Redes Veiculares de Emergência

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Abstract. The vehicular networks are formed by vehicles, which communicate directly with each other through wireless communication technologies and routing protocols suitable. As a prerequisite to communication, an efficient route between nodes must be created, and keep up with rapid change of network topology. Due to such characteristics as high node mobility, network failures and latency requirements, many of the protocols used have only a minimally satisfactory performance. More than a problem of selecting the most appropriate routing protocol, the fundamental question that arises is the design of the global communication system. In this work, was presented a Vanet architecture that enables an effective communication between vehicles, particularly in emergency scenarios and on motorways, where drivers should be alerted of emergencies with the anticipation required to take an appropriate action. Simulations where preformed to measure whether this architecture meets the necessary requirements. The simulations were implemented using the software NS-2, developed specifically for analyzing all types of communication networks, which provides native support for simulation of ad hoc networks, as is the case of VANETs. The results were essentially focused on the analysis of these two metrics: End-To-End Delay and Packet Delivery Ratio. Both give good indications about the network performance

Keywords: VANETs, Protocols, Scheduling Policies, Events Correlation

1 INTRODUCTION

1.1 Motivation

Today, the technologies of wireless communications have been developing very fast, resulting in several application areas [1]. In the field of mobile networks, initially arose the unstructured mobile networks (Mobile Ad-Hoc Network - MANET), where each node could either take over system, terminal or router functions, which allows communication between mobile nodes possible [2]. The fact that embedded systems may exist in vehicles equipped with communication skills, led to the birth of a new area of research within the MANETs, which today is known as the vehicular network (Vehicular Ad-Hoc Network - Vanet).

The VANETs are formed by vehicles that communicate directly with each other through wireless communication technologies and routing protocols suitable.

There are three broad classes of applications within the field of Intelligent Transport Systems (Intelligent Transport System - ITS): entertainment, traffic safety and assistance. The increasing mortality on the roads led to the need for an increase of safety measures within the traffic management, making timely information to drivers about critical situations a priority. Thus arises the main objective of the work that is designing and implementing a network architecture designed to serve emergencies by supporting physical safety applications. To validate the presented architecture, two main performance metrics are considered: End-To-End Delay and Packet Delivery Ratio.

1.2 Goals

The main objective is the design and implement of a network architecture designed to serve emergency support physical security applications.

The specific objectives are:

- The definition of a communication network architecture that is suitable for use in any kind of scenario, city and highway and which allows to proceed with the submission of information according to their level of criticality;
- The choice of routing protocols for allowing the transfer of information on this and Vanet to another network, if applicable;
- The selection of scheduling policies to transfer the information as a way to ensure that information is transferred according to their priority;
- The selection of mechanisms for event correlation, in order to reduce the amount of information transferred.

The architecture should propose to minimize the cost, using, for example, a communications solution that will not request the use of a network infrastructure, because that would be one of costly investments in such solutions. As with any solution that is aimed at widespread dissemination on a large scale and for all types of users, this should be as convenient as possible and shall act in a transparent manner, if possible, without recourse.

2 RELATED WORK

2.1 *Ad Hoc Networks 802.11*

The 802.11 standard, generally called wi-fi, corresponds to the working group of the IEEE LAN / MAN Standards Committee (IEEE 802) [3]. In this specification, the standard defines two basic topologies of operation: clients communicate directly with each other or, in the second case, initially bind to a central access point to communicate with each other then. In the communication ad-hoc mode, nodes communicate directly with each other. If a node is outside the scope of direct transmission from another node, communication between them is only possible with the multi-hop transmission (multiple hops), in which intermediate nodes (hops) have to retransmit the packets from origin to destination, acting as routers, using any appropriate routing protocol.

2.2 *Routing Protocol*

The transfer of information in a vehicular emergency is critical. When an accident occurs in a road environment, alarm messages need to be transmitted to inform all other vehicles. It is therefore essential that the information reaches the greatest number of us as soon as possible.

Routing protocols for VANETs can be sorted according to their type, among them all, Dissemination protocols are the most suited for applications at the level of road safety, since they are characterized by transmitting information in broadcast mode or geocast.

Thus it is possible to warn the increased number of nodes (vehicles) of accident situations, while the probability increases and decreases the time the information reaches the forces of authority.

2.3 *Scheduling Policies*

The sharing of resources in communication networks, VANETs this case, originates containment situations, due to competition for use of resources. In networks that support integration of various services as is the case, it is necessary to provide Quality of Service - QoS differentiated by class, offering guarantees of performance-critical applications (applications for security).

The scheduling algorithms play an important role in providing different levels of QoS to different applications, allowing differential control of delay, bandwidth or loss rate. What is meant by the use of a scheduling algorithm is to ensure that messages of accidents have priority over any other type of traffic passing through the network. I decided therefore to use a very simple scheduling policy, which involves the use of two different queues, one priority that will address traffic related with accidents messages and other accounted for all other traffic that cross the network.

2.4 *Events Correlation*

For a communications network can be used effectively it is essential that all its resources are managed optimally, reducing in particular the consumption of bandwidth, which is a key resource in Vanet. One possible way to make this effective management is to reduce the amount of information transferred, proceeding to the correlation of events that carry the information enriching the value of these. This correlation should be able to summarize the events that received a single event that represents the occurrence of all others.

The approach taken to implement event correlation was the use of Artificial Intelligence using rules-based systems. As the name indicates represents its knowledge base in the form of rules consisting of conditions and actions that is when something is triggered a particular action, eg an accident between vehicles.

A correlation of events efficiently and accurately is essential to reduce operating costs and improve availability, thereby improving the performance of services on the network.

3 Architecture

It was created an architecture as shown in Figure 1, which allows to decide the policy to be applied to the message, set the most appropriate routing protocol and, if necessary, to make use of event correlation. The policy to be applied to the messages, passes it to or not priority. When the system is faced with a crash message, this message will receive priority shipping, making any other kind of traffic is relegated to the background. The system uses the correlation of events when faced with more than a message of an accident, or when the accident involves more than one vehicle. With this correlation of events intended to optimize the solution, ensuring that information reaches the accident promptly to several vehicles. It is thus possible regardless of the number of messages generated, only one message traversing the network crash. Also, it is used a GPS system to find out the overall position of each vehicle.

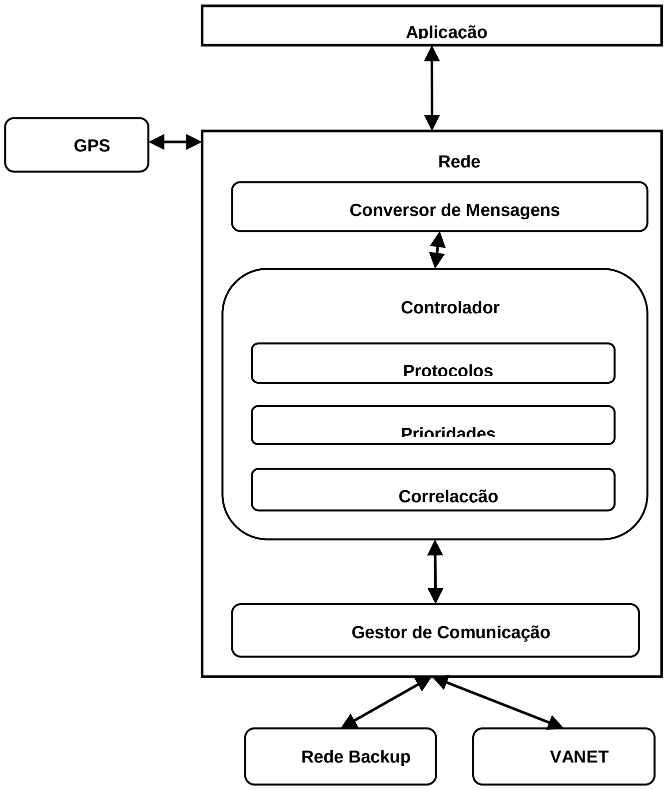

Figura 1 – Network Architecture

3.1 *Timing Requirements*

For this architecture to be realistic for a real environment implementations, a study of the temporal requirements had to be done. The time a driver takes to react [4] [5] varies for many reasons [6] [7] [8]. This time can range from 0.2s to

2.0s but the media reaction time is about 0.7s for a driver with normal reflexes.

The braking time is the time it takes to stop, this is the time it takes until the vehicle is completely immobilized, after starting to hang. Depends on the speed and mass of the vehicle: the higher the speed and mass, the greater is the time it takes it to stop.

Doing an analysis in terms of time against distance the following values are obtained:

- Reaction Time

$$\boldsymbol{T1 \approx 0.7s}$$

- Braking time
  - A2 = 59.4m
  - V = 28m/s

$$\boldsymbol{A2 = \frac{(T2 - 0.7) \times v}{2} \approx T2 \approx 4.94s}$$

This yields a total braking time:

$$\boldsymbol{T1 + T2 \approx 5.64s}$$

3.2 *Protocol*

To transfer the messages of accident, a communication protocol (MYPBCAST) was created. This protocol transmits in broadcast mode, in which messages have the following structure:

IDmensagem	IDLmensagem	IDveiculo	TTL	IPdestino	PktType	PktSize	GPS

- **IDmensagem,** is a field that stores an ID assigned to each message;
- **IDLmensagem**, is a field that holds the ID of the last received message;
- **IDveiculo**, is a field that stores the vehicle identification on the network that was the message sender of an accident;
- **TTL**, lifetime of the package;
- **IPdestino**, is the field that contains the destination address of messages, in which case messages are sent in broadcast mode;
- **PktType,** this field contains the type of packet that will be broadcast on the network, in this case the package is always of type MYPBCAST;
- **PktSize,** this field contains the packet size of type MYPBCAST;

- **GPS,** this field stores the GPS coordinates of the vehicle that generated the message of an accident the 1st time.

3.3 *Implemented Model*

Sending a message uses the accident protocol described in the previous section. A message is sent every second for sixty seconds, by the crashed vehicle, and all vehicles within a certain radius of the accident will receive them. In turn they will proceed with its retransmission again in broadcast mode. If the accident involves more than one vehicle then each vehicle will send your message to the accident, independently. This model makes use of scheduling policies that will address traffic related messages from the accident with priority over other traffic messages flowing on the network and still make use of event correlation thereby reducing dramatically the number of messages circulating on the network.

4 Simulation Studies

4.1 Simulation Scenario

To simulate an accident, it was considered a high density of vehicles. In this case, 450, thus simulating the behavior of nodes in the highway laid out along 10 km. We then created three different types of network traffic, in order to try to simulate a situation as realistic as possible.

- Voice Communications
- Sharing Files
- Messaging Accident

As an example the following image shows the disposition of all vehicles on the scene over 10km, and various types of network traffic.

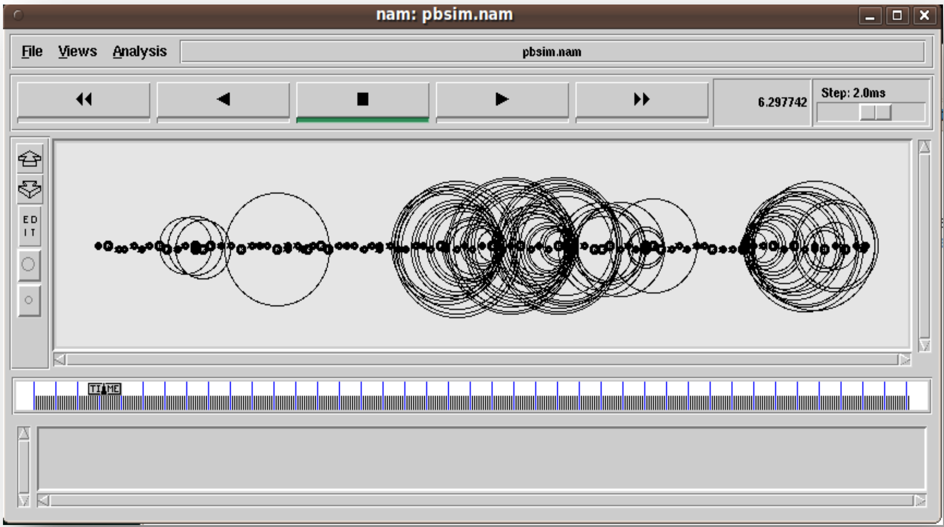

Figura 2 – *Packet-Delivery Ratio*

The generation of the traffic accident of the messages follows an entirely different methodology. Compared to the other two types, this situation is to use a custom protocol MYPBCAST, who works in broadcast mode in order to get the message as soon as possible to as many vehicles.

4.2 Simulation Results

a. Packet-Delivery Ratio

Testing of Packet Delivery Ratio intended to show the efficiency of packet delivery over several kilometers.

The first test passed simulates three simultaneous voice and two TCP communications, using the FTP service where the parties are separated by several miles trying to have communication throughout the network.

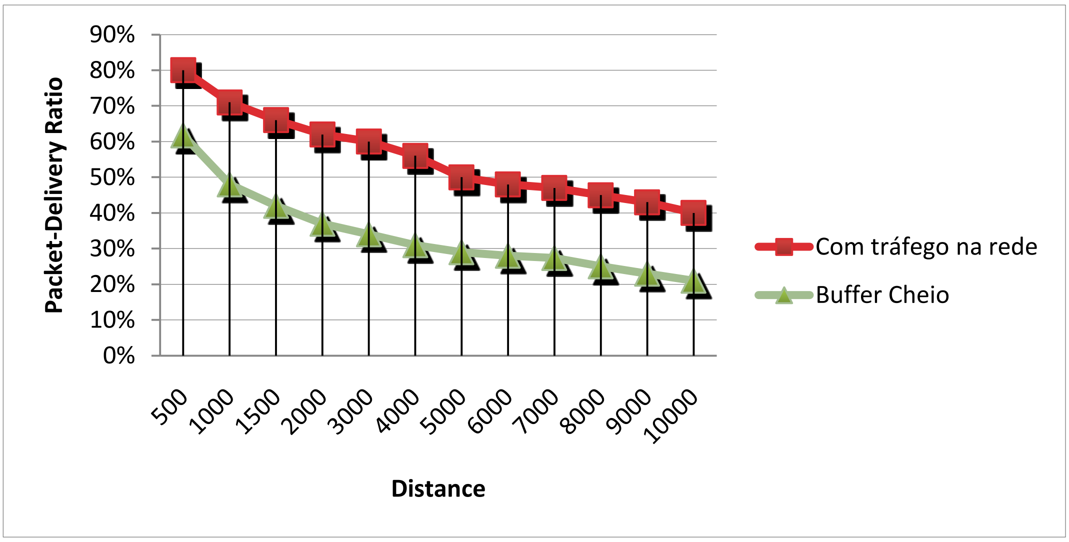

Figura 3 – *Packet-Delivery Ratio*

In figure 3 shows that the fast-Packet Delivery Ratio at the end of 500m to a situation of much network traffic has declined by 20% and continues to decline with increasing distance. This is mainly due to the existence of much network traffic. If the traffic situation increase the buffer fills that carry the messages to be discarded, the value of the Packet-Delivery Ratio is much lower, which can be seen that after 500m already dropped by 40%.

Any solution to solve these problems was to give these messages accident precedence over any other type of messages and thus managed to raise considerably the Packet Delivery Ratio (Figure 4), compared to dispatch without priorities.

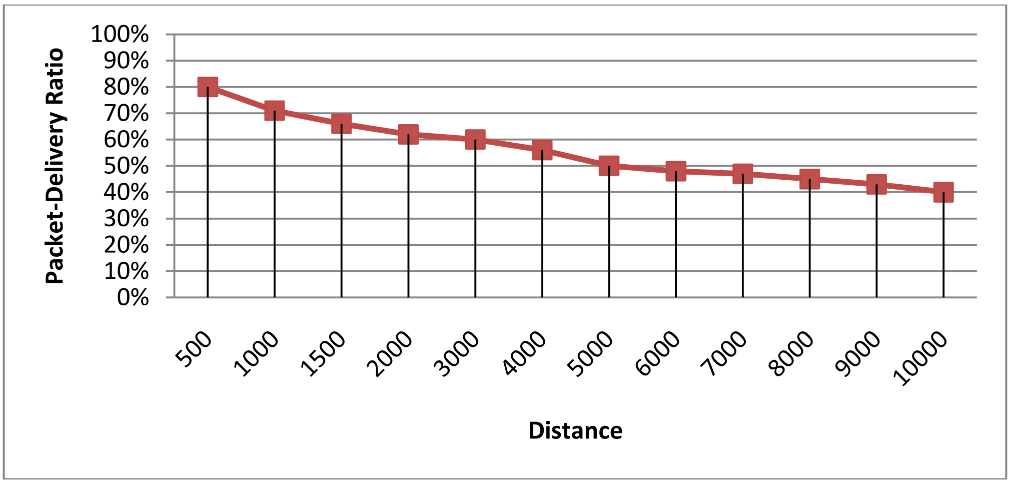

Figura 4 – *Packet-Delivery Ratio* with priorities

Depending on the number of vehicles that collide means that the number of messages in the network to grow exponentially. Unlike what was expected, analysis of table 1, the Packet Delivery Ratio improved when the number of messages in the network increases accident, this is due to the fact that there is not much traffic priority by allowing the other traffic be sent, resulting in a reduction in the number of messages of the collision accident.

Tabela 1 – *PACKET DELIVERY RATIO COM/* SEM CORRELAÇÃO

Distância	**Sem correlação**			**Com correlação**
	Entrega MSG A	***Entrega MSG B***	***Entrega MSG C***	***Entrega MSG A+B+C***
500	98%	98%	96%	76%
1000	96%	96%	96%	64%
1500	96%	95%	95%	60%
2000	96%	96%	96%	55%
3000	90%	90%	88%	52%
4000	87%	87%	85%	47%
5000	85%	86%	82%	43%
6000	81%	82%	79%	40%
7000	82%	82%	78%	39%
8000	79%	79%	76%	38%
9000	77%	78%	76%	37%
10000	75%	76%	74%	35%

Initially it seems a good solution not to use any correlation of these messages due to improvement of the values of packet delivery ratio, but the problem appears to exist the possibility of such forces the authority they need to know the exact number of crashed vehicles only receive messages two vehicles and never get a third. Table 1 also shows the Packet Delivery Ratio when using this approach to event correlation, thus providing a number of messages on the network much more limited.

b. End-To-End Delay

The testing End-To-End allow us to analyze whether the drivers are actually able to be warned in time to avoid a pile up, and at the same time have an idea how much it would take to be advised the forces of authority, where such a receiver is several kilometers from the accident.

The first test shows the actual times that the accident took messages to go ten miles.

Tabela 2 - TEMPO REAL DE AVISO DE ACIDENTE ATÉ AO QUILÓMETRO X

Situação / Distância (m)	1000	3000	5000	7000	9000	10000
SEM TRAFEGO (1 Msg)	0.14s	0.8s	1.18s	1.93	2.54s	2.67
COM TRAFEGO (1 Msg) - Sem Prioridade	3.4s	3.9s	5.5s	6.4s	6.8s	7.3s
COM TRAFEGO (1 Msg) - Com Prioridade	3.3s	3.5s	5.1s	6.0s	6.3s	7.0s

The second test refers to a situation in which three vehicles collide and measured the time that the three posts of accidents actually take to arrive at the destination.

Tabela 3 - TEMPO REAL DE AVISO DE TODOS OS ACIDENTADOS ATÉ AO QUILÓMETRO X

Situação / Distância (m)	1000	3000	5000	7000	9000	10000
C/ Tráfego (3 Msg) – PRIO/SEM CORR	0.61s	1.8s	2.21s	2.55s	3.1s	3.5s
C/ Tráfego (1 Msg) – PRIO/COM CORRE	4.45s	4.9s	6.2s	6.9s	7.4s	8.1s

For the analysis of Table 3 there is a greater number of messages circulating on the network. The probability of any of them reach the destination is much greater, hence the time is very low compared with the second situation in which a message is sent with the information crash of three vehicles. The time differences exist because as the correlation is only done to send the second message of accidents and collisions happen because the first message in sending correlated.

5 Conclusions

In conclusion, it appears that the objectives have been achieved, using the architecture proposed and tested that allowed us to take on elationships vestments important in these kind of networks.

Tests for the Packet Delivery Ratio shows that the scenario of sending a single message, using the priority brings significant results compared to the post without the use of priority.

The first two tests of End-To-End delay show that two of the defined metrics are largely met. These metrics shows us that the drivers that are far from the crash site really have the possibility of being warned to divert at time and pursue another path in order to avoid traffic jams, while offering a vision of what it would take to be warned the forces of authority, for example where a receiver is several kilometers from the accident.

As future work, several things can be studied and developed in the context of making all this work better, as well as make improvements to the algorithm developed.

It is also interesting to perform stress testing of the solution proposed in this thesis in order to identify the real limits on the number of possible messages in the network.

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