure such as transportation, hydraulic arrangement, bridges and edifice. Attending the type problems in civil engineering it finds hard to find applications of game theory to the plan of these engineering problems, but there are nice uses regarding the financial support of civil engineering developmens. It becomes obvious with examples of the use of game theory in problems concerning civil engineering. These are related to hydraulic engineering developments and transport infrastructure. Similarly, a cooperative game method is used in four of these examples, but a non cooperative approach in the left behind. In the midst of different other missions the TVA had to face the complexity of allocating the expenditure of the Wilson Dam and other projects for novel dams amid five purposes: routing, caudal control, energy creation, nationwide protection and manure creation. Therefore, the TVA faced a expenditure sharing difficulty. A number of processes were identified to assign the expenses, but the fundamental difficulty was how to decide a reasonable and acceptable distribution. Ransmeier [1942] provides a nice explanation and investigation of this difficulty and in Straffin and Heaney [1981] and in Driessen [1988] one can find a game-theoretic analysis of some of the methods studied by the TVA. In Young et al. [1982] and Young [1994] the following situation is analyzed. In the 40's some municipalities of the Skane Region in Sweden set up an organization for the running of water possessions in the region. This organization was called the Sydvatten Company. When the water requirement increased the Sydvatten corporation decisive to increase the long term water propose and to include new municipalities into the corporation. In the 70's the Sydvatten corporation invited some members of the International Institute for Practical Systems Analysis to analyze how to share the cost of the growth of the water scheme among the municipalities involved.

After studying the obtainable system, determining the expected water demand and working out the overall cost of the expansion, the last problem to solve was how to separate the price between the municipalities. They resorted to supportive games to do this, but then the problem became computational. For this reason, they separated the municipalities only into six reasonable and rational groups according to the available information, and then they first disseminated the price among the six groups and then among the municipalities. The methods analyzed included proportional distributions and classical solutions from cooperative games such as the Shapley value (Shapley, 1953) or the nucleolus (Schmeidler, 1969). By comparing the different methods, one could study that those taken from game theory had better properties. Another application to water infrastructure is originates in Berganti˜nos and Lorenzo [2004]. In a Galician valley some small villages belonging to the same municipality had problems with the water supply. For this reason, the city committee built water deposits in each small village linked to a basin. Similarly, the villagers were capable to attach their houses to the places by paying the price of association. On final all the connections, the municipality were to be the possessor of the complete scheme. But not all people had originally connected to it. After a time, everybody experienced that the water delivery scheme worked fine and then the non linked villagers asked the city committee for link to the scheme, apparently in what would be the most lucrative way. This gave increase to a disagreement of wellbeing between the associated and non associated villagers. In the end, the city committee determined to join them to the water supply scheme, paying only their association costs. Berganti˜nos and Lorenzo [2004] analyzed this problem from a no cooperative perspective for appreciation the tactical performance of the villagers and calculated a method to begin this type of circumstances. Further investigation of these games is created in Berganti˜nos and Lorenzo [2005, 2008].

Other papers on water resources development are by Suzuki and Nakayama[1976], Dinar et al. [1992], Loehman et al. [1979] and we also refer to Tijs and Driessen [1986] for a game-theoretic analysis of cost allocations problems. Now we briefly present a pair of applications of game theory to transfer communications. One of the problems in airport infrastructures administration is to decide the aircraft landing fees in order to cover up both the inconsistent and the fixed costs of a runway. So the question is how to do this. Baker [1965] and Thompson [1971] pointed out a procedure to determine the fees to be charged to each type of aircraft which Littlechild and Owen [1973] proved, is the Shapley value of a fastidious game. Likewise, this game has a nice arrangement, which one can find in other striking problems. Since the 90's the European Commission has approved several guidelines for the freedom of railway transportation in nations of the European unification. As a consequence of these guiding principle the organization of the railway transportation and move operations by train have to be separated into two different businesses. In this case, how are the licenses for in commission granted? How and when do the official operators use the railway transportation? and how are the structure and the maintenance of railway infrastructures funded? It is painfully apparent that game theory can offer solutions and impending for the first and third questions. Fragnelli et al. [2000] and Norde et al. [2002] analyzed the last question from a cooperative game point of view. They introduced the so-called infrastructure game which is the amount of an airport game connected to the enduring costs of the system and a preservation game related to its capricious costs. For this game the Shapley value, the nucleolus and the Tijs value (Tijs, 1981) can be proposed together with other ad hoc rules for allocating the cost among the agents involved.

3 Conclusion:

Likewise, in Norde et al. [2002] the non bareness of the core (Gillies, 1953) of these games is studied. the (classical) solutions in cooperative game theory, while exciting, do not always reflect fundamental aspects of the problem structure, which means they can lose some interest. Therefore, an interesting line of research, valid for almost all problems, is the construction of ad hoc solutions that are related to the structure of the problem and have good properties, from the perspective of game theory, which make them attractive or justify their use. On the second hand, the use of (classic) cooperative games may be too simple either because the value functions of agents are nonlinear or because the value of a grouping of agents depend on the coalitions that form the rest agents. In the first case, the use of cooperative games with nontransferable utility does seem more appropriate and, in the second case, the use of cooperative games in partition function form seem more plausible (see Thrall and Lucas, 1963). However, there are not many papers of application of cooperative game theory to engineering in which are applied these instructions but are, in many situations more influential and appropriate for the problem than the traditional approach. Therefore, this is another talented way for prospect investigate in supportive game applications to manufacturing. Moreover, the nature of many engineering problems is self-motivated, stochastic, or both at once, and this should be taken into report when approaching the corresponding problem. A problem may well be dynamic either because the number of agents change over time, or because the conditions that determine the value of a coalition varies over time, as often happens on the problems linked with transportation networks .

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