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A Scheme for Sharing Resource in VANET

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ABSTRACT

For the problem troubling the related researchers for sharing resource in VANET, a scheme for effective sharing resource is proposed. Its purposes are to raise the successful ratio for sharing resources and the transmission efficiency as well as reduce the communication cost and the latency for sharing resources. The scheme designs four strategies including inquiry, answer, replacing resource and notification because of achieving resource, to achieve the above purposes. Based on the real data on vehicles running, the experiments show that, compared to the other two schemes, the proposed scheme has the higher ratio of sharing resources and transmission as well as lower latency and communication cost.

Keywords: VANET, sharing resource, the vehicle activity ratio

1. INTRODUCTION

Internet of vehicles(VANET) is a wireless network built by the running vehicles in roads. Recently, as a kind of mobile internet, VANET was a research focus with the spread of mobile internets. It can get traffic security, navigate and optimize route selection as well as amuse etc.

How to achieve resource sharing is meaningful and worthy research issue. In real life, when vehicle is running, the drivers or passengers could want the resources which are nonexistent in the local memory. Under this case, they can send the inquiry information to the other vehicles by VANET so as to get the response from the vehicles that have those resources to achieve the resource sharing. But the resource sharing of VANET is a challenging. First, the inquiry vehicle does not know the location of the vehicles that have the required resources so that the goal vehicles are uncertain. Namely, the information source does not know the information destination so that all of the routing protocols in VANET cannot efficiently work. Second, in the process of resource returning, the receiver of resource is moving according to the driver's willing so that the location of receiver is uncertain. And how to return the inquired resources to the inquiring vehicle that its location is uncertain is a challenge. Last, when the inquiring vehicle received the inquired resources, there could still be the other vehicles which are attempting to return the inquired resources to the inquiring vehicle leading to making the extra communication cost. So it is necessary to design a notification policy when the inquiring vehicle received the inquired resources to reduce the communication cast.

This work propose a scheme with sharing resources (ERS) so as to increase the success rate that the vehicle gets the inquired resources and reduce the communication cost and the latency for getting the inquired resources.

2. Relate Work

As an emerging application, VANET is paid attention and become a research focus[1,2]. Of their researches, some focus on the routing. In epidemic routing[3], they exchange the routing information which is not existing in the routing list of counterpart for having the consistent routing information with each other when two vehicles meet. The epidemic routing has the high success rate of sending and low latency, but its communication overhead is huge. For the spray-and-wait and spray-and-focus protocols in the references [4] and [5], the source vehicle makes L replicas of requiring resource message and sends them to the other vehicles. When any vehicle that has the required resources meets the source vehicle, it sends the required resources to the goal. Both of the spray-and-wait and spray-and-focus protocols have a shortcoming: the parameter L is preset and cannot be changed. Different network, the required L is different, so they could not achieve a high sending success rate and a low communication cost. The reference [6] proposes a routing protocol calling OPF, In the protocol, the interval that any two vehicles encounter again is called the encountering interval. According to the encounter interval, based on First Stop Theory, in the case of given number of times for sending message, OPF can maximize the sending success rate. The author make tow assumptions for OPF: first, for any two vehicles in the system, it assumes that they follow an exponential distribution with parameter λ_{ij}; second, in the system, it assumes that the average encounter interval from any two vehicles has work out according to the history information of traffic department, and any vehicle saved the average encounter interval of any two vehicles. The second assumption needs a certain amount of storage space.

The reference [7] proposes a scheme for sharing content called Roadcast. When a vehicle inquiries resources, the scheme returns the data with high similarity to the vehicle according to the similarity between the inquiring and the local data. Roadcast calculates the similarity between the inquiring and the local data according to the matching degree of the inquiring and the local data on the keywords and the popularity of the local data. The greater the matching degree or the popularity of the data is, the greater the similarity is. But, the scheme is shortcoming that it is possible that the inquiring vehicle gets the data which is high popularity and low similarity. And because of the low similarity, the inquiring vehicle could not need these data. Moreover, when inquiring, Roadcast only consisde the inquiring within one hop, namely, the inquiring vehicle only inquiries his neighboring vehicles. It could lead to the high latency.

Some researches on VANET focus on broadcast and unicast. Flooding[8] is a broadcast protocol with wide application. When sending information, source vehicle broadcast information to its neighbors. Once receiving the information, its neighbors keep to broadcasting it. Flooding easily leads to Broadcast Storm so as to make the huge communication cost. Direct Transmission is a unicast-protocol. When needing to send information to destination vehicle, source vehicle keeps the information until encounters the destination vehicle. Although the communication cost of Direct Transmission is low, its sending success rate is low and the latency is high. The inquiries based on Flooding and Direct Transmission can all resolve the sharing resource of VANET, but they are not efficient schemes on resource sharing. In simulation experiments, this work proposes a scheme on resource sharing(ERS), and compares with Flooding Inquiry and Direct Transmission Inquiry.

3. PROBLEMS PRESENTATION

3.1 System model

In VANET, there are a total of $|N|$ vehicles, using a set N to indicate. These vehicles run in roads according their drivers' willing. Each vehicle keeps an on-board GPS and electronic map. The on-board GPS can provide a globally unique ID i, location, and current time information and so on. The electronic map can provide the global ID of every crossing. Moreover, each vehicle still carries some equipment with the capability of computing, communication and saving. When the Euclidean distance of any two vehicles in geographic location is less than or equal to the communication distance, the two vehicles are called to encounter and are neighbors to each other. If two vehicles are neighbors to each other, they can communicate each other. For any vehicle, it cannot receive and send the information in same time. And it cannot also receive the information in same time from the different information sources because of the signal collision.

For finding neighbors among vehicles, each vehicle sends periodically probe message (e.g., for every ten seconds) so that they can find it in time when the vehicle goes into the communication range of the other vehicles. Generally, the generated communication cost for the probe message is very short and can almost be neglected.

Each vehicle saves some resources in the local memory which are pictures, audios and videos etc. Each resource can be provided to the vehicles which are requiring it by VANET.

3.2 Problems description

For VANET, when a vehicle requires a resource that is not exist in the local memory, it makes a query message in VANET. It generally names the vehicle the source vehicle. The source vehicle sets a lifetime for a query message. Any vehicle receiving the message and having the required resource returns the required resource to the source vehicle so as to achieve the resource sharing.

The resource sharing in VANET include that how to inquire and reply. The index for the resource sharing includes the success rate, the average latency, the communication cost and the efficiency. The success rate indicates the ratio between the numbers received resources by the source vehicle and the numbers sent message for inquiring resources. The average latency indicates, among all of resources successfully received by the source vehicle, the interval of average time from making the inquiring message to receiving the corresponding resource. The communication cost indicates the total of number of times sending messages. The efficiency indicates the ratio between the numbers received resources and the communication cost.

As an efficient the way for sharing resources, it should achieve the high success rate and low average latency as much as possible. Moreover, it has the high efficiency and low communication cost.

4. EFFECTIVE RESOURCE SHARING SCHEME

This section describes in detail the effective resource sharing way named ERS proposed in this paper. ERS includes four strategies: Query strategy, replying strategy, Replacing strategy of resource and Informing strategy of receiving resource.

4.1 Query strategy

This section designs a query strategy that the source vehicle send query message according to it. The goal of the query strategy is to raise the success rate of resource sharing and reduce the latency and communication cost.

When needing a resource that is not exist in the local memory, the source vehicle make a query message with ID which is consist of the ID of the source vehicle and the query ID. The query ID can be structured according to the query sequence of the source vehicle and is the global unique. The content of the query message is consisted of the ID of the query message, the query request for the required resource and the lifetime of the query message. Moreover, for the convenience that the vehicles having the required resources replies the source vehicle, the content of the query message still includes the current time, the location of the source vehicle which can get from the GPS on board and the future running route expressing the crossing ID sequence within digital map of the source vehicle.

Because the location of the vehicle with the required resource is unknown, to achieve the query in ERS, the source vehicle sends the query message to his neighbors every some seconds (e.g., 60s) in VANET until the source vehicle receives the corresponding resource or the the lifetime of the query message ends. When receiving the query, a neighbor with the required resource return the the required resource to the source vehicle in time. Under the condition, the resource can be returned to the source vehicle on the one-hop way because of the neighbour relationship. If the source vehicle do not receive the required resource until the end of the lifetime of the query message, it make the query message again in VANET according to the same query strategy.

In fact, the vehicles encountered by a vehicle at a certain moment are a part of all vehicles in VANET. Due to this, only depending on the query from the source vehicle, the high success rate of the resource sharing and low latency cannot achieve. For resolving the problem, when making the query message, in ERS, a neighbor selected by the source vehicle inquires together with a neighbor selected by it. Assuming that a neighbor v_h is selected by the source vehicle, it sends the query message of the source vehicle to its neighbors every some seconds (e.g., 60s) in VANET until it hears the response from a vehicle or the lifetime of the query message end. Once received the query message from $v_{h,}$ a vehicle with the required resource timely returns the resource to the source vehicle. Because of the neighbor relationship, v_h can hear the response so as to end sending the query message.

This paper proposes two methods to select v_h: the random-based selection(RAN) and the activity-based selection(ACT). In RAN, the source vehicle selects randomly a vehicle from his neighbors as v_h. And in ACT, based on the vehicle's activity, the source vehicle selects a vehicle with highest activity as v_h from his neighbors.

It assumes that the begin activity of every vehicle is 1. And it sets a time window(e.g., 1h). When new time window begins, a vehicle can compute his own activity a_n in the current window according to the formula (1).

$$a_n = \alpha \times v_l + (l - \alpha) \times a_l \qquad (1)$$

Where v_l denotes the of number vehicles encountered by the current vehicle in the last time window, and a_l denotes the activity of the current vehicle, and α is a coefficient and the value is 0 4 1. In ERS, is 0.6. from the formula (1), the more vehicles a vehicle encounters, the more active it is. To make other vehicles know itself activity, whenever sending a query message, a vehicle must send the query message to its neighbors together with his own current activity.

4.2 Reply strategy

In the query strategy, a vehicle v_d having the required resource and responding the query may is not neighbour with the source vehicle. So it is necessary to design a route so as to return the required resource to the source vehicle along it. This section designs a reply strategy on which v_d can route and reply to resource based so as to reduce the latency and communication cost.

ERS designs a route based on road for v_d. v_d can return the required resource to the source vehicle on multi-hop way along the route. The references [10,11] show that both the time a vehicle travels on a road and a message is transmitted on a road follow the gamma distribution. And the respective mean of them can be worked out according to the traffic offices' historic information. It assumes that these mean saved into the memory of every vehicle in VANET. v_d can get the time the query message is made by the source vehicle, the location and the future running route of the source vehicle from the query message of the source vehicle. So v_d can get the mean value of the time that the source vehicle passes through every the crossings in the future. The two steps making the routing from v_d to the source vehicle: a): v_d selects a crossing among all crossings passed by in future as the goal crossing. With the Dijkstra algorithm according to the mean time spending on transmitting a message on a path, v_d finds a path with minimum mean time to send resources to the goal crossing. There are two situations when the resources are sent the goal crossing by v_d: a) The mean time the resources arrive at the goal crossing is earlier than the mean time the source vehicle arrives at the goal crossing. In this situation, it transmits the resources along the direction opposite to the vehicle traveling in future until the final crossing i_d so as to meet that the mean time the resources arriving at i_d is later than the source vehicle arrives at i_d. b) The mean time the resources arrive at the goal crossing is later than the mean time the source vehicle arrives at the goal crossing. In this situation, it transmits the resources along the same direction as the vehicle traveling in future until the final crossing i_d so as to meet that the mean time the resources arriving at i_d is earlier than the source vehicle arrives at i_d.

Now, it is to present how to select the goal crossing. Computing the mean latency arriving at a crossing to send the resources, v_d selects a crossing with the minimum mean latency from all crossings passed by the source vehicle in future as the goal crossing. Based on the formula (2), v_d computes the mean latency $D(i_c)$ the resources arriving at the crossing i_c

$$D(i_c) = D(v_d i_c) + D(i_c i_d) \tag{2}$$

Where $D(v_d i_c)$ is the mean time for transmitting the resource from the source vehicle to v_c based on the Dijkstra algorithm.

During the process returning the resource along the selected path, it generates high communication cost if every vehicle forwards the resource. For reducing the communication cost, ERS adopts the forward strategy based on distance. v_f is the vehicle to send the resource. When v_f forwards the resource to its neighbors, a neighbor v_c computes their own waiting time t_w based on the formula (3).

$$t_w = (r - d) \times t_g \tag{3}$$

Where r is communication distance, d is the distance between v_f and v_c, t_g denotes time granularity and can be milliseconds(e.g., 1ms). The formula (3) show that the farther the neighbor is from v_f, the shorter its waiting time for forwarding. So, the furthest neighbor from v_f can first forward the resource. When listening this forwarding, the other neighbors don't forward the resource so as to reduce communication cost. In the case of network disconnecting, namely, v_f(the vehicle currently forwarding the resource) can not hear any neighbor to keep forwarding the resource, v_f would use a store-carry-forward strategy.

4.3 Resource replacement strategy

During the process which the resources are returned the source vehicle along the routing path from the vehicle *with the required resources, the vehicles* running on the routing path can get the resources. In ERS, when a vehicle get a resource, although needn't the resource, it can still save the resource in the local memory so as to the check from the other vehicles. With the accumulation of time, the number of saved resources can lead to the shortage of the local memory so as to need to delete some resources. So it is necessary to design a resource replacement strategy for preventing shortage from the memory space.

In ERS, it computes resource value r_v for every resource according to the formula (4). When the local space of a vehicle is shorter than a designed threshold(e.g., 100M), it denotes that the local space is insufficient. In this case, the vehicle can delete the resource with minimum value in turn according to the resource value until the local space of the vehicle is bigger than the designed threshold.

$$R_v = r_p / r_s \tag{4}$$

Where r_p denotes the resource popularity, r_s denotes the memory size using by the resource. The initial value of popularity of a resource is 1. Once a resource is returned to the source vehicle, the popularity of correspond resource of the vehicle is increased by 1. From the formula (4), the value of a resource is proportional to its popularity, and inversely proportional to the space size using by the resource. Therefore, the greater the popularity of a resource is, or the smaller the using space is, the greater the value of this resource is.

4.4 Received resource notification strategy

When the source vehicle receives the resource, there may still be some other vehicles that are helping it to query or replying to the resource, causing unnecessary communication cost. It is necessary to design a receiving resource notification strategy to notify the other vehicles when the source vehicle receives the resource. If judging that the source vehicle has received the resource, the vehicle that is helping the source vehicle to query or replying to the resources will not keep to query or reply.

In ERS, every vehicle saves a binary vector of size 1000 bits in the local memory. As mentioned before, the ID for query message, which is used to query a resource by a vehicle, is globally unique. If a resource has been received, the ID of it is saved in a binary vector of size 1000 bits based on the algorithm Bloom Filter[12,13] by the source vehicle. A vehicle will sends the detecting message with its own binary vector, because of the size of 1000 bits, the communication cost is very small. Once received the binary vector of this vehicle, the other vehicles update the local vectors with the local vectors and the received vector based on a "bitwise OR" operation. Every vehicle can check a query message ID based on the binary vector in the local memory to determine whether the source vehicle received the resources or not. To reduce the probability of misjudgment, If more than 50% of the bits in the binary vector stored by a car are 1, the car will reset all the bits of its binary vector to 0.

When using the binary vector to save the query message ID, Bloom Filter requires several hash functions that are independent of each other. The hash functions work out hash address according to the ID, setting the bits corresponding to the hash address in the binary vector to 1. ERS adopts four ways to respectively build four hash functions: (a) Midsquare Method. After the value of the query message ID is squared, the middle 3 bits are taken as the hash address. (b) Divide and Leave The Remainder Method. After dividing the value of the query message ID by 997, the remainder is used as the hash address. (c) Radix Conversion Method. The value of the query message ID is considered as a hexadecimal number and converts it into a decimal number, taking the middle 3 digits as the hash address. (d) Pseudo-Random Number Method. This method calculates the hash address Hash(key) according to formula (5).

$$Hash(key) = (13 \times key + 11)\%1000 \tag{5}$$

Where $Hash(key)$ denotes the hash address, and key denotes the query message ID.

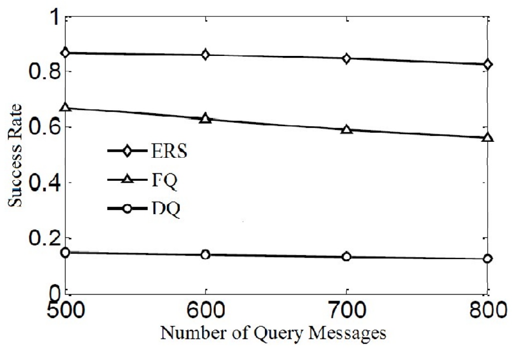

Figure1. The comparison result of the success rate

5. SIMULATION

5.1 Experimental method and parameter setting

In the simulations, the proposed protocol ERS is compared with the query based on flooding and the query based on direct transmission. The query based on flooding is called flooding query(FQ) for short; the query based on direct transmission is called direct query(DQ) for short. In FQ, the source vehicle uses the flooding broadcast method to query, and the resource-owned vehicle uses the flooding broadcast method to reply. In DQ, the source vehicle sends query messages to its neighbors every 10 seconds. If one of its neighbors has the resources, it will immediately reply the resources to the source vehicle. In addition, the simulation also compares the two methods RAN and ACT for selecting source vehicle v_h. Performance indicators for comparison include communication cost and efficiency.

The simulation uses the collected real driving data of the vehicle [14, 15]. These data are from more than 4,000 taxis and more than 2,000 buses driving in the downtown of Shanghai and is generated in real time by on-board GPS devices. The channel model of wireless communication obeys Power-Law Attenuation model.The related experimental parameter settings as shown in Table 1.

Table 1 Experimental Parameters

Parameter Name	Parameter Value
Number of vehicles	3000
Number of query messages	500~800
Size of each resource	10MB
Memory size	1GB
Data transfer rate	100Mbps
Communication distance	200m

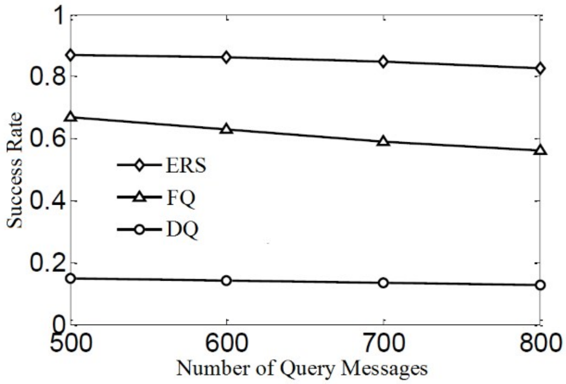

Figure1. The comparison result of the success rate

5.2 Comparison results among different methods

First, it compares ERS with FQ and DQ. In this simulation, ERS uses ACT to let the source vehicle select v_h.

The comparison result of the success rate is shown in Figure 1. It can be seen that the success rate of ERS is higher than that of FQ and DQ. In ERS, more than 80% of resources are successfully acquired. In FQ, only about 60% of the resources are successfully acquired. This is because FQ uses the flooding broadcast method to query and reply. This method is easy to cause broadcast storms and cause conflicts between data packets so as to affect the sending and receiving of messages. In DQ, less than 20% of the resources are successfully acquired, because the chance of the source vehicle directly encountering the resource vehicle is very low.

Figure 2 shows the comparison result of the average latency. It can be seen that the average latency of ERS is lower than FQ and DQ. When the number of query messages changes from 500 to 800, the average latency of ERS is within 30 minutes.

Figure 3 shows the comparison result of communication cost is. It can be seen that compared to FQ, ERS has a lower communication cost. This reason is FQ uses flooding broadcast methods to query and reply. The communication cost of this method is very large. In addition, although the communication cost of DQ is relatively small, its success rate is very low, as shown in figure 1, so DQ is not an effective resource sharing method.

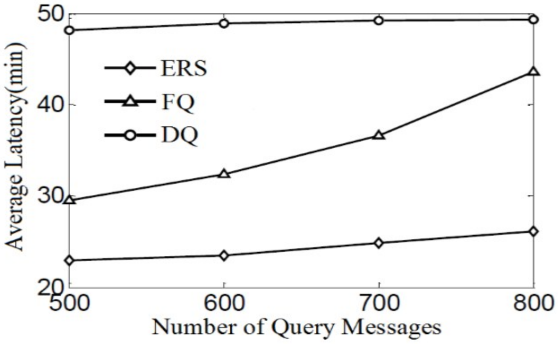

Figure 2. The comparison result of the average latency

Figure 4 shows the comparison result of efficiency. It can be seen that the efficiency of ERS is significantly higher than that of FQ and DQ. This is because ERS can achieve a higher success rate and lower communication cost at the same time, so ERS has higher efficiency.

Based on these four simulation results, it can be got that, compared with FQ and DQ, ERS can simultaneously achieve higher success rate, lower

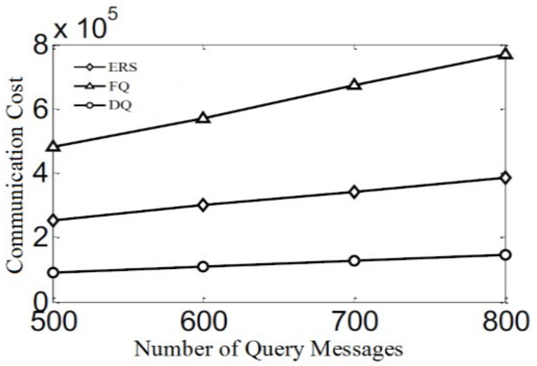

Figure 3.The comparison result of the communication cost

latency, lower communication cost, and higher efficiency, so it is an effective Resource sharing method.

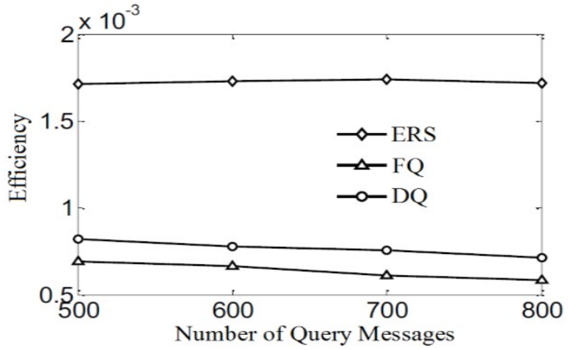

Figure 4. The comparison result of the efficiency

5.3 Comparison results between ACT and RAN

When the source vehicle chooses v_h , this paper proposes two methods: the selection based on vehicle activity (ACT) and selection based on random (RAN). This section compares these two methods.

As for the comparison result of the success rate, as shown in Figure 5, it can be seen that ACT achieves a higher success rate than RAN. As for the comparison result of average delay, as shown in Figure 6, it can be seen that ACT achieves lower average latency than RAN. This reason is when selecting a vehicle, ACT selects the most active vehicle as v_h to help query, and the greater the activity, the more vehicles it encounters, so compared to RAN, ACT has a greater chance of meeting vehicles with the resources so as to achieve a higher success rate and lower latency. Therefore, between the two methods of ACT and RAN, this paper recommends ACT with better performance.

6. CONCLUSION

This paper focuses on the resource sharing problem of VANET and presents an effective resource sharing method ERS, including four strategies, including four strategies: query strategy, reply strategy, resource replacement strategy, and received resource notification strategy. In the query strategy, the source vehicle selects the other vehicles to help it query based on the vehicle's activity. In the reply strategy, based on the future travel path of the source vehicle, select a path with the least mean latency to reply. In the replacement strategy, a value is calculated for each resource. When the local storage is insufficient, the resource with the smallest value is deleted. In the notification strategy that received the resource, the bloom filter is used to store the query message ID of the resource received by the source vehicle and spread it in VANET, informing the other vehicles to reduce the communication cost. The simulations use the real vehicle travel data, and the results show that ERS is an effective resource sharing method in VANET.

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