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Internet of Vehicles: An Introduction

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Abstract— *As more and more people drive cars and vehicles, there is a corresponding increase in the number of fatalities that occur due to accidents. As these vehicles are increasingly being connected to the Internet of things (IoT), they form the Internet of vehicles (IoV). Thus, IoV is the convergence of the mobile Internet and IoT. It is an emerging field for the automotive industry and an important part of the smart cities. This paper provides a brief introduction to Internet of Vehicles (IoV).*

Keywords— *Internet of vehicles, In-car Internet, connected cars, intelligent transportation systems, VANET*

I. INTRODUCTION

With increasing urban population and rapid expansion of cities, vehicle ownership has been increasing at a rapid rate. There has also been an increase in the deployment of electric vehicles (EV), both fully electric and plug-in hybrids. There is a need for better communications and interconnectivity among these vehicles due to their mobility. As vehicles evolve from simple transportation means to smart entities with sensing and communication capabilities, they become an integral part of a smart city.

Smart vehicles exhibit five features: self-driving, safety driving, social driving, electric vehicles, and mobile applications [1].

The Internet of things (IoT) is a global network connecting smart objects and enabling them to communicate with each other. Whenever those smart objects being connected over Internet are exclusively vehicles, then IoT becomes Internet of Vehicles (IoV). Thus, IoV is an extended application of IoT in intelligent transportation. It is envisioned to serve as an essential data sensing and processing platform for intelligent transportation systems [2]. A vehicle will be a sensor platform, absorbing information from the environment, from other vehicles, from the driver and using it for safe navigation, pollution control, and traffic management.

The Internet of Vehicles (IoV) consists of vehicles that communicate with each other as well as with handheld devices carried by pedestrians, roadside units (RSUs), and the public networks using V2V (vehicle-to-vehicle), V2R (vehicle-to-road), V2H (vehicle-to-human) and V2S (vehicle-to-sensor) interconnectivity thereby creating a social network where the participants are intelligent objects rather than the human beings. This leads to emergence of Social Internet of Vehicles (SIoV). SIoV is essentially a vehicular instance of the social IoT (SIoT). IOV may be regarded as a superset of Vehicular Ad-hoc Network (VANET) which originated from Mobile Ad-hoc Network (MANET). It extends VANET's scale, structure and applications [3].

II. ARCHITECTURE OF IoV

A typical IoV architecture consists of three layers as shown in Figure 1 [4,5]:

Perception layer: This layer contains all the sensors within the vehicle that gather environmental data and detect specific events of interest such as driving patterns and vehicle situations, environmental conditions, etc. It also has radio frequency identification (RFID), satellite positioning perception, roads environment perception, vehicle position perception, car and objects perception, etc.

Network layer: This is the communication layer that ensures connectivity to communications networks such as GSM, G5, WiMax, WLAN, Wi-Fi, and Bluetooth. It supports different wireless communication modes such as Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P). and Vehicle-to-Sensor (V2S).

Application layer: This layer includes statistics tools, support for storage, and processing infrastructure. It is responsible for storage, analysis, processing, and decision making about different risk situations such as traffic congestion, bad weather, etc. It represents smart applications, traffic safety, efficiency, and multimedia based infotainment.

For online presence of vehicles, each vehicle should have a uniquely identifiable number of the Internet. A vehicular global ID (GID) terminal is at the core of the IoV. Simply put, the GID addresses problems with RFID that include its one-way nature, limited range and coverage, lack of speed, passive and unintelligent operation. More importantly, GID provides vehicles with "cyber license plates" or "cyber IDs" [6].

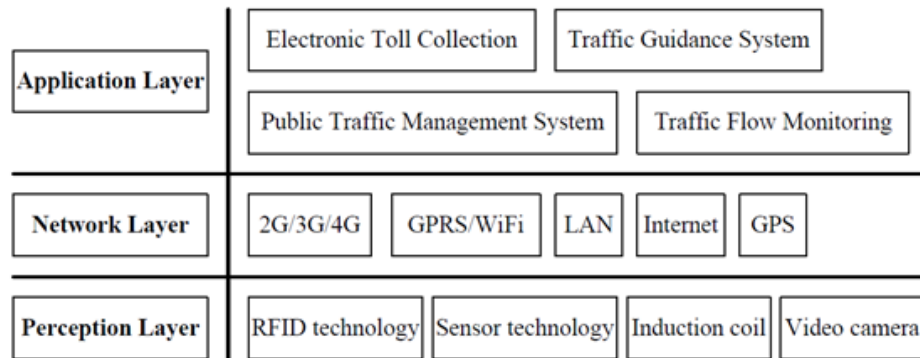


Figure 1 – Architecture of IoV [4].

III. APPLICATIONS

IoV has diverse applications which include [7, 8]:

Safe driving: This refers to cooperative collision avoidance systems that use sensors to detect imminent collision and provides warning to the driver. This application involves periodical status messages and emergence messages. An emergency message is triggered by emergence event such as traffic jam, accident, bad road condition.

Traffic control: IoV will bring about fundamental changes to urban congestion management, transport and logistics, urban traffic, and our collective lifestyle.

Crash Response: Connected cars can automatically send real-time data about a crash along with vehicle location to emergency teams. This can save lives by accelerating emergency response.

Convenience Services: The ability to remotely access a car makes possible services such as remote door unlock and stolen vehicle recovery. Connected car technology can provide transportation agencies with improved real-time traffic, transit, and parking data, making it easier to manage transportation systems for reduced traffic and congestion.

Infotainment: Connected cars can provide online, in-vehicle entertainment options that provide streaming music and information through the dashboard.

Other applications include electronic toll collection, traffic guidance system safe navigation, driverless vehicles, intelligent vehicle control, crash prevention, traffic flow monitoring, and vehicle autonomy.

IV. ISSUES AND CHALLENGES

Challenges facing IoV and slowing down its adoption include big data, security, privacy, reliability, mobility, and standards. These issues should be addressed to make IoV very reliable and widely adopted.

Big data: A major challenge is the processing and storage of big data created in IoV due to the large number of connected vehicles. For example, driverless cars are expected to process 1 GB of data per second. Mobile cloud computing and big data analytics will play important role in handling the big data.

Security:& Privacy: Since IoV involves integrating many different technologies, services and standards, there is the need for data security. As an open, public network, IoV is a target for intrusions and cyber-attacks that may lead to physical damage and privacy leakages.

Reliability: Cars, sensors, and network hardware can malfunction. The system has to deal with incorrect data, as well as faulty communications, such as denial of service attacks. As a rule, the safety of the vehicle is more important than entertainment.

Mobility: In a situation where vehicles are moving fast and network topology keeps changing continuously, it is a challenge to keep the nodes connected and provide them with resources to transmit and receive in real time.

Open standards: To accelerate adoption, standardization and interoperability are vital. Lack of standard make effective V2V communication difficult. Adopting open standards will enable smooth sharing of information. Governments should participate and encourage industries to collaborate in the development of technological best practices and open international standards.

V. CONCLUSION

Internet of vehicles (IoV) is a special application of Internet of things. It has become an indispensable platform with information interaction among vehicles, humans, and road-side infrastructures. It has attracted a lot of attention. The notion of IoV is no longer a matter of IT applications in the automotive industry; it has become a national and global concern. With time IoV will become important part of us and make intelligent transportation systems do without traffic lights, road accidents, and other related problems. It will make millions of people enjoy more convenient, comfortable, and safe traffic service.

REFERENCES

- [1] L. A. Maglaras et al., "Social Internet of vehicles for smart cities," *Journal of Sensor and Actuator Networks*, vol. 5, no. 3, 2016.
- [2] J. Kang et al., "Privacy-preserved pseudonym scheme for fog computing supported Internet of vehicles," *IEEE Transactions on Intelligent Transportation Systems*, vol. PP, no. 99, 2017, pp.1-11.
- [3] J. Cheng et al., "Routing in Internet of vehicles: a review," *IEEE Transactions on Intelligent Transportation Systems*, vol. 16, no. 5, October 2015, pp. 2339-2352.
- [4] J. Huang, "Research on Internet of vehicles and its application in intelligent transportation," *Applied Mechanics and Materials*, vols. 321-324, 2013, pp. 2818-2821.
- [5] J. Contreras-Castillo, S. Zeadally, and J. Guerrero-Ibañez, "Internet of vehicles: architecture, protocols, and security," *IEEE Internet of Things Journal*, vol. PP, no. 99, 2017, pp. 1-9.
- [6] L. Nanjie, "Internet of vehicles: your next connection," <http://www1.huawei.com/enapp/28/hw-110836.htm>
- [7] W. Wu, Z. Yang, and K. Li, "Internet of vehicles and applications," in R. Buyya and A. V. Dastjerdi (eds.), *Internet of Things: Principles and Paradigms*. Cambridge, MA: Morgan Kaufmann, 2016 chapter 16, pp. 299-317.
- [8] B. Deshpande, "7 applications of IoT-connected vehicles which may soon be common," July 2014, <http://www.simafore.com/blog/bid/207243/7-applications-of-IoT-connected-vehicles-which-may-soon-be-common>

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