# Implementation of Cellular IoT over VANETs for Efficient Communication of Safety Messages.

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**Abstract:** when it comes to communication of road safety message communication, improved packet delivery ratio, reduced delay in packet delivery are most important as the messages are critical and need to be communicated and guaranteed delivery. Along with the better delivery parameters we energy efficiency is also an important factor. This paper introduces a method to implement VANETs using LTE-M against WAVE which is particularly concentrating on different types of communications in VANETs. With the adaption of LTE-M in the VANETs the model gives some design simplifications. This raise to reduction of unnecessary stages in cluster formation such as Cluster Heads in vehicles and allow communication of vehicles directly via RSU which will reduce the no of hops between sender and receiver when the cluster head is more than 2 hops from sender to receiver. This will also reduce the computation burden on cluster head. So we achieve better delivery ratio and reduced delay in delivering packets.
**Keywords:** VANETs, Cellular IoT, LTE-M, WAVE, RSU, ITS, Position Based Routing.

## 1. Introduction

Road safety technologies are evolving very fast with VANETs, and the researches are pouring in such a way that the VANETs are termed now as ITS Intelligent Transport Systems. Communication between two vehicles was evolved as a safety measure at first, but now the ITS is a branch of communication and ITS has many different folds. ITS can be more precisely termed as more coordinated traffic management than safety message communication. So a safety message communication can be developed as a more organized sophisticated model. This model should be capable of deciding the messages criticalness and prioritize them. The prioritized messages must be delivered to the recipient in time (within no time). The communication medium used must be more reliable. The vehicles should be enabled to communicate even from the parking lots to the streets, even highways to the urban roads. The traffic patterns should not affect the quality of services. Data to be transmitted is very critical which can be reached to any corners of locations such as vehicle parking lots, which would be very useful for the vehicles entering the main traffic from behind the scenes.

## 2. Literature Survey.

G. Araniti et, al, laid out the model for vehicular Networking using LTE in [1]. This article proposes that LTE may suffer from poor uplink speeds, but still the speeds may be more than sufficient as the data to be transmitted is of critical type and the central or backend server will also serve a vital role to reduce the network by adopting selective broadcasting.

Cost reduction, reduced power consumption, enhanced coverage are the goals of eMTC enhanced Machine –type communications. Narrowband IoT (NB-IoT) is the cellular technologies that offer various advanced features suitable for IoT and VANETs. [2] Gives a detailed study about the enhancements in NB-IOT compared to eMTC with respect to the goals of eMTC. [3] Calls it an IoV, which has scope beyond the telematics or VANETs. It treated IoV as intelligent transportation, by integrating sensors, mobile devices and vehicles into global network. Its Activation, maintenance, comparison study of routing protocols for IoV are done against different parameters, in the paper.

According to [4] vehicles are equipped with OEM security systems such as Blind Spot Monitoring, Anti-Schlupf Regierung, Electronic Stability Program, Forward Collision Warning, Automatic Emergency Braking, Brake Assist System (BAS), Lane Departure Warning System. And new technologies includes V2V Accidents on the way, road works etc, V2I with lane markers, street lamps, cameras, traffic lights, RFID readers, signage parking meters which are bidirectional and wireless, V2X Pedestrian Collision Warning (PCW) components etc. [5] proposes a IoV coordination computing based on virtual vehicles VV. With the sense of physical objects things, vehicles and human in the traffic scenario, VV, swam computing gives traffic control and traffic information for traffic service. Similarly using VV Data, Traffic Data, sensing Data and interaction Data swam computing gives on-board services such as vehicle navigation and vehicle communication. A detailed study and comparison of existing technologies in various folds of IoV surveys are compared in the paper [6], various System models for IoV; Network Model, Threat Model. Taxonomy of Security Protocols for IoV; Key Management, Authentication, Intrusion Detection, Access Control, Secure Routing, and Privacy Preservation. Various Authentication Protocols and their performance comparison are done against; Light-weight Authentication, Batch Verification Based Authentication, Privacy Preserving Based Authentication, Dual Authentication, Hash Chain Based Authentication.

Corporate and standards organizations are moving better than else in the research of C-V2X i.e., Vehicle to everything. GSMA [7] has laid outline to connect Vehicles to pedestrians, Cyclists, and cloud based services through 4G and 5G, via 3GPP. GSMA finds mobile operators of most of the world are well placed to provide for V2X, and also enlightens on how 5G would help V2X.

.[8] describes different WAVE protocols and standards specified by IEEE 1609 series, with specific to channel access and schemes, single physical layer device access scheme, Multi- physical layer device access scheme, in Physical layer. WAVE MAC layer and WAVE Network services; Data Plane services, Management Plane services standards specified in 1609.0 to 1609.12 are discussed in the paper.

[9] gives a detailed overview of routing protocols required for VANETs, they are classified as; topology, position, multicast and broadcast based routing protocols. Efficiency comparisons are done based on the packet delivery ratio, throughput, end-to-end delay, Routing overhead. Three technical issues; Void area, direction of nodes and high speed are the main problems in VANET routing and the solution for that issue is discussed. Clustering of vehicles which uses WAVE technology can be clustered based on the vehicles movement direction and closeness based on the number of hops required to communicate with cluster head. Formation of cluster is based on cluster head and cluster member but the node parameters in a VANET include the position of vehicle in [10].

WiFi is used for V2V and WiMAX is used for V2I in VANETs, in [11] and they have compared the technology with WAVE and DSRC. The research found WiFi and WiMAX technologies, varies in their communication range, WiFi was more suitable for VANETs but due to coverage restrictions WiMAX is used for V2I.

### 3. WAVE and LTE-M:

WAVE technology laid by IEEE 1609 specially for VANETs Defines standards for device to device communication in 1609.0, it defines data and management services offered in 1609.1, defines secure message formats and processing in 1609.2. Network and transport layer services and routing are defined in 1609.3 it also defines a WAVE specific alternative to IPv6. Enhancements to 802.11 Medium Access Control are defined to support WAVE in 1609.4 and 1609.11 defines secure message formats for electronic payments.

With the above standards WAVE clearly forms a standard for Vehicular Communications.

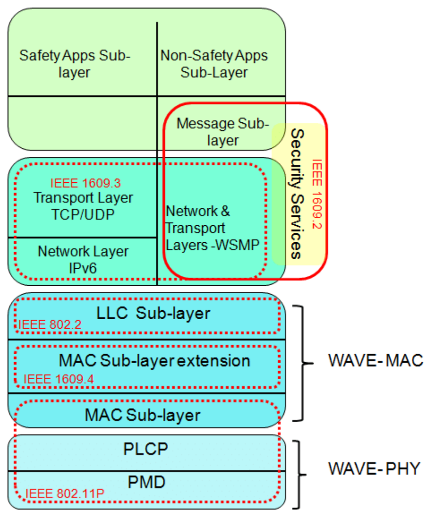
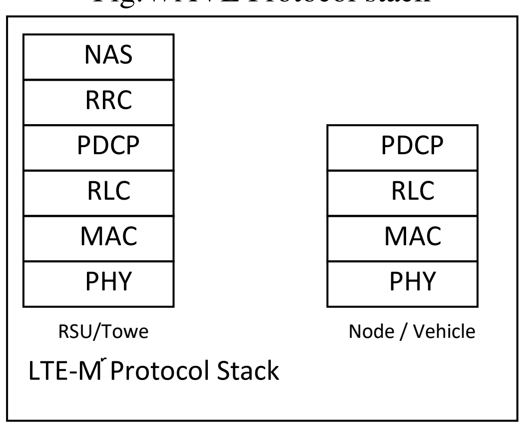



Fig:WAVE Protocol stack




*Cellular IoT Protocol stack*

Cellular IoT and LTE M: Cellular IoT was proposed by GSMA, for communicating IoT packets in unused mobile networks. It is used in two methods. NB-IoT and LTE-M. NB-IoT uses unused spectrum of cellular networks which is suitable for relatively slow communications or less data. NB-IoT uses 180kHz spectrum and is based on subset of LTE-M. in case of LTE-M which operates at 1.08MHz, concentrates for higher bandwidth and more data transfer.

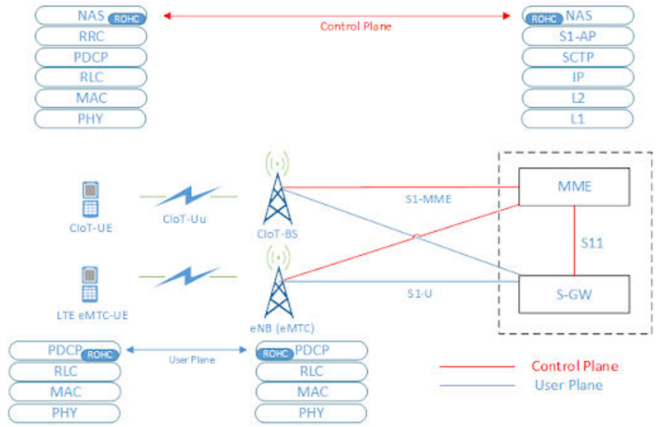



Fig: Cellular IoT Communication model

## 4. VANETs implementation with LTE-M:

The major components of VANETs are: Vehicles (Nodes), Road Side Units (RSUs), and backend Servers. Backend servers are just meant for authentication and monitoring purposes. The safety message communication happens between vehicles, and that is termed as V2V. When the sender and recipient are in the coverage of two different RSUs then the message may have to be communicated via RSUs, the communication between Vehicle and RSU is termed as V2I.

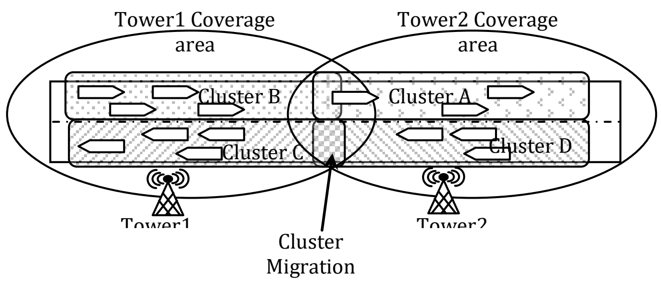



Fig: VANETs Scenario and Clustering

The above figure depicts vehicles moving along a straight road, Tower1 and Tower2 are the RSUs which serve as communication medium between communicating parties. The vehicles moving in a certain region and in a particular direction are formed under a group and termed as clusters.

V2I Infrastructure Registration: the vehicle or Node entering into the cluster area, will first send a member_request to the server. Server in turn verifies the authentication of the node and sends back acceptance. And once the new vehicle is registered in the cluster server will update the information of the vehicle to all other vehicles in the cluster. Meanwhile the newly connected vehicle will get disconnected from previous cluster (if any).

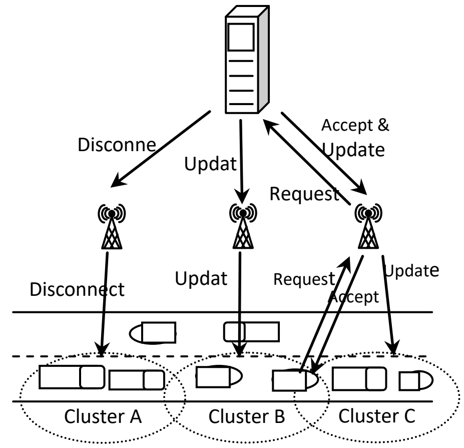
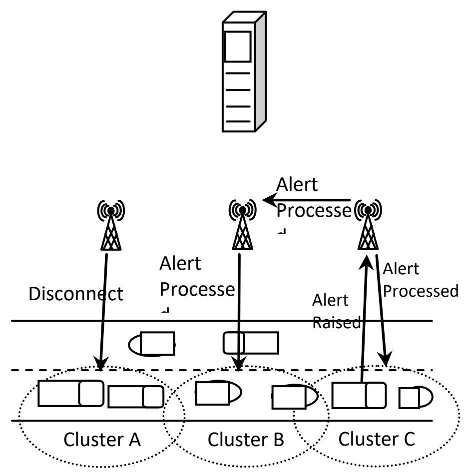



Fig: Vehicle Registration in the cluster

V2V Communication: whenever an alert is to be processed to vehicles in the network, the sender will initiate the channel access and then it sends to all the vehicles within the cluster as per the cluster data available with it, without the intervention of server.




V2I Communication: some messages are meant for vehicles within the cluser, and some messages may be intended for vehicles in previous clusters and even some messages are for vehicles in the next cluster (such as ambulance alerts) so for sending those messages vehicle has to send message via RSUs, to the RSU of the intended cluster. Normally vehicles or nodes will have database of RSUs in the adjacent clusters.

**Simulation:**

Multicast/Broadcast: The system is capable of sending only vehicles that are affected by the alerts as well as some alerts are required for all. Native V2V support and Packet scheduling and QoS support: are guaranteed by using dedicated time slots in the spectrum for the connections.

The simulations are done using SUMO and Omnet++, with VEINS framework, with the following parameters.

| | |
|---|---|
| Traffic | Random |
| Directions | Bi Directional |
| Vehicles density | 20, 60 and 100 per each km of road length |
| Speed of Nodes | 40 kmph, 60 kmph, 80 kmph |

| | |
|---|---|
| Alerts | 5 Broadcasts / min |

**Interpretation of Observations**:

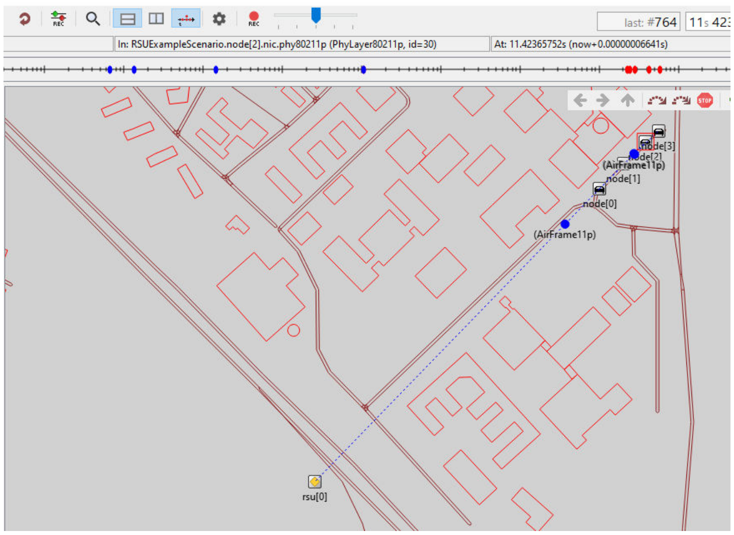



Fig: Simulation of Airframes from nodes to Nodes via RSU and through multihop.

It was observed that the delay seen using WAVE varies according to the no of vehicles in the cluster area and speed of the vehicles. Whereas using LTE-M it shows almost constant delay and delivery ratios.

| Density of Vehicles in cluster | Delay | | | Delivery Ratio | | |
|---|---|---|---|---|---|---|
| | 20 | 60 | 100 | 20 | 60 | 100 |
| WAVE | 0.5 | 0.6 | 0.7 | 92 | 90 | 88 |
| LTE-M | 0.5 | 0.5 | 0.5 | 91 | 91 | 91 |
| Speed of Nodes in kmph | Delay | | | Delivery Ratio | | |
| | 40 | 60 | 80 | 40 | 60 | 80 |
| WAVE | 0.5 | 0.65 | 0.8 | 92 | 89 | 85 |
| LTE-M | 0.5 | 0.55 | 0.55 | 91 | 90 | 90 |

## 5. Summary

As the no of hops required in a multi hop increases with the number of vehicles in the cluster, similarly packets traffic also increases with the no of vehicles in the network with the number of vehicles so the packets dropping ratio also increases which affects delivery ratio and delay in packets delivery. At the same time using LTE-M simplified architecture accommodates for more traffic and also no increase of the number of hops leads to the constant delay and delivery ratios.

Analysis of the above results gives almost better delivery ratio and reduced delay in delivery of packets when compared to WAVE. Energy efficiency of the LTE networks are also monitored by the PSM and eDRX technologies of LTE-M, Which offers better energy efficiency. The reduction of one member in the form of Cluster Head reduces considerable amount of delay in the form of Hops, and it also reduces computational overhead on the cluster head, these advantages reduces the delay and also reduces the possibility of packets loss.

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