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Enhanced Mutual Aid Packet Delivery in Wireless Infrastructureless Networks

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ABSTARCT

A coalitional game is developed to analyze the behavior of the rational mobile nodes for cooperative packet delivery. We consider the problem of cooperative packet delivery to mobile nodes in a hybrid wireless mobile network, where both infrastructure-based and infrastructure-less communications are used. A group of mobile nodes makes a decision to join or to leave a coalition based on their individual payoffs . The individual payoff of each mobile node is a function of the average delivery delay for packets transmitted to the mobile node from a base station and the cost incurred by this mobile node for relaying packets to other mobile nodes. We propose a solution based on a coalition formation among mobile nodes to cooperatively deliver packets among these mobile nodes in the same coalition. To find the payoff of each mobile node, a Markov chain model is formulated and the expected cost and packet delivery delay are obtained when the mobile node is in a coalition. Since both the expected cost and packet delivery delay depend on the probability that each mobile node will help other mobile nodes in the same coalition to forward packets to the destination mobile node in the same coalition, a bargaining game is used to find the optimal helping probabilities. After the payoff of each mobile node is obtained, we find the solutions of the coalitional game which are the stable coalitions. A distributed algorithm is presented to obtain the stable coalitions and a Markov-chainbased analysis is used to evaluate the stable coalitional structures obtained from the distributed algorithm. Performance evaluation results show that when the stable coalitions are formed, the mobile nodes achieve a nonzero payoff . With a coalition formation, the mobile nodes achieve higher payoff than that when each mobile node acts alone.

Key Words : Hybrid wireless network, social network analysis, cooperative packet delivery, coalitional game, bargaining game, carry-and-forward based data delivery

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INTRODUCTION

Wireless communications and networking technology's the key to supporting a variety of applications such as the safety and emergency notification and infotainment applications when the users are mobile (e.g., in vehicles) [1]. For such applications, which are provided through public wireless networks (e.g., IEEE 802.11-based WiFi networks), base stations (BS)/access points (AP) sporadically deployed across the roads act as the gateways between mobile nodes and other terrestrial networks (e.g., Internet) for data communication. For time-sensitive applications, a mobile node may be able to receive information in a timely manner only if it is within the transmission range of a BS and connected to the BS for a sufficient amount of time. However, if amobile node moves out of the transmission range of a BS (e.g., due to high mobility), data can be forwarded to this node by other nodes carrying data from that BS and meeting this destination mobile node (Fig. 1). Also, when the wireless link condition between the BS and a mobile node is poor (e.g., the mobile node is inside a tunnel), carry-and-forward-based cooperative data delivery will be useful to reduce the delay of data delivery. A mobile node, which is currently connected to a BS, can help the BS to forward packets to other mobile nodes until the packets reach their destinations. This is an example of hybrid wireless networking model because it uses communications among mobile nodes and BSs as well as communications among mobile nodes. A few works in the literature proposed communication models for wireless networks with relay-based schemes [2], [3], [4] to reduce the delay of data delivery. In these schemes, mobile nodes in a group (i.e., cluster) cooperatively deliver data packets among each other. However, the key assumption here is that the mobile nodes in the same group always help each other for data delivery. Since a trade off exists between performance improvement (i.e., smaller packet delivery delay) and transmission cost (i.e., bandwidth and energy-consumption) for such cooperative data delivery, this assumption may not be always true. For example, when a mobile node has limited transmission bandwidth and is of self-interest, it may not join a group for cooperative data delivery. In this context, the theory of coalitional game [5] can be applied to analyze the dynamics of coalition (or group) formation among mobile nodes. Coalitional games have been used to model and analyze the resource allocation problem in wireless networks. In [6], mobile nodes (e.g., vehicular users) form coalitions and cooperatively share the limited bandwidth of vehicle-to-roadside links to achieve high spectrum utilization. In [7], roadside BSs form coalitions in which the BSs in the same coalition cooperatively coordinate the classes of data that they transmit to mobile nodes, and thereby, improve their revenue.

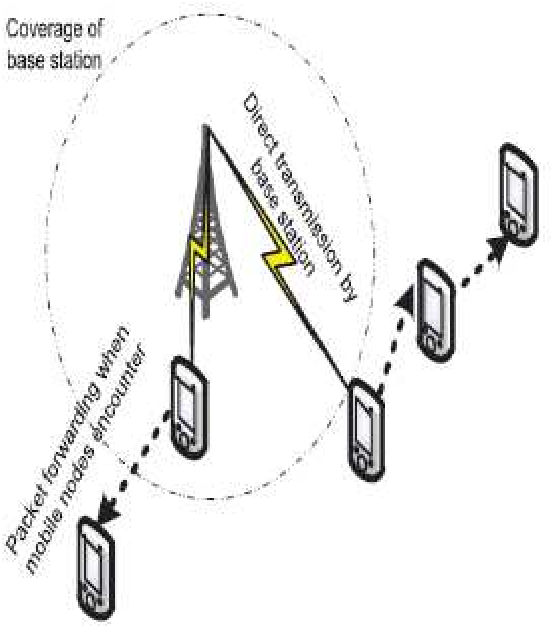

Fig. 1. In a hybrid wireless network, the mobile nodes can form coalitions to help forward data from a base station to other mobile nodes which are out of the transmission range of the base station.

Different from the above works, in this study, we present a cooperative packet delivery scheme in ahybrid wireless networking scenario. In the scenario under consideration, a base station has packets to transmit to a mobile node which may not be in the transmission range of the BS. To reduce the delay of packet delivery, coalitions of mobile nodes can be formed. The social relationship among the mobile nodes can be exploited to reduce the complexity of coalition formation. Mobile nodes in the same coalition help each other to deliver packets sent from the BS to the destination mobile nodes. Based on a coalitional game model, we study the dynamics of the behavior of mobile nodes helping each other to forward data packets based on their individual selfishness with an objective to maximizing their individual payoffs. The proposed scheme consists of three interrelated steps as shown in Fig. 2. We first use a social network analysis (SNA)-based approach [8], [9], [10] to identify which mobile nodes have the potential to help other mobile nodes for data delivery in the same group or coalition. After the SNA based mobile node grouping is done, the mobile nodes in each group play a coalitional game to obtain a stable coalitional structure. The payoff of each mobile node is a function of cost incurred by the mobile node in relaying packets and the delivery delay for packets transmitted to this mobile node from a BS. A continuous-time Markov chain (CTMC) model is formulated to obtain the expected cost and packet delivery delay for each mobile node in the same coalition. Since the expected cost and packet delivery delay vary with the probability that each mobile node helps other mobile nodes deliver packets, a bargaining game [7], [10] is used to find the optimal helping probabilities for all the mobile nodes in a coalition. For each mobile node, after the optimal probability of helping other mobile nodes is obtained, we can determine the payoff of each mobile node when it is a member of its current coalition. The payoffs obtained from the bargaining game are used to determine the solution of the coalitional game in terms of stable coalitional structure (i.e., a group of stable coalitions). A distributed algorithm is used to obtain the solution of the coalitional game and a Markov chainbased analysis is presented to evaluate the stable coalitional structures obtained from the distributed algorithm.

The major contributions of the paper can be summarized as follows:

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- We introduce a coalitional game formulation to study how mobile nodes can dynamically form coalitions to cooperatively forward data of other mobile nodes in the same coalition. We apply social network analysis to reduce thecomputational complexity of coalition formation. Two solution concepts, i.e., stable coalitional structure and core, are considered for the proposed coalitional game.
- We propose a Nash bargaining game formulation to obtain Pareto-optimal solution for the probabilities that mobile nodes will help other mobiles in the same coalition.
- A distributed coalition formation algorithm is proposed which guarantees that stable coalitional structures can be obtained. We perform a comprehensive performance evaluation of the proposed method.

MATERIALS AND METHODS

SYSTEM MODEL AND ASSUMPTIONS

A. *Models for Mobile Node Encounter, Node Mobility, and Cooperative Packet Transmission*

Mobile nodes using SNA based approach. To identify which mobile nodes have the potential to help other mobile nodes for data delivery in the same group or coalition. There is a coordinator at the application server which collects mobility information of the nodes. To model this tradeoff in the coalition formation among mobile nodes for cooperative packet delivery, a coalitional game-theoretic approach is applied. We assume that the packets are not immediately discarded from the cache of the BSs or the mobile nodes after they are sent or forwarded. In addition, there is a coordinator at the application server which collects mobility information of the nodes by using the following procedure:

- When the mobile nodes encounter each other, they make a record of the time they encounter.
- Given a certain time period (e.g., 1 hour), the mobile nodes calculate the encounter rate with other nodes by dividing the number of encounters by the length of the time period.
- The mobile nodes provide the encounter rate information to the central coordinator at the application server periodically.
- The coordinator maintains a database of the encounter rate information for all the mobile nodes in the network, and this database is used for social network analysis (SNA).

COALITIONAL FORMATION STRUCTURE

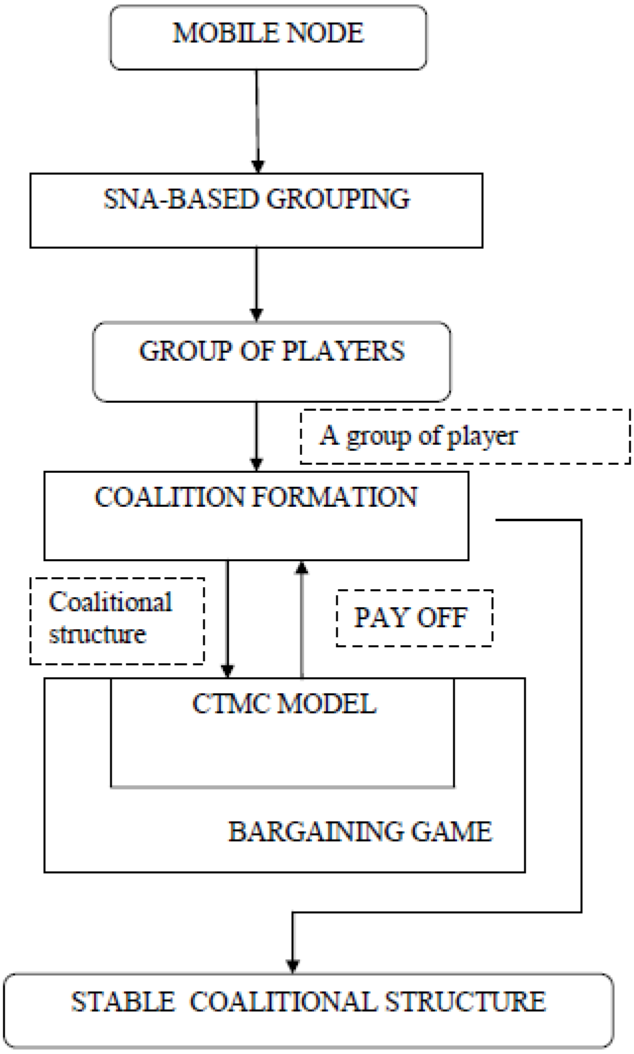

Fig. 2. Interrelationship among the three steps, namely, mobile node grouping using social network analysis (SNA), bargaining game, and coalitional game.

SNA-BASED MOBILE NODE GROUPING

The main problem of coalition formation is that the computational complexity increases exponentially when the number of nodes increases [5], [8]. Hence, the main objective of the proposed SNA based mobile node grouping is to reduce the complexity of coalition formation when there are many mobile nodes participating in the cooperative data delivery scheme. The key mechanism of the SNA-based mobile node grouping is to filter out some mobile nodes which will not contribute to the cooperative packet delivery(i.e., to divide the mobile nodes into multiple social groups in which mobile nodes in a social group do not cooperate with the mobile nodes in another social group) A social network or a group is composed of nodes and ties. In this model, each mobile node is a node and relationships of mobile nodes are ties. Whether or not a tie will be established between two nodes can be determined by using centrality metrics used in graph theory and network analysis. Centrality is a quantification of the relative importance of a vertex within the graph (e.g., how important a node is within a social network). We identify how each node is important to others based on the Poisson modelling of the network which is called Poisson process based centrality. To identify groups of mobile nodes using their Poisson process-based centrality, we propose an algorithm which ensures that for each mobile node in the same group, the probability that the packet delivery delay remains below a required time interval, can be maintained above a target threshold.

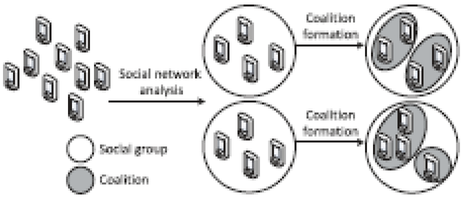

Fig. 3.The relation between social groups and coalitions. There can be multiple coalitions within a social group.

SNA BASED ALGORITHM:-

Identifies the groups of mobile nodes. The nodes in such a group are the players in the bargaining game and the coalitional game. In this algorithm, IM denotes the set of all mobile nodes and Qi is a vector denoting the relationship of mobile node i with other mobile nodes.

Algorithm - SNA-based mobile node grouping algorithm.
1: Exchange profile information (i.e., encounter information) among mobile nodes. Set K =θ . // a temporary variable
2: Initialize sets of relationships for all mobile nodes, i.e.,$Q\ IM\ i\ i = \theta$,$\forall \in$3: for each mobile node i $\in IM = \{1,....., M\}$
4: $K = K \cup \{i\}$
5: for each mobile node $j \in IM \setminus K$
6: if $ij\ j\ ji\ i\ i\ (P\ (T + T < T\ ) \geq \omega$ 0 and
$ji\ i\ ji\ j\ j\ P\ (T + T < T\ ) \geq \omega$ 0 and) $ij\ th\ n > n$
7: Add mobile node j to mobile node i’s set of relationships and vice versa
8: $Q\ Q\ \{(i, j)\}\ i\ i = \cup$

```
        $Q Q \{( j, i)\} j j = \cup$
      end
    end
  end
Use the sets of relationships Qi of all the mobile nodes to build a graph $G(W,\varepsilon)$
Set the vertices of the graph $W = IM$(i.e., vertices are the mobile nodes)
Set the edges of the graph $i M i Q =1 \varepsilon = \cup$ (i.e., edges are the mobile nodes' relationships)
Identify each group k of mobile nodes, $IN W k \subseteq$ where $IN IM k k \cup =$ , which is a maximal complete clique or subgraph in the graph $G(W,\varepsilon)$ obtained by using algorithms.
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MARKOV CHAIN MODEL FOR COOPERATIVE PACKET DELIVERY

Continuous-time Markov chain to find the expected cost and delay of each mobile node in the same coalition. The expected cost and delay depend on the probabilities that the mobile nodes will help each other to deliver data.

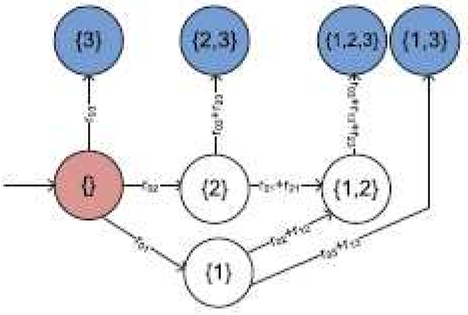


Fig. 4. The CTMC model for cooperative packet

delivery from the BS to a destination mobile node. In this scenario, there are three mobile nodes in the same coalition. Mobile nodes 1 and 2 help the BS to deliver a packet to mobile node 3. CTMC model of a packet delivery scenario when there are three mobile nodes inthe same coalition. Mobile nodes 1 and 2 help the BS to deliver the packet to mobile node 3. Given the state transition rate of the CTMC model, the corresponding discrete-time Markov chain (DTMC) also called the embedded Markov chain.

NASH BARGAINING GAME MODEL

A Nash bargaining game is used to model the interaction among a group of mobile nodes in cooperative delivery of packets. The players of this bargaining game are the mobile nodes in the same coalition. The set of mobile nodes is denoted by IN = {1,...., *N*} and a coalition of players (i.e., mobile nodes) is denoted by S $\subseteq$ IN. The action set of each player is Pi =[0,1]The strategy of each player is to choose the optimal probability, pi $\in$ Pi, that the mobile node will help other mobile nodes in the same coalition to deliver packets. The payoff of each player is a function of expected cost that the player will incur for other players and the packet delivery delay for its own packet, delivery of which is helped by other players. Any mobile node i can achieve a lower packet delivery delay due to the help from other mobile nodes in the same coalition S. However, an additional cost is incurred to mobile node i due to the packet delivery to other mobile nodes in the same coalition. The total cost of mobile node i for packet delivery to any mobile node j in the same coalition can be expressed as follows

$$C_i(S) = \sum_{j\varepsilon S, j\neq i} c_{ij}(S), |s| > 1$$

Where *C* (*S*) *i* is the expected cost that incurs to mobile node i for delivering the packet of mobile node j in the same coalition S as defined in. jSj is the number of mobile nodes in coalition S. The utility of mobile node i is defined as a function of R(S) as follows:

$$R_i(S) = \begin{cases} 1 - \dfrac{d_i(S)}{d_i}, |S| > 1 \\ 0, otherwise \end{cases}$$

Where *d* (*S*) *i* is the packet delivery delay for mobile node i ε S, and is the packet delivery delay for mobile node i without any coalition (i.e., mobile node i acts alone). The objective of each mobile node is to maximize its payoff. The payoff of mobile node i in the coalition S can be defined as follows:

u (*S*) *R* (*S*) *C* (*S*) *i i i i i* =α – β

where _i and _i denote, respectively, the positive weight constants of the utility and the cost of deliveringa packet to other mobile nodes in the same coalition. The solution of the bargaining game is presented in the next section.

Nash Bargaining Solution

Nash axioms specify the conditions for reaching Pareto optimal Nash bargaining solutions. The payoff of each mobile node depends on the probabilities of the mobile nodes to help other mobile nodes in the same coalition. As a result, for each mobile node, using the bargaining game we find the probability that it will help other mobile nodes in the same coalition deliver a packet transmitted from a BS. Let ~p ¼ ½. . . ; pi; . . ._; 8i 2 S be the vector of the probabilities that the mobile nodes help each other in the same coalition. To find a solution of the Nash bargaining game, all mobile nodes in coalition S exchange their payoff functions. We assume that the mobile nodes which are members of the same coalition can exchange their information (e.g., payoff function and active status) with the help of the base stations and the coordinator. After a mobile node obtains all other mobile nodes' payoffs, it solves the following optimization problem to obtain the probability of helping other mobile nodes:

$$\overrightarrow{P} = \arg\max \prod_{i\varepsilon S} (u_i(S, \overrightarrow{P}) - u_i^d(\{i\}))$$

$$p_i \in P_i = [0,1], \forall_i \in S$$

Subject to

$$u_i(s) \geq 0, and u_i(s) \geq u_i^d(\{i\}),$$

where *u* (*S*) *i* is defined and can be calculated as the status-quo payoff (i.e., the payoff obtained if mobile node i decides not to bargain with other mobile nodes or when the mobile node acts alone). According to and Each mobile node varies the probability from zero to one and selects the value which maximizes the Nash product term of all the payoffs. The optimal solution can be obtained by a search method. The simplex method can be used to optimize the objective function defined .

FORMULATION OF COALITIONAL GAME FOR COOPERATIVE PACKET DELIVERY

At time, any mobile node in a coalition can decide to leave its current coalition and join a new coalition. For a mobile node, we present a distributed algorithm based on the merge-and-split mechanism to find a stable coalitional structure. It is known that any algorithm constructed based on the merge-and-split rules

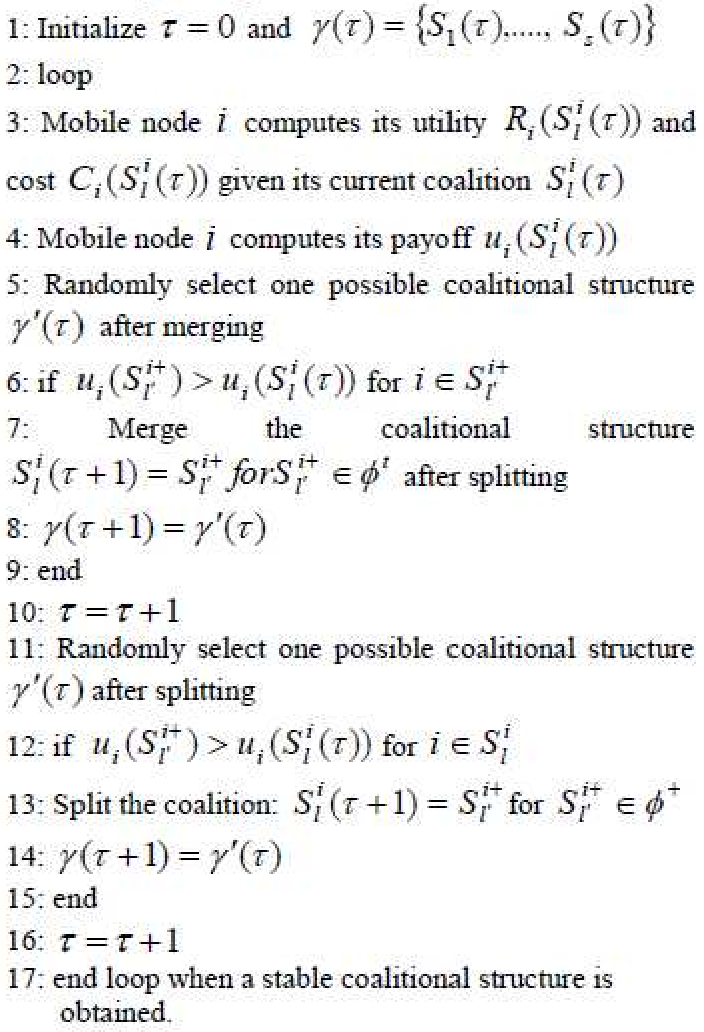
- Merge rule. Given original coalitions $\in \phi$ *i l S* the coalitions can be merged to a new single coalition if all players in all of the original coalitions obtain higher payoffs after merging, i.e.,

$$u_i(S_{l'}^{i+}) > u_i(S_l^i), \forall_i \in S_{l'}^{i+}, where S_{l'}^{i+} = \bigcup_l^i$$

- Split rule. The players in coalition can split into multiple new coalitions if the payoffs of all the players are higher than those in the same original coalition, i.e.,

$$u_i(S_{l'}^{i+}) > u_i(S_l^i), \forall i \in S_l^i$$

D1.Distributed coalition formation algorithm based on merge-and-split mechanism



```
Initialize $\tau = 0$ and $\gamma(\tau) = \{S_1(\tau),....., S_s(\tau)\}$
loop
    Mobile node $i$ computes its utility $R_i(S_l^i(\tau))$ and cost $C_i(S_l^i(\tau))$ given its current coalition $S_l^i(\tau)$
    Mobile node $i$ computes its payoff $u_i(S_l^i(\tau))$
    Randomly select one possible coalitional structure $\gamma'(\tau)$ after merging
    if $u_i(S_{l'}^{i+}) > u_i(S_l^i(\tau))$ for $i \in S_{l'}^{i+}$
        Merge the coalitional structure $S_l^i(\tau+1) = S_{l'}^{i+} for S_{l'}^{i+} \in \phi^t$ after splitting
        $\gamma(\tau+1) = \gamma'(\tau)$
    end
    $\tau = \tau + 1$
    Randomly select one possible coalitional structure $\gamma'(\tau)$ after splitting
    if $u_i(S_{l'}^{i+}) > u_i(S_l^i(\tau))$ for $i \in S_l^i$
        Split the coalition: $S_l^i(\tau+1) = S_{l'}^{i+}$ for $S_{l'}^{i+} \in \phi^+$
        $\gamma(\tau+1) = \gamma'(\tau)$
    end
    $\tau = \tau + 1$
end loop when a stable coalitional structure is obtained.
```

CONCLUSION

The mobile nodes are rational to form coalitions to maximize their individual payoffs. First, a continuous-time Markov chain model has beendeveloped to obtain the packet delivery delay and theexpected cost of mobile nodes for cooperative packet delivery. The packet delivery delay and the expected cost depend on the probability that each mobile node will help other mobile nodes in the same coalition. A bargaining game has been formulated to find the optimal helping probabilities for all the mobile nodes. To present a coalitional game framework for carry-and forward- based cooperative packet delivery to mobile nodes in a hybrid wireless network.

REFERENCES

[1] H.J. Reumerman, M. Roggero, and M. Ruffini, “The Application- Based Clustering Concept and Requirements for Inter-Vehicle Networks,” IEEE Comm. Magazine, vol. 43, no. 4, pp. 108-113, Apr. **2005**.

[2] T. Yamada, R. Shinkuma, and T. Takahashi, “Connectivity and Throughput Enhancement by Inter- Vehicle Packet Relay in Road Vehicle Comm. Systems,” Proc. IEEE Global Telecomm. Conf., pp. 1- 5, Nov./Dec. **2006**.

[3] Y. Yamao and K. Minato, “Vehicle-Roadside-Vehicle Relay Communication Network Employing Multiple Frequencies and Routing Function,” Proc. Sixth Int’l Symp .Wireless Comm. Systems, pp. 413-F417, Sept. **2009**.

[4] H. Su and X. Zhang, “Clustering-Based Multichannel MAC Protocols for QoS Provisionings over Vehicular Ad Hoc Networks,” IEEE Trans. Vehicular Technology, vol. 56, no. 6, pp. 3309-3323, Nov. **2007**.

[5] W. Saad, Z. Han, M. Debbah, A. Hjørungnes, and T. Basar, “Coalitional Game Theory for Communication Networks: A Tutorial,” IEEE Signal Processing Magazine, vol. 26, no. 5, pp. 77-97, Sept. **2009**.

[6] D. Niyato, P. Wang, W. Saad, and A. Hjørungnes, “Coalition Formation Games for Bandwidth Sharing in Vehicle-to-Roadside Communications,” Proc. IEEE Wireless Comm. and Networking Conf. (WCNC), pp. 1-5, Apr. **2010**.

[7] W. Saad, Z. Han, A. Hjørungnes, D. Niyato, and E. Hossain, “Coalition Formation Games for Distributed Cooperation Among Roadside Units in Vehicular Networks,” IEEE J. Selected Areas in Comm., vol. 29, no. 1, pp. 48-60, Jan. **2011**.

[8] W. Gao, Q. Li, B. Zhao, and G. Cao, “Multicasting in Delay Tolerant Networks: A Social Network Perspective,” Proc. ACM MobiHoc, pp. 299-308, May **2009**.

[9] E. Daly and M. Haahr, “Social Network Analysis for Routing in Disconnected Delay-Tolerant ANETs,” Proc. ACM MobiHoc, pp. 32-40, Sept. **2007**.

[10] S. Pai, T. Roosta, S. Wicker, and S. Sastry, “Using Social Network Theory Towards Development of Wireless Ad Hoc Network Trust,” Proc. 21st Int’l Conf. Advanced Information Networking and Applications Workshops, pp. 443-450, May **2007**.