Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi

Afyon Kocatepe University Journal of Science and Engineering

AKÜ FEMÜBİD **16** (2016) Özel Sayı (196-204) AKU J. Sci. Eng.**16** (2016) Özel Sayı (196-204)

An Overview of Game Theory and its Applications in Network Routing

Serap ERGÜN[1], Tuncay AYDOĞAN[2], Sırma Zeynep ALPARSLAN GÖK[3]

[1,2]*Süleyman Demirel University, Department of Software Engineering, West Campus, 32260, Isparta.*

[3] *Süleyman Demirel University, Deparment of Mathematics, East Campus, 32260, Isparta.*

e-posta:serapbakioglu@sdu.edu.tr, tuncayaydogan@sdu.edu.tr, sirmagok@sdu.edu.tr

Keywords
Network; Game Theory; Nash Equilibrium; Solution Concepts; Network Simulators.

Abstract

In telecommunication networks, users can, in many cases, make decisions concerning routing. The term routing alludes to selecting paths in a computer network along which to send data, in computer networking. Routing directs forwarding, the passing of logically addressed packets from their source toward their last destination through routers. Game theory can be defined as a mathematical framework consisting of models and techniques analyzing the behavior of individuals concerned about their own benefits. It has been applied to a wide range of fields including economics, political science, biology, psychology, linguistics, and computer science. This paper presents the detailed overview of the Game Theory concepts and its applications in the Network Routing, both from cooperative and non-cooperative perspectives with their some solution concepts. In addition, the network simulators which are used for examining the performances in the studies are given, too.

Oyun Teorisine Genel Bir Bakış ve Ağ Yönlendirmesindeki Uygulamaları

Anahtar Kelimeler
Ağ; Oyun Teorisi; Nash Dengesi; Çözüm Kavramları; Ağ Simülatörleri.

Abstract

Telekomünikasyon ağlarında, kullanıcılar birçok durumda yönlendirmeye ilişkin kararlar alırlar. Yönlendirme, bilgisayar ağındaki verilerin gönderileceği yolların seçiminde kullanılmaktadır. Yönlendirmedeki akış yönlendiriciler aracılığıyla kaynaktan hedefe doğru gerçekleşir. Çalışma kapsamında; oyun teorisi, kendi yararları hakkında ilgili bireylerin davranışlarını analiz edenmodel ve teknikleri içeren bir matematiksel çerçeve olarak tanımlanabilir. Oyun teorisi, her oyuncunun kendi faydalarını maksimize etmeye çalıştığı ya da kendi maliyetini en aza indirmeye çalışıtığı çok oyunculu sistemlerde karar verme durumları için kullanılır. Oyun teorisi; sosyal bilimler, ekonomi, psikoloji, siyaset ve telekomünikasyon gibi karmaşık sorunları çözmek için kullanılmaktadır. Bu çalışma Oyun Teorisi ve çözüm konularıyla ilgili olarak kapsamlı bir bilgi vererek, hem İşbirliksiz hem de İşbirlikçi Oyun Teorisi kısımları çerçevesinde detaylı bir bakış sunmaktadır. Ayrıca, çalışmalardaki performans değerlendirmeleri için kullanılan ağ simülatörleride verilmiştir.

1. Introduction

Network routing refers to the ability of an electronic communication network to send a unit of information from point A to point B by determining a path through the network, and by doing so efficiently and quickly. Network routing can be broadly divided into three basic fundemental categories: packet routing, circuit-switched routing, and transport routing; certainly, a combination is possible. The evolution over the past quarter-century has brought to the foreground the need to understand and examine where and how different dimensions of routing, from algorithms to protocols to architectures, can differ for different types of networks, where they intersect. We can see that packets are to be routed from a source to a destination. Such packets may need to traverse many cross-points, similar to traffic intersections in a road trasportation network. Cross-points in the Internet are known as routers and a router's functions are to read the destination address marked in an incoming IP packet, to consult its internal information to identify an outgoing link to which packet is to be forwarded, and then to forward the packet (Orda et al., 1993).

The broad scope of network routing is to address routing algorithms, routing protocolss, and

architectures, with architectures encompassing several different aspects for efficient routing.

In this paper, we consider Network Routing literature in the framework of Game Theory concept.

2. Game Theory

Game Theory (Owen, 1995; Rosenthal, 1973) is the study of mathematical models, which are used in a situation when multiple entities interact with each other in a strategic setup. The theory in its true sense deals with the ability of an entity or individual (player) to take a certain decision keeping in view the effect of other entities decisions on him, in a situation of confrontation. A wage negotiation between a firm and its employees can be considered as a game between two parties, where each party makes a decision or move in the negotiation process based on other party's move. Similarly, a business run by a group of people can be considered as a game played against its competitors or customers.

The concept of modern Game Theory was introduced by John Von Neumann and Oskar Morgenstern in 1944, who described the word 'game' for the first time by systematically specifying the rules of the game, the move of players, the information they possess during their moves and the outcome for each player at the end of the game (Wang and Li, 2006). The progress of Game Theory continued since its inception and later on and was used in many other fields other than economics. Game Theory has now become an important mathematical tool, which is used in situations that involves several entities whose decisions are influenced by the decisions of other entities playing with them.

Game Theory is useful for acting and predicting behavior of others and designing systems with multiple participants. Also games are strategic interaction between rational entity and players. Game normally defines by the players, a set of strategies for each player and a preference relation for each player over possible outcomes. A player gives the set of strategy or action for every player in the game. In Game Theory, there is a basic and crucial assumption of the rationality that says every player is the utility optimizer or maximizer, in order to minimizing the cost or maximizing the utility and player has a payoff function for optimizing the payoff function (Kontogiannis and Spirakis, 2005; Shah, 2012).

Depending on the player's knowledge about each other's strategies, payoffs, and past histories; games can be subdivided into different categories. Depending upon the number of players, a game can be classified as 2-player game or n-players where n>2. Depending upon the cooperation level, information available and the occurring of moves of the individual players the games can be broadly categorized as follows (Shah, 2012).

In non-cooperative games, each participant player acts in his own interest and the unit of analysis is always the individual player instead of group of players. In these types of games, the players are always selfish – i.e., they always try to increase their own individual payoffs without taking care of other player's payoffs in the game. So, non-cooperative game theory studies the competitive nature of individual players where players come into contact with the sole aim to increase their own benefits from the strategic situation (Economides and Silvester, 1990; Shah, 2012).

In cooperative games, the groups of players are the unit of analysis and the players tend to increase their group payoffs as well as their own. A cooperative game can be considered as a competition among the groups in a game rather than individual players. The applications of cooperative game theoretical models are in the situations where players form groups, called coalitions, and the individual or group of player's contribution towards the game depends on the actions of other agents in the game (Banner and Orda, 2007; Shah, 2012).

Most of the problems in Communication Systems have been modeled as non-cooperative games, where each node is considered to be a selfish self-maximize without taking care of the benefit of other nodes in a conflicting situation. However, there are some studies where the coalition games have been modeled to study the individual nodes behavior in a network each contributing to a coalition (Banner and Orda, 2007).

3. Applications of Game Theory in Network Routing

Game Theory has been extensively used in networking research as a theoretical decision-making framework, e.g., for routing, congestion control, resource sharing, and heterogenous networks. We limit our discussion to game theory models as cooperative and non-cooperative game theory in network routing.

From 1983 to 2016, about 626 research papers with topics on or closely to Game Theory (GT) for Network Routing (NR) were published. Figure 1 shows the yearly distribution of these published papers.

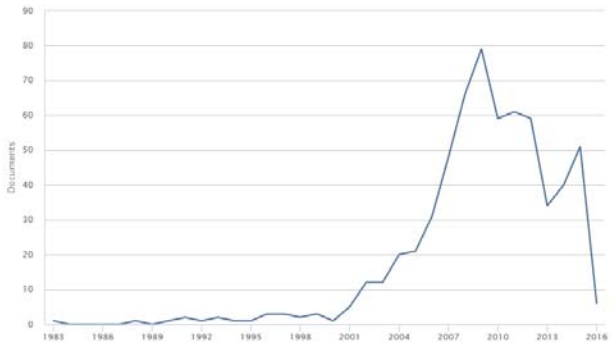

Fig. 1. Yearly publications on GT for NR

Most applications of GT and NR involve in the areas of computer science, engineering, mathematics, decision sciences, biochemistry, genetics, social sciences, business, management, physics, astronomy, chemical engineering, material science, energy, earth and planetary sciences, environmental science, chemistry, economics, medicine, multidisciplinary, neuroscience, etc. Figure 2 shows the documents by subject area distribution.

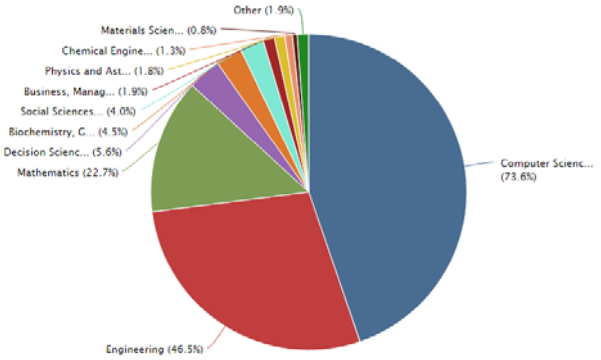

Fig. 2. Documents by subject area

If we want to see which contries study in these fields, Figure 3 will help us.

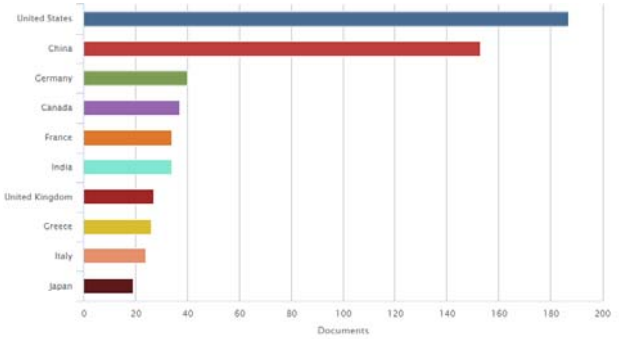

Fig. 3. Documents by country/territory

Similarly, routing and routing algorithms are studied as a combined problem in various studies. Routing algortihms have to keep routing table reasonably small, choose best route for given destination (this can be fastest, most reliable, highest throughput, cheapest route, etc.), keep table up-to-date when node dies, moves or joins, require small amount of messages/time converge.

About 238 research papers with topics on or closely to GT for routing algorithms were published between 1983 and 2016. The distribution is similar to the years and the subject areas according to Figure 1 and Figure 2, respectively. However, China is has also published more paper than United States. The other countries' sort is the same.

The variety of network simulators are used in about 133 paper such as NoC, OPNET, NS-2, NS-3, BookSim, Exata, CINSIM, MATLAB, J-Sim,

GloMoSim, Tossim, AncLes, OMNeT++, etc.

The routing layer problems have been solved in many contexts, initially taking the concept of the application of non-cooperative game theory in transportation system and then extending the same findings to the network routing (Altman et al., 2006). Thus, the aim of applying the game theoretic models for routing solves the path finding problem, where routing and resource allocation problems have been solved as a joint game formulation. The non-cooperative routing games aim to solve the 'path' problem where a path is the route established inside a network from a source to destination, both aim to maximize the route benefit for themselves and compete with other source, destination pairs in the network.

The studies of (Blum et al., 2006; Economides and Silvester, 1990; Fotakis et al., 2002) have addressed network routing games in general.

A class of game theoretical model for routing in transportation networks has been presented by Rosenthal (Rosenthal, 1973). The author has considered n players in a competitive environment, each wants to ship one unit from source to destination while minimizing its transportation cost. The existence of pure strategy Nash Equilibrium has been proven in this model.

Routing in general wired networks has been studied as a non-cooperative game in (La and Anantharam, 2002; Orda et al., 1993; Kameda, 2002; Altman et al., 2002; Roughgarden, 2001), where conditions for the existence of Nash Equilibrium has been derived. Banner et al. (2007) have extensively studied the non-cooperative routing problem in wireless networks based on split-able and unsplitable flows.

There exist several main terminologies in GT (Table 1). The Nash Equilibrium for non-cooperative games, The Shapley value and the Core for cooperative games. They can be found as solution concept in the literature. Some papers use both of solutions in cooperative and non-cooperative games.

Table 1. Common Terminologies in Typical GT in NR

	Typical GT Methods in NR		
Terminology	Cooperative	Non-Cooperative	Cooperative, Non-Cooperative
The Nash Equilibrium	(Coimbra et al, 2010)	(Abbad et al., 2006; Altman et al., 2002; Anderegg and Eidenbenz, 2003; Anshelevich et al., 2008; Barth et al., 2005; Borges et al., 2010; Boulogne and Altman, 2001; Busch and Magdon-Ismail, 2009; Caragiannis et al., 2005; Chang et al., 2012; Coimbra et al., 2010; Correa et al., 2004; Correa et al., 2005; Costa-Requena et al., 2005; Coucheney et al., 2010; Erçetin and Tassiulas, 2003; Gairing et al., 2006; Georgiou et al., 2006; Hespanha and Bohacek, 2001;Huang and Jiao, 2008;Kabranov et al., 2003; Kesselman et al., 2005; Kontogiannis and Spirakis, 2005; Koutsoupias et al., 2003; Kuruc and Lója, 2005; La and Anantharam, 2002; Liu et a., 2005; Lója et al., 2005; Lownes et al., 2011; Lukyanenko and Gurtov, 2009; Nimbar et al., 2012; Otrok et al., 2008; Rocha et al., 2006; Roughgarden, 2001; Sahin and Simaan, 2004; Siddiqi et al., 2014; Wang and Li, 2006; Wang et al., 2005; Wang et al., 2008; Xiao et al., 2008; Yang et al., 2013; Yoo and Agrawal, 2006; Yuan et al., 2006)	(Gairing et al., 2006; Sagduyu and Ephremides, 2006; Yan and Hailes, 2008; Yan et al., 2008)
Shapley Value	(Anshelevich et al., 2008; Bianzino et al., 2011; Jain and Vazirani, 2001; avadi and Jamalipour, 2009; Javadi and Jamalipour, 2011; Wu and Shu, 2005; Yan, 2009; Yan et al., 2008; Zhong et al., 2007)		(Gairing et al., 2006; Sagduyu and Ephremides, 2006; Yan and Hailes, 2008; Yan et al., 2008)
The Core	(Eido et al., 2009; Markakis and Saberi, 2005)		

3. The Conclusion

This paper has summarized the recent developments in Game Theory for Network Routing. Game Theory has the capability to

examine a larger amount of possible scenarios before performing the action. Game Theory can make a decision process more sophisticated while routing. The potential of appliying Cooperative Game Theory to Network Routing is prospective. Some researchers have already explored the game-theoretic approach to non-cooperative game theory in routing scenarious or problems. However, studies towards cooperation has not become widespread as non-cooperative games. Representative contributions are listed to give a general overview. This paper appears to be a promising avenue for future development in the network routing, routing protocols and routing algorithms.

References

Abbad, M., Azouzi, R. E. and Kamili, M. E., 2006. The problem of capacity addition in multi-user elastic demand communication networks. Mathematical Methods of Operations Research, 63(3), 461-471.

Altman, E., Başar, T., Jimenez, T. and Shimkin, N., 2002. Competitive routing in networks with polynomial costs. Automatic Control, IEEE Transactions on, 47(1), 92-96.

Altman, E., Boulogne, T., El-Azouzi, R., Jiménez, T. and Wynter, L., 2006. A survey on networking games in telecommunications. Computers and Operations Research, 33(2), 286-311.

Altman, E., El Azouzi, R. and Abramov, V., 2002. Non-cooperative routing in loss networks. Performance Evaluation, 49(1), 257-272.

Anderegg, L. and Eidenbenz, S., 2003. Ad hoc-VCG: a truthful and cost-efficient routing protocol for mobile ad hoc networks with selfish agents. In Proceedings of the 9th annual international conference on Mobile computing and networking (pp. 245-259). ACM.

Anshelevich, E., Dasgupta, A., Kleinberg, J., Tardos, E., Wexler, T and Roughgarden, T., 2008. The price of stability for network design with fair cost allocation. SIAM Journal on Computing, 38(4), 1602-1623.

Aumann, R. J. and Dreze, J. H., 1974. Cooperative games with coalition structures. International Journal of game theory, 3(4), 217-237.

Banner, R. and Orda, A., 2007. Bottleneck routing games in communication networks. Selected Areas in Communications, IEEE Journal on, 25(6), 1173-1179.

Barth, D., Blin, L., Echabbi, L. and Vial, S., 2005. Distributed cost management in a selfish multi-operators BGP network. In Next Generation Internet Networks, 2005 (pp. 24-30). IEEE.

Bianzino, A. P., Chaudet, C., Rossi, D., Rougier, J. L and Moretti, S., 2011. The green-game: Striking a balance between qos and energy saving. In Proceedings of the 23rd International Teletraffic Congress (pp. 262-269). International Teletraffic Congress.

Blum, A., Even-Dar, E., and Ligett, K., 2006. Routing without regret: On convergence to Nash equilibria of regret-minimizing algorithms in routing games. In Proceedings of the twenty-fifth annual ACM symposium on Principles of distributed computing (pp. 45-Owen, 1995). ACM.

Borges, V., Borkar, S., Sardesai, C., Kamat, A. and Kamat, P., 2010. Dynamic Power Conservation Routing in MANETs: A New Approach. In Emerging Trends in Engineering and Technology (ICETET), 2010 3rd International Conference on (pp. 808-812). IEEE.

Boulogne, T. and Altman, E., 2001. Competitive Routing in Multicast Communications. Networks, 46(1), 22-35.

Busch, C. and Magdon-Ismail, M., 2009. Atomic routing games on maximum congestion. Theoretical Computer Science, 410(36), 3337-3347.

Caragiannis, I., Galdi, C., and Kaklamanis, C., 2005. Network load games. In Algorithms and Computation (pp. 809-818). Springer Berlin Heidelberg.

Chang, C. W., Liu, H., Huang, G., Lin, B. and Chuah, C. N., 2012. Distributed measurement-aware routing: Striking a balance between measurement and traffic engineering. In INFOCOM, 2012 Proceedings IEEE (pp. 2516-2Owen, 19950). IEEE.

Coimbra, J., Schutz, G. and Correia, N., 2010. Forwarding repeated game for end-to-end QoS support in fiber-wireless access networks. In Global Telecommunications Conference (GLOBECOM 2010), 2010 IEEE (pp. 1-6). IEEE.

Correa, J. R., Schulz, A. S. and Stier-Moses, N. E., 2004. Selfish routing in capacitated networks.

Mathematics of Operations Research, 29(4), 961-976.

Correa, J. R., Schulz, A. S. and Stier-Moses, N. E., 2005. On the inefficiency of equilibria in congestion games. In Integer Programming and Combinatorial Optimization (pp. 167-181). Springer Berlin Heidelberg.

Costa-Requena, J., Kantola, R. and Beijar, N., 2005. Incentive Problem for Ad Hoc Networks Scalability. In Autonomic and Autonomous Systems and International Conference on Networking and Services, 2005. ICAS-ICNS 2005. Joint International Conference on (pp. 70-70). IEEE.

Coucheney, P., Gaujal, B. and Touati, C., 2010. Self-optimizing routing in MANETs with multi-class flows. In Personal Indoor and Mobile Radio Communications (PIMRC), 2010 IEEE 21st International Symposium on (pp. 2751-2756). IEEE.

Damme, E. E. C., 2000. Non-cooperative games. Tilburg University. Discussion Paper.

Economides, A. A. and Silvester, J. A., 1990. A game theory approach to cooperative and non-cooperative routing problems. In Telecommunications Symposium, 1990. ITS'90 Symposium Record., SBT/IEEE International (pp. 597-601). IEEE.

Eido, T., Pekergin, F., Marot, M. and Atmaca, T., 2009. Multiservice Optical Packet Switched Networks: Modeling, Performance Evaluation and QoS Mechanisms in a Mesh Slotted Architecture. In Networking and Services, 2009. ICNS'09. Fifth International Conference on (pp. 288-295). IEEE.

Erçetin, Ö. and Tassiulas, L., 2003. Market-based resource allocation for content delivery in the internet. Computers, IEEE Transactions on, Owen, 1995(12), 1573-1585.

Fotakis, D., Kontogiannis, S., Koutsoupias, E., Mavronicolas, M. and Spirakis, P., 2002. The structure and complexity of Nash equilibria for a selfish routing game. In Automata, Languages and Programming (pp. 123-134). Springer Berlin Heidelberg.

Gairing, M., Monien, B. and Tiemann, K., 2006. Routing (un-) splittable flow in games with player-specific linear latency functions. In Automata, Languages and Programming (pp. 501-512). Springer Berlin Heidelberg.

Georgiou, C., Pavlides, T. and Philippou, A., 2006. Network uncertainty in selfish routing. In Parallel and Distributed Processing Symposium, 2006. IPDPS 2006. 20th International (pp. 10-pp). IEEE.

Hespanha, J. P. and Bohacek, S., 2001. Preliminary results in routing games. In American Control Conference, 2001. Proceedings of the 2001 (Vol. 3, pp. 1904-1909). IEEE.

Huang, X. and Jiao, C., 2008. Congestion control in satellite networks. In Wireless Communications, Networking and Mobile Computing, 2008. WiCOM'08. 4th International Conference on (pp. 1-4). IEEE.

Jain, K. and Vazirani, V., 2001. Applications of approximation algorithms to cooperative games. In Proceedings of the thirty-third annual ACM symposium on Theory of computing (pp. 364-372). ACM.

Javadi, F. and Jamalipour, A., 2009. Multi-path routing for a cognitive wireless mesh network. In Radio and Wireless Symposium, 2009. RWS'09. IEEE (pp. 232-235). IEEE.

Javadi, F. and Jamalipour, A., 2011. A multi-path cognitive resource management mechanism for QoS provisioning in wireless mesh networks. Wireless Networks, 17(1), 277-290.

Kabranov, O., Yassine, A. and Makrakis, D., 2003. Game theoretic pricing and optimal routing in optical networks. In Communication Technology Proceedings, 2003. ICCT 2003. International Conference on (Vol. 1, pp. 604-607). IEEE.

Kameda, H., 2002. How harmful the paradox can be in the Braess/Cohen-Kelly-Jeffries networks. In INFOCOM 2002. Twenty-First Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE (Vol. 1, pp. 437-445). IEEE.

Kesselman, A., Leonardi, S. and Bonifaci, V., 2005. Game-theoretic analysis of internet switching with selfish users. In Internet and Network Economics (pp. 236-245). Springer Berlin Heidelberg.

Khalili, H., 2013. Performance Evaluation of a Game Theoretical routing protocol over Mobile Ad Hoc Networks.

Kontogiannis, S. and Spirakis, P., 2005. Atomic selfish routing in networks: A survey. In Internet and Network Economics (pp. 989-1002). Springer Berlin Heidelberg.

Koutsoupias, E., Mavronicolas, M. and Spirakis, P., 2003. Approximate equilibria and ball fusion. Theory of Computing Systems, 36(6), 683-693.

Kuruc, G. and Lója, K., 2005. Routing Protocols with Smallest Maximal Latency. Periodica Polytechnica Electrical Engineering, 49(3-4), 209-221.

La, R. J. and Anantharam, V., 2002. Optimal routing control: Repeated game approach. Automatic Control, IEEE Transactions on, 47(3), 437-450.

Liu, Y., Zhang, H., Gong, W. and Towsley, D., 2005. On the interaction between overlay routing and underlay routing. In INFOCOM 2005. 24th Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings IEEE (Vol. 4, pp. 2543-2553). IEEE.

Lója, K., Szigeti, J. and Cinkler, T., 2005. Inter-domain routing in multiprovider optical networks: game theory and simulations. In Next Generation Internet Networks, 2005 (pp. 157-164). IEEE.

Lownes, N., Wang, Q., Ibrahim, S., Ammar, R., Rajasekaran, S and Sharma, D., 2011. Many-to-many game-theoretic approach for the measurement of transportation network vulnerability. Transportation Research Record: Journal of the Transportation Research Board, (2263), 1-8.

Lukyanenko, A. and Gurtov, A., 2009. Towards behavioral control in multi-player network games. In Game Theory for Networks, 2009. GameNets' 09. International Conference on (pp. 683-690). IEEE.

Markakis, E. and Saberi, A., 2005. On the core of the multicommodity flow game. Decision support systems, 39(1), 3-10.

Medhi, D., 2010. Network routing: algorithms, protocols, and architectures. Morgan Kaufmann.

Nimbar, H., Kotak, P. and Shah, N., 2012. Intelligent computer networks: A Game Theoretic Approach to Compute the Traffic Equilibrium of Various Routing Schemes for multimedia applications in wireless networks. In Communication Systems and Network Technologies (CSNT), 2012 International Conference on (pp. 407-411). IEEE.

Orda, A., Rom, R. and Shimkin, N., 1993. Competitive routing in multiuser communication networks. IEEE/ACM Transactions on Networking (ToN), 1(5), 510-Owen, 19951.

Osborne, M. J., 2004. An introduction to game theory. New York: Oxford University Press.

Otrok, H., Mehrandish, M., Assi, C., Debbabi, M. and Bhattacharya, P., 2008. Game theoretic models for detecting network intrusions. Computer Communications, 31(10), 1934-1944.

Owen, G., 1995. Game theory. London, UK: Academic Press, 3rd edition.

Rocha, B. G., Almeida, V. and Guedes, D., 2006. Increasing qos in selfish overlay networks. IEEE Internet computing, 10(3), 24.

Rosenthal, R. W., 1973. A class of games possessing pure-strategy Nash equilibria. International Journal of Game Theory, 2(1), 65-67.

Roughgarden, T., 2001. Designing networks for selfish users is hard. In Foundations of Computer Science, 2001. Proceedings. 42nd IEEE Symposium on (pp. 472-481). IEEE.

Roughgarden, T., and Tardos, É. (2002). How bad is selfish routing?. Journal of the ACM (JACM), 49(2), 236-259.

Sagduyu, Y. E. and Ephremides, A., 2006. A game-theoretic look at simple relay channel. Wireless Networks, 12(5), 545-560.

Sahin, I., and Simaan, M. A., 2004. A game theoretic flow and routing control policy for two-node parallel link communication networks with multiple users. In Personal, Indoor and Mobile Radio Communications, 2004. PIMRC 2004. 15th IEEE International Symposium on (Vol. 4, pp. 2478-2482). IEEE.

Shah, I. A., 2012. Channel assignment and routing in cooperative and competitive wireless mesh networks (Doctoral dissertation, Brunel University).

Siddiqi, U., Shiraishi, Y., Takahashi, S. and Sait, S. M., 2014. An Evaluation of Game Theory for Rip-Up and Re-Routing in Global Routing, ISCA 29th International Conference on Computers and their Applications (CATA 2014), March 24-26, Las Vegas, NV, USA.

Von Neumann, J. and Morgenstern, O., 2007. Theory of games and economic behavior. Princeton university press.

Wang, Q., Fiondella, L., Lownes, N., Ivan, J., Ammar, R., Rajasekaran, S. and Tolba, S., 2011. Integrating equilibrium assignment in game-theoretic

approach to measure many-to-many transportation network vulnerability. In Technologies for Homeland Security (HST), 2011 IEEE International Conference on (pp. 351-357). IEEE.

Wang, W. and Li, X. Y., 2006. Low-cost routing in selfish and rational wireless ad hoc networks. Mobile Computing, IEEE Transactions on, 5(5), 596-607.

Wang, W., Eidenbenz, S., Wang, Y. and Li, X. Y. 2006. OURS: optimal unicast routing systems in non-cooperative wireless networks. In Proceedings of the 12th annual international conference on Mobile computing and networking (pp. 402-413). ACM.

Wang, X., Hou, M., Wang, J. and Huang, M., 2005. A microeconomics-based fuzzy QoS unicast routing scheme in NGI. In Embedded and Ubiquitous Computing–EUC 2005 (pp. 1055-1064). Springer Berlin Heidelberg.

Wang, Y., Dahlberg, T. A. and Wang, W., 2008. Routing game in hybrid wireless mesh networks with selfish mesh clients. International Journal of Autonomous and Adaptive Communications Systems, 1(4), 425-446.

Wu, M. Y. and Shu, W., 2005. Intersensornet: strategic routing and aggregation. In Global Telecommunications Conference, 2005. GLOBECOM'05. IEEE (Vol. 2, pp. 5-pp). IEEE.

Xiao, J., Xiong, N., Yang, L. T. and He, Y., 2008. A joint selfish routing and channel assignment game in wireless mesh networks. Computer Communications, 31(7), 1447-1459.

Yan, L., 2009. Game theoretic packet relaying model for wireless ad hoc networks. International Journal of Communication Networks and Distributed Systems, 3(1), 68-89.

Yan, L. and Hailes, S., 2008. Designing incentive packet relaying strategies for wireless ad hoc networks with game theory. In Wireless Sensor and Actor Networks II (pp. 137-148). Springer US.

Yan, L., Hailes, S. and Capra, L., 2008. Analysis of packet relaying models and incentive strategies in wireless ad hoc networks with game theory. In Advanced Information Networking and Applications, 2008. AINA 2008. 22nd International Conference on (pp. 1062-1069). IEEE.

Yang, D., Xue, G., Fang, X., Misra, S. and Zhang, J., 2013. A game-theoretic approach to stable routing in max-min fair networks. IEEE/ACM Transactions on Networking (TON), 21(6), 1947-1959.

Yoo, Y. and Agrawal, D. P., 2006. Why does it pay to be selfish in a MANET?. Wireless Communications, IEEE, 13(6), 87-97.

Yuan, J., Li, Z., Yu, W. and Li, B., 2006. A cross-layer optimization framework for multihop multicast in wireless mesh networks. Selected Areas in Communications, IEEE Journal on, 24(11), 2092-2103.

Zhong, S., Li, L. E., Liu, Y. G. and Yang, Y. R., 2007. On designing incentive-compatible routing and forwarding protocols in wireless ad-hoc networks. Wireless networks, 13(6), 799-816.