Game Approach for Handover Scheme Based on Road-section in VANET

Di Wu[1], Yingrong Bi[1]
[1]School of Computer Science and Technology /Dalian University of Technology, Dalian, China
Email:{wudi23893, yrbi1850}@sina.com

Jie Liang[1, 2]
[2]School of Engineering Science/Simon Fraser University, Burnaby, BC, Canada
Email:jiel@sfu.ca

***Abstract*—In VANET (Vehicular Ad Hoc Network), vehicles moving from one RSU's coverage region to another will cause access congestion problem if vehicles use improper handover scheme. In this paper, we present a novel mobility handover scheme for vehicles with seamless Internet access in urban VANET scenario, which is called Game approach for Handover Scheme based on Road-section (GHSR). The main advantages of our scheme are that it uses Sequential Game and it based on 802.11p standard proceeding from service and the vehicles needing to handover will game each other to gain no smaller payoff by selecting an appropriate road-section. Performance evaluations demonstrate that our scheme outperforms the threshold scheme significantly in terms of both the traffic load of RSUs and the QoS (Quality of Service) of vehicles users, and QoS of vehicle users increase by up to 33.68%.**

***Index Terms*—Urban VANET; Sequential Game; Handover**

I. Introduction

VANET is a special Mobile Ad Hoc Networks (MANET), which consists of the Infrastructures (Road Side Units, RSUs) and vehicles equipped with Onboard Units (OBUs) that provide the basic wireless communication capability. VANET is characterized by high speed mobile users and frequent network topology change. In recent years, with the deployment of RSUs, many researchers consider using 802.11p standard to realize the interaction between vehicles and Internet by accessing to RSUs, whose feasibility is confirmed [1]. In VANET, based on some communications protocols specially designed for VANET, such as [2], the communication usually occurs among Vehicles (Vehicle-to-Vehicle, V2V), or between Vehicle and Infrastructure (Vehicle-to-RSU, V2R) [3]. When services are being provided by RSUs, seamless handover is desired for continuous connectivity to provide uninterrupted service when the vehicle moves from one RSU's region to another, as seen in Fig. 1.

Under the IEEE802.11p, the handover progress removes the identification and interaction of wireless networks, such as Wi-Fi and so on, since IEEE802.11p is a protocol for VANETs that is designed for communication during high-speed mobility (up to 200 km/h) among vehicles or between vehicles and RSUs with a range of up to 1,000m [18]. In addition, few vehicles can provide or share their own service to others, in VANET. Therefore, in order to guarantee vehicles to

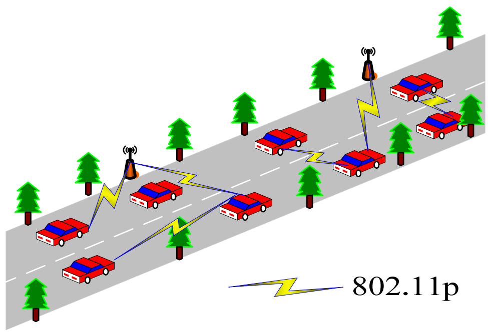


Figure 1. Service architecture in VANET

keep downloading real-time service during driving in the dense scenario (the hotspot in urban such as crossings, supermarkets and petrol service station), RSUs should be deployed densely to provide continuous connectivity and optimal coverage [4] [5]. As well, in order to prevent the interference of the two RSUs, we define that vehicles have two interfaces to receive beaconing from two RSUs respectively, but vehicles can only get service from one RSU. Therefore, we study the scenario with overlapping area of two RSUs. In recent years, as most applications of the IEEE 802.11p standard mainly consider the delivery of short text messages, it does not study handover between adjacent RSUs [6]. However, when a lot of vehicles disconnect from RSU1 to RSU2 at the same time, this circumstance will lead to congestion and the following problems:

1) Vehicles handover at the same time will lead to network congestion, increase the block probability and the handover delay, and decrease the QoS of users;
2) Most vehicles access to RSU2 at the same time, which gives rise to RSU load imbalance—over-load of RSU2 and wasted capacity of RSU1, which will hurt the network performance in terms

doi:10.4304/jcp.9.11.2621-2628

of service quality and the utilization of network resource.

Game theory provides a mathematical modeling for the study of competition strategies in a game where players have conflicting benefits and consider the strategy of rivals to make its own strategy [7]. By the reason of non-cooperation of vehicles, each vehicle competes with others to get better QoS, which conforms to the game theory research framework. In recent years, the game theory is applied to study wireless networks and VANET perfectly, such as imbalance problem of RSU's traffic load [8], resource distribution [9], selfish behaviors [10] and router [11] and so on. Hence, in this paper, we use game theory to solve the handover problem between RSUs. In addition, during the game, the decisions that players make are sequential. For these reasons, we employ the sequential game [12] [13] approach with the advantage of first action for handover scheme based on road-section to solve the handover congestion problem.

In summary, the main problem studied in this paper is the handover congestion and its aftermaths (imbalance traffic load of RSUs and inferior QoS of vehicles users) when many vehicles come from one RSU to another in the hotspot of urban VANET. We mainly consider the factors of velocity of vehicles, distance and link quality between vehicle and RSU, traffic load, channel capacity and bandwidth of RSUs, channel capacity can help the vehicle to decide to handover in the proper road section. The method of our paper is modified sequential game. All the participants can design a corresponding payoff function under the special conditions. Under the game, all factors balancing mutually make payoff function to achieve a balance of value, namely vehicle handover time. We aim to remit the imbalance of RSUs and guarantee QoS of vehicle users.

The rest of the paper is organized as follows. Related work is reviewed in Section II. Section III presents the system models. Section IV studies the simulation and analysis. We conclude our paper and discuss future work in Section V.

II. Related Work

In many existing work, the AP (Access Point) or RSU handover mainly include four processes: scanning, synchronization, ranging and certification in cellular network, WLAN and VANET. Among them, the scanning has the longest delay [14]. To reduce the handover delay, many existing handover schemes get the channel information of AP in advance according to the oncoming vehicle. When the vehicles move into another AP's coverage, they will directly access to another AP to reduce the scanning delay according to these predefined channel information. In [15], a VFHS mechanism is proposed, which use the AP physical and MAC layer information from the oncoming vehicle to reduce the handover delay. In [16], it is pointed out that when vehicles travel from coverage of RSUm to another RSUn, they need to re-secure the authentication. RSUm transmits the vehicles' authentication messages to RSUn in advance to shorten the time for authentication as well as handover delay. Group handover in the multi-access network (many vehicles handover to the same RSU at the same time) was studied in [17]. To resolve the possible problem of congestion, a group handover mechanism was proposed in it to prevent a large number of vehicles from switching simultaneously. Instead, the switch will use AP's remaining resources in each participating group to optimize handover time.

All aforementioned methods are based on IEEE802.11 a/b/g protocols to minimize scanning and authentication delay and to ensure fast handover. However, IEEE 802.11p does not have authentication and association processes, so that it can reduce the channel scan time. Therefore, the previous methods to ensure fast handover by reducing scan delay is no longer suitable for 802.11p-based VANET. Especially, when there are many vehicles need to handover at the same time, traditional 802.11 handover mode cannot realize seamless handover because of the complexity of the handover process. Therefore, in this paper we propose an effective handover scheme to solve the problem of the large number of vehicle handovers.

III. System Models

A . Scene Model

The demand for seamless real-time QoS on the driving way gives rise to the need of handover in the IEEE 802.11p-based VANET. Since a fast moving vehicle can run across two adjacent RSUs, as shown in Fig. 2, which is a straight road with unidirectional traffic that is typical in urban VANET. Obviously, whether handover can be handled properly or not will affect the QoS of vehicle users directly. If the handover delay is not short enough, some real-time services of vehicle users will be affected or even interrupted. Therefore, in this paper, we start from the congestion problem caused by multiple vehicle

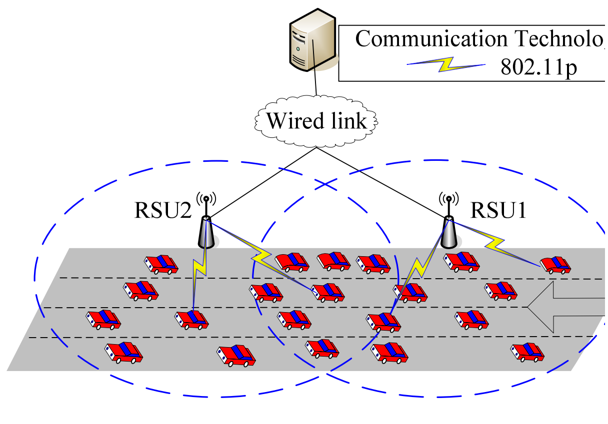


Figure 2. Handover scene in VANET

handovers and propose a scheme to guarantee the QoS of users and to balance the traffic load of the two RSUs to improve the VANET performance.

In order to simplify the problem, our system model has the following assumptions:

(1) There are no traffic accidents and other fault that influence the normal driving action;
(2) Vehicles access to only one RSU to get service at the same time;
(3) RSUs have the same transmission range and the capacity is sufficient;
(4) Vehicles are not allowed to stop.

B. Scene Geometric Model

RSU's coverage range is R 1000 m according to 802.11p protocol [18]. The distance between two RSUs is 1000 m to guarantee the QoS of users. When vehicles enter the coverage of RSUs, they can generate requests and receive responses.

The scene geometric model is shown in Fig. 3. Vehicles are travelling from right to left in four lanes. We assume the width of lane is r, so $|o,r1|$ $|o,r2|$ $2r$. Similarity, $|o,R1|$ $|o,R2|$ $R/2$, $|r1,R2|$ $|r1,R1$ $r^2R^2/4$. The distance between $b1$ and $R2$ as well $b1$ and $R1$ are the transmission range of RSUs, i.e., $o,b1$ $o,b2$ $R^2R^2/4$ R. From the figure we can see, $|R2,a2|$ R and $|a2,a|$ $2r$, so that $|R2,a|$ $(R^2 4r^2)^{1/2}$; As $|R2,a|$ $|o,R2||r1,a2|$, $|r1,a2|$ $(R^2 4r^2)^{1/2}R/2$. Therefore, the distance of overlap area between two adjacent RSUs is $|a1,a2|$ $2|r1,a2|$ $2*(R^2 4r^2)^{1/2}R$. In this paper, we only consider the vehicles in the overlapping area.

C. Game Model

Sequential game is a kind of dynamic game to analyze

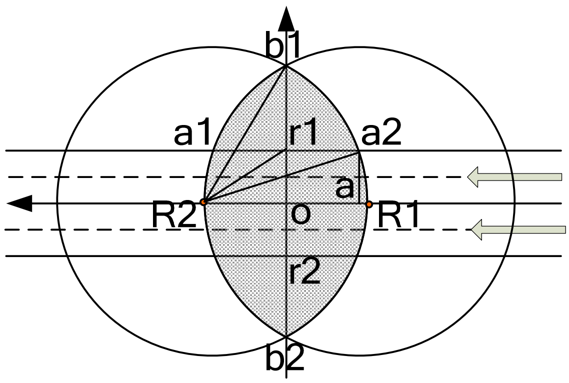


Figure 3. Handover geometric model

the strategy with order and repetition. Players decide the current action choice or strategy selection according to the balance of future outcome of themselves. In this paper, we only study soft handover (SHF), i.e. we use the game method to study the handover process according to some factors. We assume the number of vehicles in their non-overlapping area of RSUs is same, that is, the vehicles in area ı are as many as vehicles in area in Fig. 4.

In this paper, our study objects are the handover vehicles in area and they are the players of game. Vehicles drive into area and at the same road-section will start to game each others. Vehicles during the driving may get periodical advertisements from a connected RSU and can use the Received Signal Strength Indicator (RSSI) to determine the link quality between vehicles and the connected RSU [19]. When a vehicle detects that it is leaving from RSU1, it will access to RSU2 actively to guarantee its QoS. If all the handover vehicles access to RSU2 at the same road section, the traffic load of RSU1 will fall suddenly and the traffic

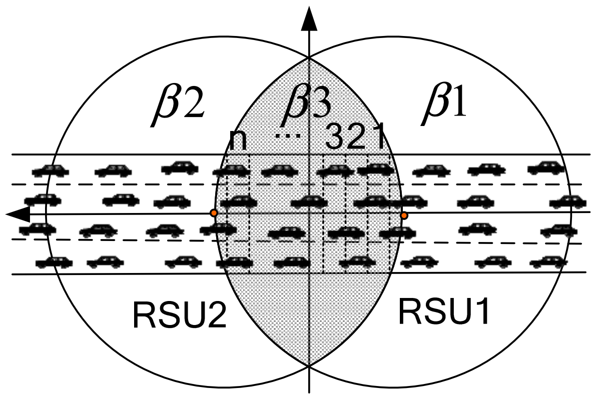


Figure 4. Handover game model

load of RSU2 will increase sharply. Therefore even though the vehicles can access to RSU2 successfully they will not get better QoS.

To form a game-theoretic framework, we define a game model G, G=<I, S_i, U>, where I={Veh_1, Veh_2, Veh_3,…} is the set of players, i. e., the vehicles in area that have no access to RSU2; S_i={S_{i,R_1}, S_{i,R_2}, S_{i,R_3}, … S_{i,R_j},…}, $i\in$. S_{i,R_j} is the strategy set of player i in the road-section R_j, that is the selection sequence of Veh_i. Here, the strategy of Veh_i in the road-section R_j is defined as follows:

$$S_{i,R_j} = \begin{cases} 0, & Veh_i \text{ accesses to } RSU1 \text{ in the road section } R_j \\ 1, & Veh_i \text{ accesses to } RSU2 \text{ in the road section } R_j \end{cases}$$

(1)

In the process, once S_{i,R_j} 1, vehicle i will access to RSU2 successfully and will stop to game with others. U {$A_{i,m}$* $\sum_{m=1}^{2} u_{i,m}(R_j)$| $i\in I$, $m\in\{1,2\}$} is the utility function of Veh_i in the road-section R_j; $A_{i,m}$ is binary number; If Veh_i accesses to RSU_m, $A_{i,m}$ 1, otherwise $A_{i,m}$ 0. In this paper, we suppose vehicles in the RSUs coverage must access to one RSU, i.e. $\sum_{m=1}^{2} A_{i,m}$ 1.

Therefore, the utility functions of Veh_i in road-section R_j accessing to RSU1 and RSU2, respectively, are given by:

$$u_{i,1}(R_j, S_{i,R_j}) = \begin{cases} 0, & S_{i,R_j} = 1 \\ \dfrac{1}{N_1} * W \log\left(1 + \dfrac{S/N}{(d_{i,1}(R_j))^r}\right) * \dfrac{d_{i,2}(R_j)}{\alpha * V_i}, & \\ & S_{i,R_j} = 0, j \ge 1, i \in [1,n] \end{cases} \quad (2)$$

$$u_{i,2}(R_j,S_{i,R_j})=\begin{cases}0, & S_{i,R_j}=0\\ \frac{1}{N_2}*W\log(1+\frac{S/N}{(d_i^2(R_j))^r})*\frac{d_{i,1}(R_j)}{\beta*V_i}, & S_{i,R_j}=1, j\geq 1, i\in[1,n]\end{cases} \quad (3)$$

where, the channel capacity of Veh_i in road-section R_j under the coverage of RSU_m is:

$$W_{i,m}(R_j)=\frac{1}{TL_m(R_j)}*W\log 2(1+\frac{S/N}{(d_{i,m}(R_j))^r}), \quad j\geq 0,\ m\in\{1,2\} \quad (4)$$

W is channel bandwidth; S/N is SNR (Signal to Noise Ratio); $d_{i,m}(R_j)$ the distance between Veh_i and RSU_m in the road-section R_j; γ is path loss exponent [18] and $TL_m(R_j)$ is the traffic load of RSU_m, defined as, in the start stage, when j=0,

$$TL_1(R_j)=N_{R_j}-b*\sum_{i=1}^{n}d_{i,1}(R_j)*1/W_{i,1}(R_j)+d*\sum_{i=1}^{n}d_{i,2}(R_j)*1/W_{i,2}(R_j) \quad (5)$$

$$TL_2(R_j)=N_{R_j}-b*\sum_{i=1}^{n_2}d_{i,2}(R_j)*1/W_{i,2}(R_j)+d*\sum_{i=1}^{n_2}d_{i,1}(R_j)*1/W_{i,1}(R_j) \quad (6)$$

When j>=1,

$$TL_1(R_j)=N_{R_j}-b*\sum_{i=1}^{n_1}d_{i,1}(R_j)*1/W_{i,1}(R_j)*\frac{TL_{1,R_{j-1}}}{TL_{1,R_{j-1}}+TL_{2,R_j-1}}+d*\sum_{i=1}^{n_1}d_{i,2}(R_j)*1/W_{i,2}(R_j)*\frac{TL_{2,R_{j-1}}}{TL_{1,R_{j-1}}+TL_{2,R_{j-1}}} \quad (7)$$

$$TL_2(R_j)=N_{R_j}-b*\sum_{i=1}^{n_2}d_{i,2}(R_j)*1/W_{i,2}(R_j)*\frac{TL_{2,R_{j-1}}}{TL_{1,R_{j-1}}+TL_{2,R_{j-1}}}+d*\sum_{i=1}^{n_2}d_{i,1}(R_j)*1/W_{i,1}(R_j)*\frac{TL_{1,R_{j-1}}}{TL_{1,R_{j-1}}+TL_{2,R_{j-1}}} \quad (8)$$

The function ω*log(1+$W_{i,2}(R_j)$) is similar to ω*log x_i in [20]. It can get a weighted proportional fair distribution of resources. This is a Lyapunov function, used to prove the stability of the equilibrium of ordinary differential equation. V_i is the speed of Veh_i; $d_{i,m}(R_j)/V_i$ is connect time and present the selection bias at the same time. The bigger $d_{i,2}(R_j)$ is, the more preferable $u_{i,1}(R_j, S_{i,R_j})$ is; As well, the faster V_i is, the earlier vehicle i can access to RSU2, so that α and β are velocity coefficients. This is also true for $u_{i,2}(R_j, S_{i,R_j})$. N_{R_j} is the number of vehicles in the overlapping area between two RSUs.

Our goal is to make the vehicle Veh_i gains the biggest payoff on the road R_j, that is:

$$\max u_i=\max\sum_{m=1}^{2}u_{i,m}(R_j,S_{i,R_j}) \quad (9)$$

$$s.t.\ \frac{N_m+1}{N_m}*W*\log(1+\frac{S/N}{(d_{i,m}(R_j))^r})\leq W, m\in\{1,2\}$$

$$\sum_{m=1}^{2}d_{i,m}(R_j)=500m,\ j\geq 1, \alpha\geq 1, \beta\in(0,1]$$

The game process of vehicle is described in Fig. 5.

Sequential game uses sequential rationality (sequential rationality) hypothesis, that is, no matter what happened in the past, participants should optimize their own decisions at each point in the game. In the limited Sequential game, the users adjust their own offer ceaselessly according to the result of the game in last time, as shown in figure 3, and it gradually forms a kind

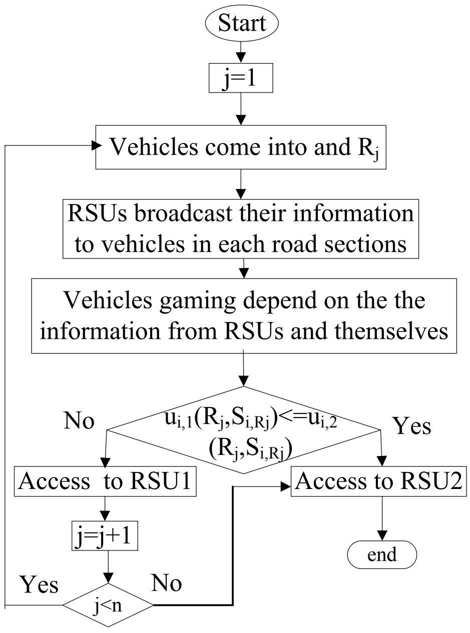


Figure 5. Game flow

of balanced situation and makes the resource load tend to a stable value in the end. Sequential game belongs to the dynamic game from the time point, from the perspective of the information, each game section uses the result of the last game as a condition. Therefore, different Nash equilibrium from the last time game was be become.

Theorem 1: the user in the each process of game, the Game Nash equilibrium is the one and only one .

Proof: in this paper, the principle of switching is ultimately comes down on the vehicle user's earnings. It is to say that the vehicles will choose the road section to access to the RSU which the vehicles users can gain the bigger payoff. That is, we need to prove :

$\Delta u=u_{i,1}(R_j,S_{i,R_j})-u_{i,2}(R_j,S_{i,R_j})$ is monotone decreasing, and has the one and only one value is 0.

First, when the vehicles entering RSU2 transmission range, that is, when $d_{i,1}\propto 0$,:

$$\Delta u=u_{i,1}(R_j,S_{i,R_j})-u_{i,2}(R_j,S_{i,R_j})\approx\frac{W*|R1,R2|}{\alpha*V_i*N_1}\succ 0 \quad (10)$$

Second, when the vehicle leaves away from RSU1, approaching RSU2, that is, when $d_{i,1} \propto |R1,R2|$:

$$\Delta u = u_{i,1}(R_j,S_{i,R_j}) - u_{i,2}(R_j,S_{i,R_j}) \approx -\frac{W*|R1,R2|}{\beta * V_i * N_2} \prec 0 \tag{11}$$

Next, we analyze the derivation of the formula:

$$\frac{du_{i,1}(R_j,S_{i,R_j})}{dR_j} \to \frac{du_{i,1}(R_j,S_{i,R_j})}{dd_{i,1}} = \frac{-W}{\alpha N_1 V_i} * [\frac{S/N*(|R1,R2|-d_{i,1})}{\gamma * d_{i,1}(d_{i,1}{}^{\gamma} + S/N)} + \log(1+\frac{S/N}{d_{i,1}{}^{\gamma}})] \prec 0 \tag{12}$$

and

$$\frac{du_{i,2}(R_j,S_{i,R_j})}{dR_j} \to \frac{du_{i,2}(R_j,S_{i,R_j})}{dd_{i,1}} = \frac{W}{\beta N_2 V_i} * [\frac{S/N * d_{i,1}}{\gamma * (|R1,R2|-d_{i,1})[(|R1,R2|-d_{i,1})^{\gamma} + S/N]} + \log(1+\frac{S/N}{(|R1,R2|-d_{i,1})^{\gamma}})] \succ 0 \tag{13}$$

Therefore,

$$\frac{d\Delta u}{dR_j} \to \frac{d\Delta u}{dd_{i,1}} = \frac{du_{i,1}(R_j,S_{i,R_j})}{dd_{i,1}} - \frac{du_{i,2}(R_j,S_{i,R_j})}{dd_{i,1}} \prec 0 \tag{14}$$

In conclusion, the user in the process of game, there is only one road section can be choose to switch, and avoid the "ping-pong effect".

IV. SIMULATION

In this section, we simulate and analyze the change of two RSUs' traffic load and the QoS of the vehicles users' in details. In addition, in order to show the advantage of our model and scheme, we evaluate the performance of our method by comparing with a threshold handover method [22]. In the threshold method, the handover of vehicles is only based on the channel congestion time according to the geometric model. We know that $|a1,a2|=2|r1,a2|=2(R^2-4r^2)^{1/2}-R\approx R$. The length of a typical car is 4 *m*. Therefore, we divide the road into 50 sections.

TABLE I
THE SIMULATION PARAMETERS

Parameter	Value
Lane width r	3.5m
Vehicle length c	4m
RSU's transmission range R	1000m [18]
SNR S/N	30
path loss exponent γ	3 [18]
Weight coefficient b	0.01
Weight coefficient d	0.0005
Bandwidth W of RSU	10 MHz [21]

A. The Effectiveness and the Correctness of Game Method

Fig. 6(a) and (b) describes the payoff and the corresponding strategy of a vehicle by accessing to the two RSUs with the same constant traffic load, RSSI and bandwidth, which means that when a vehicle accesses to the two RSUs, the best point for handover is $d_{i,1}(R_j)$=500*m*. That is, the vehicle will choose the middle point between the two RSUs to handover. The corresponding strategy is concurrent, which indicates the correctness of our method. The effectiveness of our game method is proved in Fig. 6(c), because when the traffic load of RSU1 increase, the vehicles game with each other

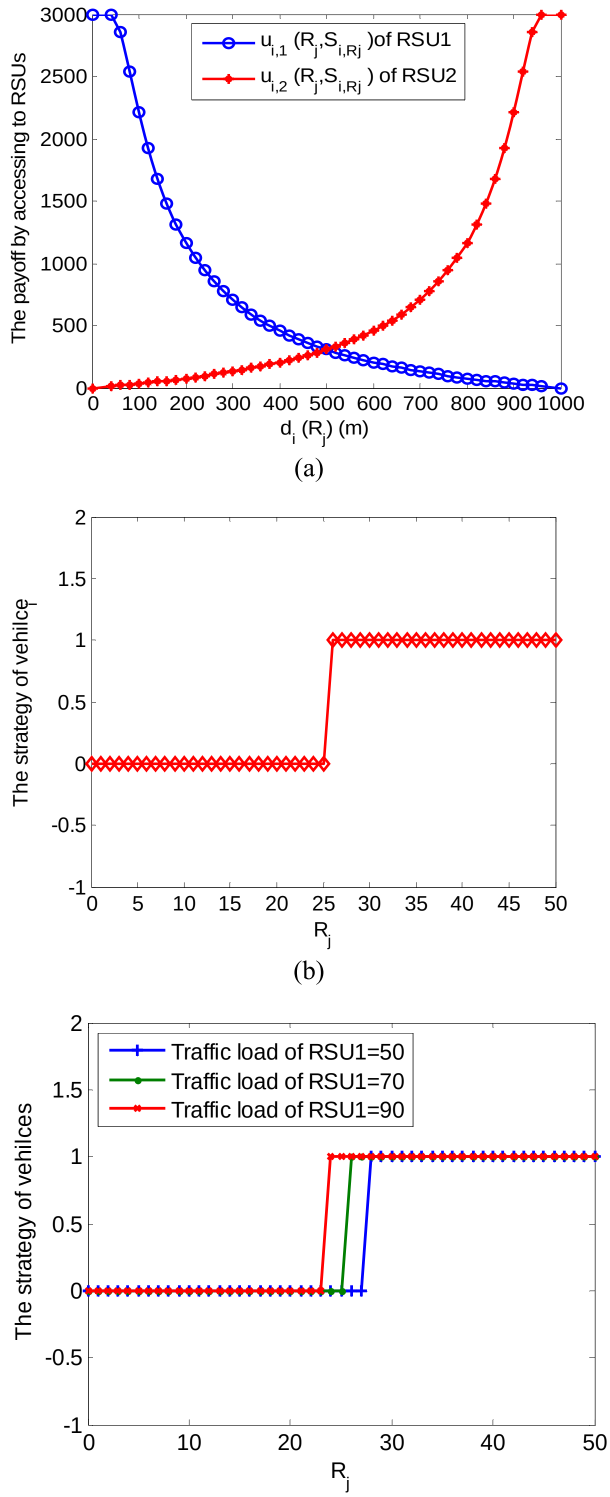
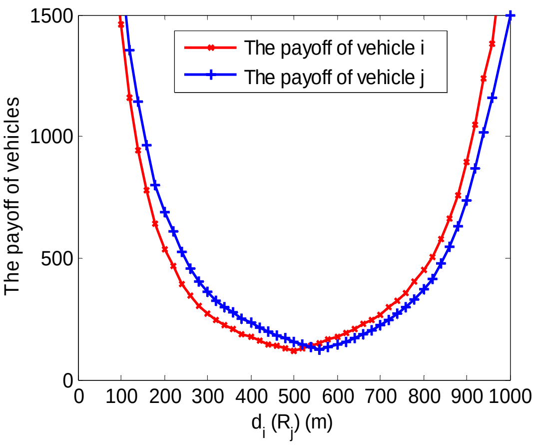
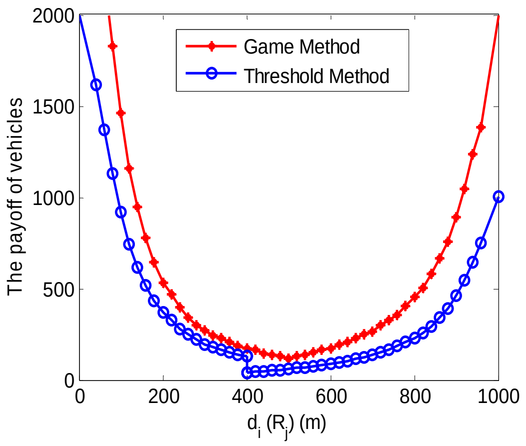


Figure 6. The payoff of vehicle access to RSUs and corresponding strategy

to ensure the no smaller payoff and decide to access to RSU2 in advance if the performance of RSU1 is declining. The corresponding strategy are $S_{i,R_{23}}$=1,



(a) Gaming each other



(b) Using different handover method

Figure 7. The payoff of two vehicles.

$S_{i,R_{25}}$=1 and $S_{i,R_{27}}$=1, which also demonstrates that our game method is correct .

B. *Analysis of the Payoff for Vehicles*

The payoff of the two vehicles gaming each other is reported in Fig. 7(a), which shows the two vehicles using our game method get almost the same payoff. When the vehicle begins to leave RSU1, the payoff of the vehicle will decrease significantly, because the main influence factors are bandwidth and RSSI. But in the middle road section, the bandwidth is small and the main influence factor is the distance, the payoff therefore changes little. This is the same as in Fig. 7(b). It shows that the vehicle using the threshold method will get an obvious decrease of payoff in the threshold point. And the average payoff during the overlapping area of RSUs is smaller than that of the game method. This is because that before the handover, vehicles always access to RSU1. At the threshold, most vehicles handover two RSU2, no matter vehicle accesses to which RSU it will get small payoff in the old thred. Fig. 7 proves that the game method can improve the QoS of vehicle users by 33.68%.

C. *The Number of Handover Vehicles*

The number of handover vehicles in every road section is shown in Fig. 8. It can be seen that when the game

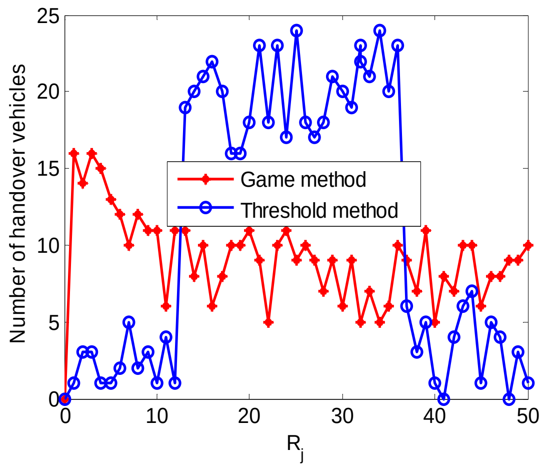


Figure 8. The number of vehicles handover in each Road section

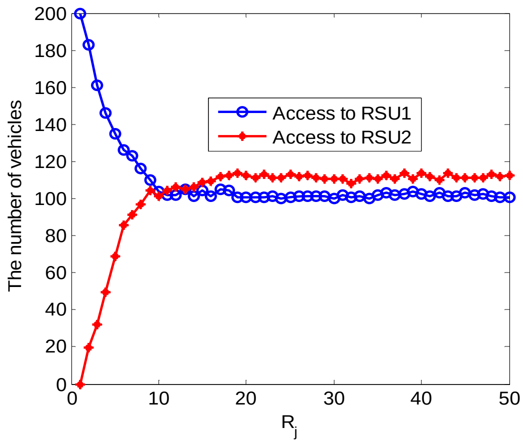
method is used, at the beginning, there will be more handover vehicles, because vehicles all access to RSU1, leading to overload of RSU1. As the decrease of RSSI and bandwidth, vehicles will handover to RSU2 to guarantee the QoS. In the threshold method, the handovers are concentrated in R_{14} to R_{38} ,which is due to more vehicles access to RSU2, so the traffic load of RSU1 decrease but no vehicles use it and the QoS of vehicle users will decrease obviously. However, the game method will make all the vehicles handover in different road sections, which banlances the traffic load of two RSUs and gurantees the QoS of users.

D. *Traffic Load of RSUs*

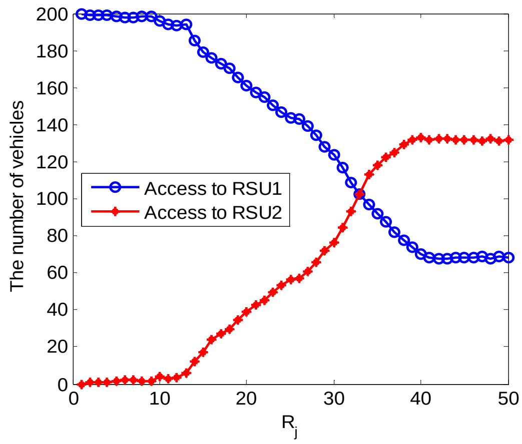
Due to the assumption that vehicles in the non-overlapping area are equal to each other, the number of vehicles is the number of handover vehicles. The numbers of vehicles accessing to the two RSUs with the game method and the threshold method are shown in in Fig. 9.

Fig. 9(a) shows all vehicles access to RSU1 at the beiginning lead to the vehicles prefer to access to RSU2 to guarantee the QoS of vehicle users for themselves. Therefore, the traffic load of RSU1 dcrease and RSU2's increase. As the game proceeds, the traffic loads of RSU1 and RSU2 tend to be balanced, which slows the competition among vehicles and guarantee QoS of vehicle users and consistent with the result of Fig. 8. However, The threshold method makes the traffic load of two RSUs out of balance in all the roa d sections as we can see from Fig. 9(b). At road section R_{14} to R_{18}, the vehicles handover intensively, which leads to the traffic load of RSU1 change from RSU2 idle and RSU1 congestion to RSU2 congestion and RSU1 idle, respectively. This wastes RSUs' capacity resource and decreases the network resource utilization.

V. Conclusion And Discussions



(a)



(b)

Figure 9. The traffic load of RSUs: (a). game method, (b) Threshold method

In this paper, we present a novel road section and sequential game-based mobility handover scheme for vehicles with seamless Internet access in urban VANET scenario. All the vehicles that need to handover will game each other to gain some payoffs to select an appropriate road-section to handover from a RSU to another. The performance evaluations demonstrate that our scheme outperforms significantly in terms of both the traffic load of RSUs and the QoS of vehicles users. So far we have only worked on vehicles with the ideal circumstance and considered the service layer. In the future work we will consider the lower layer applications, such as link building process and the two RSUs' interference problem.

Acknowledgment

This work is supported by National Natural Science Foundation of China (61370201), the Scientific Research Foundation for the Returned Overseas Chinese Scholars (45), Liaoning Provincial Natural Science Foundation of China (2013020019), High-Tech 863 Program (2012AA111902).

References

[1] J.Ott, and D. Kutscher, "A disconnection-tolerant transport for drive-thru internet environments," *INFOCOM*, pp. 1894-1862, Mar 2005.

[2] M. Sathiamoorthy, A.G. Dimakis, B. Krishnamachari and F. Bai, "Distributed storage codes reduce latency in Vehicular Networks," *INFOCOM 2012*, pp. 2646-2650, Orlando, FL, USA, Mar 2012.

[3] K. Zhou and Lok, "Power control for uplink transmission with mobile users," *IEEE Trans. on Vehicular Technology*, pp.2117-2127, 2011-6.

[4] D. Niyato and E. Hossain, "A unified framework for optimal wireless access for data streaming over Vehicle-to-Roadside Communications," *IEEE Trans. on Vehicular Technology*, VOL. 59, NO. 6, JULY 2010.

[5] D. Zhang and C. K.Yeo, "A cooperative content distribution system for vehicles," *IEEE GLOBECOM 2011*, pp. 1-6.

[6] J. Choi, W. Dong and N. G. Lee, "Supporting handover in an IEEE 802.11p-based wireless access system," *MOBICOM*, pp. 75-80, 2010.

[7] Robert J. Aumann, *Handbook of game theory with economic applications*, Elsevier, Amsterdam, Netherlands[M], 1994

[8] W. Xu, C. Hua and A. Huang, "A game theoretical approach for load balancing user association in 802.11 wireless networks," *GLOBECOM 2010*, pp. 1-5, Dec. 2010.

[9] K. Ko, Chun-Han and Wei HY, "Game theoretical resource allocation for inter-bs coexistence in IEEE 802.22," *IEEE Trans. on Vehicular Technology*, pp.1729 -1744, 2010.

[10] T. Chen, L. Zhu, F. Wu and Z. Shen, "Stimulating cooperation in vehicular ad hoc networks: a coalitional game theoretic approach," *IEEE Trans. on Vehicular Technology*, pp: 566 – 579, 2011.

[11] Chunyu Ren, "Research on Single and Mixed Fleet Strategy for Open Vehicle Routing Problem". *Journal of Software* ,Vol 6, No 10 (2011), pp. 2076-2081.

[12] D. Shen and J. B. Cruz, "Nash strategies for dynamic non-cooperative linear quadratic sequential games," *IEEE Conference on Decision and Control, 2007,* pp. 4075-4080.

[13] Guowei Wu, Zichuan Xu, Qiufen Xia, Jiankang Ren, "An Energy-Aware Multi-Core Scheduler based on Generalized Tit-For-Tat Cooperative Game," *Journal of Computers* , Vol 7, No 1 (2012), pp. 106-115.

[14] S.K. Lee, K. Sriram, , K. Kim, H.K. Yoon and N. Golmie, "Vertical handoff decision algorithms for providing optimized performance in heterogeneous wireless networks," *IEEE Trans. on Vehicular Technology,*Vol:58, pp.865-881, Feb.2009.

[15] K.L. Chiu, R.H. Hwang and Y.S. Chen, "A Cross Layer Fast Handover Scheme in VANET," *ICC 2009*, pp. 1-5, June 2009.

[16] K. Xue, P. Hong and X. Tie, "Using security context pre-transfer to provide security handover optimization for vehicular ad hoc networks," *VTC Fall 2010*, pp. 1-5, Sept. 2010.

[17] W. Lee and D.H. Cho, "Group handover scheme using adjusted delay for multi-access networks," *ICC 2010*, pp. 1-5, May 2010.

[18] M. Cheung, F. Hou, Vincent and W. Wong, "Dynamic optimal random access for vehicle-to-roadside communications", *ICC*, pp.1-6, 2011-6.

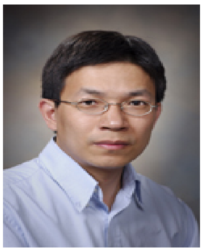
[19] J. P. Sheu, C. Y. Lo and W. K. Hu, "A distributed routing protocol and handover schemes in hybrid vehicular ad hoc networks," *International Conference on Parallel and Distributed Systems*, pp. 428-435, Dec. 2011.
[20] F. Kelly, "Mathematical modeling of the internet. in mathematics unlimited," pp. 685 –702, 2001.
[21] J.A. Fernandez, K. Borries, L. Cheng and F. Bai "Performance of the 802.11p physical layer in Vehicle-to-Vehicle environments," *IEEE Trans. Vehicular Technology 2012*, vol. 61, no. 1, pp. 3-14, Jan 2012.
[22] D. Ding, D.T. Ma and J. Wei, "A threshold-based handover prioritization scheme in LEO satellite networks," *WiCOM*, pp. 1-6, 2008.

Di. Wu born in April 1972, Liaoning, associate professor and master tutor of School of Computer Science and Technology /Dalian University of Technology, Dalian, China. The main research directions are the VANETs, Internet, wireless ADHOC networks, computer network and the computer simulation application in the engineering, etc.

Since 2001, he is the associate professor of Dalian university of technology, college of computer and the Internet of things institute. 2009-2010, he as a visiting scholar to the Canadian Simon Fraser University, college of compute.1999-2001, he is the postdoctoral in Northeastern university, institute of computer application and the network and communication center. He has published more than 50 papers and 2 patents in domestic and international academic conferences and journals.He is He is a senior member of computer society.

Yingrong Bi born in November 1988, in Shandong, the graduate student of Dalian university of technology. The main research directions are VANETs and DTN network.

she has published a paper in Journal of China Universities of Posts & Telecommunications (SCI).



Jie Liang received the B.E. and M.E. degrees from Xi'an Jiaotong University, China, the M.E. degree from National University of Singapore (NUS), and the PhD degree from the Johns Hopkins University, Baltimore, Maryland, USA, in 1992, 1995, 1998, and 2003, respectively. Since May 2004, he has been with the School of Engineering Science, Simon Fraser University, Canada, where he is currently an Associate Professor. In 2012, he visited University of Erlangen-Nuremberg, Germany, as an Alexander von Humboldt Research Fellow. From 2003 to 2004, he worked at the Video Codec Group of Microsoft Digital Media Division. From 1997 to 1999, he was with Hewlett-Packard Singapore and the Center for Wireless Communications (now part of the Institute for Infocomm Research), NUS.

Jie Liang's research interests include Multimedia Communications, Multirate Signal Processing (wavelet and filterbank), Information Theory, and Wireless Communications.

He is currently an Associate Editor for the IEEE Transactions on Circuits and Systems for Video Technology, Signal Processing: Image Communication, EURASIP Journal on Image and Video Processing, and Circuits, Systems, and Signal Processing (CSSP). He is a member of the IEEE Multimedia Systems and Applications (MSA) Technical Committee, and is a Professional Engineer in British Columbia.