Reduction of reaction time in Vehicular Networks using VANETs

Akshath S.K[1], Ajit R[2], Amogh M.P[3], Bharatraj DG[4], and Nandhini Vineeth[5]

Dept. of Computer Science and Engineering, BMS College of Engineering, Bangalore, India

IJASR 2021
VOLUME 4
ISSUE 5 SEPTEMBER – OCTBER **ISSN: 2581-7876**

Abstract: Intelligent Transport Systems (ITS) and Vehicular Ad-Hoc Networks (VANETs) help in the improvement of the overall travelling experience. They aid and assist the driver with the help of communication between the vehicles, providing high safety and being cost effective as well. One of the advantages of using these technologies is that they offer services to communicate between vehicles even without internet, unlike other traditional methods which use the internet extensively. We use these concepts of VANETs and ITS to provide a better solution to an emergency situation such as an accident. The work aims at notifying an ambulance, in case of an accident in the least possible time, using the vehicles in the way and ensuring that the ambulance reaches the accident spot in the least possible time through the shortest route. The ambulance can take the least possible time by notifying the vehicles on the shortest path of its arrival in an attempt to make way for the ambulance. The key parameter of interest in this work is the reduction of the end to end delay and to provide better results considering the existing standards.

Keywords: ITS - Intelligent Transport Systems, Routing Protocols AODV, VANETs - Vehicular Adhoc Networks, Image Recognition, Ambulance

INTRODUCTION

The technological advancements and the progress that go with it impacts various aspects of human life. While necessities brought up the initial development of any technology, excessive refining to improve the efficiency and satisfaction levels are also something to look into. Vehicles have moved from the stage where it was just a medium to transport people from point A to B, to become an essential and integral part of human life. Modern tools and techniques such as a vast array of sensors, data analysis, automation across various sectors in production. The immediate inference one can clearly visibly see is the Driver Aid Systems in Vehicles, Smart Pollution and Traffic Management systems that are in place today.

As with any domain the developments branch into its related subdomains along the way. The developments in the field of IOT and the technological developments in vehicles brought forth the new domain called the Internet of Vehicles or IOV in short. The domain has its own architectural stack, models and the associated challenges that go with it. The VANET and the associated architecture of VANETs is a byproduct of the technological advancements in this domain.

The ever-increasing statistics when it comes to accidents is a major concern. Agreed with technological advancements the risks associated with it also increases. There are active research and developments that go into the reduction of these problems with the aid of the cumulative technological advancements across various domains.

The main advantage when it comes to VANETs as compared to the existing 2G/3G/LTE networks is the fact that VANETs

offer more bandwidth, higher QOS, cheaper to implement and run.

One of the existing schemes which were looked into, termed as the Ambulance Traffic Control System basically monitors and controls the traffic lights at every intersection and turns them green whenever ambulance approaches. This helps the injured or patients to reach the hospital at the earliest [19,20].

We leveraged the various advantages possessed by VANETs to relay the information from the site of the accident to the ambulance. By which the ambulancetakes the least possible time by notifying the vehicles on the shortest path of its arrival in an attempt to reach the destination quickly.The key parameter of interest is the reduction of the end to end delay and to provide better results considering the existing standards.

LITERATURE STUDIES

As this work includes VANETs, AODV and DSR protocols for message dissemination and routing, Image Detection, a survey has been done on these topics.

ITS and VANETS

Technology and Innovation always finds a way out. Technological advancements aren't restricted to one domain in any case. Even with the plethora of advantages that the VANETs possesses, one can easily question the need of it with the presence of other technologies like Anti-lock braking system, Electronic Speed Control or any of the other innovations take place in the automotive industry on a day to day basis. To implement safety various data is exchanged across various agencies to improve the overall state. The key notion behind any development is to relay the information to the driver beforehand so one can easily take necessary actions.

Communication normally is influenced by various factors like the medium, the type and capacity of the medium in use and bandwidth to state a few. As we move away from the traditional communication and more into Vehicular communication, this brings up its own problems such as limited broadcast range, no stable fixed route to relay these messages and as with the case with anything, the developments can bring up its own problems like interference of electromagnetic signals, or attacks on the system.

There is always scope for improvement in any field, communication in VANETs possesses the following advantages- broad coverage area overall, very low latency, no power challenges and no service fees. But then it has the following shortcomings wherein there are continuous mobile nodes, changing topology, unstable networks. Various proposals have been stated to overcome these shortcomings such as integration of LTE and Cloud to provide better bandwidth, even lower noise than the existing systems.

VANETs normally work by using the Onboard Unit that has GPS, and computational capabilities inbuilt. There is also the presence of the Roadside Units which it can leverage for much effective communication, which basically helps in the overall scheme of effective traffic management. Some of the VANETs applications include Road Accident Prevention, Traffic management, infotainment etc.

PROTOCOLS

When we consider wireless communication there are two new and upcoming concepts which are predominant. Them being Cognitive Radio Networks that has entire information of the environment that allows communication between theusers and Vehicular Adhoc Networks that allow communication between moving vehicles.

As we are discussing about travelling and communication, both of which have similar core ideology wherein something moves from point A to B. There are fundamental operations that come into the picture such as decision making to choose the optimal route and when it comes to communications there is a variety of options such as the creation of the route, route maintenance etc. Thus, the routing protocols aid in the selection of the most optimal route for transmission of data.

There are different protocols that work on Routing in VANETs. There are seven such categories - Adhoc, geo-cast routing, delay tolerant, cluster-based etc. Ad-hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) are two of the most popular standard routing protocols. These are reactive routing protocols meaning they dynamically find the path as the destination is known.

AODV is based upon the Bellman-Ford algorithm. It uses sequence numbers to ensure there is no loop formation and to ensure the validity of the route. The fundamental operations are route discovery and route maintenance.DSR is a uniform reactive routing protocol, simple and very efficient, and is based on a method of source routing. The nodes are placed in a header of a packet and the route that the packet must follow from a source to a destination is fixed.The two fundamentaloperations are route discovery and route maintenance.

VANETs simulators are used to analyze their performance before using them in real-world scenarios.The observations indicate thatAODV outperforms DSR for our requirements.The parameters influencing the outcome were the area under consideration, packet delivery ratio,throughput, the number of nodes, average end to end delay, packet loss,mobility models, transmission range, routing overhead, packet loss and speed. DSR protocol was suited to small clusters.AODV has proven itself suitable to the city and the highway scenario.

Even with extensive research and developmentin the domain of VANETs, there is no way to ensure that emergency messages would reach the destination successfully while maintaining ideal parameters such as a low end to end delay, very high throughput and a high delivery ratio at one time.

IMAGE CAPTURING AND ANALYSIS

The camera on the dashboard of vehicles capturesimages and broadcasts it through a wireless channel. This helps the vehicle to recognize necessary data such as location, route and accident. This data is relayed onto the drivers of vehicles driving behind with optimal parameters into consideration

The image recognition can be implemented by either by training a new model to fit our requirements or to choose an existing model. Since a sophisticated accuracy is required to prevent false calls so we looked at various models that were pre-trained and has successfully known to give high levels of accuracy rather than building one and have it reach that level of accuracy.

Inception was trained against the ImageNet dataset and was compared with various other models. It's easy to train as the transfer learning part handles most of the important work like feature extraction from the original dataset and not against the custom dataset thrown at it, it was compared against VGGNet, BN-Inception, GoogLeNet and the PReLU and gave out 2.1% decrease in error percentage against the next closest competitor with respect to Top-1 error and a decrease of 1.32 % decrease in error percentage against the next closest competitor with respect to Top-5 error.

PROPOSED METHODOLOGY

This section describes about the architectural implementation, the modules implemented and the algorithm.

ARCHITECTURE OF THE SYSTEM

The following section describes the architectural and the various working schemas of the implemented system. The following section describes the following schemas:

- System architecture from the site of the accident to the ambulance.
- System architecture from the ambulance to the site of the accident.
- Sequence diagram of the system.
-

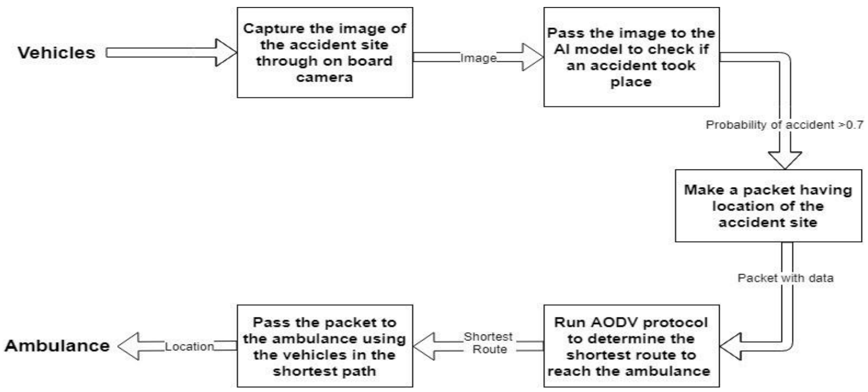


Figure 1. System Architecture of the Site of Accident to Ambulance

As depicted in the above image, The image of an accident is captured by a camera mounted on a nearby vehicle. This image is processed by an AI model which determines whether it is an accident or not. In case of an accident that is, when the probability of an accident is greater than 0.7 a packet is created which contains the location of the accident spot. AODV protocol is used to determine the shortest path to reach the ambulance. The packet is transmitted to the ambulance through vehicles in the shortest path where each vehicle acts as an independent node.

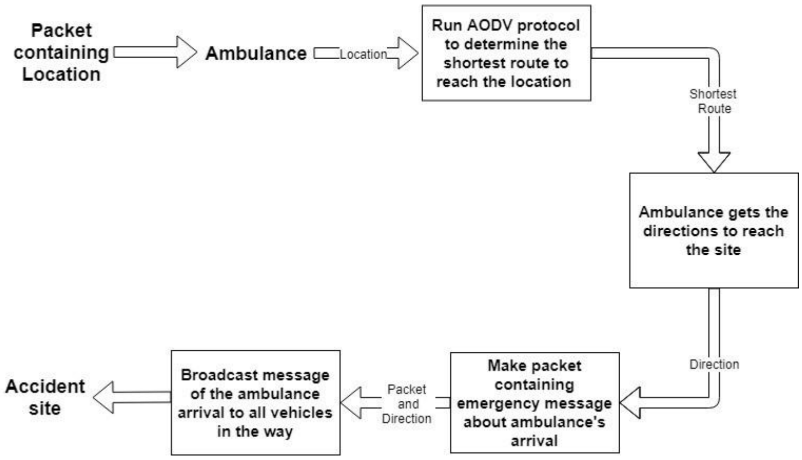


Figure 2. System Architecture of the Ambulance to Site of Accident

As depicted in the above image, When the packet containing the location of the accident spot reaches the ambulance, the AODV protocol is used to determine the shortest path to the accident spot. Ambulance gets directions to reach the accident spot at the earliest. A packet containing an emergency message about Ambulance arrival is created. This message is broadcasted to all the vehicles in the way of the ambulance so that they make way for the ambulance by taking an alternate route.

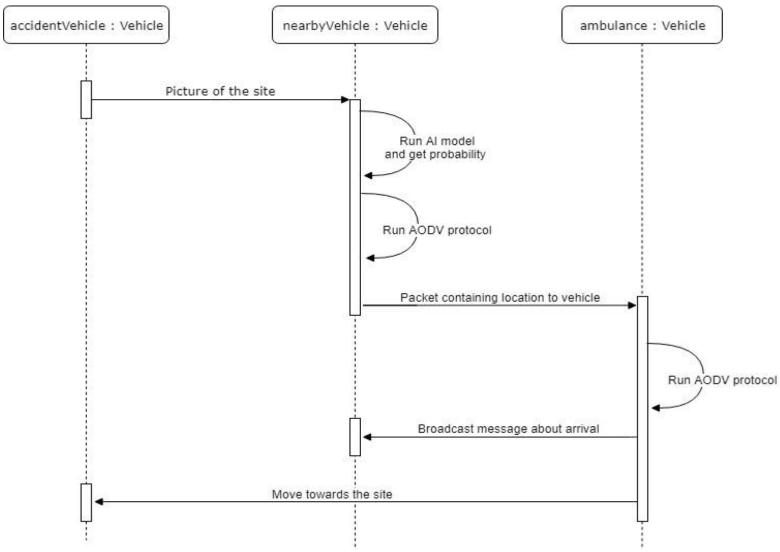


Figure 3. Sequencediagram of the system

As depicted in the above image, A picture of the accident vehicle is taken by a nearby vehicle. An AI model is run and probability is calculated to identify whether it is an accident or not. AODV protocol is run in the vehicle to determine the shortest path to the ambulance. A packet containing the location of the accident spot is transmitted to the ambulance. Ambulance runs AODV protocol to find the shortest route to the accident spot. A message is broadcasted to all vehicles about ambulance arrival. The ambulance moves to the accident spot in the shortest path.

IMPLEMENTED MODULES

The following section describes the modules implemented AI Detection, Dissemination of message, Routing and Broadcasting.

3.2.1 AI MODEL TO DETECT AN ACCIDENT

The core idea of our project needs the vehicle to detect the accident autonomously and relay it to the ambulance. The image recognition part of the project was implemented by Transfer learning which is a machine learning method which utilizes a pre-trained neural network.

The model which it is built upon is Google's inception v3 model which consists of:

- Feature extraction part with CNN.
- Classification part with fully-connected and SoftMax layers.
- It is a 42-layer deep learning network and has very low error rates.
-

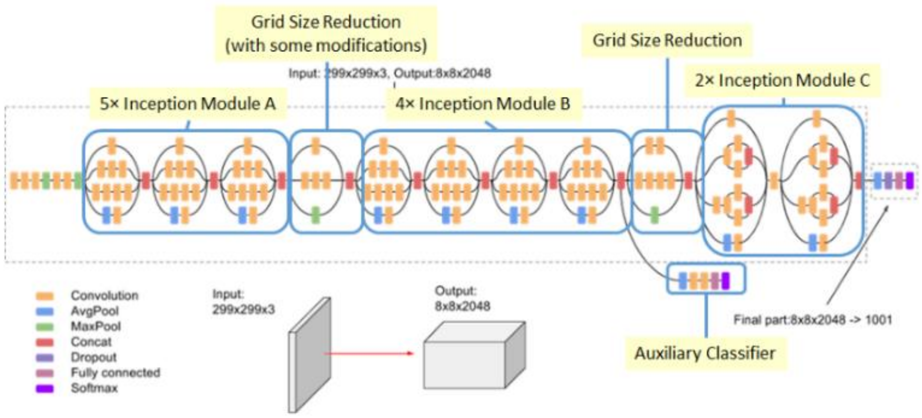


Figure 4. Architecture diagram of the Inception v3

The steps and procedure followed to implement this model to our requirement are:

- The model is built and pre-trained with more than 1000 classes and the features of these models are taken and later which is helpful in our classification.
- We build a new model for the original dataset.
- We reuse the feature extraction part and re-train the classification part with our dataset.
- The dataset used in this consists of 2500 images of vehicles before and after the accident so in total of nearly 5000 images.

The output of this model is in the percentage saying the probability of the accident. Based on the capability of this model we decide a threshold value of 65% to initiate the call to an ambulance.

3.2.2DISSEMINATION OF EMERGENCY DATA

To pass data to the ambulance and for the ambulance to move to the site of the accident, data transfer happens using the concepts of Ad-Hoc networks. In an Ad-Hoc network each node participates in routing by forwarding data for other nodes, so the determination of which nodes forward data is made dynamically on the basis of network connectivity and the routing algorithm in use. A vehicle in VANET is considered to be an intelligent mobile node capable of communicating with its neighbors and other vehicles in the network.

Unicast is communication between a single sender and a single receiver over a network. An earlier term, point-to-point communication, is similar in meaning to unicast.

Using the network simulator data transfer happens in two phases:

- In the first phase, we transfer data from the accident site, in case of an accident, to the ambulance. This involves making a packet containing the location of the accident site and then transferring this packet through the vehicles in the way to the ambulance. This will involve running a routing protocol to find the shortest route to the destination and then passing the packet through the vehicles in that direction. The data transfer, in this case, happens using unicast.
- The second phase involves finding the shortest route from the ambulance to the packet data containing the location. This will involve running a routing protocol to find the shortest path to the accident site.

3.2.3 ROUTING PROTOCOL IMPLEMENTATION

An Ad Hoc On-Demand Distance Vector (AODV) is a routing protocol designed for wireless and mobile ad hoc networks. This protocol establishes routes to destinations on demand and supports both unicast and multicast routing. The AODV protocol was jointly developed by Nokia Research Center, the University of California, Santa Barbara and the University of Cincinnati in 1991.

The AODV protocol builds routes between nodes only if they are requested by source nodes. AODV is therefore considered an on-demand algorithm and does not create any extra traffic for communication along with links. The routes are maintained as long as they are required by the sources. They also form trees to connect multicast group members. AODV makes use of sequence numbers to ensure route freshness. They are self-starting and loop-free besides scaling to numerous mobile nodes.

In AODV, networks are silent until connections are established. Network nodes that need connections broadcast a request for connection. The remaining AODV nodes forward the message and record the node that requested a connection. Thus, they create a series of temporary routes back to the requesting node.

A node that receives such messages and holds a route to a desired node sends a backward message through temporary routes to the requesting node. The node that initiated the request uses the route containing the least number of hops through other nodes. The entries that are not used in routing tables are recycled after some time. If a link fails, the routing error is passed back to the transmitting node and the process is repeated.

In our implementation we use the AODV routing protocol in 2 cases:

- In the first case, we use AODV to transfer the data about the location of the accident from the site of the accident to the ambulance, using the shortest route and hence the least time.
- In the second case, AODV is used to find the shortest route from the ambulance to the accident site.

3.2.4 BROADCAST OF EMERGENCY MESSAGE

Broadcasting is the simultaneous transmission of the same message to multiple recipients. In networking, broadcasting occurs when a transmitted data packet is received by all network devices.

In our implementation broadcast happens about the arrival of an ambulance in the direction got by running the AODV protocol. Initially, a packet containing an emergency message is made. This packet is then broadcasted to all the vehicles in the route to reach the accident site. In an attempt to allow the vehicles to make way or take an alternate route to help the ambulance to pass in the direction the site has reduced traffic and reduced time.
The sequence of steps followed during implementation is listed below.

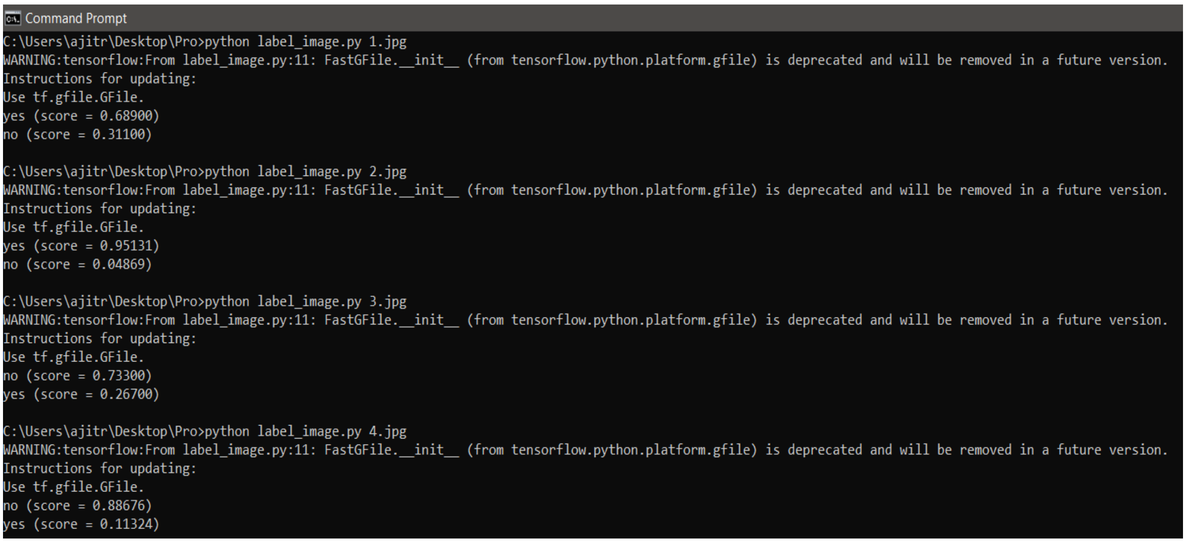
ALGORITHM FOR THE IMPLEMENTATION PROCEDURE

1. The Detection of the accident is done using an AI model which uses the inception v3 model.
2. The model returns the probability of the accident when an image is provided. Initiation of a call to the ambulance happens only when the probability is greater than a threshold value, in our case 0.7
3. A grid topology of twenty-five VANET nodes is set up.

4. The routing protocol – AODV is installed and the mobility model where the vehicles move with different but constant velocities is set up.
5. VANET environment is set up by implementing 802.11p standards with packet size as 1024 bytes.
6. The unicast transmission between the nodes implemented for transmission of location from the accident site to the ambulance.
7. Location data is made into packets are transmitted towards the receiver which reads the packet data.
8. The movement of the packets taking the shortest path to reach the destination, in this case, the ambulance is monitored and time taken is calculated.
9. The packet size is constant at 1 byte.
10. The ambulance then calculates the shortest route by which it can reach the accident site, considering that the positioning of the nodes in the way would have changed and will run the AODV protocol again.
11. Emergency message about the ambulance arrival is made into a packet.
12. The packet is broadcasted in the path to the accident site.

RESULTS AND DISCUSSION

The diagram below shows the various percentages of the accident with respect to various accident scenes as it crosses a set threshold of 65%, we implement the ambulance and message routing system.



```
Command Prompt
C:\Users\ajitr\Desktop\Pro>python label_image.py 1.jpg
WARNING:tensorflow:From label_image.py:11: FastGFile.__init__ (from tensorflow.python.platform.gfile) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.gfile.GFile.
yes (score = 0.68900)
no (score = 0.31100)

C:\Users\ajitr\Desktop\Pro>python label_image.py 2.jpg
WARNING:tensorflow:From label_image.py:11: FastGFile.__init__ (from tensorflow.python.platform.gfile) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.gfile.GFile.
yes (score = 0.95131)
no (score = 0.04869)

C:\Users\ajitr\Desktop\Pro>python label_image.py 3.jpg
WARNING:tensorflow:From label_image.py:11: FastGFile.__init__ (from tensorflow.python.platform.gfile) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.gfile.GFile.
no (score = 0.73300)
yes (score = 0.26700)

C:\Users\ajitr\Desktop\Pro>python label_image.py 4.jpg
WARNING:tensorflow:From label_image.py:11: FastGFile.__init__ (from tensorflow.python.platform.gfile) is deprecated and will be removed in a future version.
Instructions for updating:
Use tf.gfile.GFile.
no (score = 0.88676)
yes (score = 0.11324)
```

Figure 5. TheOutput of Image detection module

Communication among twenty-five vehicles is considered in this work. This is scalable to any number. Network Simulator 3 is used for implementing the algorithm discussed above with the simulation in NetAnim.

The various criteria considered for implementation are tabulated in the following table below.

Criteria	Value
No. of Vehicles	25
Mobility model	Constant Velocity Mobility model with vehicles moving with different but constant velocities
Speed of Vehicles	Varying between 10 to 40 kmph
Bandwidth	10MHz
Routing Protocol	AODV

Figure 6. Table of parameters for implementation

AODV protocol is chosen in this work as this is a reactive protocol which makes routing decisions dynamically. Considering the frequent link disconnections between the vehicles, a reactive protocol like AODV best suits the environment. The Wi-Fi standards are implemented using 802.11p.

According to the standards, a site response time of 5 minutes, achieved by having an ambulance stationed every 5 square kilometers, for the CATS ambulances had been recommended by the All India Institute of Medical Sciences (AIIMS), under the aegis of the health ministry.

An ambulance on an emergency run may be made at 15 miles per hour (24.14 km per hour) over the posted speed limit as per the internationally accepted standards. The following diagram depicts the working of the system.

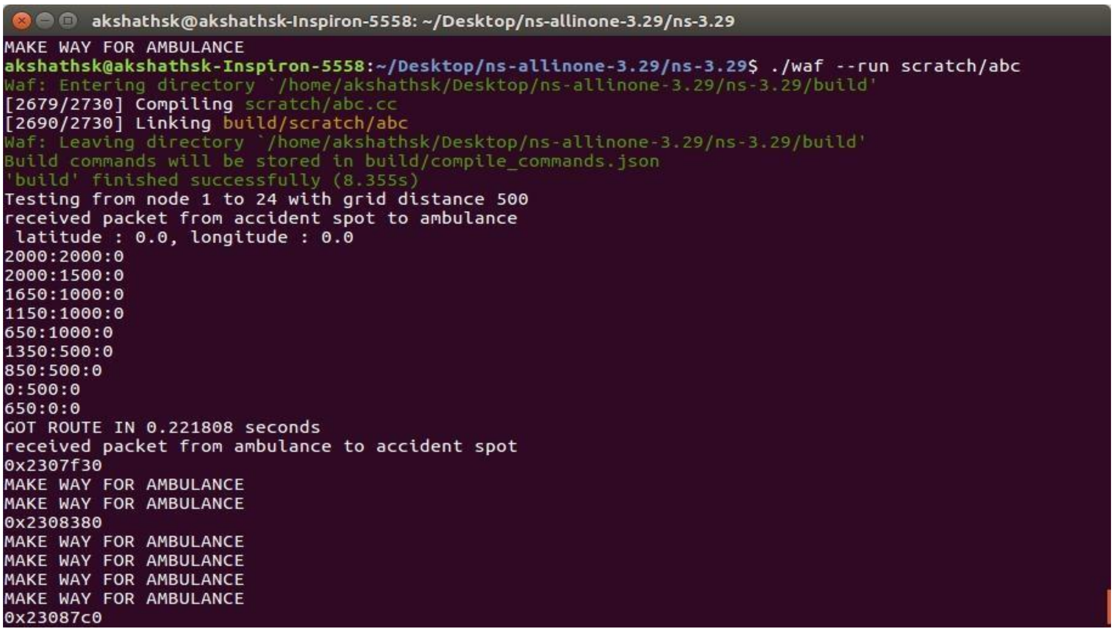


Figure 7. The Output of AODV Routing in NS3

The following section describes the calculation of the performance of our system:

In our implemented system -
We use a scale of 500 units on grid-scale = 500 meters in the real world
Using the given scenario: Considering a 4 km square area on the grid
Distance travelled by ambulance = 3707.16 m
Assumed average speed = 60 kmph
Time taken = (3.70716km/60kmph) = 0.061786 hour = (0.061786 * 60) = 3.7716 min
Time taken to find the shortest route (average) = 0.221808 sec
Total time / End to End time = 3.7752968 min
For a 5 km square area End to End time = 4.719121 min

In our consideration, we use a 4x4 grid with 25 vehicles and get an end to end time of 4.72 minutes which is lesser than the recommended best-case time of 5 minutes. The diagram below represents the topology and the working, using a NetAnim simulator.

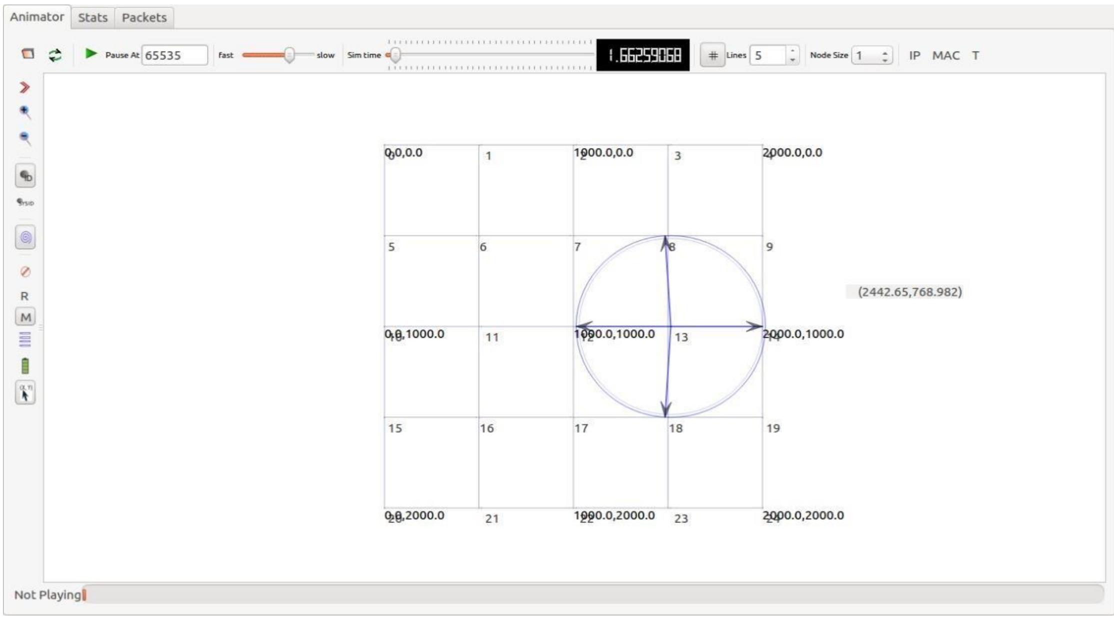


Figure 8. NetAnim Visualization in NS3

As a general observation, we can reduce the time taken by traditional methods in case of emergency situations by using Ad-Hoc networks. Using mobile networks in case of emergency messages to communicate the message will be inefficient because it involves physical work, as compared to the automated system implemented. This implementation can also be extended to various other scenarios such as, in military areas or areas affected by floods and earthquakes where there is little to no internet connectivity.

CONCLUSION

The system in this work proposes a faster and efficient way of data transfer in emergency situations. In our system, we use AI to detect an accident and the data transmission happens using Ad-Hoc networks or vehicular communication in VANETs. The system will show the location data being transferred to the ambulance using the AODV routing protocol. The shortest route to the accident site is got again using the AODV protocol, from the ambulance end. Through the proposed system we have reduced the end to end delay for the ambulance to reach the site with a worst-case time of 4.72 min for a 5 km square area. Hence, the use of AI and selecting the optimal route by using VANETs can reduce the effective end to end delay in error message transmission which can be extended to other emergency situations like military areas and areas affected by floods and earthquakes as well.

FUTURE ENHANCEMENT

As with any system in implementation there is always a wise scope for improvement so one of the factors in VANETs can be disconnection of network due to lack of availability of nodes so there can be an integrated network consisting of cloud support and integration of Road Side Units by which day can be relayed onto these units which can be then sent out later.

One more enhancement could be the addition of navigation modules integrated so when the driver is suggested to take an alternative route, this module can inherently help them navigate in the new route so that even they don't get too much inconvenienced by this and so that they can also reach their destination on time.

REFERENCES

1. P. H. Lee and T. C. Huang, "A geocasting application for ambulance service," *2014 Int. Conf. Comput. Netw. Commun. ICNC 2014*, pp. 1086–1090, 2014.
2. F. Y. Leu, M. H. Chen, Y. L. Huang, and C. C. Lin,

3. "Controlling traffic lights for ambulances," *Proc. - 2012 7th Int. Conf. Broadband, Wirel. Comput. Commun. Appl. BWCCA 2012*, pp. 462–467, 2012.