Wireless Pers Commun (2015) 85:1987–2001
DOI 10.1007/s11277-015-2886-0

WVANET: Modelling a Novel Web Based Communication Architecture for Vehicular Network

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Published online: 21 July 2015

Abstract Vehicular Ad hoc Network (VANET) is considered as most emerging technology for the past decade of years. Research in VANET brings up new communication architecture for reliable communication. This paper proposes a novel communication architecture for vehicular ad hoc network. In the proposed architecture VANET and web technology are integrated together to form Web VANET architecture known as WVANET. WiMAX is fixed at the roadsides to transfer the web signals to vehicles and Extensible Messaging and Presence Protocol is used to transfer and receive messages among the vehicles. The proposed communication architecture is modelled and better communication performance is obtained. The web communication architecture in VANET reduces the overheads existing in the previous communication models. Message transmission is very fast in WVANET, since web technology is integrated. Overall, the proposed communication model is reliable and fast than the other communication models exist in VANET.

Keywords WVANET · VANET · Web · PVNC · OBU · RSU · Ad hoc · XMPP · XML · WiMAX

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1 Introduction

Emerging technologies for the past decade of years are Vehicular Ad Hoc Network (VANET) and Web technology. Considering the first, various research development on MANET found the advanced Ad hoc network known as Vehicular Ad hoc network [1–3]. In MANET, the mobility position of each node will be at random movements, whereas the mobility position of vehicular network will be within the given topology [4]. Each vehicle is considered as mobile node in vehicular Ad hoc network and the mobility speed of each node is very high compared to MANET nodes [5–9]. Each vehicle consists of On Board Unit (OBU), which is capable of transmitting and receiving messages for establishing network communication [10–12]. Transmission of messages among the vehicles can be done with the help of protocols, the same as that of used in MANET can be used in VANET architecture [13, 14]. This vehicular communication model is very much needed to ensure the safety of passengers.

Considering the second technology is used to form the communication among electronic devices by World Wide Web [15]. Web service communication is formed among the electronic devices with the network address to access the service over World Wide Web [15]. The various research carried out on web technology laid the foundation for the development of web 2.0 [16–18]. The development on Information Technology (IT) made wireless communication available anywhere and anytime to transfer messages [19]. This web technology made the communication quite simple and it is possible from anywhere. Transmission of messages from one location to another location can be done within a fraction of time [23].

In this paper, these two emerging technologies are used and a new web based vehicular network communication architecture is created. When web technology is integrated in vehicular ad hoc network architecture, this will be the cheapest communication model.

2 Related Work

The past decade of years, research in vehicular network has been carried out in the following communication models:

- Roadside Unit Communication
- Car to Car Communication
- Cluster based Communication

2.1 Roadside Unit Communication

Earlier research in vehicular network was implemented by establishing Roadside Units to communicate with the vehicles [20, 21]. In this communication model antenna is fixed at the side of the roads and signal is propagated from it [20]. The vehicles that pass on the way receive signals from the roadside unit and the communication is carried out. All the vehicles are connected to the nearby roadside unit and all the roadside units are interconnected to form the vehicular network architecture. However, this communication model is not flexible enough, since the range of the signal is very low and large number of Roadside units are needed to establish a good communication. Hence, a new communication model is needed ultimately.

2.1.1 *Drawbacks of Roadside Unit Communication*

- Communication is only possible through RSU.
- Many number of RSUs are needed to establish a fair communication among nodes.
- Fixing of RSUs are very expensive.
- Nodes away from the RSU cannot communicate.
- Message transmission takes more time as message is transmitted through RSU.

2.2 Car to Car Communication

Researchers considered the limitations of Roadside Unit communication model and established a new communication model known as Car to Car Communication model. In this new communication model each vehicle is equipped with On Board Unit (OBU), which functions to send and receive messages among vehicles [21, 22]. This communication model is much better than the Roadside Unit communication model. In car to car communication model each vehicle acts as a router to communicate the information from one vehicle to another vehicle. However, this communication model was not suitable for transmission of messages. This communication model is similar to multi hop communication model that is transmission is possible with many intermediate vehicles. In this network scenario if anyone of the vehicle's on board unit gets failed, the entire communication will be collapsed. In car to car communication model, transmission of messages took a lot of time due to multi hop communication.

2.2.1 *Drawbacks of Car to Car communication*

- Communication is possible only through intermediate vehicles.
- As message is transmitted through intermediate vehicles, message transmission time is high
- Intermediate vehicle cannot be trusted
- Intermediate vehicle can change or duplicate the data.
- Weak security.

2.3 Cluster Based Communication

Researcher introduced a novel communication architecture known as Cluster based communication to overcome the delay that persists in Car to Car network model [21]. This novel communication procedure eliminates the entire vehicular network failure due to the failure of any one of the vehicles' on board unit [21]. In this Cluster based communication model, vehicles within the cluster range are grouped and one vehicle is elected as the cluster head [21]. Similarly many cluster groups are created based on the density of the vehicles [21]. All the cluster heads are interconnected, so that messages from one cluster group to another cluster group can be sent through cluster heads by eliminating multi hop communication environment [21]. Hence, this communication model reduces the delay and produces better communication performance than the other communication scenarios. However, this communication model maintains separate database for each cluster head, which occupies more memory space by storing the redundant data and cluster creation, cluster head election and cluster head switching procedure's overheads are high.

2.3.1 Drawbacks of Cluster Based Communication

- Redundant data is stored in all the Cluster Heads
- Inefficient Memory utilization.
- Message between two neighboring vehicles can be sent through cluster head, which takes more time to transfer the message.
- Cluster heads communication link can be broken due to long distances.
- Cluster Head Election and Head Switching overheads are high.

A novel communication model is needed obviously to establish a fair communication in vehicular network. This research paper considered VANET communication as the research parameter and established a novel communication model by incorporating the web technology in vehicular ad hoc network.

3 Architecture of WVANET

A novel communication model is represented in Fig. 1 to overcome the limitations present in the previous communication models. The proposed communication model makes use of the WiMAX technology to establish network communication among the vehicles. The range of the WiMAX technology will be miles of distance, hence a single tower could be used for long distance. All the vehicles that move on the road will get the communication

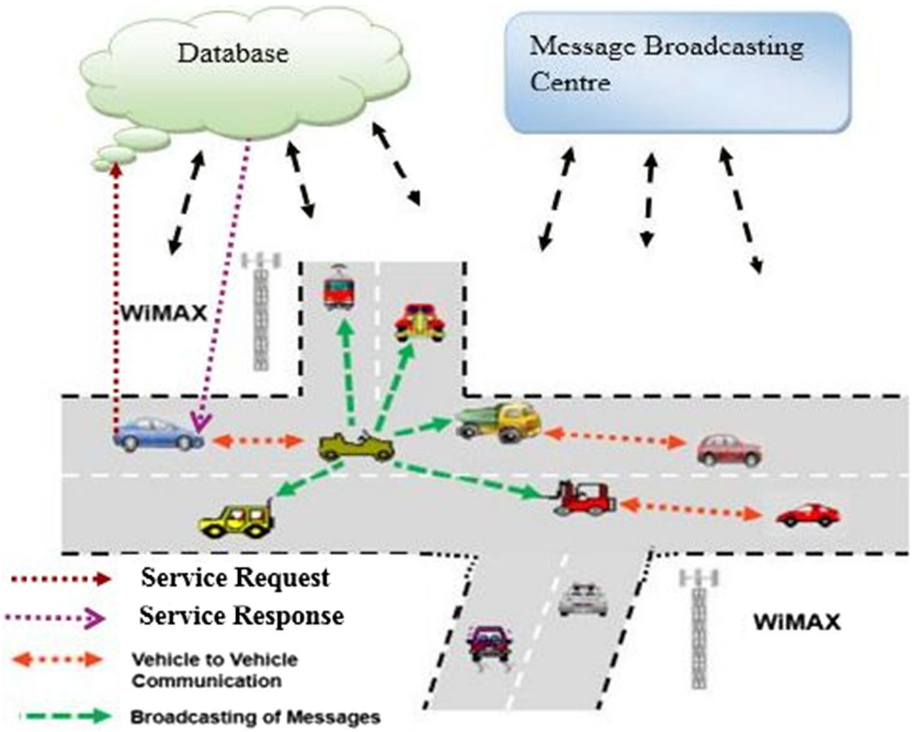

Fig. 1 WVANET architecture

signal strength from the WiMAX towers that is available on the roadsides. Once the vehicle receives the signal, the vehicle is connected to the internet. Similarly, when all the vehicles are connected to the internet, the communication is possible with other vehicles. In the proposed communication model the following types of communications are possible:

- Car to Car Communication
- Broadcasting of messages from a vehicle to other vehicles
- Service Discovery

Car to Car communication is the process of exchanging messages between two vehicles and this communication is similar to P2P communication. In this communication scenario, any one vehicle can exchange the message with any other vehicle.

Another type of communication is broadcasting of messages from a vehicle to other vehicles. This type of message broadcasting is needed especially during emergency situations. At the time of accident or any other emergency situation a message needs to be sent to all the other vehicles that are passing on the way. Hence, broadcasting of message service is needed to provide better vehicular network communication. Service Discovery is the process of vehicle requests for a service to the server and server will send the requested service information to the vehicle.

3.1 Modeling of Web VANET (WVANET)

In the proposed Web VANET (WVANET) architecture, all the vehicles must be manufactured with WiMAX receiver and GPS device. The WiMAX receiver is used to establish vehicular network communication to exchange messages with one another. As we know, the coverage of WiMAX will be miles of distance, hence this could be a perfect device for vehicular communication as vehicles move at high speed in the road. The WiMAX towers available at the side of the roads will generate the signals, which will be received by the WiMAX receivers available in the vehicles for comfortable communication among the vehicles. The Global Positioning System (GPS) plays a vital role in WVANET communication. It has been proposed that each vehicle should have the GPS device to identify its current location. As web communication is proposed in this paper, the vehicles should know the nearest passing vehicles to communicate with it. The current location of all the vehicle is known by the GPS device and based on the location statistics, communication panel of each vehicle will list out the nearest vehicles. Once the nearest vehicles are listed out in the communication panel, the communication can be made to those vehicles. The listing of nearest vehicles status will be updated in a periodical time based on the data obtained from the GPS device. The detailed working flow of the model is described in the following sections. As web service communication is used in vehicular network, the same technology used in web service environment to store the data can be used separately for WVANET. The following thing must be noticed that the proposed WVAET communication is a Private Vehicular Network Communication (PVNC). That is, the communication is possible among vehicles through the device, which is manufactured in the vehicles. Other users from outside such as mobile user or laptop user or any other smart device user cannot connect and communicate in WVANET communication. This WVANET communication is set as Private Vehicular Network Communication (PVNC) to provide secure communication.

4 Implementation

The proposed Web VANET (WVANET) communication architecture has been implemented to execute the Car to Car Communication, Broadcasting of messages among vehicles and Service discovery. The implementation phase is executed with the Extensible Messaging and Presence Protocol (XMPP), which is developed by using Extensible Markup Language (XML). The detailed description is given in the following sections.

4.1 Protocol Description

In any network architecture usage of protocol is must to transport and receive messages from a host to another host. In the proposed architecture web based communication model is implemented in vehicular network. Hence, a web based protocol much needed to deliver the messages among the vehicles. The most popular protocol used in web based applications to deliver the message is Extensible Messaging and Presence Protocol (XMPP). This XMPP is developed by using Extensible Markup Language (XML) and this protocol is used to deliver the message and to detect the online presence of a user. This protocol allows internet users to send instant messages to any other user in the internet regardless of the operating system and browser used. In the proposed architecture web communication is implemented and it is obvious that web communication is nothing but sending instant message to other user, who is online. Vehicular communication is experimented in this paper using the XMPP protocol.

4.2 Car to Car Communication in Web VANET (WVANET)

The first metric of the proposed architecture is car to car communication. In this network architecture each car receives the web coverage from the WiMax towers, which are fixed at the roadsides. As discussed above all the vehicles are equipped with GPS device to track

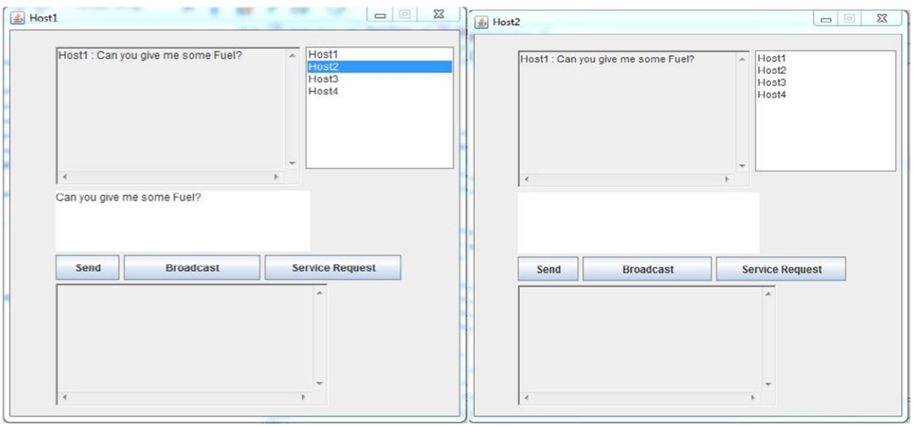

Fig. 2 Car to Car communication in WVANET

the current location of the vehicle. Once the current location of the vehicle is identified, then all the nearer vehicles are listed out in the communication panel of the corresponding vehicles.

Car to car communication model is illustrated in Fig. 2. As depicted in Fig. 2 Host 1 has all the nearer vehicle's list obtained through the GPS device and from the communication panel user can choose any other vehicle to communicate with each other. The Fig. 2 represents that Host 1 sends a message to Host 2 and the message is received at the other end. Similarly the Host 2 user can reply back to the Host 1 user. The online message transmission is done through the protocol XMPP. The proposed web communication model yields to another added advantage that the end user will come to know the delivery status of the message and message reading status. The user list displayed on the communication panel will be updated based of the location obtained from GPS device in a periodical time.

```
Car_to_car_Communication ()
Begin
    Presence_of_Vehicle ()
    Begin
           <presence>
                 <show> available</show>
                 <status> Driving </status>
                 <priority> 1 </priority>
           </presence>
           <iq from ='vehicle@vanet.net' type='get'
id='roster_1'>
                <query xmlns = 'jabber : iq:roster'/>
           </iq>
           <iq to= 'vehicle@vanet.net' type='result' id=
'roster_1'>
                 <query xmlns = 'jabber:iq:roster'>
                 <item jid = 'vehicle_1@vanet.net'
                 name='Host1' subscription= 'both'>
                 <group> PVNC</group>
                 </item>
                 </query>
           </iq>
    End
Communication (Vehicle, Vehicle 1)
   Begin
           <message xml:lang='en'
                 to='vehicle@vanet.net'
                 from='Vehicle_1@vanet.net'
                 type='chat'>
                 <body>Can you rent me some fuel?</body>
           </message
   End
End
```

Algorithm 1 Car to Car Communication in WVANET

The Algorithm 1 illustrates how car to car communication is established in the proposed web based communication model using XMPP. When the vehicle start moving, it should state its online presence to sever. So that particular vehicle is identified that it is active for network communication. The presence state of vehicles can be achieved by the code included in the <presence> and </presence> tags as shown in the Algorithm 1. Once each vehicle becomes available in the web based communication, it should request for the roster (contact list) to the server. As soon as the request is received at the server end, the server will send the roster list to the particular vehicle. The requisition and receiving of roster list can be achieved by the codes included within the <iq> and </iq> tags as represented in Algorithm 1. Once the roster list is updated based on the current location of the vehicle, then the vehicle can communicate to any other vehicle at any time. In XMPP the <message> and </message> tags contain the message, which is to be transferred to the intended vehicle. This tag consists of "to", "from", "type", and "body" attributes. The "to" has the receiver vehicle's address, "from" identifies who has sent the message to the particular vehicle, "type" shows the type of communication that is, "chat" of "group chat". This "chat" values is used for car to car communication, whereas the "group chat" is used for message broadcasting. Finally the "body" tag contains the message to be sent to the intended vehicle.

4.3 Broadcasting of Messages in Web VANET (WVANET)

Broadcasting of messages is an important metric of vehicular network communication. This service is certainly needed to pass the message to all the vehicles in around of a particular place especially during the emergency situations such as road block, accidents and so on. The proposed web based architecture do support to the broadcasting a single message to all the vehicles. When an emergency message is received at the broadcasting message Centre, automatically that particular message is routed to all the vehicles that are travelling in the same location after verifying the message. The location of the vehicle that broadcast the message can be come to know through GPS device. Once the location is identified, the message will be delivered to all the vehicles that are moving in and around of the particular place.

Broadcasting of Message service shown in the Fig. 3 which represents how a single emergency message is routed to all the four vehicles that are moving in the same location. This message broadcasting service is under the control of message broadcasting Centre. When a message broadcast request is received at the message broadcasting Centre, the message is verified for its trustworthy by enquiring the truthfulness of the message to other vehicles that are moving in the same location. Once the message is verified, the message is routed to all the vehicles that move on the particular location.

```
Message_Broadcasting ()
Begin
    Presence_of_Vehicle ()
    Begin
           <presence>
                 <show> available</show>
                 <status> Driving </status>
                 <priority> 1 </priority>
           </presence>
           <iq from ='vehicle@vanet.net' type='get'
id='roster_1'>
                <query xmlns = 'jabber : iq:roster'/>
           </iq>
           <iq to= 'vehicle@vanet.net' type='result' id=
'roster_1'>
                 <query xmlns = 'jabber:iq:roster'>
                 <item jid = 'vehicle_1@vanet.net'
                 name='Host1' subscription= 'both'>
                 <group> PVNC</group>
                 </item>
                 </query>
           </iq>
    End
Broadcasting (Vehicle, Message)
   Begin
           Message_Broadcasting_Centre ()
           Begin
           <message xml:lang='en'
                  to='Broadcasting_Server@vanet.net'
                  from='Vehicle@vanet.net'
                  type='groupchat'>
                  <body>Road block ahead at 5km</body>
           </message
           Query the message incident to all the nearby
           vehicles
           If (message is trust worthy) then
                 Track all the vehicles on the particular
           location
           <message xml:lang='en'
                  to='all the vehicles tracked on the particular
           location'
                  from='Broadcasting_Server@vanet.net'
                  type='groupchat'>
                  <body>Road block ahead at 5km</body>
           </message
           End if
           End
```

Algorithm 2 Message Broadcasting in WVANET

Message broadcasting service of the proposed web based communication model is illustrated in the Algorithm 2. Online presence of a vehicle must be activated in order send and receive messages among vehicles. This presence status can be activated through the <presence> and </presence> tags as represented in the Algorithm 2. Once a vehicle become online in the communication environment, it should obtain the roster (contact list to send and receive the messages) from the server. Particular vehicle must request to the server for the roster list and once a request is received at the server, the server will send the roster list to the particular vehicle. This scenario of updating the roster information can be obtained with the help of the <iq> and </iq> tags. Once the roster list is received, then the vehicle can communicate with the other vehicles as needed.

However, certain times it may be necessary to broadcast a single message to all the nearby vehicles during emergency situations. This message broadcast service is taken care by the message broadcasting Centre. As depicted in the Algorithm 2, the particular vehicle that would like to broadcast the message sends the broadcasting message to the broadcasting server. Once the message is received, the broadcasting server evaluates the message trustworthy. The message is evaluated by querying the truthfulness of the message to the other vehicles that are passing on the particular location. Once the message is verified, the message is routed to all the vehicles that are moving on the particular location. If the received the message is false, the message is dropped and the particular message is not broadcasted.

4.4 Service Discovery

Service Discovery is process of requesting for a service and get the response back from the server for the service requested. In the WVANET architecture car to car communication is established to communicate with other vehicles. Similarly broadcasting of a single message to all the vehicles also implemented. Service discovery is another useful and important metric in vehicular communication. That is, while a vehicle move, it may be in need of a service such as next petrol station, restaurant and hotels and so on.

In Web VANET (WVANET) architecture separate database is maintained to store the messages received from the vehicles and other service information received. When a vehicle request for a service, the requested service information is searched in the database based on the current location of the vehicle obtained through GPS. Once the requested information is available in the database the requested service information is sent to the vehicle. If the requested information is not available in the database, service not available at present information is sent to the vehicle. The following Algorithm 3 illustrates the service discovery working flow in WVANET architecture.

Service discovery process plays a vital role in WVANET communication architecture. The proposed Algorithm 3 represents how the service discovery process in carried out in WVANET architecture. As shown in the algorithm, the vehicle that needs a service sends the details to the server. Once the message is received at the server, it checks for the availability of the service in the server database. If the requested service is available, the server fetches at most five service information from the server database. After fetching all the service information, the server checks for the present location of the vehicle. It might be possible, that the vehicle might have crossed one or two of the retrieved service information's location. Hence, the present location is matched with the retrieved service information. All the service information that has been crossed by the vehicle among the fetched five service information are dropped and the remaining service information is updated to the vehicle that requested for the service. If the requested service information is not available at the server database, the service not available information is communicated to the vehicle. As illustrated in the Algorithm 3 the service discovery process works and send the service information to the requester in an efficient manner.

```
Service_Discovery ()
Begin
Service_Processing (Vehicle, Service)
   Begin
      <message xml:lang='en'
         to='server@vanet.net'
         from='Vehicle@vanet.net'
         type='chat'>
         <body>Where is the next fuel station?</body>
   </message
         Track the location of the vehicle
         Search the service in the server database
    While (service is available)
    Begin
         Retrieve the five service information and its
         distance
         Query the present location of the vehicle
 If (vehicle crossed any the of the retrieved service details)
Then
         Drop the crossed service information details
         Send the remaining service details to the vehicle
         <message xml:lang='en'
           to='vehicle@vanet.net'
           from='server@vanet.net'
           type='chat'>
           <body>HP at 5 Km, Bharat at 8 km, Indian oil
     at 15 km</body>
     </message>
    End if
    End
    If (service information not available) Then
         <message xml:lang='en'
            to='vehicle@vanet.net'
            from='server@vanet.net'
            type='chat'>
            <body>Requested Service information not
      available</body>
      </message>
   End if
   End
End
```

Algorithm 3 Service Discovery Process in WVANET

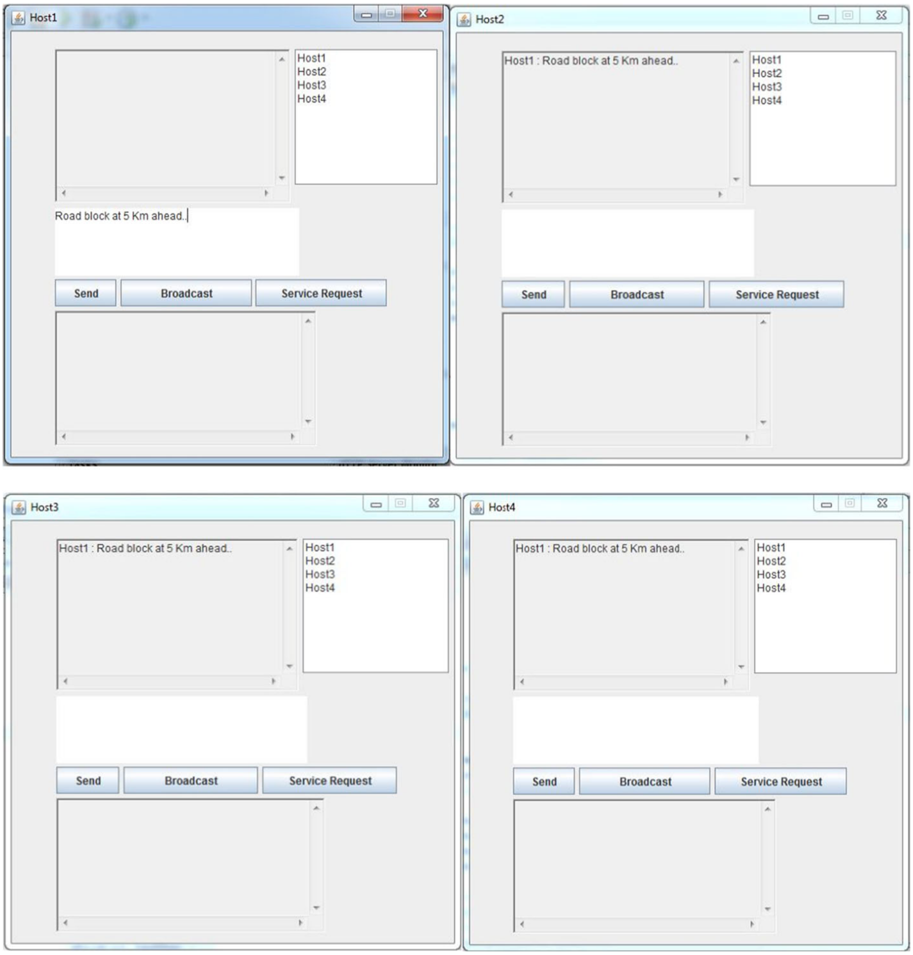

Fig. 3 Broadcasting of messages in WVANET

5 Conclusion and Future Work

Vehicular Ad hoc Network (VANET) communication is a prominent research field, in which communication is carried out the through radio frequency signals. In Roadside Unit Communication model, communication is possible only through Roadside Unit. Entire communication is processed and controlled by the Roadside Unit. In this approach processing of large set of data is quite difficult and it will slow down the communication process when multiple requests are received. Similarly, Car to Car communication model makes use of intermediate vehicles as router to transmit the messages to the corresponding destination. This communication approach is a multi-hop communication that is communication is not possible without intermediate vehicles. If anyone of the intermediate vehicle becomes malicious node that will collapse the entire communication. On the other hand, Cluster based communication model somewhat reduces the multi-hop communication by introducing cluster head. In this approach, if anyone of the cluster head becomes malicious node that will collapse the entire communication and also if the cluster head gets failure then the entire nodes within that cluster cannot communicate with one another. Similarly same data is stored in all the cluster heads which increases the database redundancy. As radio frequency is used in all the previous discussed communication models link disconnection may occur often and processing of large set of data is quite difficult.

In order to improve the communication performance, Web based communication model is proposed in this paper. In the proposed web based communication model web technology is integrated with vehicular ad hoc network to form a novel communication architecture known as Web VANET (WVANET). When web based communication architecture is implemented in vehicular ad hoc network, all vehicles will be connected with the internet technology. Since all the vehicles are connected in the web, link disconnection among the vehicles can be avoided. Message transmission among vehicles can be transmitted within a fraction of time, as web technology is integrated in Vehicular ad hoc network. Emergency message broadcasting is one of the crucial applications of VANET. In the proposed Web VANET (WVANET) emergency message can be disseminated as quick as possible to any number of vehicles within the network as web based communication model is implemented. Service discovery is yet another application where vehicles request for some kind of services and get the response back from the server. In the service discovery process large set of data needs to be processed. It is difficult to process huge amount of data in the previous communication models. In the proposed Web VANET (WVANET) large amount of data can be processed as quickly as possible. In addition to that other data which are available in the internet also can be used in Vehicular ad hoc network. Web communication model in VANET will increase the communication performance obviously. However, this proposed web VANET (WVANET) needs to be enhanced with various security parameters. As web communication is implemented in the proposed WVANET model, all the internet attacks are also possible in the Web VANET (WVANET).

Our future research work in the proposed WVANET model is to prevent the various web services attacks to enhance the reliable communication. Our next steps are to study and model a secure authentication procedures for authenticating the vehicles in Web VANET. We also plan to implement the security algorithms to prevent the hackers as well as worm propagation from the malicious node in the WVANET architecture.

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