Infrastructure-aided encounter transfer protocol for vehicle communication networks

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Abstract—**Because of the increasing demand of communication, VANETs (Vehicle ad hoc networks) attracts more and more attention all over the world. However the high mobility and the poor connectivity require further studies on better performance of the communication network. This paper is going to discuss on the data transfer in vehicle communication networks. We divide the whole process of communication into three phases: (1) the disseminating of the packages which are going to delivered to the destination node among APs, and the transfer of the package between the infrastructure (here refers to the AP); (2) the data transfer between vehicle and vehicle with encounter situations; (3) the reply process from the vehicles to the APs.**

I. INTRODUCTION

Ad hoc networks are constituted by series of wireless mobile or static nodes which are always moving. Because of the self-organization of the topology, the ad hoc networks are always known as complex distributed systems. VANETs are similar to the common ad hoc networks in many aspects, while they bear some differences. To be more specific, the VANETs have a relatively low power limitation, but the high speed of the vehicles make the throughput and the connectivity an essential criteria to take into consideration. It has been proved that dynamic has improved the connected situation compared to statics [1]. Although the result of it gives us an optimistic view about the VANETs, we have to pay attention to the sacrifices of the perfect percentage of the connectivity, the delay included.

Pure vehicle-to-vehicle communications obtain a low connection time compared to the vehicle-to-infrastructure communications, while vehicle-to-infrastructure communications suffer a relatively small communication covering area when it is compared with the vehicle-to-vehicle communications [13]. Considering both of the connectivity and the communication covering area, we decide to make use of the integration of both the V2V and the V2I networks.

The integration of VANET and other infrastructure-based networks, including cellular networks, WLAN, and internet can expand the coverage area of network as well as providing some services which are not offered by pure V2V networks. Roadside infrastructures are able to provide new services such as Internet access, information sharing, and information of each driver containing the way each of the vehicle will take. As to V2V communication systems provide services such as collision avoidance support and road safety by exchanging warning messages among vehicles [3].

The remainder of this paper is organized as follows. In section II, we present some of the previous works which are related to the VANET works. In section III, we will provide our assumptions for our model. In section IV and section V, the two phases of the process in our communicating system. In section VI, the performance will be showed, and the simulation is presented. In section VII, we conclude the paper.

II. RELATED WORKS

Integration of the V2V and V2I networks has been discussed for long. For most of the previous studied, a clustered node regarded as a gateway is applied [3] [4]. The selection of gateway, of which the mobility, the power consuming and the hops or the distance to the APs etc. should all be taken into consideration, is regarded as one of the most important issue in those works [15] [6] [7]. The routing protocol to find the gateway is also of great significance.

Besides, there is another mechanism in data transfer applied in vehicle communication networks. And those works on "drive-through-internet" [8] [9] [10] [11] are mostly related to our works. One paper addresses the problem of content exchange between a pair of moving vehicles, and they stress the importance of an efficient information exchange between a pair of moving vehicles, and in their paper a bulk transfer protocol using bit-vector acknowledgement to achieve the data transfer [12]. The Encounter Transfer Protocol (ETP) for opportunistic vehicle communication [2] takes many of the factors which contribute to the throughput loss over through the whole process of their protocol (ETP), and proposes ETP to obtain a relatively long information exchanging process with pre-fetching and post-processing method. But we find that they fail to discuss about the possibility of the encountering.

Another paper also published at IEEE INFOCOM 2011 gives us another view about the data transfer [5]. In this paper, the authors propose a Shared-Trajectory-based Data Forwarding Scheme. Thus it uses the moving trajectory information provided by the GPS systems to calculate the possibility of the encounter, and that is to say to prediction the encounter. But the assumption in this paper is so strong that every vehicle has the knowledge of all the trajectory information of the other vehicles. Our work will pay attention to this point that the memory of the vehicles is limited. Data forwarding schemes for VANETs have adopted the carry-and-forward approach, and Dedicated Short Range Communications (DSRC) [14] [16] is widely used for its high efficiency and throughput.

The differences of our work compared to the previous work are as follows:

- Previous works assume that the every vehicle has the large amount of information of all the other vehicles' trajectory. Although the GPS can be used to locate any vehicle in the covering area, but it will takes a lot of time in calculating and finding the vehicles in surrounding paths. Here we utilize the roadside APs to spread the information quickly at first and leaving the work of calculating the possibility of encountering the destination vehicle node saves a lot of resources.
- The feedback information about the successful reception of the packets at the destination vehicle node can be given to the APs after all the packets have been transferred either by the destination node or the last intermediate node.
- It saves the cost of the vehicle node, and has a relatively high efficiency.

III. PROBLEM FORMULATION

Firstly, we have to pay special attention to the high mobility in VANETs, thus making it difficult to achieve the efficient data transferring. Then, our model is as follows:

A. Infrastructures are regarded as the APs, and they are deployed mainly at the core traffic lights. The deployment may have several reasons. One of the reasons is that there is a high possibility that vehicles will stop there, and a static communication between the vehicles to AP is much more stable.

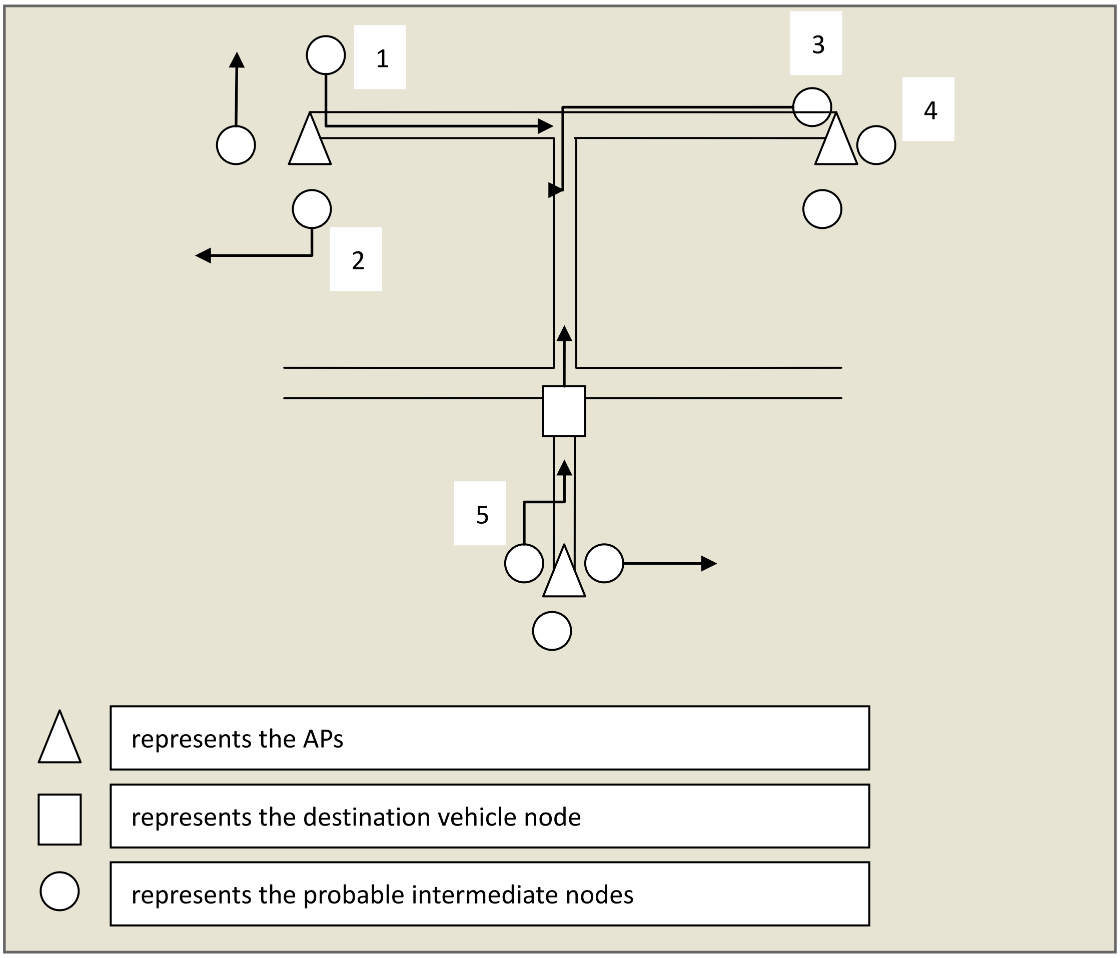
B. Every vehicle is able to communicate with the APs directly instead of transferring data to the gateway at first.

C. APs are available of the trajectory information with the help of the GPS and other tools. This assumption is not that much heavy than that the information can be obtained by every vehicle which burdened the vehicle node with heavy memory requirement.

D. APs can calculate the possibility of the encounter between the surrounding node and the destination node, and spontaneously download the packets to the selected intermediate node.

E. Every vehicle has a serial number, and it broadcast the number periodically to inform the adjacent vehicles about its own information.

Secondly, base on the assumptions, we can establish our model, of which the whole process should be divided into three parts mainly. Phase 1 is the communication between the vehicle and AP, which can be called the preparation period. Phase 2 is the communication between the vehicles, which can be called the opportunistic encountering data transferring. Phase 3 is the response of the vehicle to the AP that all the packets have been received, and the APs can use the memory to save other information. The model can be showed in figure 1.



IV. PHASE 1: communication between vehicle and AP

Because of the limitation of pure vehicle communications, the introduction of the APs reduces the delay to some extent.

Generally, the APs collect the information of the trajectory. Once the packets arrive at the APs, they will abstract the information of the destination vehicle node, and with the aid of the GPS system, they gain the trajectory information as well. Then, with sufficient information, the APs disseminate the information to all the other APs through the internet quite conveniently. With the information, the APs are able to know the geographical location of the destination node currently, and the nearby APs should get ready to download the information to the chosen intermediate vehicle nodes. There's an important point to notice is that whenever any vehicle communicate with any AP, it will absolutely tell the AP about its route plan. Only on the basis of this action will the AP able to judge whether the node is suitable for play the intermediate node role.

The algorithm 1 is showed in figure 2.

t_{max} is the maximization keeping time, but once the information come again, it will start a new round.

Take the situation in our model (figure 1) into consideration. As the requests appear, the instantaneous spread of the packets and destination node information through the internet ensure the possibility of the location even if the destination is far away from the sources. Besides, because of the wide spread of the information, we can quickly cage the destination node into a small area, for example in figure 1, once the APs get the information, they spontaneously download the information to the selected intermediate vehicle node, and thus forming a kind of besieging network.

Algorithm 1 (for APs):

```
When APs receive any information:
If (requests for sending) then
    abstracting the information given about the serial number of the destination vehicle node;
    calculate the current trajectory of the destination node;
    disseminate the related information and the packets among all APs;
    if (is one of the 5 nearest APs away from the destination) then
        if (t<=tmax) then
            keeping the relevant information;
            waiting for other vehicles to come
        endif
    endif
else (passing vehicle nodes)
    analyze the trajectory information of the accessing node
    if (get the intermediate node) then
        download all the related information and packets to the accessing node;
    endif
endif
```

V. PHASE 2: communication between vehicles

In the V2V encounter situations, we apply the Encounter Transfer Protocol which has been described in [2] basically, but we have to have a change on it to some extent.

The main difference is at the beginning of the protocol. In [2], once the client receives the beacon of the server, it produces a query. But in our model, it is the intermediate vehicle node that bears the packets searches for the destination node. And once they receive the target serial number signal, our Modified Encounter Transfer Protocol (METP) begins.

The protocol can be described as follows (figure 2&3 shows the diagram):

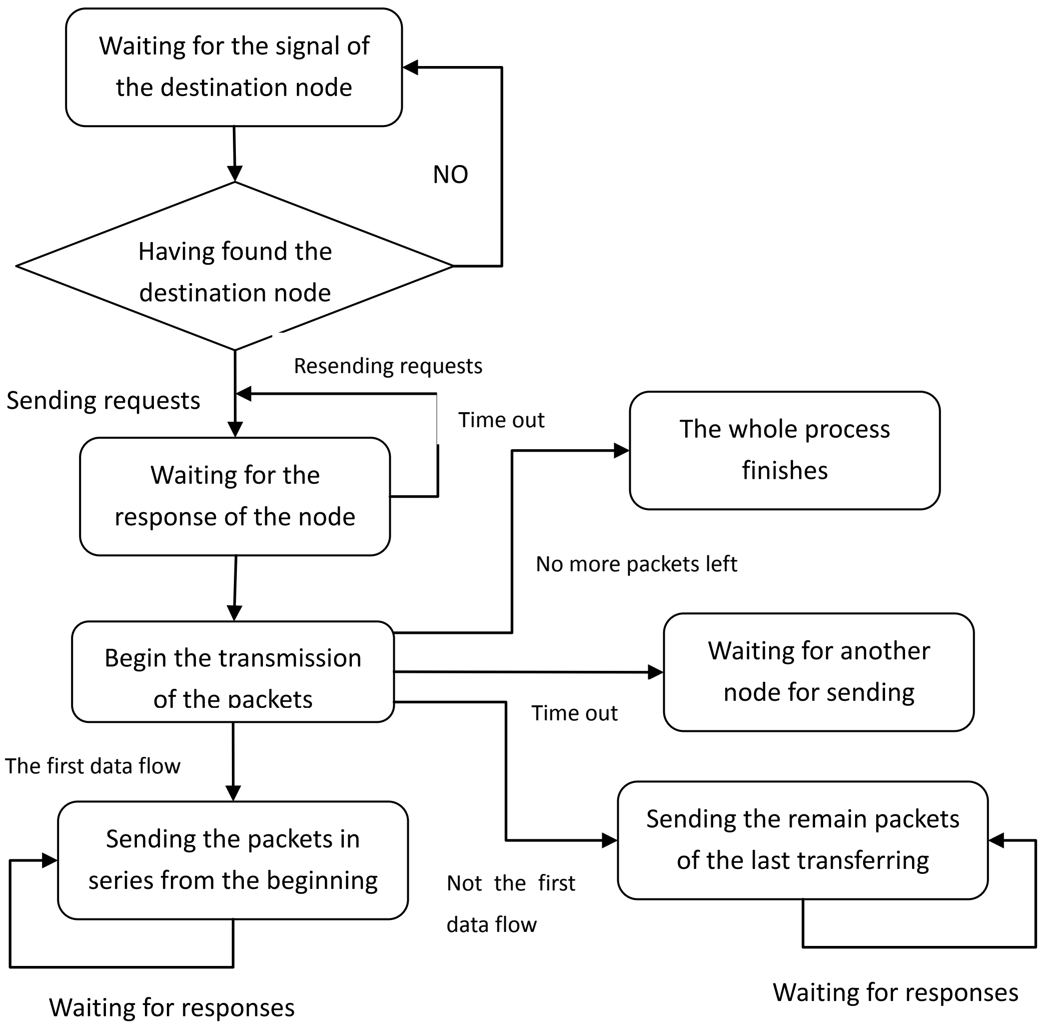


Figure 2 the intermediate vehicle node's state diagram

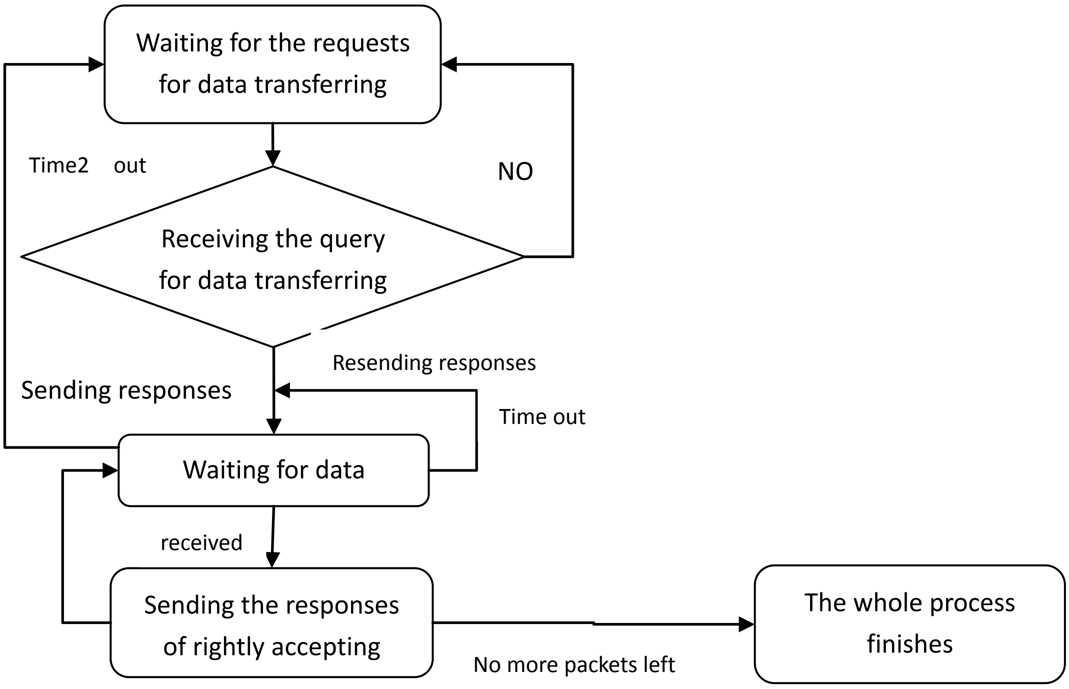


Figure 3 the destination vehicle node's state diagram

VI. PHASE 3: responses of successful reception

After the accomplishment of the data transferring phase, the process almost goes to the end. But as a matter of fact, if the requests ultimately stay in the memory of the APs and the intermediate vehicle node, it will waste a lot of resources. As a result, it is essential to set up a releasing process. To be more specific, the room for outdated packets and information should be used to store more additional information. Thus we have designed a releasing protocol, which is described in algorithm 2.

Algorithm 2:

```
If (t<=the longest memorial time) then
    If (all packets have been successfully accepted by the destination node) then
        If (encounter a AP) then
            Telling AP about the end of the process;
            AP spreads the ending information all over the APs;
            APs erase all the outdated memory;
        endif
    Else
        Keep on seeking for the destination vehicle node;
    endif
else
    all the memory about this transmission should be erased;
endif
```

VII. PERFORMANCE

Complete performance comparation needs to be done. But as far as we can see, in the previous models that has been proposed either in [2] or in [5] met some problem. In [2], the author hasn't considered the encounter probability at all, and in [5], although a probability calculation is computed, the whole process continues under a big assumption. But in this paper, we consider that the besieging method which solves the encounter possibility problem, while the process need not lots of assumptions.

The performance will have to be of great significance.

VIII. CONCLUSION

In this paper, we utilize the roadside APs to spread the information quickly at first and leaving the work of calculating the possibility of encountering the destination vehicle node saves a lot of resources. And the feedback information about the successful reception of the packets at the destination vehicle node can be given to the APs after all the packets have been transferred either by the destination node or the last intermediate node. The model saves the cost of the vehicle node, and has a relatively high efficiency. Further work should be done about the performance evaluation.

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