An Approach to Extended Drive Thru Access to Internet in Multihomed Vanets

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ABSTRACT

Internet access is a major issue to be considered for many commercial enterprises. Multi-homing is an area under Mobile Ad Hoc Network (MANET) that grants host connectivity to the Internet. To achieve this, each mobile network node must forward traffic unrelated to its own use. Load balancing is one of the challenging issues in multi-homing. Load balancing is the technique for evenly distributing traffic across all available lines, thus utilizing the bandwidth effectively. This paper proposes a strategy to enhance the data rate, for both incoming and outgoing packets, through load balancing in Vehicular Ad hoc networks (VANET). The paper theoretically checks for applicability of our strategy in different scenarios. The strategy defines a set of access points, which can connect to one or more mobile devices. The request and response, from Internet, to this mobile device will depend on a server which is directly connected to the routers. The details of this process are shown by considering different cases. The performance of solution is verified by simulation studies.

KEYWORDS

MANET, multi-homing, Internet, AL-Server, BFS, VANET, OSPF

1. INTRODUCTION

A Vehicular Ad-Hoc Network, or VANET, is a form of Mobile ad-hoc network, to provide communications among nearby vehicles and between vehicles and nearby fixed equipment. The main goal of VANET is providing safety and comfort for passengers. To this end a special electronic device will be placed inside each vehicle which will provide Ad-Hoc Network connectivity for the passengers. This network tends to operate without any infra-structure or legacy client and server communication. Each vehicle equipped with VANET device will be a node in the Ad-Hoc network and can receive and relay others messages through the wireless network.

Multi-homing is to provide constant access to the Internet and to enhance the overall connectivity of hosts. The key enabling technology for this revolution is multi-homing load balancing, which spreads an enterprise’s Internet traffic among multiple access links to increase the aggregate throughput, and diverts traffic away from non-functional links when they fail. In multi-homing environments, Mobile Routers often suffer from scarce bandwidth, frequent link failures and limited coverage. Hence, there is need to utilize the bandwidth effectively.

There are three major issues to be considered in multi-homing, namely Load balancing, Fail-over and Quality of service. These issues affect the throughput of incoming packets as well as outgoing packets.

Load balancing is a technique to distribute workload evenly across two or more computers, network links, CPUs, hard drives, or other resources, in order to get optimal resource utilization, maximize throughput, minimize response time, and avoid overload. Using multiple components with load balancing, instead of a single component, may increase reliability through redundancy. The load balancing service is usually provided by a dedicated program or hardware device.

This paper proposes a Load balancing strategy in multi-homed VANET (Vehicular Ad hoc Network). The idea starts with a server which maintains an adjacency list data structure. This adjacency list contains the Mobile Network Nodes as entities in it. Adjacency list will describe the paths through which packets can go to Internet and enter the network back. Thus the server only needs to keep track as to what amount of traffic ratio should be divided on each link. Each mobile router will query the server for appropriate paths that packets can take and at the same time utilizing all the bandwidth available on all lines.

Another variation to this scheme can be that each router to maintain adjacency list but in that case whenever a mobile network node gets disconnected, each and every router has to perform a delete operation for that node which increases the processing on each router which may in turn increase delay. These Adjacency list data structure is efficient when compared to Trees data structure with regard to the number of operations that has to be performed whenever the mobile network node gets connected and disconnected.

[1] Explain that the multi-homing technique of SCTP did not contribute to the performance improvement because of the unstable routes in MANET. For the purpose of taking advantage of SCTP multi-homing techniques, we need more efficient protocols to adapt it for MANET.[2] defines methods to management of address of the wireless mobile nodes in an environment. [3] Says different ways in which different mobile nodes can be configured. [5] Presents ExOR, an integrated routing and MAC protocol for multi-hop wireless networks in which the best of multiple receivers forwards each packet. [6] Proposed to replace default routes with explicit tunneling between the source node and the gateway. This requires that the source node explicitly discovers available gateways. [7] Describes a new scheme belonging to ‘Traffic’ based type, it can distribute Traffic load evenly among nodes in the ad hoc
network. [8] Analyzes both customer satisfaction and service providers. An intelligent technique proposed forwards packets via suitable network interface to satisfy both customer and service provider. [9] Propose to load balance the incoming traffic of a stub access network by keeping the link utilizations in proportion to their available bandwidth. The scheme ensures that utilizations of the links are fairly balanced even if the measurement of bandwidth metrics is approximate. [10] Firstly contributes comprehensive analysis of the design space of multi-homing load balancing systems and, secondly contributes to present the first quantitative measurements to evaluate the effectiveness of various design decisions of load balancing algorithms.

As a result the maintenance of the server in the multi-homed scenario proves to be very efficient for increasing the throughput through load balancing in the multi-homed VANET. The rest of this paper is organized as follows. Section 2 gives a brief description of adjacency list and it working mechanism on graphs. In section 3, we explain the theoretical aspects of the proposed mechanism. Section 4 evaluates the performance of the proposed mechanism. Section 5 deals with the conclusion part.

2. ADJACENCY LIST AND ITS WORKING

In graph theory, an adjacency list is the representation of all edges or arcs in a graph as a list. If the graph is undirected, every entry is a set of two nodes containing the two ends of the corresponding edge; if it is directed, every entry is a tuple of two nodes, one denoting the source node and the other denoting the destination node of the corresponding arc. Typically, adjacency lists are unordered. The adjacency list representation of the graph is shown above. In computer science, an adjacency list is a closely related data structure for representing graphs. In an adjacency list representation, we keep, for each vertex in the graph, all other vertices which it has an edge to that vertex is inserted in adjacency list for that vertex. To complete the structure, each edge must point back to the two vertices forming its endpoints. The adjacency list algorithm uses breadth-first search to find the adjacent nodes. The algorithm for adjacency list is as follows.

(1) Initialize the cells.
(2) Repeat through step 4 until the end of the linked list.
(3) Perform a BFS on the initial node to find the adjacent nodes
(4) Insert the adjacent elements in the linked list of the appropriate cell.
(5) Combine all the cells to form a bucket.
(6) Stop.

In graph theory, breadth-first search (BFS) is a graph search algorithm that begins at the root node and explores all the neighboring nodes. Then for each of those nearest nodes, it explores their unexplored neighbor nodes, and so on, until it finds the goal. BFS is an uninformed search method that aims to expand and examine all nodes of a graph or combination of sequences by systematically searching through every solution. In other words, it exhaustively searches the entire graph or sequence without considering the goal until it finds it. The algorithm of BFS in turn uses a queue to find and store the adjacent elements in the adjacency list. Here we assume to call the left most vertical column as bucket and each element in bucket is called cell. Associated horizontal list with each element is called a link.

3. THEORITICAL ASPECTS OF PROPOSED WORK

Address auto-configuration in MANET is a vital technique which allows a mobile node to have a unique address. However, most of the auto-configuration techniques proposed assume a single network interface (that is, single-homing) [2, 3], which are not suitable for auto-configuration solutions with multiple network interface (that is, multi-homing). Additionally during resolving address conflict due to network connection and disconnection with the mobile systems, much overhead of exchanged control traffic occurs. This overhead is avoided using SCTP (Stream Control Transmission protocol) by assigning all the mobile nodes multiple Ipv4 addresses [1]. Initial acquisition of multiple addresses is performed as described in [1]. During this process, the joining mobile nodes requests its ipv4 addresses from the access point (router) by sending an Address Request message to access point. The access point itself creates a pool of available addresses and assigns addresses to the mobile nodes [1].

In addition to using default routes for outgoing packets, a mechanism is required to ensure that return traffic from the Internet gets routed back to the appropriate vehicle. In this context different cases are considered to prove the efficiency of the strategy proposed.
Fig.2 Mobile nodes connecting to the access points
As shown in the Fig. 2, the mobile devices connect to the access points and acquire ipv4 addresses as described in [1]. The access points are interconnected and also connected to AL-server (Adjacency List server). The AL-server consists of the adjacency list of all the access points, routers and the mobile devices which are connecting to each access point. In order to compute the elements of the adjacency list, the DFS algorithm is applied only to the access point and adjacency to access points is detected by examining the routing table of each access point. The directly connected routes, in the routing table of each access point, shows that a particular mobile device is currently connected to that access point. These directly connected routes are added to the adjacency list in the AL-server. The mobile devices are appended on a FCFS (First Come First Serve) basis in the adjacency list. The adjacency list for Fig. 2 is shown below in Fig. 3.

![Adjacent Network Diagram](image1)

Fig.3  Adjacency list at AL-Server

The adjacency list in the AL-server consists of router Ids, which are the loop-back address of the router. Each loop-back address will be present in the bucket (which is the very first vertical column in the diagram of adjacency list). The concept of loop-back addresses can be seen in OSPF (open shortest path first) routing in wired networks [11].

The horizontal list (that is the linked list following each cell in the bucket) will consist of the neighbors of the access points and the ipv4 addresses of the mobile nodes, which are present as directly connected in each access point’s routing table.

Each access point notifies the server about its status, i.e. dead or alive, by sending hello packets every second. This is to avoid fail over in the network. Once a router (access point) fails, the server deletes the cell from the bucket and the corresponding linked list as well.

Fig.4 Node C moves from the proximity of access-point A to the proximity of access-point B.

The above figure shows the case when the mobile node C moves from proximity of access point A to proximity of access point B. Since the node moves out of the area of access point A, the mobile node C loses its connection with access point A and connects to access point B. During this process, if mobile node C sends a request to Internet and is waiting for a response, normally the access point A would drop the reply packet coming from Internet, since the mobile node C got disconnected.

If the proposed strategy is applied, the loss of reply packet to mobile node C can be avoided. When the mobile node C gets disconnected from access point A, the access point A updates its routing table and also sends an update of its routing table to the AL-server. The AL-server performs a search process on its adjacency list and deletes the element, which is the ipv4 address of the mobile node C.

Now access point B comes into picture. The mobile node C connects to the access point B, since it entered the proximity of access point B. The access point B again goes through the entire ipv4 address assignment on mobile node C, and adds a directly connected route to mobile node C in its routing table, thus, updating its routing table. Since both the access points share the same pool of available ipv4 addresses, the mobile node C gets the same ipv4 address, which it had previously, when it was connected to access point A. Similar update is sent to the AL-server. The AL-server performs append operation, in its adjacency list, in the appropriate cell of the bucket. Therefore, the resulting adjacency list is shown below.

![Updated Adjacency List Diagram](image2)

Fig.5 Updated adjacency list when Node C moves to Access point A

Thus, the reply packets, which were previously sent to access point A, are sent to access point B, after access point A queries the AL-server for the path the reply packets should take. Hence the loss of incoming traffic from Internet can be avoided to a great extent.

Another variation to the above mentioned mechanism is to remove the server from the scenarios and the access points (routers) will do the processing. All the procedures mentioned above occur in the same way in this variation as well. The advantage of this variation is the cost reduction, which was a disadvantage in the above mechanism due to the establishment and maintenance of a server in the scenario. The network diagram for the variation on Fig. 2 is shown below in Fig. 6.
The access points, on the other hand, will perform processing on the adjacency list and route the incoming packets, from Internet, to appropriate destinations. This will make the access points update each other of any topology changes that occur in the network, thus, increasing the traffic between access points, which may reduce the flow of incoming packets from Internet to mobile devices. This disadvantage leads us to the establishment of the server in the above proposed mechanism.

Fig. 6: Alternative measure to proposed mechanism

4. PERFORMANCE EVALUATION
The previous section described briefly about the working and application of adjacency list in VANETs. This section evaluates the usefulness and efficiency of proposed mechanism. For ease of implementation, variation to the proposed mechanism is implemented. Ad hoc On-Demand Distance Vector routing protocol (AODV) is used in our study through Qualnet simulation version 4.5 and its 802.11 radios. The algorithm of adjacency list is incorporated within the protocol and performance is evaluated. The vehicles are equipped with wireless interfaces which corresponds to the access points on the road way. Our simulation study has selected the packet-size of 512 bytes. The simulation will run for 30 seconds.

4.1. SIMULATION SETUP
The simulation topology consists of two to three vehicles each equipped with a wireless interface and two internal gateways operating on same channel. Traffic is sent and received between internet located correspondent node and wireless interface using Constant Bit Rate (CBR). The mobility of vehicles is set in such a way that the performance of proposed mechanism is best evaluated. One vehicle (V1) will follow a straight path from one access point to another and the other vehicle (V2) will follow a zigzag path. V1 will be always in the proximity of the either of the access points and starts its path from access point A. V2, initially, will be in the proximity of the access point B and as the scenario runs, V2 will move out of the proximity of access point B and communicates with V1. After a while, V2 enters the proximity of access point A and communicates through access point A. Another vehicle (V3) with the different path as that of V1 and V2 is added to the scenario. The vehicle V3 will remain out of the proximity of either of the routers but will communicate through the other vehicles (vehicle V1 and vehicle V2). Another vehicle V4 is added whose path will be same as vehicle V3 but at a farther distance from the access points. Thus, the results of simulation for four vehicles are evaluated.

As expected, the throughput of the modified AODV protocol is more efficient that the typical AODV protocol. The following graphs represent the packets sent and received status of the internet nodes and the vehicles. The rise and fall that occurred in the graph due to the modifications in the AODV protocol can be seen below. Hence, the vehicles sending and receiving of packets are high for the modified AODV protocol when compared to the typical AODV protocol.

Fig. 7: Comparison of Overall throughput for modified AODV and typical AODV protocol
5. CONCLUSION
In this paper, we proposed a mechanism for efficient load balancing in a multi-homed VANET. In addition to using default routes for outgoing packets, a mechanism is required to ensure that return traffic from the Internet gets routed back to the VANET. Moreover, the packets should be routed back to the correct mobile device. The mechanism, in this paper, speaks of a server which does the entire load balancing in the network. The server directly connects to the access points and these access points are interconnected. The algorithms of adjacency list are introduced which are implemented in the AL-server. After, initial connection establishment mechanism is described which is followed by the strategy to avoid incoming packet loss. The paper also gives another variation to the proposed strategy and finds the advantage of it over typical AODV protocol. The paper, finally, by evaluating the performance of the proposed mechanism and comparing the performance with the performance of typical AODV protocol.

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