Analysis of Vanet Technologies

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Abstract— Rapid Development in wireless communication technologies and Vehicles have increased the growth of Intelligent Transport System (ITS) which solves various vehicular transportation problems like traffic congestion, shortest routing, accident etc. Vehicular Ad-Hoc Network (VANET), is an integral part of ITS in which moving vehicles are connected and communicate through wireless technology. Wireless communication technologies play a major role in providing Vehicle-to-Vehicle (V2V) and Vehicle-to Infrastructure (V2I) communication in VANET. This paper surveys some of the key vehicular wireless access technology standards which serve as a base for supporting both safety and non-safety applications and their comparisons.

Index Terms— ITS, VANET, V2V, V2I, I2I,DSRC, WiFi,WiMax,WAVE, IEEE 802.11p, CALM.

1 INTRODUCTION

The Vehicular Ad-Hoc Network is a technology that uses moving cars as nodes in a network to create a mobile network. VANET considers every participating car as a wireless router or node, allowing cars approximately 100 to 900 meters of each other to connect and, in turn, create a network with a wide range. It supports both V2V and V2I communication over wireless network. ITS support safety critical applications and non-safety infotainment applications. Safety applications such as collision avoidance, pre-crash sensing , Anti-lock Braking System (ABS), Traction Control System (TCS) or lane changing are aimed at minimizing road accidents[6]. Non-safety applications, enable driver and passengers to access various services like Internet, music, news, online games, payment services and information updates[2]. The driver and passengers can access both kinds of services from the nearby infrastructure seamlessly using wireless access technologies [5].

A VANET consists of four major components such as: Vehicles, Devices/Sensor such as GPS enabled devices, Road Side Units(RSU) and Traffic Management Centre (TMC) [1]. All these components communicate with each other using wireless protocols. A VANET could use most of the networking technologies such as WAVE IEEE P1609, DSRC IEEE802.11p, WiMAX IEEE 802.16, Bluetooth IEEE 802.15.1, MBWA IEEE 802.20, Infrared and Cellular to facilitate ad-hoc communication among the vehicles [3],[5]. This paper describes the properties of wireless access protocols and their comparisons.

2 WIRELESS ACCESS STANDARDS

In VANET, vehicles employ a number of wireless access technologies to communicate with other vehicles and roadside base stations [4].

These protocols are broadly classified into five categories: i) Cellular systems ii) WLAN/Wi-Fi Standards iii) DSRC/WAVE Standard iv) CALM Standard and v) miscellaneous standards including Bluetooth, ZigBee, and Infrared. These protocols can also be grouped into three categories based on their range as shown in Table 1.

Table 1:VANET Technologies

Communication Technology		
Long Range	Medium Range	Short Range
Cellular	Wi-Fi	IR
Wi-MAX	DSRC	Bluetooth
MBWA	WAVE	ZigBee
Microwave	CALM	UWB

2.1 LONG RANGE PROTOCOL

CELLULAR SYSTEMS (2G/3G/4G):

Cellular system uses radio waves to transmit data over long distances. In the first generation, analog signals were used to transmit data. The Second Generation supports secure, digital transmission. It has various forms such as GSM, CDMA and PDC. In these GSM is the most popular one. It uses FDMA along with TDMA technique. GSM supports a data transfer rate of 9.6 Kbps. Its extension is called GPRS. GRPS and GSM together are called 2.5G. They support a data transmission

speed of up to 170 Kbps and enables internet access [6]. 3G/UMTS operates in the band from 1.8 GHz to 2.5 GHz. It uses more advanced adaptive modulation techniques. The 4G technologies were developed to offer high speed, broadband, cheaper mobile services.3G Cellular network has already been used for timely data dissemination to support VANET applications such as accident prevention and traffic jam avoidance [19].

WiMAX STANDARD

Worldwide Interoperability for Microwave Access provides Internet access at the distance of up to 50km with a speed of 70Mbps.The new standard, WiMAX Mobile (IEEE 802.16m), uses advanced modulation techniques[7].

MBWA STANDARD

The IEEE 802.20 or Mobile Broadband Wireless Access (MBWA) was developed to provide wireless Internet access to highly mobile devices. It support for mobility up to vehicular speeds of 250 km/h. It also supports seamless and fast handoffs [16].

MICROWAVE

The standard IEEE 802.15.4 uses a frequency between 0.3GHz and 300GHz and transmits data up to 16 Gbps over long distance. It can be used to support both safety and infotainment applications. 2G cannot be used to support time-critical, safety applications in a VANET. 3G and 4G can be used for long range data communications in ITS. The 3G enables constant access to infotainment services through the Internet irrespective of the high mobility of vehicles. WiMAX Mobile, supports mobility up to 350 kph and increases the data transfer rate up to 1 Gbps.

2.2 MEDIUM RANGE PROTOCOLS

WLAN / Wi-Fi STANDARDS:

local area network or wireless fidelity standards are widely used to create ad-hoc networks due to their low cost, high data transfer rates. These consist of several standards including 802.11a, 802.11ac, 802.11b, 802.11e, 802.11g and 802.11n. The IEEE 802.11b operates in the unlicensed 2.4 GHz frequency band and achieves data rates of up to 11Mpbs using DSSS. IEEE 802.11a operates in the licensed 5 GHz frequency band and supports high data rate of 54 Mbps. This is incompatible with 802.11b and costlier. 802.11g, an extension of 802.11b, has the same data rate of 802.11a. 802.11e defines the rules to improve QoS of WLAN through modifying the MAC Layer [15]. The 802.11ac is an emerging standard which provides high data rate of up to 1 Gbps only in the 5 GHz frequency band. Wi-Fi Standards are used to create an Independent Basic Service Set (IBSS) in VANET. But as the number of vehicles increases it affects the performance of the Wi-Fi network.

DSRC/WAVE -IEEE 802.11p:

DSRC / WAVE (Dedicated Short Range Communication) was exclusively developed to meet the requirements of VANETs[23].]. It can provide services to both V2V and V2I up to 1 km and supports data rate of up to 27 Mbps. DSRC spectrum comprises a 5 MHz guard band, one 10 MHz Control Channel (CCH) and six 10 MHz Service Channels (SCHs). The CCH is dedicated to transmit only safety-related messages. However, SCHs are used to support both safety and non safety applications. In DSRC, the Road Side Unit (RSU) and On Board Unit (OBU) communicate using either 802.11p or Wireless Access in Vehicular Environment (WAVE) standard. DSRC can use the WAVE Short Message Protocol (WSMP) to support V2V & V2I safety applications. DSRC comprises the following sub standards:

IEEE P1609.1- Resource Manager
IEEE P1609.2 - Security Services
IEEE P1609.3 - Networking Services IEEE P1609.4 Multi-Channel Operation

CONTINUOUS AIR-INTERFACE, LONG & MEDIUM RANGE (CALM) :

CALM operates in the 5.9 GHz band. CALM media are classified into five categories: 5 GHz wireless LAN systems Cellular systems,60 GHz systems, Infrared communication and a Convergence Layer [9][10]. It is capable of selecting a transmission media based on the location and OBU of the vehicle. CALM can support all kinds of ITS applications including safety applications and comfort applications.It handles media handoffs more effectively than the WAVE standard [9]. It can support three modes of communication V2V, V2I and I2I communication. Unlike DSRC, CALM supports five communication scenarios: V2I Non-IPv6 communications, V2I/V2V Local IPv6, V2I MIPv6, V2I NEMO and V2V Non-IPv6. CALM has seven sub working groups that work on various CALM related standards concerning architecture, networking, application management, non-IP networking and security.

The CALM standard is not widely used since it is still under development. Some projects have used CALM standards to enhance interoperability among networks and applications. The Cooperative Vehicular Infrastructure Systems (CVIS) project, funded by the EU, has tried to use CALM to develop various ITS applications. CALM is used by Germany's LKW-MAUT project and applied to develop applications for in-vehicle internet access, dynamic navigation, safety warnings, and collision avoidance, CurveWarning, Hazard-Warning, Traffic information [8].

SHORT RANGE PROTOCOLS :

BLUETOOTH

The Bluetooth (IEEE 802.15.1) protocol is used to transfer data at the rate of up to 1 Mbps to 4 Mbps over a distance of 10m. Bluetooth operates in the 2.4 GHz band and uses Frequency Hopping Spread Spectrum technique to overcome signal interference [11]. Bluetooth technology can be used to support both V2V and V2I applications [12]. As compared to other Wi-Fi standards, it requires low power. However, it cannot be used to build safety. Frank et al [20] have used this technology to exchange data between two cars while moving.

ZIGBEE

ZigBee (IEEE 802.15.4) uses the license-free 2.4 GHz band to transfer data at the rate of 250 Kbps up to 70 meters. It also uses lower frequency bands 915 MHz (US) and 868 MHz (Europe) to supports data transmission rates of 40 Kbps and 20 Kbps respectively. It is simpler and cheaper than Wi-Fi and Bluetooth standards. Like Bluetooth, it can be used to support V2V and V2I applications [14]. However, it is not suitable for bandwidth intensive infotainment applications such as VoIP, web browsing [13]. Bhargav et al used ZigBee to track the vehicular positional coordinates during rescue missions of vehicular accidents [21].

INFRARED

It is another popular wireless access technique which uses invisible light to transfer data. It operates in the frequency band between 300 GHz and 400 THz. This broad spectrum is divided into three sub-bands: near-infrared, mid infrared and far-infrared. It can be used to support safety application due to its ability to support high network traffic and large bandwidth.

ULTRA WIDE BAND (UWB)

It operates on unlicensed frequency band between 3.1 and 10.6 GHz, can support a STA with mobility of 10 kph [18]. In VANET, it can be used for collision avoidance. This standard and differential GPS (DGPS) together were used to determine the relative position of a vehicle [22].

3.COMPARISION

The suitability of various wireless access standards to support VANET applications including infotainment applications are compared in terms of Bandwidth, Interference, Accessibility, Maintenance, Cost and Security. The data transmission rate determines the amount of data transmitted between the ends of communication at a time. Infotainment applications such as large data transfers, video chat, VoIP needs more bandwidth.

The comparison of some of the vanet technologies is depicted in Table.2.given below. It is observed from the comparison that many wireless standards operate in either the 2.4 GHz or 5 GHz frequency band. Cellular Systems, WiMAX, MBWA are used to provide services to large coverage over a wide geographical area. Most of the wireless standards like Cellular Systems, CALM and DSRC now provide highly secure data transmissions. Cellular systems such as 3G/4G, Mobile WiMAX and MBWA can be used to provide infotainment services over long distances. Though 3G supports high mobility of STA, it reduces the data rate to 144 kbps. Similarly, Mobile WiMAX (IEEE 802.16e) can support a Mobile Station (MS) with the speed of 60 kph but it drops the data rate to 10Mbps over 2km. MBWA and 4G LTE can provide highest spectrum efficiency, STA mobility up to 250 kph and fast mobile-IP connectivity. It is noted that 4G, DSRC/ MBWA/WiMAX with 3G are adequate to support all types of VANET applications.

The Wi-Fi based protocols such as DSRC and CALM are more suitable for VANET. These standards are already used to implement V2V and V2I applications particularly safety related applications. Safety applications require low latency and high reliability, whereas infotainment applications demand maximum throughput, efficient resource utilization and minimum packet loss. One of the biggest challenges in VANET is data dissemination which is the key component of infotainment applications [17]. To provide fair data dissemination, a VANET must use different wireless protocols.

4. CONCLUSION

The development of Intelligent Transport Systems (ITS) has further improved driving efficiency. it has the potential to support infotainment applications which are built for the comfort and convenience of the drivers and passengers. A VANET is an important component of ITS which employs multiple wireless communication protocols in order to support applications for both V2V and V2I.

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Table 2 : Comparison of Technologies

Wireless Standard	Max Signal Coverage ≈	Cost	Security	Mobility ≈ km/h	Suitable for Safety Applications	Suitable for Non-Safety Applications
Cellular Systems	50 km	High	High	100-250	No	Yes
WiMAX 802.16m	50 km	High	High	60-250	No	Yes
MBWA 802.20	15 km	High	High	100-250	No	Yes
Wi-Fi 802.11a	100 m	High	Low	40-120	No	No
Wi-Fi 802.11b	100 m	Moderate	Low	40-150	No	No
Wi-Fi 802.11g	140 m	Moderate	Low	40-120	No	No
Wi-Fi 802.11n	250 m	High	High	40-120	No	No
DSRC 802.11p	1 km	Moderate	High	40-150	Yes	Yes
CALM	10 km	High	High	40-150	Yes	Yes
Infrared	100m	Low	High	250	No	No
Bluetooth	100m	Low	Low	20-30	No	No
ZigBee	100m	Low	High	10-20	No	No
UWB	10m	Low	High	10-20	No	No

REFERENCES

[1] M.Faezipour, M. Nourani, A.Saeed, S.Addepalli, "Progress and challenges in intelligent vehicle area networks," Communications of the ACM, Vol.55, Issue 2, pp. 90-100, 2012.

[2] P.Pereira, A. Casaca, J.Rodrigues, V. Soares, J. Triay, C.Cervello-Pastor," From Delay-Tolerant Networks to Vehicular Delay-Tolerant Networks," Communications Surveys & Tutorials, IEEE, Vol.14,Issue.4, pp. 1166 1182,2012.

[3] S.Panichpapiboon, W. Pattara-atikom, "A Review of Information Dissemination Protocols for Vehicular Ad Hoc Networks," Communications Surveys & Tutorials, IEEE, Vol.14, Issue.3, pp. 784 - 798, 2012.

[4] Wai Chen, Ratul K. Guha*, Taek Jin Kwon, John Lee, Yuan-Ying Hsu," A survey and challenges in routing and data dissemination in vehicular ad hoc networks," Proc. Of IEEE International Conference on Vehicular Electronics and Safety, pp. 328 - 333 2008.

[5] M.L.Sichitiu, NC.Raleigh, M. Kihl, "Intervehicle communication systems: a survey," Communications Surveys & Tutorials, IEEE, Vol 10, Issue. 2, pp.88 – 105, 2008.

[6] Rasheed Hussain* and Heekuck OCooperation-Aware VANET Clouds: Providing Secure Cloud Services to Vehicular Ad Hoc Networks:J Inf Process Syst, Vol.10, No.1, pp.103-118, March 2014

[7] Yaghoobi, Hassan, "Mobile WiMAX Update and IEEE 802.16m," IEEE, March 2009,http://ieeetmc.net/r6/scv/sps/WiMAX_Update_802-16m.pdf

[8] http://www.cvisproject.org/download/qfree_Com mCalmCvis_aalborgbrochure.pdf

[9] http://www.itu.int/ITU-T/spd/docs/002-twCALM.pdf

[10] http://en.wikipedia.org/wiki/Communications,_Airinterface,_Long_and_Medium_range

[11] R.Shorey, BA.Miller, ".The Bluetooth technology: merits and limitations," IEEE International Conference on Personal Wireless Communications, pp- 80 – 84, 2000.

[12] H.Mamdouhi, S.Khatun, J. Zarrin," Bluetooth Wireless Monitoring, Managing and Control for Inter Vehicle in Vehicular Ad-Hoc Networks", Journal of Computer Science, Vol.5, Issue.12, pp.922-929, 2009.

[13] K.Selvarajah, A.Tully, P.T.Blythe, "ZigBee for Intelligent Transport System applications," Road Transport Information and Control - RTIC 2008 and ITS United Kingdom Members' Conference, IET, pp.1-7, 2008

[14] Keeratiwintakorn, P., Thepnorarat, E., Russameesawang, A.," Ubiquitous Communication for V2V and V2I for Thailand Intelligent Transportation System," Telecommunications Research and Industrial Development Institute (TRIDI), 2009.

[15] Zeyun Niu, Wenbing Yao, Qiang Ni, Yonghua Song," Study on QoS Support in 802.11e-based Multi-hop Vehicular Wireless Ad Hoc Networks," Proc. Of IEEE International Conference on Networking, Sensing and Control, pp. 705- 710,2007

[16] A.Greenspan, M.Klerer, M.Tomcik, R.Canchi," IEEE 802.20: Mobile Broadband Wireless Access for the Twenty-First Century," Communications Magazine, IEEE, Vol.46, Issue.7, pp. 56 – 63, 2008.

[17] HT Cheng, H.Shan, W.Zhuang," Infotainment and road safety service support in vehicular networking: From a communication perspective", Mechanical Systems and Signal Processing,Vol. 25, Issue. 6, pp. 2020–2038, 2011.

[18] Jin-Shyan Lee; Yu-Wei Su; Chung-Chou Shen, "A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi," Industrial Electronics Society, 2007. IECON 2007. 33rd Annual Conference of the IEEE , pp.46,51, 5-8 Nov. 2007

[19] Yuyi Li; Kai Ying; Peng Cheng; Hui Yu; Hanwen Luo, "Cooperative dissemination in cellular-VANET heterogeneous wireless networks," data High Speed Intelligent Communication Forum (HSIC), 2012 4th International , pp.1,4, 10-11 May 2012

[20] Frank, R.; Bronzi, W.; Castignani, G.; Engel, T., "Bluetooth Low Energy: An alternative technology for VANET applications," Wireless On-demand Network Systems and Services (WONS), 2014 11th Annual Conference on , vol., no., pp.104,107, 2-4 April 2014

[21] Bhargav, K.R.K.; Singhal, R., "Zigbee based VANETs for accident rescue missions in 3G WCDMA networks," Global Humanitarian Technology Conference: South Asia Satellite (GHTC-SAS), 2013 IEEE , vol., no., pp.310,313, 23-24 Aug. 2013

[22] D. Wang, K. O'Keefe, M.G. Petovello," Decentralized Cooperative Positioning for Vehicle-to-Vehicle (V2V) Application Using GPS Integrated with UWB Range", Proceedings of the ION 2013 Pacific PNT Meeting, pp. 793 – 803,2013

[23] Saini, M., Alam, K.M., Guo, H. et al.," InCloud: a cloud-based middleware for vehicular infotainment systems", Volume 76, Issue 9, pp 11621–11649 , May 2017.