# Options to Broadcast Information in VANET

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***Abstract.*** *To ensure traffic flow and its safety, it is necessary for the vehicle and its crew to dispose information about current road conditions. One of the common approaches is broadcasting in VANET (Vehicular Ad hoc NETwork). In VANET, broadcast can be used to exchange information between several types of nodes, especially between vehicles, but also Road Side Units (RSUs). However, the most important is to ensure the exchange of information between the vehicles. This article introduces design and implementation of a new solution to broadcast in these networks between vehicles only. The approach entitled BBPiV-v1 (Basic Broadcasting Protocol in VANET - version 1 is based on IEEE 802.11p standard and its efficacy has been demonstrated using the simulation tools.*

## Keywords

***Broadcast, BSM, simulation, VANET, WSM.***

## 1. Introduction

Vehicles in traffic (or their drivers) need to be provided with information about the current traffic situation in order to ensure fluency and safety of the traffic. The transmission of this information could be ensured by a broadcast type transmission. Broadcast is a type of transmission in which every node within the transmission range of the source node is a recipient of a message [1].

This paper describes the basic principle of broadcast between vehicles (V2V communication) and presents design of a new protocol BBPiv-v1 (Basic Broadcasting Protocol in VANET - version 1) for this task. This protocol introduces a new idea on how basic information could be transferred between the road users. It would not use RSUs (Road Side Units) for transmission, but it would take advantage of the fact that vehicles in traffic are also moving in the opposite direction, and these would be used to send messages to vehicles outside the range area. This way, the RSUs could be removed and only vehicles would be used for the communication.

This paper consists of the following sections. Section 2. introduces the VANET issue. Section 3. deals with IEEE 802.11p standardization. Section 4. presents possible problems in broadcasting in VANET networks. Section 5. introduces the basic message types used in VANET. Section 6. presents the actual protocol design. Simulation tools are described in Sec. 7. , while Sec. 8. contains description of a new protocol simulation. Finally, Sec. 9. presents the conclusions drawn from the simulation.

## 2. VANET

Vehicular Ad hoc NETwork (VANET) is an ad hoc network that is mainly used for vehicle-to-vehicle communication. However, there are other elements included, namely RSU, which is known as Infrastructure [1]. In general, there are 3 types of communication in VANET (see in Fig. 1):

- V2V – Vehicle-to-Vehicle communication,
- I2I – Inter-Infrastructure communication,
- V2I – Vehicle-to-Infrastructure communication [2].

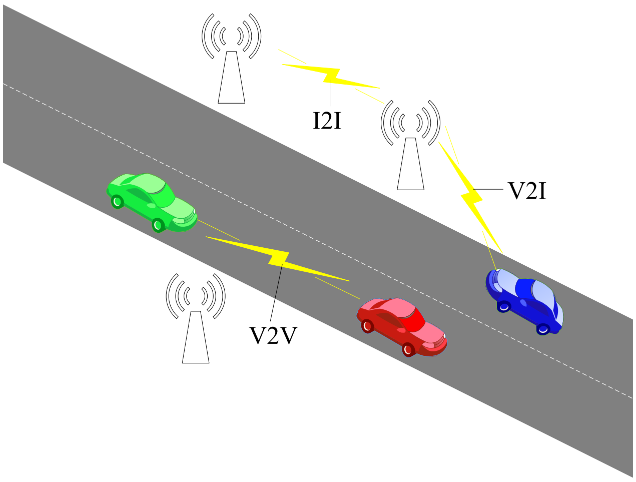


**Fig. 1:** Types of communication in VANET.

VANET can be referred to as an Ad hoc network due to its ability to convey specific information such as traffic situation, service updates, and route planning. Communication in VANET consists of sending and receiving information necessary to ensure traffic safety, such as to keep traffic fluent, and to warn about traffic accidents or adverse road conditions. The main challenge in VANET is to ensure that spreading of information is safe and that the delay is kept to a minimum. VANET is a specific type of MANET (Mobile Ad hoc NETwork) in which the nodes are vehicles (or RSUs) equipped with wireless communication devices. However, the difference between the two is that in VANET, a stable connection between vehicles moving on the road at high speed (higher than in MANET) needs to be ensured [3].

Broadcast is the main mode of communication between vehicles in VANET, since all nodes have to share the same traffic information. VANET is based on signalling, which means that nodes have to send information to all other nodes at regular intervals [4].

## 3. IEEE 802.11p

IEEE 802.11p is considered to be the standard for transmission of messages in VANET. It belongs to the IEEE 802.11x standard and is, in fact, an extension of the IEEE 802.11a and IEEE 802.11e standards. It is also referred to as WAVE (Wireless Access in Vehicular Environments).

IEEE 802.11p is a standardization for the physical and link layer of wireless communication. This standard specifies wireless communication using WiFi technology and is the base standard for DSRC (Dedicated Short Range Communications) in the 5.85–5.925 GHz band. The main task of the standard is to ensure transmission of safety and information messages in all types of communications [5], [6] and [7].

## 4. Problems in Broadcasting

Due to the rapidly increasing number of vehicles and thus associated traffic jams, accidents and traffic delays are unavoidable. But more vehicles on the road also mean more problems in broadcasting between them.

In Vehicular Ad hoc NETworks (VANET) vehicles work in collaboration to convey data through multi-hop paths, without the need of centralized control. The communication range is a critical parameter for distant vehicles to respond in a short time. The message will reach its destination by means of smaller number of hops, if all vehicles operate greedily by maximizing their transmission range. Hence, more vehicles will contend at every point for using the same channel which may collapse due to increased collisions. On the other hand, short transmission range requires more hops and increases delay [8].

Vehicle-to-vehicle communication is mainly focused on broadcasting. All nodes need to receive the transmitted information messages, for which the communication protocol needs to be as reliable as possible. A reliable communication protocol is essential for successful use of the vehicle-to-vehicle communication service [8], [9] and [10]. The transmission range of each node is reduced in the protocol design. In the example given in Sec. 8. , the range value depends on the traffic density and is set to 100 m. This causes that there are fewer direct receivers and more nodes on the established path from the source to all receivers. Although the number of transmissions is practically unchanged in this case, fewer nodes are transmitting at the same time.

## 5. Message Types

According to the IEEE 802.11p standardization, a vehicle in VANET network can send 2 types of messages to another vehicle:

- BSM (Basic Safety Message),
- WSM (Wireless Short Message).

The BSM message is broadcasted at certain regular intervals and it is also called "Hello message". It is also known as a "Beacon message". It is only used to let the vehicle know about itself to other vehicles within its range (position, speed, etc.). WSM message is used to send out messages about emergency situations, such as a traffic accident. It is also known as a non-periodical message [5].

# 6. Protocol Design

A drafted communication protocol will use broadcasting messages to all cars that are within the range of the broadcast node. Each car or node can send both BSM and WSM messages and can also react to their receipt from another node. BBPiV-v1 protocol is aimed at spreading of extraordinary information. So, it is aimed at broadcasting of WSM messages. It was necessary to configure a vehicle to know when and how to send a WSM message, but also how to react to its reception. The vehicles are divided into four categories in terms of the design:

- Vehicles that are the first to start transmitting information about a critical situation (e.g. a vehicle that causes or encounters an accident, a vehicle with right of way, etc.).
- Vehicles that have not detected the critical situation but will be constrained by the situation (they have a route on the same road and in the same lane where the critical situation occurred).
- Vehicles that are moving in the opposite lane to the lane where the critical situation occurred (they are passing the critical situation in the opposite direction and are not constrained by the situation).
- Vehicles that are not constrained by the critical situation (their route does not cross the road where the critical situation has occurred).

Since for the last group of vehicles it actually does not matter whether they receive the WSM information or not, this group is not included in the design. As for the first group of vehicles, these vehicles will be configured so that if they detect a traffic constraint on the road that forces them to stop, they will start counting the duration during which they do not change their position. If this duration exceeds a limit set to 10 seconds, it will start sending a WSM message about constraint on that road. Since the range is limited, it cannot send this information to all nodes that may be affected by the critical situation. Therefore, it was necessary to ensure further spreading of this message. Vehicles are programmed in such a way that during the time when the constraint still persists, they broadcast the information at certain regular intervals. This interval depends on two variables:

- maximum speed allowed on a given road,
- range of the transmitting antenna.

Using these two variables, we can determine the time interval required for a car approaching a car involved in a critical situation to receive WSM information about the constraint before it reaches such constraint. An example calculation for a specific situation is discussed in Sec. 8.

The second group of vehicles is the target recipient of sent WSM. These are programmed so that after receiving WSM from the broadcast of the first vehicle, they immediately rebroadcast it further. This will ensure that the information will spread beyond the coverage area of the first vehicle. Such transmission of information creates a sort of chain of vehicles along which the message can be spread.

To ensure that the message is spread to even greater distances where this chain no longer reaches, the proposed protocol will also use the third group of vehicles mentioned above – oncoming ones. All vehicles are programmed in such a way that when they receive WSM from a source, they compare ID of the road they are on with the ID of the road they received via WSM, which is constrained. This is how they detect if they are on the same road or in the opposite lane. An example of the evaluation will be explained in Sec. 8.

When the vehicle evaluates that it satisfies the condition of a third group vehicle, it stores ID of the constraint road in its memory after receiving the WSM. Then, when it goes out of coverage of the vehicles sending this WSM message and are in the opposite direction of driving, the vehicle starts broadcasting a WSM message containing the ID of the road on which the critical situation occurred. However, this only occurs when it receives a BSM message from another vehicle driving opposite to it, and which does not yet have information about the constraint. At that point, the vehicle responds to the receipt of the BSM message by creating a new WSM with the ID of the constraint road and broadcasts it. In this way, a vehicle that is not connected to the vehicle in front of it can receive information about the critical situation on its road. This situation is shown in Fig. 2.

# 7. Simulation Tools

## 7.1. SUMO

SUMO (Simulation of Urban MObility) is a freely available simulation software that can simulate road traffic [11].

Its development was initiated by the German Air Force Center as early as 2001. Since then, SUMO has evolved into a full-fledged toolbox for traffic modelling, which includes, for example, creation of the road network, road users, and how the traffic should flow.

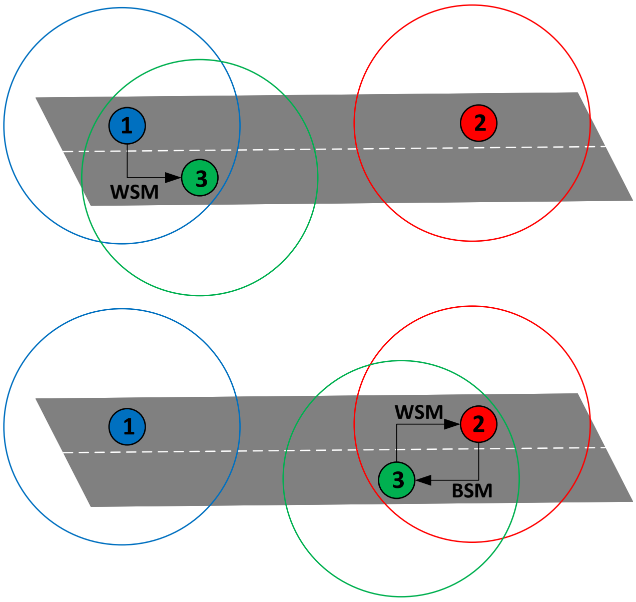


**Fig. 2:** Receiving information via vehicle riding in the opposite direction.

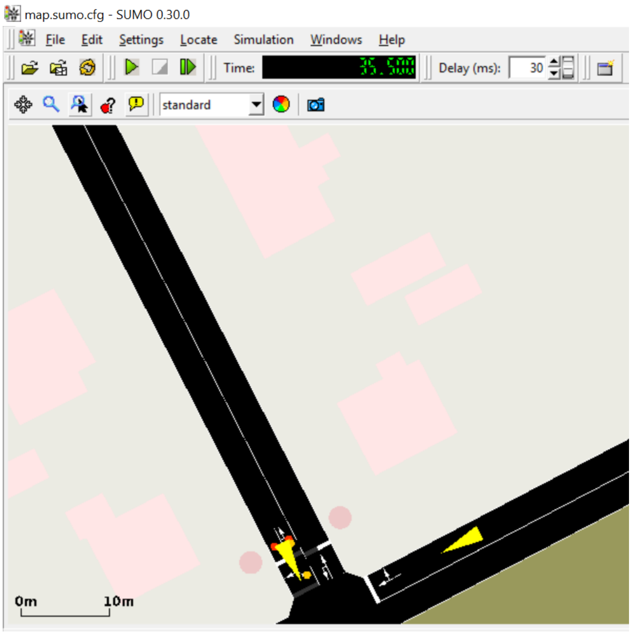


**Fig. 3:** SUMO interface.

There is also a possibility to create custom traffic networks at the user's discretion or the user can import a real map exported from Open Street Map [12] and [13].

## 7.2. OMNET++

OMNET++ is a freely available simulation library used to create network simulators [14].

It is used to simulate various types of networks, such as wired and wireless communication networks, or net-

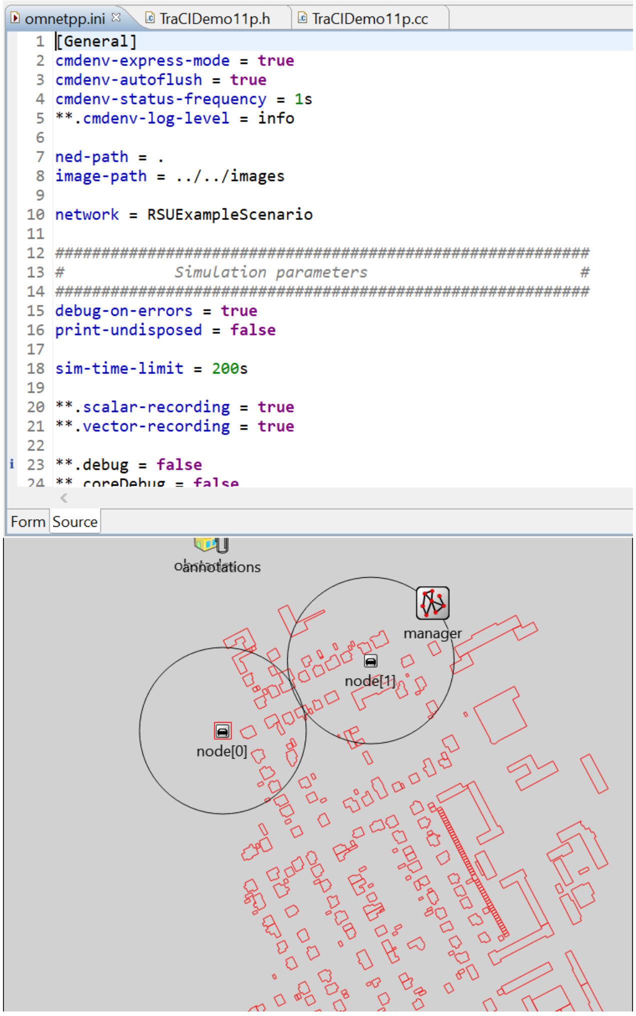


**Fig. 4:** OMNET++ interface.

works on a chip. It provides component architecture creation for different network models. These components are programmed in C++ language. NED language is used to connect them to higher network components. Veins contains a large number of simulation models and components that are applicable to VANETs and which can be used in the simulation [15] and [16].

## 7.3. Veins

Veins is a freely distributable OMNET++ project, which uses for simulation of VANET type network [17].

It serves as a basis for programming own simulation code. Thus, although the Veins project can be used without modifying it, the user can customize it according to his own needs. Of course, the user is also able to replace the map on which the simulation takes place with his own in this project. Veins includes many of simulation models and components that are applicable in VANET and which can be used in its simulation.

Veins simulation must run in parallel in two simulators: SUMO and OMNET++. A road traffic simulation takes place in SUMO. Simulation of network is done in OMNET++. Thanks to this cooperation, nodes in OMNET++ (vehicles) are able to change their positions [18] and [19].

## 8. Simulation

In this part, an example case of a critical situation is used to demonstrate how the proposed BBPiV-v1 protocol works. In this case, it is communication between 6 vehicles. The vehicles move within the points marked in Fig. 5.

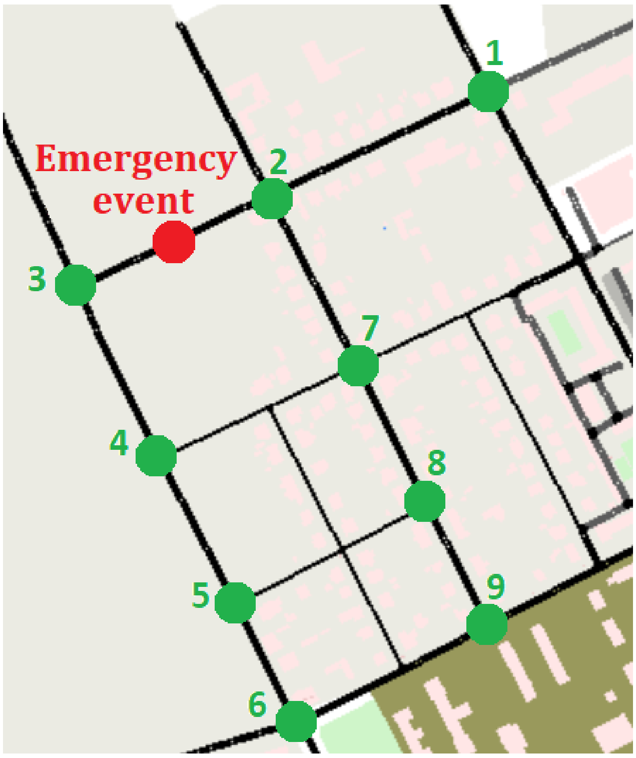


**Fig. 5:** Points of possible routes (green) and accident event (red).

As we can see in the Tab. 1, vehicle node(4) moves in the opposite direction to the other vehicles. This direction of travel was selected to represent the information transfer for the vehicle node(5), which is not in the range of the vehicle node(3). This means that node(5) cannot receive the accident information from vehicle node(3) going in the same direction as node(5). Therefore, we choose to route the WSM message through node(4).

The Tab. 2 contains parameters for simulation of this scenario. According to it, the vehicle node(0) causes an accident in the simulation time of 30 s. At that time, it will be at the location marked in Fig. 5 called as Emergency event.

**Tab. 1:** Vehicles parameters.

| Vehicle | Planned route | Driving start time (s) | Vehicle, which causes an accident |
|---|---|---|---|
| node(0) | 1-2-3-4-5-6 | 0 | YES |
| node(1) | 1-2-3-4-5-6 | 20 | NO |
| node(2) | 1-2-3-4-5-6 | 30 | NO |
| node(3) | 1-2-3-4-5-6 | 40 | NO |
| node(4) | 3-2-1 | 60 | NO |
| node(5) | 1-2-3-4-5-6 | 70 | NO |

**Tab. 2:** Simulation parameters.

| | |
|---|---|
| The count of accidents | 1 |
| Accident time | 30 s |
| Accident duration | 50 s |
| Transmission range | 100 m |
| BSM sending interval | 0.5 s |
| Bit rate | 6 Mb·s$^{-1}$ |

Thus, according to the proposed communication protocol, we can classify the vehicle node(0) into the first group of vehicles. This means that after 10 seconds (plus a delay) from the stop, the vehicle will start to broadcast the WSM message. As mentioned in design of the communication protocol, the vehicle will broadcast the WSM at specific time intervals. This time interval is determined by the maximum speed allowed on the road (in this case 50 km·s$^{-1}$) and the range of the vehicle's transmitting antenna (in this case 100 m). A speed of 50 km·s$^{-1}$ means that the vehicle will travel 100 m in 7.2 s. There is a probability that the vehicle will hit the accident site. This is exactly the case we want to eliminate. Thus, it means that the vehicle must receive WSM before it will be placed at the point of traffic accident. This means that the WSM send interval must be set to less than 7.2 seconds. For the simulation, the interval was set to 4 seconds.

In the simulation in Fig. 6, the moment, when the node(0) starts to broadcast WSM, node(1) is already in its range.

Node(2) and node(3) have also already started their ride. Vehicle node(1) receives the message and responds to the reception by changing its route to the destination through points 1-2-7-8-9-6 according to Fig. 5. It also broadcasts the WSM message further. There is a node(2) in its range; it receives the message and rebroadcasts the WSM. The same is repeated with node(3). However, there is no vehicle beyond its range. Figure 7 shows how nodes(0–3) are in mutual coverage and are in a state where each of them has already been reached by the WSM.

However, node(4) and node(5) vehicles have reached the road in the meantime. When node(4) comes within range of vehicle node(0), it can receive a WSM message.

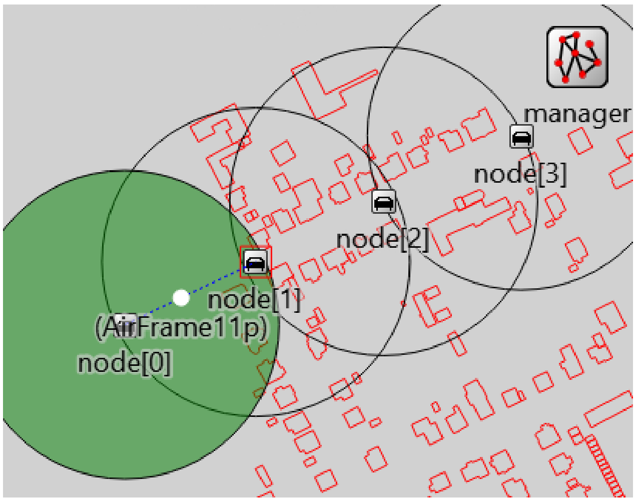


**Fig. 6:** First broadcast by node(0).

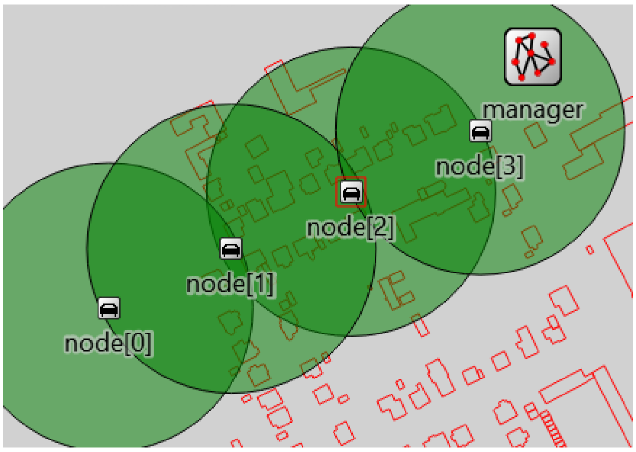


**Fig. 7:** Vehicles node(0–3) after receiving WSM.

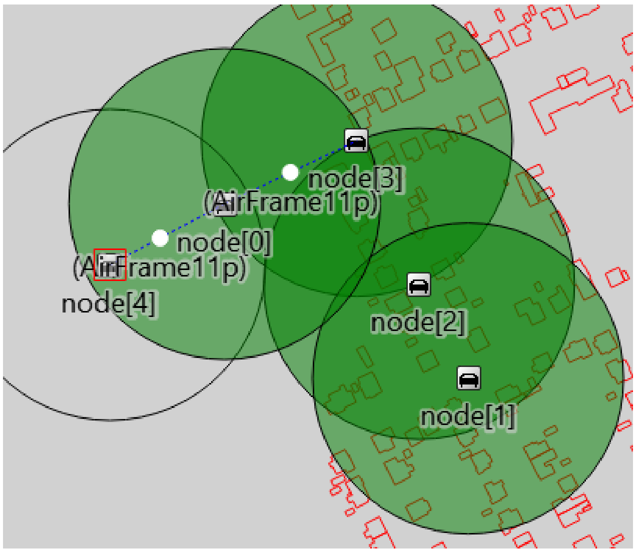


**Fig. 8:** Sending WSM to node(4).

After it is received, the vehicle starts to evaluate if it is on the same road but in the opposite traffic lane. Thus, from the data received by WSM, the vehicle determines that the accident happened on the road marked 60686580#4. It also finds that it is located on the road marked 60686580#4. If the IDs of the roads are the same except for the sign, it means that the vehicles are on the same road but in opposite traffic lanes. It is evident from IDs of the roads that node(4) is in the opposite lane to where the accident happened, and thus where node(0) is located. Thus, node(4) meets the condition to be classified in the third group according to the proposed protocol. After evaluation, it stores the blocked road ID in memory. In the Fig. 9, we can see how node(4) and node(5) reach their mutual coverage and node(5) broadcasts a BSM that is received only by node(4).

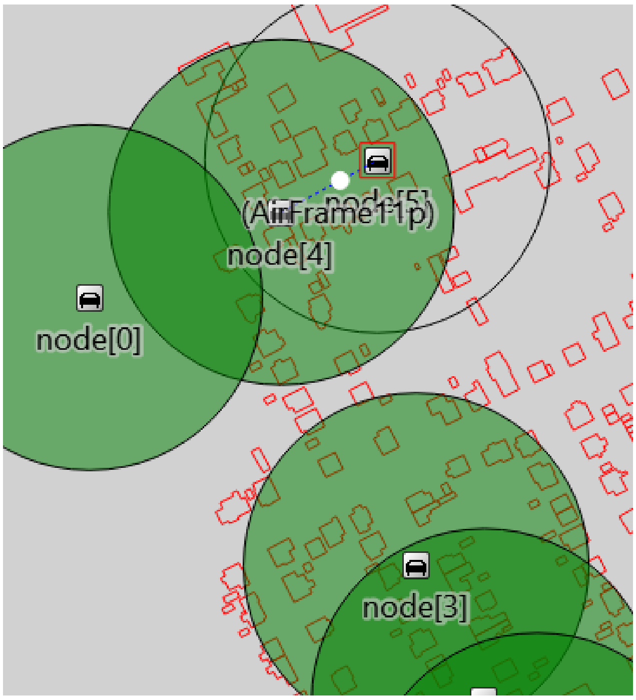


**Fig. 9:** Sending WSM by vehicle in the opposite traffic lane.

Based on this message, node(4) evaluates that there is a vehicle in its range that does not yet have constraint information. Therefore, it broadcasts WSM and based on this the vehicle node(5) changes its road to the destination via points 1-2-7-8-9-6. Simulation thus causes that vehicles nodes(1,2,3,5) finished their travel by using a new road.

## 9. Conclusion

Through simulation, we have shown that the new proposed BBPiV-v1 protocol is able to deliver WSM messages with information about critical situation on the road. All vehicles received the message and avoided the road with the constraint. Transmission of information without using RSU was functioning. A result of this simulation is that this method could be applied in real traffic. There is no need to use RSU to inform about emergency situations; the use of vehicles only is sufficient. Of course, the simulation was shown on a small sample of vehicles, and it is not guaranteed that this would work in real traffic where there are more vehicles. However, this solution provides a suitable basis for further development.

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## Author Contributions

D.V. developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. D.V. and I.B. contributed to the final version of the manuscript as authors. I.B. and J.H. supervised the project.

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