



# ITS Based OBU: A Fallback Mechanism in Vehicular Ad-Hoc Network

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**Abstract.** Vehicular Ad-Hoc Network (VANET) is the largest growing sector for research in wireless communication. Advancing the research in VANET overcomes major issues present in current in wireless technology related to vanet. Major challenges include network reliability, security and safety. This paper discusses some current technologies related to ITS and sensor which are based on VANET which are used in the dissemination of information in vehicular environment. This research also proposes a phase 2 mechanism, which compliance of hardware in On Board Unit (OBU) which works as an alternative medium providing safety and an independent vehicular traffic flow which do not rely on network connectivity.

**Keywords:** Ad-Hoc · VANET · OBU · Sensors · Wireless · ITS · RSU

## 1 Introduction

VANET a concept which is a mainstream in today's researches in wireless communication. The advancement in this field is recognized all over the nations. VANET which aware us about several network related confronts like reliability, security and passenger safety. To resolve these challenges a model of Intelligent Transport System (ITS) in VANET is introduced. ITS model interchanges information among vehicles. ITS do examined as a ascending case of Mobile Ad-hoc Network (MANET) [2], here the system's facilities are assign to vehicle which generates a impulsive network tracking the motion of vehicles along road side flawless during unreliable network connection with Road Side Units (RSU) of base station. MANET do authorize the probability of direct wireless communication from Vehicle-to-Vehicle (V2V) as shown in Fig. 1. In other hands ITS too is the prime technology which intensify traffic establishments and road safety. It abets to carry signal with hotspot and also with other nearby entities through Direct Short Range Communication (DSRC).

### 1.1 Architecture

This section outlines the system architecture of vehicular Ad-hoc networks. According to the author in [6] of the architecture standard guidelines, one is capable to attain the VANETs system which can be summarized into three domains: (1) The Mobile Domain, (2) The Infrastructure Domain, and (3) The Generic Domain.

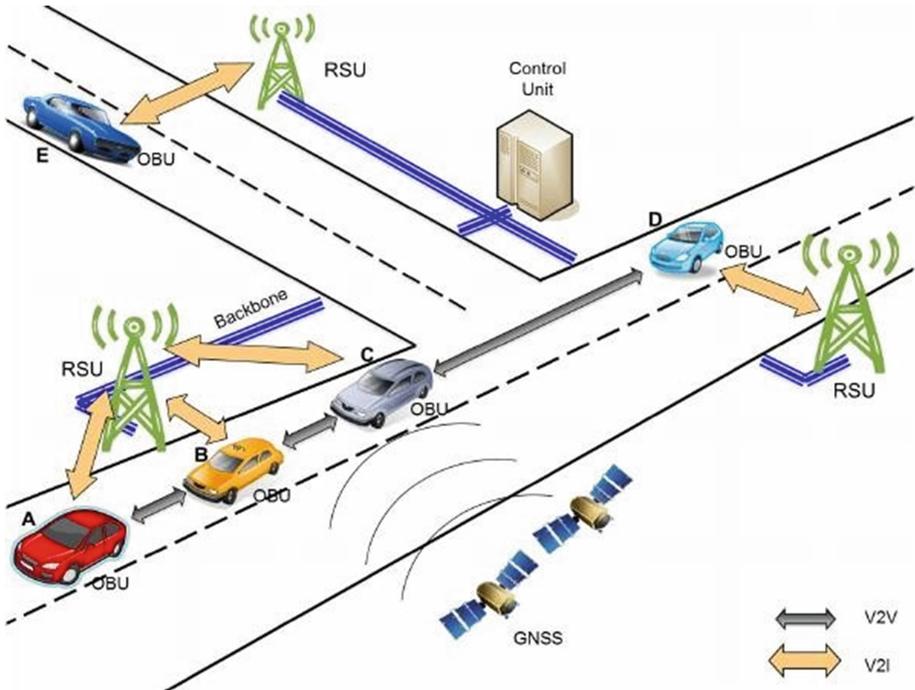


Fig. 1. VANET architecture [6]

## 1.2 Intelligent Transport System

In present view of Vehicular Network, the world now is at a brink of digital revolution and Internet of Things (IoT) which indicates the forthcoming frontier [1]. The attention after this development is based on two main principles i.e. (1) “Adaptive Security architecture” and (2) “Internet of Things”, both are listed in Gartner’s strategic technology trends which was published in 2016 [1]. IoT also reserves a position in Vehicular Network which alters vehicles into excellent sense-and-move policy and assist in secure driving, increases energy efficiency, decreases delay and gains control in congestion management for proper flow of traffic [1]. ITS vehicles uses sensors with lower in range and are able to sense, communicate and process data by accumulating information of vehicles velocity and position. The statistics are exchanged with nearby vehicle after performing computation using DSRC having range of 300 m and authorizing vehicles to communicate [1]. It relates to the mobile domain which consists of two parts: (1) The Vehicle Domain and (2) The Mobile Device Domain. Vehicles such as cars and buses are comprises in Vehicle domain and portable devices like personal navigation devices and smart phones are comprises in mobile device domain. The methods like connection oriented and connection less, which reveals some parts of the domain like vehicle domain which is connection oriented, that includes:

1. Internet infrastructure domain
2. Road side infrastructure domain
3. Private infrastructure domain
4. Central infrastructure domain.

Where on the other side, Mobile device domain is considered, as connectionless domain that includes:

1. A raspberry prototype domain
2. Infrastructure sensor based domain
3. Li-Fi technology based domain.

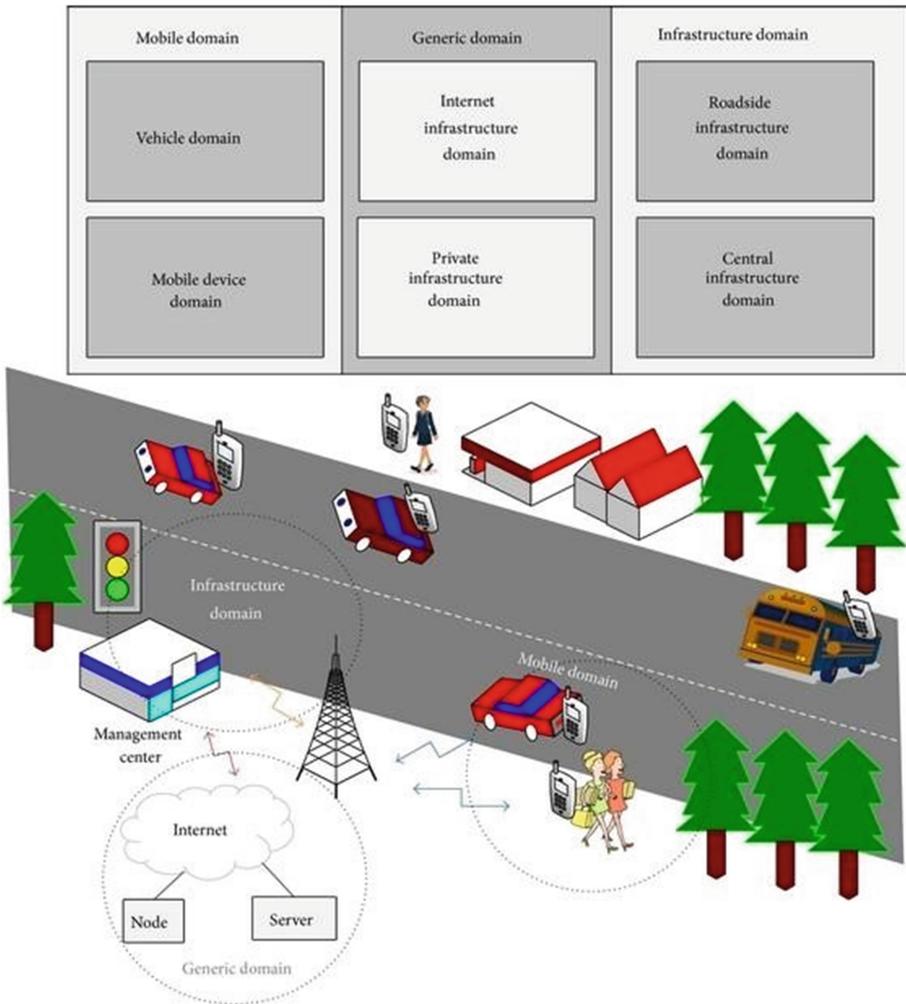


Fig. 2. VANET scenario [8]

OBU is one of the major sections in vehicular domain followed by application units (AU's), which combines and form a wired as well as wireless connections, however a ad-hoc domain comprises of OBU's and RSU's as described in Fig. 2 [8].

### 1.3 Connection-Oriented

An OBU can be seen as a mobile node of an ad-hoc network and RSU is a static node likewise.

An RSU can be connected to the Internet via the gateway; RSUs can communicate with each other directly or via multihop as well. According to the author Shrestha R. [7], a special case of mobile ad-hoc network (MANET) is described in which the vehicles are itself the mobile nodes, here vehicles not only communicate with the vehicles but it also communicate with the (RSU).

The two infrastructure domain access, Hot spots (HSs) and RSU's. OBUs may interact with Internet via RSUs or HSs. If one of those two are absent which is RSUs and HSs, OBUs can also interact by using cellular radio networks (GSM, GPRS, UMTS, WiMAX, and 4G) as there is merely researches done for no network coverage or unreliable network connection as shown in Fig. 3.

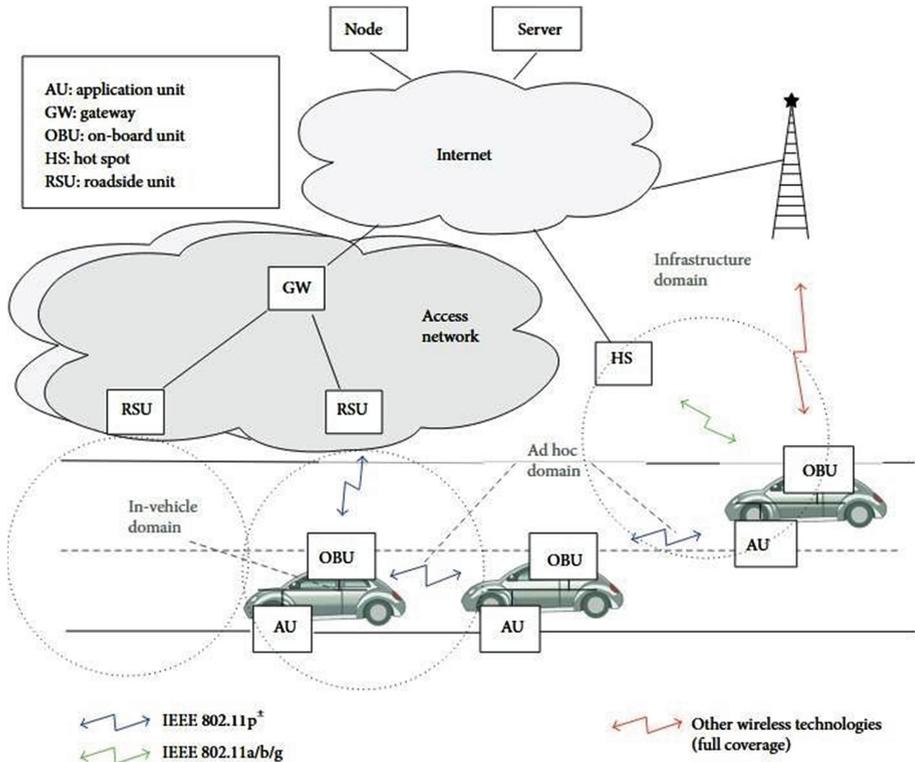


Fig. 3. VANET communication modes [8]

The greatest challenge apart from many in VANET is Quality of Service (QoS). A good QoS is tough to attain in VANET because of various topologies in networks and also due to the unavailability of information for routing [2].

#### 1.4 Connection-Less

The backbone of all the technologies can be referred as Signal connections. If the connection is loses its connectivity from, base station unit (BSU) to targeted vehicles then, a terrible scenario can be seen. To prevent this scenario, author Truong in [3] proposed a prototype using raspberry-Pi which detects nearby vehicles with the help of Infrared sensor.

Similarly in [6] a data dissemination model is shown where Light Fidelity (Li-Fi) technology is used where data is disseminated in vehicular environment using (Li-Fi). Thus, mechanism must be introduce to handle the situations in terms of unreliable network connection in ITS. Thus, to overcome the certain issues related to connection oriented scenario a proposed block diagram named as “ITS based OBU” is proposed in this paper as a fall back mechanism which consist of two phases. Phase 1 of the block diagram with the algorithm described in [10], here the network continuously tracks the connection with making decision on commencement of phase 2. Phase 2 possesses the actual mechanism here when network is disconnected the mechanism takes over the vehicle and controls until the connection is reestablished.

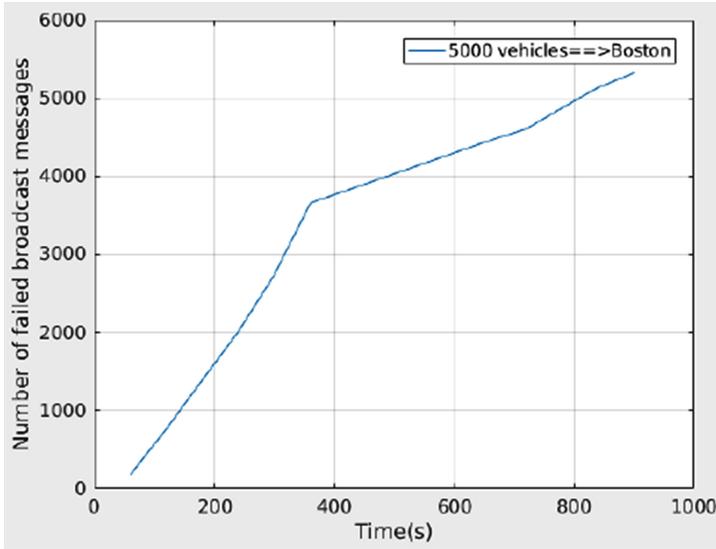
## 2 Related Work

Number of technologies are working on VANET to get the best out of ITS, such as Wi-Max, WAVE and GSM. Some of the protocols like DSRC is also proposed in [13] that works on low latency high speed v2v and v2i communication establishment. This technology consists of a range of band from 5850 to 5925 GHz for protocol of public allocated by Federal Communication Commission. Here data interchange and its sensitivity is the main challenge encounter in VANET. The data transmission is being done in two ways (1) Push Model and (2) Pull Model.

Here for the proper understanding, the vehicles transmit data in the form of velocity and location with each other in Push model. Whereas the transmission of emergency signal to all the vehicle is done in pull model in VANET. Thus, it results in network crowding, as it floods the network with the broadcast messages. As a result of failed broadcast messages transmitted for 5000 nodes obtained when simulated using a VANET simulator is shown in the paper.

Figure 4, shows the graph of average travel time observed as 900 s in Boston which increased in non-successful of transmitted messages which eventually resulted in the expansion in travel time. Thus when, traffic congestion increases it ultimately increase the ratio of failure in broadcasted messages, therefore as a result an unstable network layout is formed. This emphasize that better broadcast medium is required.

In this paper [8] author has proposed a three levels autonomous vehicle prototype using Raspberry Pi, this system is detects the close ranged vehicles with the use of Infrared sensor. Here the main goal is to analyze the vehicles at autonomous foam from



**Fig. 4.** VANET failed broadcasted messages [2]

at microscopic level, having focus on every vehicle with their data transmission from nearby vehicles and RSU. In this prototype a set of passive and active experiments were run, for demonstration of the interconnectivity of the developed prototype. The emulation based system on chip were incorporated with several sensors.

Moreover there are two systems which controls traffic that is centralized or decentralized in [2], although in hybrid systems which are also termed as centralized systems possess high computation and communication cost, whereas Artificial Intelligence (AI) is required in the decentralized system which is a lot more expensive than other. Thus, a white paper proposed in 2012, where autonomous vehicle uses a sensor and communication based technologies is used in which cameras and software assist driver and the computer to handle the situation in response of any problem arises.

In a paper proposed by [3] a Speed Based Lane Changing System (SBSL) is proposed. This system enables the cars to changes lanes when a desired gap distance meets the defined requirement in the algorithm at a certain speed. Here a vital role is played by OBU and it notifies the vehicle driver to change its lane. If for so called reasons the driver does not follow instructions then, the nearby vehicle and RSU convey this information to control center which looks over the traffic surveillance and the vehicle driver is punished.

A new method in [4] presented, does the vehicle detection and speed estimation task. Here the computer computes the velocity of the vehicle based on its position. An algorithm is derived as a self-locating mechanism of every vehicle on assumption basis. Thus, it is concluded that it maintains a proper speed limit also warns the driver to change velocity as well as lanes.

A framework of smart city in [5], is given where VANET is attracting research community and industry at a same time as it contains the information dissemination for both of them.

In paper [11] a challenge also arise for unbounded network size, a frequent network partitioning is occurred during rush hours in urban areas at day time as low traffic load is formed in rural areas and at night time in urban areas, this frequent traffic flow during day time in rural areas creates frequent network congestion and collision occurs in network.

Network Security is as essential as vehicle security thus various attacks are being analyzed, and among all Paper [12] made a move for detecting a Sybil attacks in vanets, which discusses to provide security in data dissemination in vanet, the author aware us with a critical review on techniques to detect Sybil attacks to secure the network by such kind of Sybil attacks.

A OBU platform based paper [14] proposes a prototype as SMARTDRIVE, it is a application based prototype which accessed though navigation system which allows road maps, current locations of vehicle and rout information, this android based application is integrated with OBU via a Bluetooth device. It also allows pedestrians to report the authorities in case of any misfortune if application is installed in a smart phone.

A “Light Fidelity (Li-Fi) as an Alternative Data Transmission Medium in VANET” provides a solution using Li-Fi, this system directly coordinates with the central processing unit with the on board unit which are directly embedded with sensor system present in it. Here, certain parameters of speed, acceleration and distance are measured by the Sensors functions from the neighboring vehicle [6]. The comparative literature review of VANET is as shown below in Table 1.

**Table 1.** Comparative literature review of VANET

Sr. no.	Paper	Year of pub.	Controller	Simulator	Remarks
1	“VANET routing on city roads using real-time vehicular traffic information”, “IEEE Transactions on Vehicular technology” [1]	2009	–	–	This paper aims to design and implement a reactive protocol RBVT-R and a proactive protocol RBVT-P and compared them with protocols representative of mobile Ad-hoc networks and VANETs
2	“Software-defined networking for RSU clouds in support of the internet of vehicles”, “IEEE Internet of Things Journal” [2]	2015	–	–	This paper aims the use of reinforcement learning to select configurations that minimize reconfiguration costs in the network over the long term

*(continued)*

**Table 1.** (continued)

Sr. no.	Paper	Year of pub.	Controller	Simulator	Remarks
3	“Software defined networking based vehicular Ad-hoc network with fog computing”, “IFIP/IEEE International Symposium on Integrated Network Management” [3]	2012	SDN	Ns2	This paper aims to propose a solution to ensure the fog computing ensuring less response time
4	“DASITS: driver assistance system in “intelligent transport system”, “30 <sup>th</sup> International Conference on Advanced Information Networking and Applications Workshops” [4]	2016	Ns2, Sumo	Ns2	This paper aims to propose a solution to ensure the quality of service and assistance for lane changing
5	“A raspberry-pi prototype of smart transportation”, “IEEE 25 <sup>th</sup> International Conference on Systems Engineering” [5]	2017	Raspberry pi	Real test bed	System is focusing on each vehicle and their communications with the nearby vehicles and road-side units using several IR sensors
6	“Light Fidelity (Li-Fi) as an alternative data transmission medium in VANET”, “IEEE European Modelling symposium” [6]	2017	Li-Fi	VANET simulator [15]	Optimized latency and introduce Li-Fi technology but it need to maintain a straight position

### 3 Implementation and Proposed Work

Here in the proposed system it is assumed that it is the driverless and autonomous vehicle scenario where, the OBU consist of two phase, where phase one is already derived in [10] where the phase two consist of all the rights to take over the vehicle in control whenever a unreliable network or signal disconnection is from with RSU is encountered.

The proposed block diagram named as “ITS based OBU” for the mechanism is shown below in Fig. 5 named as “Block Diagram of ITS based OBU” is separated into two parts, phase1 and 2, here we shall observe the operation for phase 2, if the connectivity from RSU with OBU is lost then, the activation signal from phase 1 to the mechanism in phase 2 is send. Where, possibility of the connection reestablishment is found then, the deactivation signal from phase 1 to the mechanism in phase 2 is send. Here in this scenario, phase 1 consist of global system for mobile communication board which acts as a RSU, aarduino nano micro controller board for decision making and network service is used as a RSU signal broadcaster. A dedicated and controlled closed environment is used to perform this test which will vary from real life and day-to-day environment.

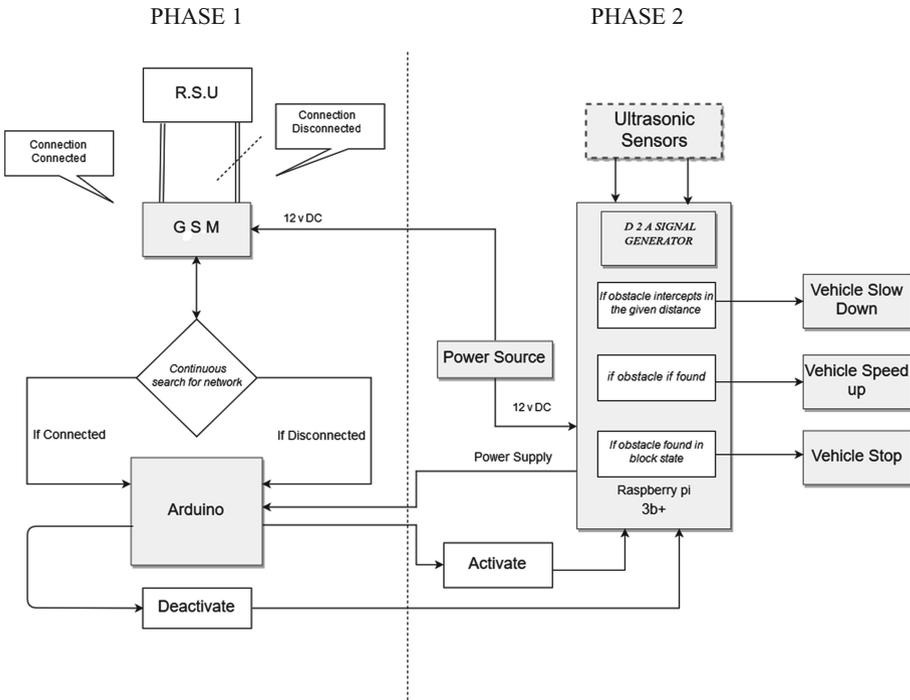


Fig. 5. Proposed block diagram

When phase 1 conveys the signal, operation of phase 2 starts. When phase 1 disconnects from the network the phase 2 activates and the mechanism starts. Phase 2 consists of ultrasonic sensors as an input of data sensors is located on the front, back and both sides of the vehicle. The sensors takes data and the mechanism starts an action to slow down the car or speed up as described in the algorithm and parameters in Sect. 3.1. The test bed is limited to 15 cm distance for a controlled atmosphere, where ultrasonic sensors have 3000 cm as working range in real terms.

Below we will have a look at the algorithm for the phase 1 followed by phase 2 which is used for the operation of this proposed work.

### 3.1 Proposed Algorithm

The algorithm 1 for ITS based OBU was derived for phase 1 in [10], where signal state was given as (i), 0 is the connected state and 1 is disconnected state. There, the system will continuously check for the signal whether it is connected or not. If the signal state is disconnected from the road side unit then, the phase 1 will send a request to phase 2 to activate the mechanism. If the vehicle is connected with the road side unit then, the phase 1 will send request to phase 2 to stand by the system in the on board unit placed in vehicles.

Therefore focusing further to this paper the below given algorithm consist of phase 2 where, the input is received from phase 1. The system will be activated and will start performing accordingly. Here, the system state is denoted as  $i$  (where,  $i = 0, 1$ ) i.e. 1 = ON and 0 = OFF. The algorithm works in three phases denoted as F = Front, S = Sides (left and right) and B = Back, where all three of the phases works simultaneously. In the proposed block diagram when the GSM board stops receiving signal from network provider which acts as a RSU then, the arduinonano will follow the instructions provided in the form as shown in algorithm 2.

This algorithm is divided into 3 phases, 1st phase is front side which is denoted as (F), 2nd is both sides which is denoted as (S) which includes left (L) and right (R) both sides and 3rd is back side which is denoted as (B). In 1st phase the system will check for the signal state, if the system state is off then no action will be taken but, if the system state is on then, the mechanism will be activated.

When the mechanism is activated it will simultaneously takes readings from all the three phases. Here, the first phase will take readings from the ultrasonic sensor which is located in the front side of the vehicle, this readings will be send to system i.e. if the front side sensor will detect obstacle which is having distance more than 15 cm then, no action will be taken to the actuators. Else, the condition will apply where if the distance will be lesser than 15 cm then, the vehicle will reduce the speed with the help of the actuators, and if the distance will reduce the distance to 10 cm then the vehicle will stop. Thus, this process will be carried out with all the three phases at the same time to avoid vehicle collision.

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**Algorithm for ITS based OBU Phase 2**


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1.  $i \leftarrow \text{System\_State}$ 
2.  $\triangleright$  Where,  $i$  is used to check the system state whether
   it is on or off i.e. 1 = on and 0 = off
3. for  $F \leftarrow d$  [vary from 1 to  $n$  where  $F \leftarrow$  front, and  $d \leftarrow$ 
   distance]
4. do if  $i = 1$  [Front Phase(F)]
5.   then, send "System On" signal
6.   Initiate sensor reading from  $a$  and  $b$ 
7.    $\triangleright$  Where,  $a$  and  $b$  are the sensors for  $F$ .
8.    $n \leftarrow \text{Sensor\_Range}$ 
9.    $n1 \leftarrow \text{Threshold\_Value}$  for slow down vehicle
10.  if  $d > n1$ 
11.    then, send "Do Not Stop" signal
12.  else if  $d < n1$ 
13.    then send "slow Down Vehicle" signal until
       $d \geq n1$ 
14.    Activate Actuator until  $d \geq n1$ 
15.     $n2 \leftarrow \text{Threshold\_Value}$  to stop the vehicle for  $F$ 
16.  else  $d < n2$ 
17.    send "Stop Vehicle" signal for  $F$ 
18.    Release Actuator after  $d \geq n2$ 
19. do if  $i = 1$  [Side Phase (S)]
20.  then, send "System On" signal
21.  Initiate sensor reading from  $c$  &  $d$  and  $e$  &  $f$ 
22.   $\triangleright$  Where,  $c$  &  $d$  are left side (L) sensors and  $e$  &  $f$ 
   are right side (R) sensors
23.  do if  $d \geq n2$ 
24.    then, send "Do Not Stop" signal
25.  else if  $d < n2$ 
26.    then, send "Slow Down Vehicle" signal until  $d$ 
       $\geq n2$ 
27.    Activate Actuator until  $d \geq n2$ 
28.     $n3 \leftarrow \text{Threshold\_Value}$  to stop the vehicle for  $S$ 
29.  else  $d < n3$ 
30.    send "Stop Vehicle" signal for  $S$ 
31.    Release Actuator after  $d \geq n2$ 
32. do if  $i = 1$  [Back Phase(B)]
33.  then, send "System On" signal
34.  Initiate sensor reading from  $g$  and  $h$ 
35.   $\triangleright$  Where,  $g$  and  $h$  are the sensors for  $B$ 
36.  do if  $d \geq n1$ 
37.    then, send "Do Not Stop" signal
38.  else if  $d < n1$ 
39.    then, send "Slow Down Vehicle" signal until
       $d \geq n1$ 
40.    Activate Actuator until  $d \geq n1$ 
41.  else  $d < n2$ 
42.    send "Stop Vehicle" signal for  $B$ 
43.    Release Actuator after  $d \geq n1$ 
44.  else  $i = 0$ 
45.    do "Stand by" Signal to the system
46. Repeat Step - 3 until  $i = 1$ 
47. End

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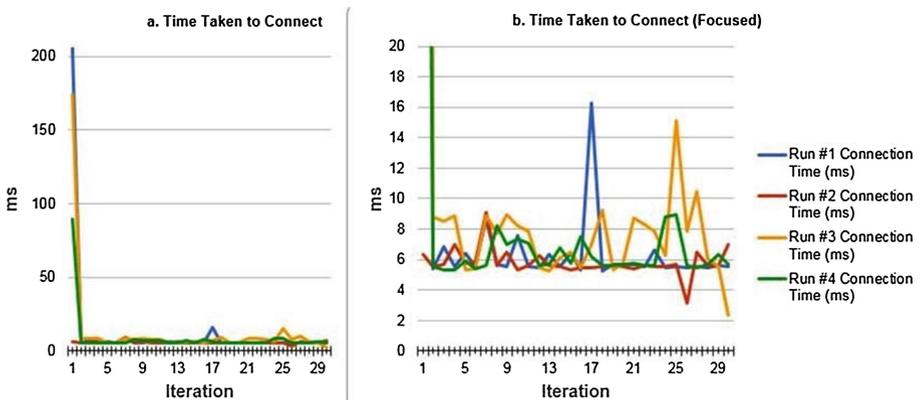
## 4 Comparative Analysis

The comparative analysis of the ITS based OBU had been analyzed and reading between ultrasonic sensor and infrared sensor are obtained which are given as below in Table 2.

**Table 2.** Comparative analysis of US-IR sensor in VANET

Sr. no.	Objects	Ultrasonic sensor (ms)	Infrared sensor (ms)	Infrared sensor [9]
1	Cardboard	8.6	9	10.6
2	Paper sheet	40	20	20.2
3	Sponge	5	20	21.6
4	Wood	9	35	36.6
5	Plastic	4.3	24	25.1
6	Rubber	4.4	57	58.3
7	Tile	11	23	23.8
8	Aluminum	11	13.2	NA
9	Glass	10	NA	NA
10	Smoke	4	15	NA
11	Fog	6	17	NA
12	Water	19	22	NA

The above given results are obtained under a closed and dedicated environment which may differ from real life environment which has to be adjust accordingly when performed in real environment. The result itself denotes the clear indication that the ultrasonic sensor in any circumstances gives better results against infrared sensors.



**Fig. 6.** Comparative of IR sensor in terms of connection

The above given Fig. 6 describes the comparative graph of response time in milliseconds and in Fig. 7 the graph of the comparative results using no connection is obtained.

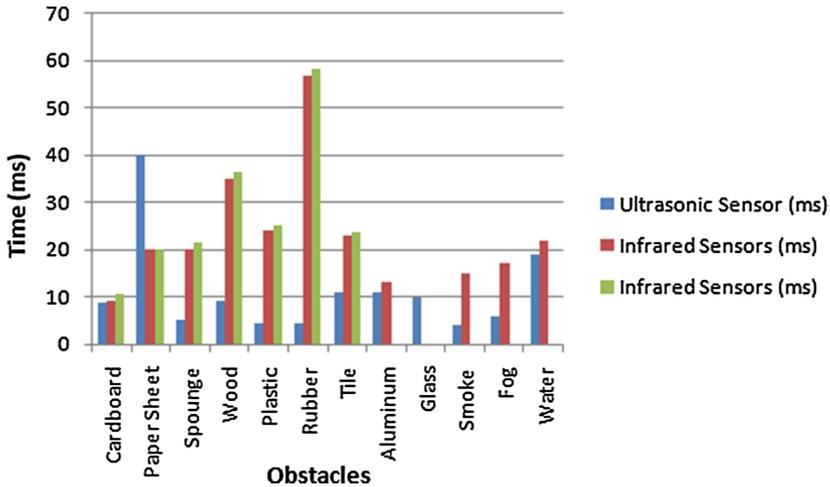


Fig. 7. Comparative of US and IR *Source*: Fictitious data, for illustration purposes only.

## 5 Conclusion and Future Work

There is a lot of work done in VANET but are dependent on certain connectivity with RSU thus, during the implementation of this proposed work a successful outcome of phase 1 in [10] and phase 2 with interconnection of boards and sensors with low response time with the comparative outcome is obtained. It is believed that a more optimized algorithm can be obtained and can achieve more fruitful results in future.

In future, one can also work on new design and architecture to gain more optimized response time by using new sensor such as microwave sensor.

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