Possibility of Vehicular Communication in a 6G Network

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Abstract- In today's modern world connected by various technologies vehicular communication is an important and essential application. V2X based on 5G network has attracted a lot of research in these field. V2X encompasses of various other technologies that can help to better understand and research in depth about the vehicular communication network. In vehicular communication there are certain critical requirements such as low latency, high data rate and reliable communication. Imagine that latency is high in vehicular communication these would result in late indicator signal which can led to accidents, so these requirements should be strictly considered. These requirements could be easily fulfilled by 6G communication system these comes with various advance concepts like 6G V2X, advance beamforming, Machine learning for self-driving cars, mm Wave communication in 6G, etc. In this article, we have firstly introduced the existing 5G vehicular network with evolution of 5G and the need for 6G. After that we have discussed some applications of 6G in vehicular communication, then we have discussed technologies that can be a key aspect in the deployment of 6G in vehicular communication and then the limitations that need to be considered. Finally, we have concluded this article with a short description of the topics and technologies covered in the article.

Indexed Terms- V2X, 6G V2X, Beamforming, Machine learning, Brain controlled vehicles, fully automatic vehicles

I. INTRODUCTION

IN these modern era of advance technologies smart vehicular communication is becoming an important part of the one's life. Intelligent transportation system (ITS) is an advance application for smart vehicles that helps people in their day-to-day life while driving the vehicle like entertainment, assisting in driving, etc. V2X knows as vehicle to everything communication is improving the vehicular communication system we have today, it consists of various advance technologies like Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P), Vehicle-to-Vehicle (V2V) and Vehicle-to-Network (V2N). Vehicles interconnected with vehicles, pedestrian, infrastructure, and networks collects a lot of critical information from each other and make smarter and faster decision [1]. So, for a vehicular communication to be efficient and widely accepted there are certain requirements that need to be satisfied such as low latency, reliable communication, higher data rate, etc. This requirement ensures that users are getting the benefits of road safety, entertainment inside the car and uncomplicated user experience. Existing advancement in the vehicular communication network is V2X which is evolved from DSRC (Dedicated short-range communication) and C-V2X (Cellular vehicular to everything communication) [2]. ITS has various application mainly divided into a) Life-safety applications, b) Efficiency in terms of fuel consumption, energy usage, etc.

applications and c) Infotainment and Comfort applications. Classification of ITS main Applications and its subdivided parts is shown in Fig1.

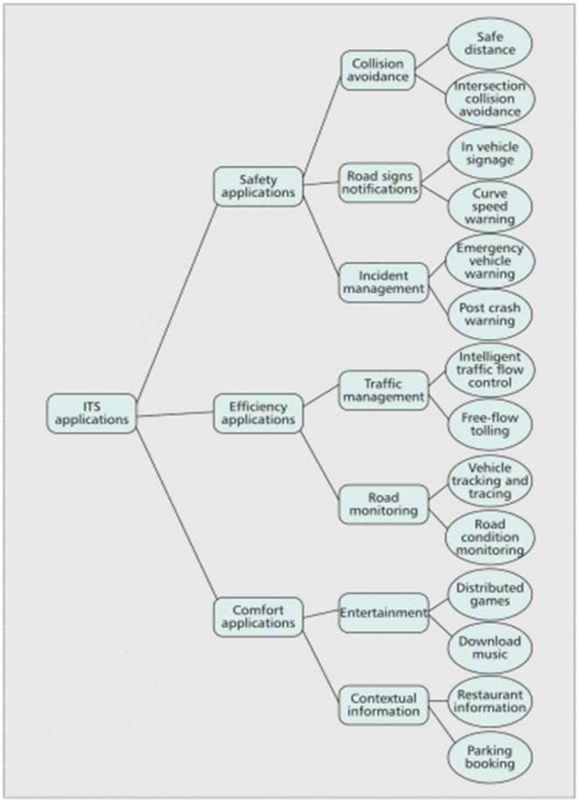

Fig 1: Classification of ITS applications [3]

To give users, the benefits of the above the ITS applications different technologies have been tested and developed in recent years. Existing technologies like DSRC and C-V2X is used to deploy such applications in practical world [2].

A. Evolution of vehicular communication network (V2X)

Vehicular communication network (V2X) has evolved a lot in recent years since it was first introduced in 2010. There are two types of V2X communication a) Non-cellular V2X and b) Cellular-V2X (C-V2X). For non-cellular V2X communication DSRC 802.11p was the technology introduced in 2010 for the first time this technology performs good in low density but as the density of the vehicles increases the performance starts decreasing so to overcome this issue an evolved version was developed and still going on known as 802.11bd. In cellular V2X case first ever technology was introduced in 2016 by 3GPP and it was known as LTE-V2X with Rel.14 [4].

After these, continuous upgrades of the technology took place with each new release, every release version bought improved performance and features which helped the vehicular communication to grow over the past few years. Still C-V2X is evolving to satisfy the future need of the smart vehicular communication network. Evolution of C-V2X is shown in the Fig 2 [4].

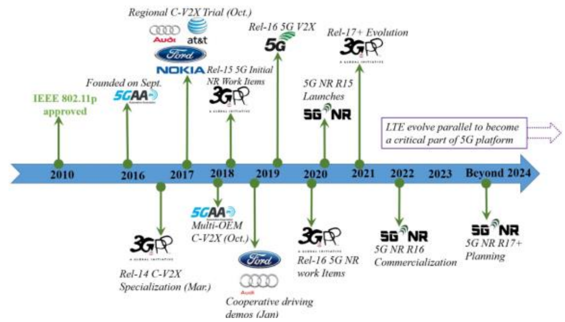

Fig 2: V2X evolution towards 5G NR [4]

B. Need of 6G in vehicular communication

Even though, 5G NR is the most advance version of vehicle communication with a ton of improved performance compared to the older version, it comes a heavy price of resource usage such as spectral usage [5]. According to [6] in 2020 the total number of autonomous vehicles in the world was about 35.02 million and it is anticipated to grow even further in the coming years. With these increase in the autonomous vehicles, the demand for a high-end vehicle communication standard will also be needed. With the advance technology, there will be different needs in the communication devices and the applications it is used in like for vehicles 3D Holographic view of the map for getting a better view of the map, ultra-low latency, ultra-reliable communication. Existing technologies can't stand up against these requirements of the future vehicular communication. Also, there is a lot of improvements needed in the existing vehicular communication technologies such as cost/spectral efficiency, security, communication range, etc. [7]

All these goals or requirements could not be achieved by the existing 5G NR based vehicular communication standard. For cellular mobile network sixth generation network is already in its trail phase. 6G in vehicular communication could be the future of advance fully automatic vehicles. It will bring some advances like extremely high data rate (Tbps), smarter energy efficiency, etc. It is also predicted that Machine learning (ML) and Artificial Intelligence (AL) would be integrated with the 6G which will open doors to various innovative and conceptual applications like self-awareness of the smart vehicle, self-configuration, etc. to be deployed in real world scenario [5]. 6G V2X communication could be the solution that existing smart vehicles need to become fully automatic and intelligent.

II. APPLICATIONS OF A 6G ENABLED VEHICULAR COMMUNICATIONS

The usefulness of and possibilities of a 6G technology-enabled vehicular communication is immense and broad. Below are a few of the applications.

A. UAVs as mobile BTSs in a case of natural disaster:
Unmanned Aerial Vehicles have been dimmed lately as a perfect solution to the improvement of the agility and effectiveness of the coverage area within a network by supplementing the terrestrial network infrastructure on the ground. Also, a very important use of the UAV Base stations is the deployment and use of it during the occurrence of a natural disaster such as an earthquake, which invariably damages the ground Base stations (BSs) and limits access to them. Also, because of the mobility provided by the UAV-based network of BSs, it can be deployed to locations where a sharp increase in traffic demand is observed [8]. UAVs like drones can also be used as unmanned surveillance vehicles that can be used to monitor human living areas and detect thieves, incidents like fire, or even accidents [9].

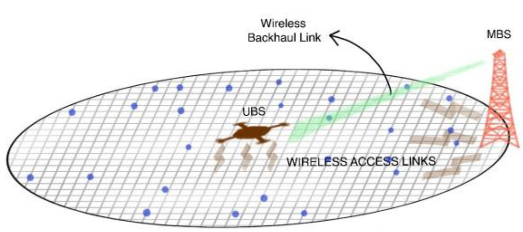

Figure 5. UBSs assisted heterogeneous network architecture [8].

All of these can be achieved made perfectly autonomous through the integration of a 6G-based vehicular communication which also has the ultra-low latency capability needed in real-time by fast-moving UAVs for quick decisions and real-time actions.

B. Vehicular movements/self-driven vehicles:
This refers to vehicles based on Artificial intelligence (AI) that can self-drive. 6G-based vehicular communication will make it possible to achieve this without fear of network lag that could cause death or accident in the spur of the moment. These self-driven cars could be employed as ambulances; the intelligent car could monitor the vitals of the patient like the blood pressure, the pulse and communicate this back to the nearest GP while driving to the nearest hospital. There are several complex algorithms required to accomplish this feat, in [10], it was stated that ‘These complex algorithms are divided into several modules such as path planning, vehicle monitoring, automatic driving, obstacle detection, etc.’.

The Ultra-low latency and symmetrically high download and upload speed 6G technology provide, however, makes it the next technology to be explored and used in this area.

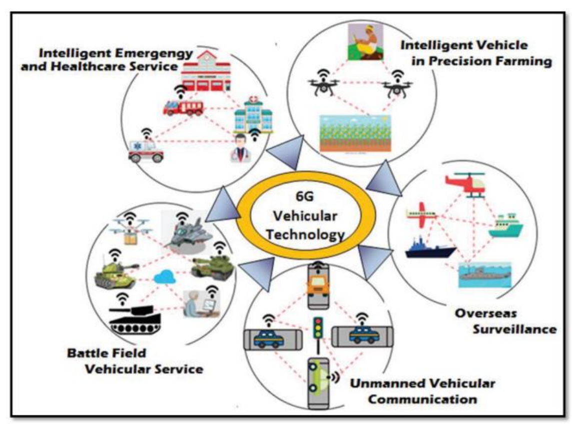

Figure 6. Intelligent Vehicular Communication using 6G Technology [10]

III. TECHNOLOGIES TO ENABLE 6G V2X

A. Symbiotic Sensing and Communications (SSaC):
SSaC essentially takes advantage of the mutual advantages of both communication and sensing to provide a wide range of services, one major such service is its integration into intelligent systems such as autonomous self-driven vehicles. It is sacrosanct that the ability to sense intrusions and obstructions, be

integrated into an autonomous driving vehicle to enable accident aversion capabilities. SSaC leverages either the use of electromagnetic wave signals or the use of sensors systems (like cameras, microphones, humidity sensors, etc.). Zhiqin et al stated that 'The main design principle in SSaC is to seamlessly integrate and effectively utilize both the wireless sensing and communications in the same system (by sharing the same frequency, signaling, hardware, etc.) in a reciprocal and symbiotic way.' [11].

B. Internet of Everything: To make vehicular communications and autonomous capabilities a possibility, it is expediently important that the vehicle is connected to other vehicles (V2V), connected to the network (V2N), Vehicle to pedestrian (V2P), etc. This gives autonomous vehicles the correct knowledge of the environment, which allows for a safer environment with less probability of hazards and collisions on the road. It provides improved driving experiences with real-time route checks and recommendations [13]. The integration of the Cellular system and V2X technology provides an increase in the communication range between vehicles, humans, and things, the transmission mode incorporated is known as the direct C-V2X which is also 6G compatible [12]. A depiction of this network system is seen in figure 7 below

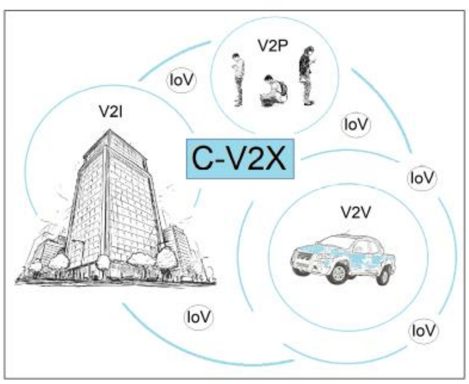

Figure 7. IoV on C-V2X [13]

C. Edge Intelligence: Edge computing is used for the integration of cloud computing into an intelligent system [10]. Edge Intelligence (EI) essentially integrates artificial Intelligence (AI) with mobile edge computing (MEC) which further unravels the potential of edge-side data [15]. In this technology, the transportation system is represented as a network, the network consists of components called the Roadside Equipment (RSE) and the Internet of Vehicles (IoV), vehicles are able to communicate with each other via the RSEs which establish the network [14]. A framework of an edge-centric network is depicted below showing how the Edge intelligence can be incorporated into a transportation and vehicular communication system.

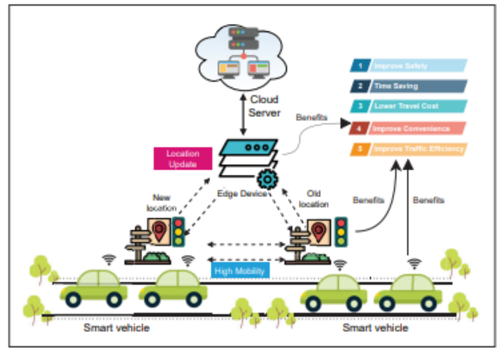

Figure 8. Edge-Centric smart transportation system [14].

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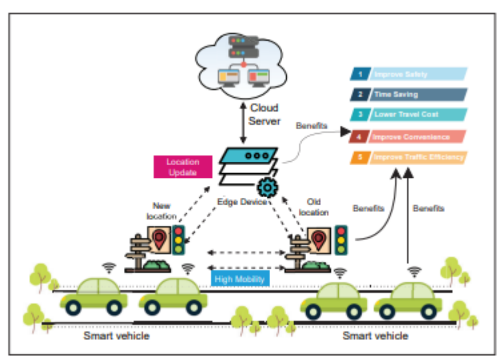

Figure 8. Edge-Centric smart transportation system [14].

IV. LIMITATIONS

Machine learning (ML) in 6G manufacturing introduces plenty of new challenges that must be addressed and understood before moving on with research or design. Although a full study of ML difficulties is beyond the scope of this article, however, some of the most recent ones are discussed in this treatise

A. The Critical Role of Data

While launching an operation in a 6G terrain, high-quality datasets are needed for ML operations, and the kind of data (labelled or unlabeled) is a crucial issue when determining which sort of learning to use.

It should be noted that constructing datasets from computer simulators isn't always the best strategy in wireless communication scripts, since ML algorithms will learn the principles of simulator coding, which doesn't show unpredictability. The implementation of visible features will take place in the actual world (i.e., learning from real data). The failure of actual datasets for 6G mobile and wireless dispatches is the most delicate chain for experimenters and ML interpreters. Several wireless issues necessitate the collaboration of researchers and global professionals to provide a tasteful depiction of the data. This is known as feature engineering, and it usually involves a great deal of effort and ingenuity. In other circumstances, ML automated feature learning can eliminate the requirement for custom feature engineering, particularly in big systems. This method, also known as feature learning, involves feeding all the data into an algorithm that determines which attributes are most essential. Some wireless technologies allow for real-time data updates and analysis. This problem was solved by updating the variables in phases using web-based learning.

This business asset is one of the most essential commercial ways for the telecoms industry, which creates massive amounts of data every day. As a result, 6G exploration groups, academics, and important assiduity partners are establishing and enforcing 6G structure to provide their own datasets for exploration. The library keeps track of wireless shadowing data from a variety of locations, which it uses to create algorithms and estimate data.

The No Free Lunch Theorem

In ML, this theorem states that if we sum the distribution created by all existing data, any ML system would perform inversely well at predicting unknown data. Otherwise, no ML method outperforms another on a worldwide scale. When we add up all the potential distributions that yield the data in the real operation, we obtain the same outcome. This indicates that the goal of ML isn't to figure out which learning algorithm is the most effective. Rather, we must determine which distribution kinds are critical for our 6G/B6G techniques, as well as which ML algorithms operate best with that data.

Hyperparameters Selection

Prior to the commencement of training, the value of the ML algorithm was well specified. These settings are included as hyperparameters since their selection has an impact on the final parameters (coefficients or weights) that are adjusted by the learning outcomes. In polynomial regression, the learning rate hyperparameter controls the model's convergence rate to discover the best weight, whereas the amplitude hyperparameter governs the degree of the polynomial, for some cluster analyses, we can create a remote function or hyperparameter of the viscosity threshold using unsupervised learning. Two hyperparameters that impact the learning process in RL are the mean number of trials and the value of environmental variables. More DNN settings are accessible, including the number of layers, the number of neurons in each subtype, the training lot size, and so on. In another case, though, it may not be useful or practicable (for example, if the ML system works well in a problem area such as navigation and wireless scheduling). Researchers start with outcomes that have previously been proven to function in another setting and find themselves making major alterations and enhancements before arriving at a conclusion. As a result, we may aim to develop a customized ML method to address the new 6G issues.

Performance Metrics

It's crucial to test an ML algorithm's performance on unlabeled/unlabeled data to see how well it works in real-world circumstances. Performance measurements are usually tied to the task that the system is completing. The model's accuracy is used to assess how effectively it performs tasks like categorization. The proportion of samples for which the algorithm gives an accurate result is referred to as accuracy. We can also get information about performance by looking at the error rate (the proportion of instances that the model produces incorrect outputs). We employ a test dataset apart from the data used to train the ML system to evaluate these performance indicators. The selection of performance metrics may appear straightforward and objective but determining what needs to be measured is often complex. We must employ a separate performance metric for non-supervised learning tasks like density estimation, which awards continuous-valued scores per occurrence to the model. The most popular way is to present the model's average log probability for a given case. RL algorithms contain the verifiable assurance that they will converge to asymptotically optimum behavior in theory. The proxy soon hits the 99 percent ideal level for most applications. Convergence speed is an accurate performance metric since optimality is frequently an asymptotic result. Rather than doing the best from the start, appropriate performance measurements might be determined by analyzing the predicted drop in rewards because of executing learning algorithms. Regret is a metric that penalizes mistakes committed throughout the learning process.

Privacy and Security

Because ML can snappily acclimatize to changing situations, it has come a standard tool for computer security, intrusion discovery, and cyber-physical attacks on mobile and wireless dispatches. Ironically, rigidity is a vulnerability in the network that can lead to unintended consequences. For illustration, CNNs can be fluently wisecracked by virulently generated noisy illustrations or unhappy agents in RL that seek to maximize the prices they gain from the environment of the dialogue. can be plant by deception. In fact, one of the limitations of ML algorithms is that they can be combated, that is, input patterns can be acclimated to classify the model into orders other than its original order forced. In fact, the need for further confidence in the results may increase the inflexibility of the model (i.e., how explosively the model fluctuates in its inputs). A good ML defense approach will include training, testing, and evaluation phases, as well as dataset protection and confidentiality.

In addition, due to the large quantum of data rotation needed in machine literacy operations, data security and sequestration issues need to be considered, similar as authentication/ confirmation, legal conditions, key/instrument rotation, etc. To achieve unified protection across the entire system, a thorough understanding of the native software security model and the sequestration programs of the different ML sub-frameworks is necessary. This is especially important in ML as numerous factors are frequently piled together to produce end-to- end results. Significant sweats will be made to ameliorate the resiliency and security of ML, especially in the security-sensitive areas of wireless dispatches, where slight miscalculations can have disastrous goods.

Interpretability Vs. Accuracy Trade-Off

We want to know why one BS gives more network capacity for a given stoner than another, or why a certain RAT is utilized to link specific UEs in HetNets, after imposing ML algorithms in a specific 6G script. Why did you make this decision? The complicated interplay between these distinct components is sensitive to appreciate from a stakeholder standpoint, and it is not inescapably understood as a business. When discussing why a specific model is suitable for a given circumstance and how the choice of algorithm is applicable to a given use case, it's simpler to appreciate the trade-off between accuracy and interpretation, see Fig. 1.

Depending on the operation, our objective is to strike the right balance in a model that provides both delicacy and detail.

To comprehend the DNA model, you must first comprehend how several retired layers function and how bumps are initiated. The comprehension of network operation is simplified when the network is divided into groups of connected neurons. Understanding how DNNs produce independent generalities that may be included into the final output is another crucial component of constructing explanations. In either scenario, while advocating a DL model, you may have to pay a premium for delicacy.

CONCLUSION

In this article, we first mentioned about the existing 5G enabled vehicular technologies with the evolution from the first vehicular communication standard launched. Then the limitations of 5G were brought up that will not be able to measure up with future needs. 6G is the future for vehicular communication and various applications were discussed in the article. Key technologies that will provide a great contribution to the deployment of 6G in vehicular communication is discussed which are theoretical concept, but trails are going on to make them practically applicable. Limitations is the section that needs to be considered before trying to deploy any communication standard, so it is discussed in the above section. Overall, all the possible applications, key technologies and limitations are provided to help the reader to better understand 6G in vehicular communication in simple form.

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