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PRELIMINARY REPORT

Application of 5g Network to Autonomous Vehicle Mobility

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Abstract: General technological progress has improved all areas of human activity and especially effects are pronounced in the automotive industry. One of the new technologies, which promises a lot, is communication using the 5G network. Compared to its predecessors, 5G has many times greater capabilities and data transfer speeds. By applying the 5G network, vehicles will be connected to each other but also to the environment. With the help of 5G network and V2X communication, the vehicles will be enabled to communicate with other vehicles and exchange telemetry data, but also to "see" through the vehicle in front of it. The full application of these technologies will bring many advantages, but disadvantages are to be expected aswell.

Keywords: 5G network, V2X communication, autonomus vehicles.

INTRODUCTION

Today, we have a 5G network in use, which will further improve all management functions and enable a complete interaction between the vehicles themselves and their connection to the environment. Increased data transfer and processing capabilities will contribute to faster response of the vehicle system to disturbances and corrective actions. In such a way, the safety of the use of these systems and driving itself will increase, which at this time is still insufficiently protected from the influence of third parties or systems.

Appreciating the desired goals, there will be many benefits that these technologies bring, but they will not pass without unintended consequences. Given that the driver is the focus of research that will be conducted, it is important to try to assess the effects from the point of view of future safety, comfort and disturbances in the labor market.

5G NETWORK

5G is a fifth generation mobile network. It is the new global wireless standard after 1G, 2G, 3G and 4G networks.

5G refers to the fifth generation mobile communications network and is therefore a direct successor to LTE or Advanced LTE (4G) and UMTS (3G). The new standard aims at higher data rates, improved capacity and an intelligent network.

5G uses a system of cells that divides space into sectors and sends coded signals between access points using radio waves. Each cell must be connected to the main network, either wirelessly or via cables. [1]

The ITU Standardization Body has defined the specifications, that 5G must meet the IMT-2020 standard [2]:

- Maximum data transfer speed: 10 - 20 Gbit / s
- Peak spectral efficiency: 10 - 30 Gbit / s / Hz
- User data transfer speed: 50 - 100 Mbit / s
- Latency less than 1 ms
- Connection density: 1,000,000 devices per km²
- Network availability 99.999%
- Almost 100% coverage
- Battery life of IoT devices up to 10 years.

The biggest advantage of 5G technology compared to its predecessors is the much higher data transfer speed. In the future, television broadcasts could be broadcast online without delay from multiple perspectives. Smart cars can share their telemetry data with each other and prevent accidents. Briefly: data speed is growing, the number of devices in the network is growing exponentially, and at the same time latency and load time are decreasing.

The beginning of the application of mobile communication technologies dates back to 1979 and the first, 1G network that enabled the development of analog telecommunications. With the 2G network, the commercial era of mobile communications technology began in 1991, enabling the transmission of speech and short text messages with limited data traffic. The next leap in the development of this technology occurred in 1998, when a

more serious Internet access was achieved with the help of the 3G network, and since 2008 the 4G network has contributed to achieving even faster Internet access. This has enabled the transmission of content that requires better transmission network performance, such as e.g. videos.

5G is a new generation of mobile communications networks whose application is tied to 2019. The 5G network uses the resources of existing technology but also brings great improvements. The 5G network provides significantly faster Internet access and interconnection of a large number of connected devices (picture 1.). In addition, the 5G network allows very secure and efficient communication with low latency and allows the so-called "Network slicing", i.e. the allocation of transmission resources according to established priorities. This will be of great importance for future Internet of Things (IoT) or special services.

Picture 1. 5G network, illustration

However, the 5G network also has drawbacks. Due to the high frequencies used for transmission in the 5G network, the number of transmission poles must be significantly increased. Costs - both for network construction and for operation - are likely to be higher than costs for 4G networks due to higher pole density. Extensive network coverage tests, quality assurance and integration into existing infrastructure are also required for commissioning. Successful installation and commissioning of the national 5G network first of all requires time and money.

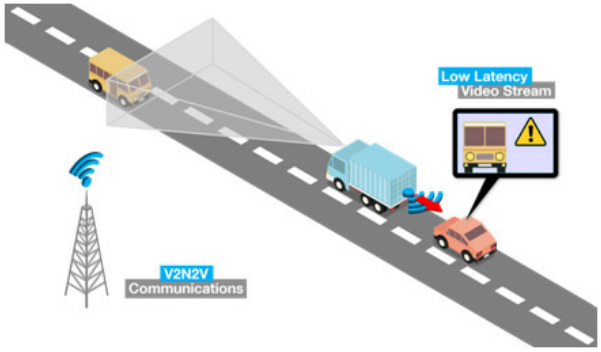
VEHICLE AND ENVIRONMENT CONNECTION IN ROAD TRAFFIC USING 5G NETWORK

Widespread use of autonomous driving is still not a reality and will require a reliable, robust and extended wireless network. Promising high data rates and very low latency, 5G is the future of autonomous vehicles. With the implementation planned as early as 2020, vehicle communication or V2X communication (Vehicle-to-Everything) will enable vehicles to interact in real time with their environment to increase road safety, traffic efficiency and energy savings (picture 2.).

Picture 2. V2X communication

Two main use cases illustrate the potential of 5G technology to improve vehicle connectivity via mobile networks: the self-explanatory "emergency vehicle approach warning" and the "transparent" use case, which allows drivers to see through the vehicle [3] (picture 3.).

The "Emergency Vehicle Approach Warning" aims to warn the driver that an ambulance is approaching even before it is visible because it is either too far or it is on an adjacent road. In order to do this, the connected ambulance sends its position to the server via its mobile router, which will show whether its emergency lights are activated or not. The server redistributes an ambulance position message to nearby vehicles, which then warn its drivers of its position if the emergency lights are activated.



Picture 3. Case of using 5G network

Another use case developed during the Towards5G partnership allows the driver of a vehicle to see "through" a vehicle in front of him that obstructs his view, which can help when overtaking, for example. To achieve this, a vehicle equipped with a high-definition camera connected to a mobile router can transmit a video stream when automatically requested by the mobile router of a vehicle that is behind. The video stream is then transmitted over part of the vehicle using a local interrupt, ensuring low latency.

The main limitation of the case of use in this form is the fact that is uses high bandwidth. However, the advantage is that it provides an incredibly visual display of vehicle performance at low latency while maintaining speed, compared to the mobile broadband limit, which is the first to be affected by any deterioration in radio and network performance.

"Lane connection" is used to assist an autonomously connected vehicle when connecting to a double carriageway or highway. This is made possible by the "traffic orchestrator", an application module located on the network and connected to a V2X server. It collects information on the positions and dynamic parameters of vehicles on the highway and suggests routes for vehicles to be connected as well as those within the connection zone in order to optimize the free flow of traffic and facilitate connection.

While connected vehicles permanently tell their position to the V2X server and are therefore taken into account by the orchestrator, unconnected vehicles detect smart cameras arranged around the junction zone and detect the positions of all vehicles. To do this, they use image processing techniques that rely on artificial intelligence. Data from these cameras is then sent to a V2X server, where the data fusion module compares them with data compiled by connected vehicles to avoid duplication.

APPLICATION OF 5G NETWORK TO AUTONOMOUS MOBILITY

Autonomous driving is considered a paradigm shift, but technically it is an evolutionary process. Prerequisite is the presence of sensors (radar, video, laser) and actuators (in engine control, steering wheel, brakes) in the vehicle. Autonomy is provided by computers in the car, which connect sensor data, form an image of the environment, automatically make driving decisions and pass them on to actuators. Machine learning is often used to handle large amounts of data, for example when recognizing traffic signs, before it is implemented in vehicles. Media theorists call for a broader social dialogue on the effects of autonomous driving, especially in situations of dilemma when the trip computer can no longer avoid damage, but must assess the damage - basically an ethical decision. [4]

Enabling even faster connectivity between transportation systems, the 5G network will offer new application options that enhance the development of autonomous cars. Not only will they be able to make decisions independently in the future, but they will also communicate and cooperate with each other. Automatic driving is a term used to describe scenarios in which, as a result of these possibilities, a fully interconnected and intelligent road transport system is created.

5G transmits huge amounts of data without interruption - as long as the network is firmly connected. Exactly these are the prerequisites for autonomous driving: fast, reliable communication networks and seamless data transmission. The car must be able to receive all safety information at all times. This is the only way to ensure safety while driving autonomously and avoid accidents. Only then can artificial intelligence (AI) take over the ride itself with the help of networked sensors and communicate completely reliably with other road users. Traffic jams would also be a thing of the past. The necessary technical standards are currently being fiercely debated and must be precisely defined.

Thanks to wireless technology and internet connection, connected cars with their digital and location-based services can greatly improve our driving comfort. The car relies on regular updates of navigation data, e.g. detailed roadmaps, plus updates in unexpected traffic situations such as congestion, rain or ice. Combined with driver and cloud applications, maintenance information or other status reports can be downloaded and sent. Thanks to mobile edge computing, these functions have already been implemented today, based on LTE at speeds of up to 300 megabits per second and latencies of less than 100 milliseconds, even in emergencies or remotely controlled driving at low speeds. 5G will offer even greater quality for many in-car digital services in the future.

Fifth-generation wireless technology will be a key trigger of more reliable communication for vehicles, which will play a key role in managing the safety challenges that come with vehicle automatization and autonomy. There are more, often complementary technologies that can be used for both direct and network-based communication - including 4G / LTE, satellites, DSRC and 802.11p.1 5G will significantly reduce latency and increase reliability compared to current technologies, enabling new use of cases such as route sharing, local real-time updates and coordinated driving. The application of these technologies will create conditions for additional progress in the development of intelligent transport systems.

Automatic systems reach their limits when unexpected or unknown situations arise. In that case, the "autopilot" will decide to deactivate the system for security reasons, if in doubt. The autopilot would then return the task and responsibility of driving to the driver himself. However, if the driver does not take control of the vehicle, or not as fast as needed, then the car will pull to the edge of the road in safe driving mode.

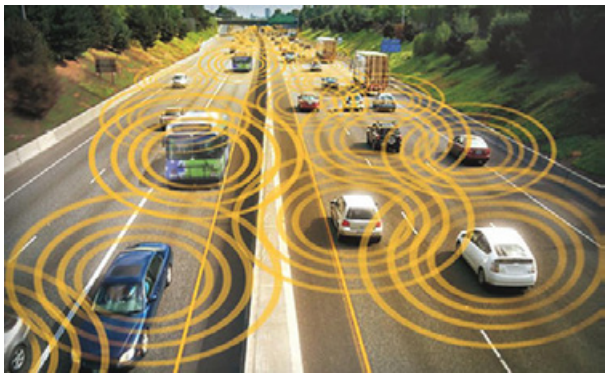
With 5G, the car could, for example, be remotely controlled by an outside operator acting as a traffic controller. Remote control via operator, however, is definitely impossible without a 5G network, which offers key features such as very short response times and guaranteed network resources.

One huge advantage of 5G is what is known as network cutting. The wireless network is divided into virtu-

al network levels. One level of the network is then used only for automatic driving, for example. This ensures that notifications related to the safety of self-driving cars do not end up in traffic jams on highway for data transfer and that they are given priority over other infotainment services used parallel.

Another advantage is the processing and storage of data in data centers that are close to transport routes. Such "edge" data centers ensure that data can be processed even faster on the network.

The sensors are used to implement car-to-car communication for automated driving. This includes, for example, intelligent camera and radar systems (picture 4.), which allow direct data exchange between cars. However, these systems have key physical deficiency. They can neither look around corners, nor over hills, nor through obstacles. That is why they limit the work of self-driving cars. This simple form of automatization is also inappropriate at higher speeds.



Picture 4. Communication between vehicles

Mobile technology expands the scope of autonomous mobility through direct and, above all, fast and broadband data communication with cars and properly equipped transport infrastructure, such as traffic lights. This can ensure improved traffic flows, for example by allowing cars to travel at higher speeds or reducing their speed at times when needed.

CONCLUSION

Automatic driving has already started with assisted driving. However, vehicle automatization is gradual. Fully automated driving, which can work reliably in a large number of driving situations, is only the final stage of a long process.

The functions of the autonomous car steering system are already partially performed by driver assistance systems, such as steering and lane keeping assistants. Nowadays self-parking cars are already available. Despite these assistants, it is the driver who remains responsible at all times. However, if the vehicle is fully automated, the responsibility is shifted from the driver to the means of transport, and thus to its manufacturer or operator. That is why, many automation functions will initially be limited to driving situations that can be sufficiently controlled, such as driving at low and medium speeds on motorways or parking in a demarcated parking space.

People use automated functions in their everyday lives mainly to save time, which can then be used in a more meaningful or convenient way. So in the future - as ordinary passengers in self-driving cars - using mobile networks, we will surely be able to read the latest news on our smartphones or tablets, participate in video conferences or work, use entertainment services or shop online while on the go. Or we could simply sleep while driving to arrive at our destination rested or come to a business meeting refreshed and relaxed.

In addition to all the benefits that these technologies bring, the risks that accompany complex systems and are related to the reliability and protection of the system should be faced.

Nevertheless, the development and application of advanced autonomous driving technologies will cause drastic changes in the labor market in the future. From the current situation, when there is a chronic shortage of professional drivers, it will happen that drivers will no longer be needed at all, so the driver will disappear from the list of occupations.

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