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Research paper

Recent Vehicular Communication Protocols, DSRC Vs C-V2X

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Abstract

Vehicular technology is getting popular around the world under the developing technologies such as Autonomous Vehicles, Intelligent Transportation Systems(ITS) and Advanced Driver Assistance Systems(ADAS). Considering the road safety and comforts, vehicle communications technologies would be needed for Vehicle-to-Vehicle(V2V), Vehicle-to-Infrastructure(V2I) and Vehicle-to-Everyhting(V2X) in order to successful implementation. IEEE 802.11p Standards would be the main technology for V2X as DSRC based application and the alternatives are 4G LTE or 5G based cellular V2X communications.

Keywords: *Cellular Vehicular Technology, DSRC, ITS, V2X*

1. Introduction

This paper is intended to search about V2X, V2V, V2I and other vehicle communication technologies, protocols and system architecture. There are applications already on the ITS industry that ready to implementation. However the topic is new and developing, it is needed to discuss about design topologies, system architecture and systems engineering applications. Smart cities, smart infrastructure and smart vehicles technologies will bring our daily lives different advantages such as security, comforts, to be connected to any time, sustainability etc. Therefore, research and development projects must be implemented to foresee the advantages and to implement the best project for an efficient system design.

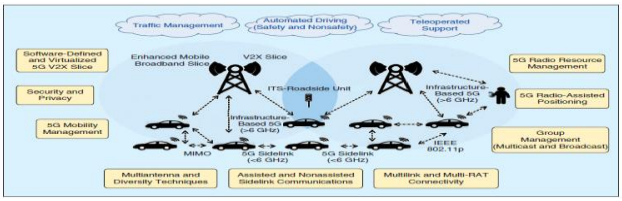

Fig 1: 5GCAR Concept [1]

2. Significance and Statement of V2X

This paper is significance for road safety, driving related errors and comfortability.

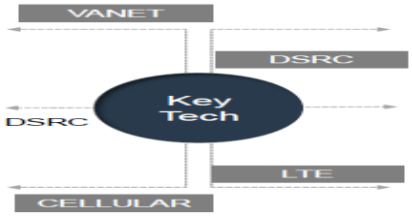

Fig 2: Key Findings – DSRC and Cellular Technologies are Key Communication Technologies for V2X [2]

VANETs

Vehicular Ad-Hoc Network provides communication between vehicles and road side units(RSA). And also VANET is sub form of MANET(Mobile Ad-Hoc Network). VANET improves traffic efficiency, reduce traffic congestion and improve road safety[13].

DSRC

DSRC is an ad-hoc technology for V2V and V2I applications. It is standardized by IEEE 802.11p

C-V2X

Cellular Vehicle to Everything technology is that cellular based LTE communication technology. According to Frost&Sullivan, C-V2X is much more expensive than DSRC technology and also it is not yet standardized [2].

However according to a latest news on 5GAA(5G Automative Association), C-V2X technology performance is much more better than DSRC/ITS-G5 [3].

With the help of the V2X technology, public road might be safer that any case of bad road conditions or bad weather situations will be informed to driver. Especially in the Philippines, traffic congestion is always a big problem in terms of delay on the transportation and securing the roads.

C-V2X Enabled Road Safety Applications

C-V2X provides some useful application to increase our daily lives road safety that;

- Vehicle platooning
- Co-operative driving
- Queue warning
- Avoiding collisions
- Hazards ahead warning
- Increasingly autonomous driving
- Collecting road tolls

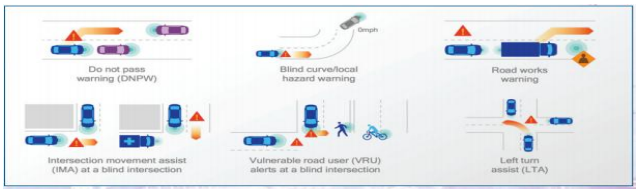

Fig 3: V2X Applications [5]

3. Review of the Related Literature

Connected cars are complex IoT(Internet of Things) technologies that have connection to a network thru On-Board Unit (OBU). The OBU is communicating with a Road-Side Unit(RSA) to join the network. In that architecture not only vehicles but also other network enabled things might connect to network to create V2X network which is big and complex IoT application. In our modern lives, a vehicle has many sensors and it is continuously collecting information in its environments while moving.

In terms of VANETs design and architecture, one of the approach is blockchain based VANETs that aims to improve reliability of the network and building a trusted communication [6]. According to article [6], the distributed ledgers will provide faster information gathering compared to traditional cloud computing. The diagram shown on Fig 5.

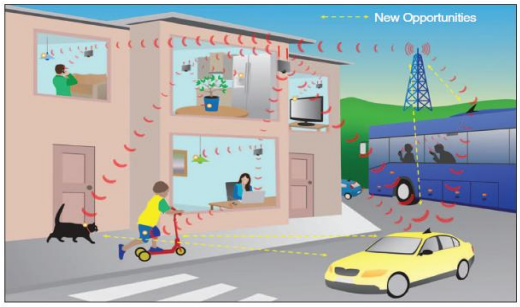

Fig 4: Integrating Moving Networks[1]

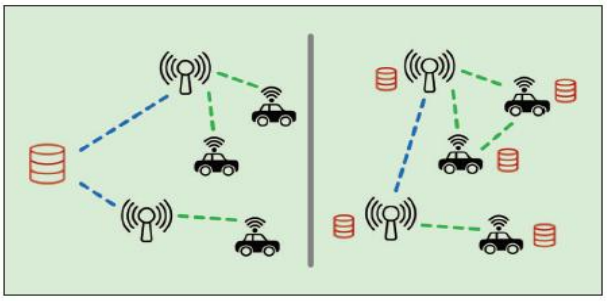

Fig 5: Blockchain of VANET

C-ITS Platform groups testing V2I technologies on modified Toyota Prius including pedestrian warning, greenlight optimal speed advisory, road hazard and traffic manager notifications[8]. The project is being tested in 8 cites in Europe as C-Mobile pilot sites that Barcelona(Spain), Bilbao(Spain), Bordeaux(France), Copenhagen(Denmark), Newcastle(United Kingdom), North Brabant Region(Netherlands), Thessaloniki(Greece), Vigo(Spain) [9].

	High-Level Reference Architecture	Medium-Level Concrete Architecture	Low-Level Implementation Architecture
Definition	Describes the system's high-level architectural elements, their dependencies and responsibilities.	Enhances reference architecture with functional interfaces, and primary interactions.	Enhances concrete architecture with detailed functions, interfaces, and interactions.
Concerns	Functional capabilities, generic interactions, and functional design philosophy (perspective).	Same as reference architecture but also external interfaces (data, event, control flows), primary internal structure (has impact on the system's quality characteristics).	Same as concrete architecture, but also external interfaces, internal structure (Has impact on the system's quality characteristics).
Model Kinds	SysML Block Definition Diagram	SysML structural (Block Definition Diagram, Internal Block Definition diagram) and behavioural diagrams (State Machine, Activity and Sequence Diagrams)	SysML diagrams and UML diagrams for software architecture design

Fig 6: C-Mobile Architecture [10]

4. Data and Result

Comparison of DSRC and Cellular technologies in terms of vehicular technology defined on Table 1.

Table 1: DSRC vs Cellular [2]

DSRC (802.11p)	**Cellular(LTE)**
Medium range connectivity 300 to 1000 meters	Long range connectivity up to 2km
Adequate rate of data transmission up to 27Mbps	High rate of data transmission up to 75Mbps-Uplink and 300Mbps-Downlink
Highly suitable for V2V application and moderately suitable for V2I applications	More suitable for V2I applications and moderately supports V2V applications
Key proposed applications: Collision detections, Electronic Toll Collection Traveler Information Services	*Key proposed applications:* Traffic Management Systems, Multimedia Services

According the test of 5G AA, C-V2X performs better than DSRC in terms of Reliability, Interference and Congestion.

Table 2: Relative Performance of C-V2X and DSRC [4]

Reliability	Lab Cabled Tx and Rx Tests	C-V2X better
	Field Line-of-Sight (LOS) Range Tests	C-V2X better
	Field Non-Line-of-Sight (LOS) Range Tests	C-V2X better
Interference	Lab Cabled Test with Simulated Co-Channel Interference	C-V2X better
	Lab Cabled Near-Far Test	Pass
	Field Co-existence with Wi-Fi 80 MHz Bandwidth in UNII-3	C-V2X better
	Field Co-existing of V2X with Adjacent DSRC Carrier	Pass
Congestion	Lab Cabled Congestion Control	Pass

The equipment description of OBU used in the testing of 5G AA defined on Table 3 and 4.

Table 3: DSRC OBU, Sawari MW1000

Component	Description
Processor	1 GHZ iMX6 Dual Core
Memory	1 GB DDR3 DRAM
Storage	Up to 16 GB Flash
Radio	Dual DSRC
GPS	U-Blox. Tracking Sensitivity: -160 dBm
Secure Flash / HSM	Infineon HSM SLE97
Operational Temperature	-40C to +85C
Antenna / GPS Connectors	Fakra type Z/C
Other Interfaces	CAN, 2 USB, MicroSD, Serial, Ethernet
Display	16 x 2 LCD
Standards Compliance	802.11p, IEEE 1609.x and SAE J2735 (2015), J2945
Security	1609.2, IPSec & SSL
Enclosure	140 x 133 x 42 (L x W x H)

Table 4: C-V2X OBU, Qualcomm Roadrunner

Component	Description
Processor	Automotive Snapdragon820 (APQ8996) 1200 MHz ARM A7 (in MDM9150)+B2
Memory	2 GB (APQ)
Storage	64 GB + 2 GB, microSD slot
Radio	PC5 Mode 4
GNSS	Multi-constellation Qualcomm QDR3 Dead Reckoning XTRA + Time injection
Secure Flash / HSM	Infineon HSM SLI97
Operational Temperature	-40C to +85C
Antenna / GPS Connectors	Quad Fakra
Other Interfaces	USB 3.0 OTG, USB Host, 3x 1 Mbps CAN, 1000BT Ethernet, RS232
Standards	3GPP Rel 14, IEEE 1609.3 (not used), ETSI ITS G5 (not used), SAE J2735, SAE J3161 (draft)
Security	IEEE 1609.2 (Via Savari & On Board Security)
Other Radios	Automotive QCA6574AU - Wi-Fi: 2.4 GHz, 802.11n, 2 x 2 - Bluetooth 4.2 + BLE

Operation band of C-V2X is 5.9 GHz and 70MHz spectrum range allocated for ITS DSRC communications in Europe and North America, and also 5.8GHz spectrum in Japan.

5. Conclusion

According to Frost&Sullivan, they believe and support that DSRC technology is better[2] for V2C communication however the report of 5G Automative Association, C-V2X technology outperforms[3] DSRC/ITS-G5 in comprehensive tests. In terms of practical applications of DSRC, it has much more applications and matured technology that trusted by ITS sectors. According to Greg Winfree, "DSRC is the one technology that's mature and ready to be rolled out". And also according to one of his interview in a magazine, DSRC is now being installed in GM, Mercedes and Toyota vehicles [11]. And also another application from Huawei is that first C-V2X RSU launched [12].

There are various newly implemented applications in ITS industry and the discussions are about DSRC vs C-V2X. Pros and cons still being compared and technology is still being developed under the 5G promises even 6G. Different companies and researchers are still proposing either DSRC or Cellular based V2X application. The implemented technology is still doubtful for some reasons in terms of protocol of application. For instance, Ford Motor Company is pioneering C-V2X however GM, Mercedes and Toyota already preferred DSRC for the application.

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