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An Integrated Scenario Towards Amelioration of QoS in Intelligent Transport System

V. Devarajan and R. Gunasundari

Department of Electronics and Communication Engineering,
Pondicherry Engineering College, Puducherry, India

Abstract: This Rapid growth in the transportation domain has made us to concentrate more on the improvement towards the services that are more crucial in life saving scenarios, these improvements can be fined tuned there by making it to adopt for various mode of transportation. The Intelligent Transport Systems comprising of theses smart vehicles will update users about the road condition, traffic conditions, amenities nearby and other infotainment applications which will make journeys safer, This will also help in linking the user and make use of the transport networks in a smarter way. The main problem in implementing this system is providing seamless connectivity with low delay and high data rate. In this paper integration of VANET (Vehicular Ad Hoc Networks) with WiMAX (World Wide Interoperability for microwave access) and LTE (Long Term Evolution) is proposed to solve this problem. Vehicle to Vehicle (V2V) communication supports services such as car collision avoidance and road safety by exchanging warning messages across vehicles. Coupling the high data rates of IEEE 802.11p-based VANET with WiMAX and the wide coverage area of LTE networks, envisions a VANET-LTE-WiMAX integrated network by which the performance of the networks can be improved. QualNet v6.1 simulation tool is used to evaluate the performance. Encouraging results are obtained in terms of less delay, high data packet delivery ratios and throughput.

Key words: ITS · VANET · WiMAX · LTE · V2V

INTRODUCTION

The Recent advances in wireless networks have to lead to the introduction of a new type of networks called Vehicular Networks. Vehicular Ad Hoc Networks (VANET) is a form of Mobile Ad Hoc Networks (MANET). VANETs provide us with the infrastructure for developing new systems to enhance drivers' and passengers' safety and comfort. VANETs are distributed self-organizing networks formed between moving vehicles equipped with wireless communication devices. This type of networks is developed as part of the Intelligent Transportation Systems (ITS) to bring significant improvement to the transportation systems performance. Each Vehicle Node is equipped with WAVE (IEEE 802.11p) protocol known as OBUs (On Board Unit). There are mainly two types of communications scenarios in vehicular networks: Vehicle-to-Vehicle (V2V) and Vehicle-to-RSU (V2R or V2I). The RSUs can also communicate with each other and with other networks. Vehicular Networks are expected to employ variety of advanced wireless technologies such as Dedicated Short Range Communications (DSRC), which is an enhanced version of the WAVE (IEEE802.11p) technology suitable for VANET environments. The DSRC is developed to support the data transfer in rapidly changing communication environments [1].

WiMAX is an acronym meaning Worldwide Interoperability for Microwave Access. It is part of the IEEE 802.16 standards and was developed by the Institute of Electrical and Electronic Engineers (IEEE). The first WiMAX standard was IEEE 802.16-2004 also known as 802.16d [2]. It supported fixed wireless internet service and was published in 2004. The second standard 802.16-2005 also known as 802.16e was published by IEEE at the beginning of 2006 and provided further enhancements by adding the support of mobile wireless access [3]. The WiMAX forum, an industry consortium, is promoting the 802.16 family of standards for broadband wireless access systems. Their task is to certify the interoperability of WiMAX products [4].

Corresponding Author: V. Devarajan, Research Scholar, Department of Electronics and Communication Engineering, Pondicherry Engineering College, Puducherry, India.

Long Term Evolution (LTE) is latest technology which has some new extraordinary features that were new to the field of wireless and mobile communications and made LTE an advantage and fast adaptable technology compared to other technologies. Apart from that, some features that were included in older releases of the current mobile telephony standard, called Universal Mobile Telecommunications System (UMTS), were improved and refined in order to provide LTE with the capability of performing better than any other mobile communications standard and in order for it to cover the needs of a great variety of applications. By the advance features that are implemented in LTE have made the performance can be optimized in order to accommodate the special needs of the vehicular environment such as low latency, transmission of small periodic packets and reception of a transmission by multiple receivers etc. In this section, the features, functionality and capabilities of LTE will be presented so that its role in a future ITS network can be evaluated [5].

In this paper, we are proposing an integration of VANET with WIMAX and LTE. Vehicle to Vehicle (V2V) communication supports services such as car collision avoidance and road safety by exchanging warning messages across vehicles. Coupling the high data rates of IEEE 802.11p-basedVANET with Wimax and the wide coverage area of LTE networks, envisions a VANET-LTE-WiMAX integrated network which is a better integration with QoS features. Vehicles are dynamically clustered according to related metrics. From these clusters, a minimum number of vehicles, with onboard IEEE 802.11p and E-UTRAN interfaces and also access the WiMAX access point, are selected as vehicular gateways to link VANET with LTE. The former aims for enhancing the link stability within the VANET, whereas the latter sustains inter-connectivity of the VANET with LTE. A Cluster Head (CH) or gateway election mechanism to manage the VANET sub-clusters is done.

In this paper, the envisioned VANET-LTE network architecture is described in detail in section II. The performance of proposed system is analyzed for VANET, LTE and its integrated network separately described in section III. The paper concludes in section IV.

Comparison of Vanet-Wimax-Lte Networks: These three networks are the most distinct networks by nature and their mode of communication which made us to compare these to form a rare combination of network to achieve a better QOS and other parameters which are required to make a stable network in terms of packet delivery [3].

Release and Deployment: WiMAX was developed and released in 2005, which is much earlier than LTE, which was released in 2009. Currently there are 592 WiMAX networks in 149 countries [6]. On the other hand, the commercial use of LTE just has started in 2009 and thus it is not much widespread yet [7]. This is a huge advantage over LTE's deployment, which has recently started leading to a wider spread of WiMAX. In VANET, Vehicle to vehicle communication needs a unique Ad-hoc communication scheme that is self-organizing and it can function without a pre-existing cellular infrastructure network.

Transfer Rates: WiMAX reaches peak transfer rates of 46 Mbps in the downlink and up to 4 Mbps in the uplink, whereas LTE offers up to 300 Mbps in the downlink and 75 Mbps in the uplink. LTE is definitely superior to WiMAX in this case. It also supports a bigger range of channel bandwidths from 1.4 MHz to 20 MHz than WiMAX with 3.5 MHz to 10 MHz in VANET available data rates are halved compared to 802.11a, namely 3-27 Mbps. The spectrum around 5.9 GHz has been allocated specifically for use by vehicular communications systems a total BW of 70 MHz is available for 802.11p which is divided into seven 10 MHz channels.

Equations: Mobility: WiMAX and LTE are mobile telecommunication networks, so they have to offer good mobility features. The coverage of cells and the power efficiency of the devices are some of the most important factors.

Coverage: WiMAX signals can reach up to 50 km but this is only acquirable with much loss in signal quality. WiMAX is more optimized for shorter distances like 1.5 to 5 km. LTE, on the other hand, can cover up to 100 km, which is twice as much as WiMAX' coverage. LTE also offers connectivity with speeds up to 350 kmph. So, it's even possible to be connected on a LTE-network when sitting in a high speed train. On the other hand, WiMAX supports speeds up to 120 kmph, because of its optimization for nomadic speeds. In IEEE 802.11p optimum range is 300m but it can reach a maximum of 1000m.

Power Efficiency: Both LTE and WiMAX offer power saving mechanisms. They can be both sent into an off-state where less or even no power is needed. LTE can even turn the transmitter off while having a call when there are longer breaks. Also LTE uses SC-FDMA in the uplink, which is more power efficient than OFDMA.

Table 1: Comparison of Networks

	CEN DRSC	ITS	WiMAX	LTE
Standard	CEN-EN 12253-2004	IEEE 802.11p	IEEE 802.16	LTE
Antenna	Rooftop	Rooftop	Rooftop MIMO	Rooftop MIMO
Frequency (MHz)	5795-58055805-5815	5855-58755875-59055905-5925	Support for several bands	Support for several bands
Range (m)	3-15	500	Coverage max 50k	Coverage max 100k
Data rates (kbps)	DL-500UL- 250	6000UL=DL	DL-70 000UL-70 000	DL-100MpUL-50Mps
Latency (ms)	5ms	Implementation dependent	Implementation dependent	Implementation dependent
Priority QoS RT support	No	4 Qos classes. No real-time support	Yes. QoS depends on proximity to access point	Yes. Qos depends on proximity to BS
Transmission modes	Directed Two-way Broadcast	Omni-directional Two-way Broadcast	Omni- directional	Omni-directional
Requirements	RSU	None	Access point	Base station

Mobile device power issues are usually not a significant constraint in vehicular networks as in the case of classical ad hoc or sensor networks, since the node (vehicle) itself can provide continuous power to computing and communication devices. This makes mobile devices use less power, which increases their battery life.

Security: Concerning security aspects both, LTE and WiMAX, are on the same level. They both offer techniques and use protocols, which ensure safe connections. All in all, Long-Term Evolution is superior to WiMAX when it comes to the technology. But there are also downsides. LTE was released several years after WiMAX, so that many telecommunication companies already invested in WiMAX and already offer commercial services. For some telecommunication companies it is not rentable to switch from WiMAX and invest into a new technology [2]. Comparison of three networks with CEN DSRC is as shown in Table 1.

Integration of Vanet-Wimax-Lte Heterogenous Network: In this paper the performance analysis of integrated VANET-WiMAX-LTE wireless networks and effective group communication between the spatially-apart VANETs through the nodes and LTE backhaul network, making the best use of EUTRAN and eNB resources. In order to achieve an end-to-end group communication effective lower-tier multicasting within VANETs and upper-tier communication with the WiMAX access point and LTE eNB is needed. A combination of LTE and WiMAX to severally furnish V2I and V2V connectivity in a V2V2I vehicular network. To insure the cogency of vehicular network, a suitable information interchange between node extremities of a network expects, amid additional features, the comprehension of node mobility below dissimilar environmental circumstances. The try out comprises of two vehicles (mobile nodes) that are associated with an ad-hoc Wi-Fi association and a stationary place post with a committed WiMAX association to one of the vehicles. The LTE network is undertaking the WiMAX network, so the problem of WiMAX is overcome by integrating the WiMAX and LTE. Vehicles in the VANET, which are lying in or moving into the 4G active region and equipped with the E-UTRAN interface, are termed as the Gateway Candidates (GWCs). The E-UTRAN interface is enabled on the GWCs. Rest of the vehicles that are either not instantaneously present in the 4G active region or unequipped with LTE E-UTRAN interfaces are termed as Ordinary Vehicles (OVs). The E-UTRAN interface is either absent or disabled on them. Dynamic clustering is performed on the GWCs, resulting in individual GWC sub-clusters with a Cluster Head (CH), present in each of them. In group communication scenarios, multi-casting within VANETs is controlled and coordinated by the CHs. A minimum number of gateways (GWs) are adequately elected out of them. Only the GWs are activated with their interfaces to communicate with the Base station. The QoS requirements of the multicast sessions are handled by the four modules [5]:

- Policy Provisioning Module (PPM) - Handles priority requirement of the multicast sessions on the GW side
- Session Admission Control Module (SACM) – Decides Session admission /drop based on the requirements of the GW.
- Sub-Cluster Management Module (SCMM) - Manages vehicular mobility, multicast mesh maintenance and resources within the VANET sub cluster.
- GW Management Module (GWMM) - Reserves and manages resource for GWs on the LTE eNB side.

Based on these requirements, the Base station multicasts data to GW, which shall further multicast data to the intended destination vehicles [8, 9].

Table 2: Simulation Parameters

Parameter	Value
System Parameters	
Terrain	2500*1500m2
Channel Bandwidth	5 MHz
Network Protocol	IPv4
Packet size	512 bytes
Simulation Time	150ms
WIMAX Parameters	
Number of Base station	1
Number of users	2
Transmit power	46dBm
Antenna Configuration	Tx-1, Rx-1
Antenna model	Omni-directional
Antenna height	1.5m
eNB Scheduler Type	Round Robin
LTE Parameters	
Transmission Mode	Half-Duplex
Transmission Power	50dBm
Antenna Configuration	Tx-1,Rx-1
Antenna Model	Omni-directional
VANET parameters	
Transmit Power	46dBm
Antenna Model	Omni-directional
Mobility	Random Way Point
Number of users	4

Simulation Result: Qualnet [10] is a network simulation tool that simulates wireless and wired packet mode communication networks.

Qualnet Developer is a discrete event simulator used in the simulation of MANET, WiMAX networks, LTE networks, satellite networks and sensor networks, among others. Qualnet has models for common network protocols that are provided in source form and are organized around the OSI Stack.

A study done by Hsu et al compared performance results from a real world ad hoc wireless network deployment to the results obtained from a model of the network in Qualnet and concluded that Qualnet modelled the deployment scenario with remarkable accuracy, thus validating the ability of Qualnet to model realistic wireless environmental effects [11].

Scenarios of integrated VANET with WiMAX and LTE is discussed and analyzed in terms of its performance. The Simulation parameters are as shown in the Table 2.

The performance of the network is evaluated in terms of Data Packet Delivery Ratio (DPDR), Delay, Jitter and Throughput parameters, defined as follows.

- Data Packet Delivery Ratio (DPDR) is defined as the ratio of the total number of successfully-transmitted data packets to the total number of data packets sent from the source to the destination.
- Delay is defined as time taken by a bit of data to travel across the network from one node or endpoint to another.
- Jitter is defined as the varying of delay.
- Throughput is the average rate of successfully transmitted data packets over the communication channels' capacities.

Integrated VANET–WiMAX-LTE Scenario with its Performance: The Integrated VANET-WiMAX-LTE simulation model is as shown in FIG.1, Here node with ID 11 and 5 are LTE base station and node with ID 1 is WiMAX access point. The nodes with ID 4, 6 are WiMAX users and node with ID 15, 16, 17 and 18 are VANET users among which Node 18 will act as VANET Network gateway with all three network interfaces.

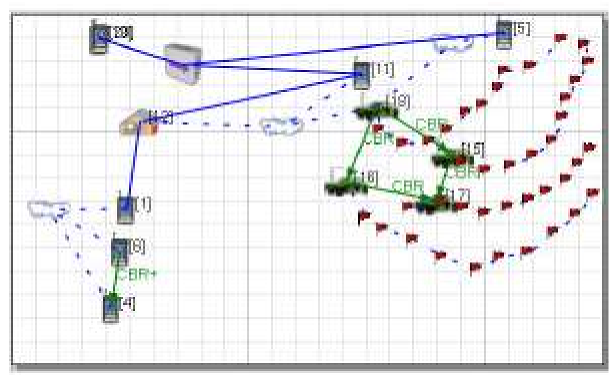

Fig. 1: Integrated Network Scenario

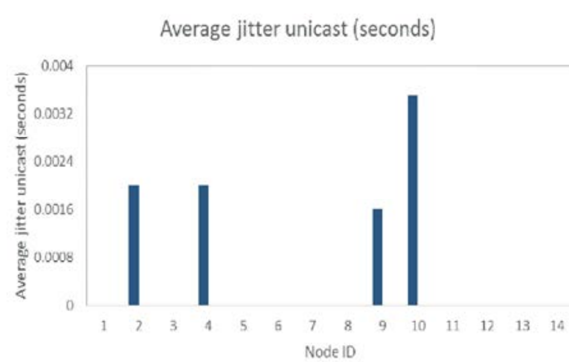

Fig. 2: Average Delay

Delay in Integrated Network Scenario: Delay incurred by the integrated network is as shown in Fig.2, Here Nodes with Id 4 & 6 are WiMAX users and Nodes with Id 15, 16 & 17 are VANET users. Node 17 which is far away node

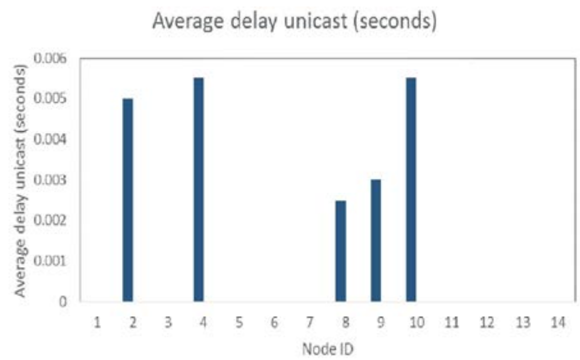

Fig. 3: Average Jitter.

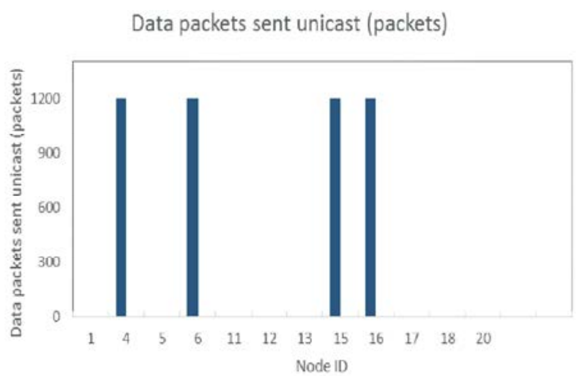

Fig. 4: Data Packet Sent

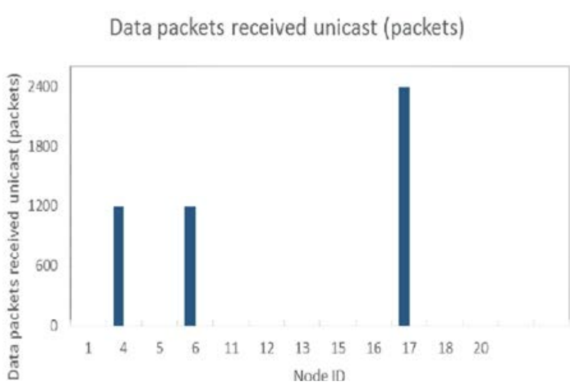

Fig. 5: Data Packet Received

with reference to Nodes 15, 16 is not properly serviced by the VANET IEEE802.11p and WiMAX which has been evidently serviced by LTE for maximum efficiency.

Jitter in Integrated Network Scenario: The jitter of various node present in the integrated scenario is as show in FIG.3, The Nodes with Id 4 & 6 are WiMAX users and Nodes with Id 16 & 17 are VANET users, The far away node (Node 17) is underperforming with reference to jitter, The performance of this node has been considerably increased with the help of LTE integration.

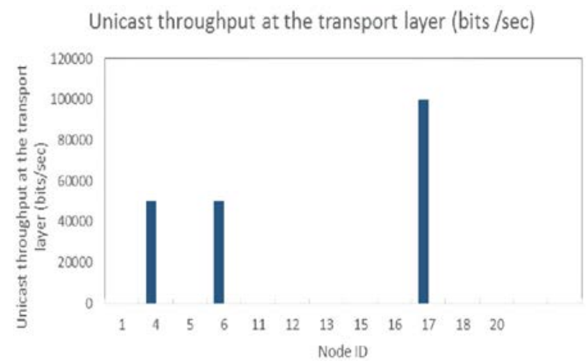

Fig. 6: Throughput

Data Packet Delivery Ratio in the Integrated Network Scenario: Data packet delivery ratio of the integrated scenario is shown in FIG.4 & FIG.5, Node with Id 4 & 6 are WiMAX users and Node Id 17 is VANET end user. It clearly shows that there is minimum drop in data packet received by Node 17 and the delivery ratio has been considerably increased.

Throughput Performance of Integrated Network Scenario: Throughput of the integrated network at the transport layer is as show in Fig.6, Here Node with Id 4 & 6 are WiMAX users and Node Id 17 is a VANET end user who is far away also gets better throughput.

CONCLUSIONS

The performance of WiMAX compared with of LTE is good response of a wireless network. The problems in WiMAX network is overcome by the LTE network. Here the major problem of the WiMAX network is coverage area which is less compared to LTE. But the LTE has minimal restriction. Both of the networks are reliable networks. Compare with WiMAX network and LTE technology is more secure, reliable service.

VANET network integrated with WiMAX and LTE is evident that both far away users enjoy the similar performance as of the nearby user from the Base Station which is evident from the results obtained and as a scope for extending the work the data dissemination problem can be considered will is one of the major problem in implementing Intelligent Transport System.

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