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FLEXIBLE CONTROL OF AUTOMATIC TRAFFIC VEHICULAR COLLISION AVOIDANCE BASED ON 5G WIRELESS MOBILE COMMUNICATION SYSTEM

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With the development of economic and industrialization, many countries entered the era of the automobile society. Anti-collision control system is very important to improve the safety of the automatic machine. The researching of anti - collision control system belongs to 5G wireless system has been paid much attention by different ISP, equipment provider and universities. There have many different collision avoidance control systems in automatic traffic machine science 1971, such as collision avoidance which controlled by ultrasonic, laser, infrared, microwave. However, there are many shortcomings to impede development of anti-collision control system. Automatic traffic machine collision avoidance is based on vehicular mobile network, integration of sensors, RFID (radio frequency identification), data mining, automatic control technologies. According to communication protocols and standards to achieve dynamic mobile communications is a typical application of Internet of things technology in transportation systems. Vehicles as mobile communication devices in the form of topology nodes to organize network. Due to the mobility of access increased frequency, increased node coverage, complex communication environment. 5G mobile communication network will integrate advanced technologies such as millimeter-wave communication technology, large-scale antenna array, ultra-dense networking and cognitive radio (CR) with developing which has low latency and high reliability applications will solve problems in current Automatic traffic machine collision avoidance. The base stations and infrastructures do not need to established in Vehicular mobile system bring a historic opportunity for the development. “Automatic traffic machine in millimeter wave anti-collision system" has become a hot topic in the international researching in recent years.

Keywords: wireless telecommunication, flexible control system, automatically traffic machine, RFID

1. Introduction. Automatic traffic machine control structure in 5G.

Nowadays, the vehicular application becoming more and more popular in researching filed of information technology according to the 5G wireless network development. The feature of 5G vehicular system mainly include multi-network fusion and multi-channel which provide the terminal devices for connected to internet. At present, a variety of networks coexist in vehicular system, such as WLAN which based on the IEEE 802.11a / b / g / n / p standard protocols, 2G / 3G, LTE, mobile cellular communications system, and satellite communications networks [1]. The data processing and information exchange is imperfection because of the different standards and protocols are used in vehicular communications. However, 5G wireless will unified a variety of networks for vehicular system achieve seamless information exchange and communication switching. The 5G wireless communication network including a cellular layer and a device layer. The cellular layer involves direct communication between a base station and a terminal device, D2D (device-to-device) communication is an important part of 5G mobile communication technology in device layer. According to the allocation of resources which by the base station, D2D terminal communication can be divided as follow: 1) Terminal data forwarding to EPC is controlled by the base station. The terminal device completes data forwarding according establishes a connection with the base station. 2) Terminal devices communication between each other which controlled by the base station. The base station will not participate terminal data forwarding, however a control link between the base station and the terminal need to established in this situation [2].

2. Multi-identity simulation in 5G base station

A large number base station will be deployed in 5 G wireless network and become an ultra-dense structure on Fig.1. Precise positioning function will also be given to the user.

1) Collaborative Relay. 5G base station as a wireless access point between car and internet communications.

2) 5G base station will replace RSU to broadcast traffic control information for vehicle in ad hoc network to ensure real-time security among vehicles in high-speed operation environment.

3) accurate locating. The current GPS as OBU positioning system is very vulnerable which attack from cheating, blocking. Large deployments of base stations in 5G wireless network will use high radio frequencies wave (millimeter-wave) and large-scale antenna arrays to reduce positioning errors in NLOS complex environments [3].

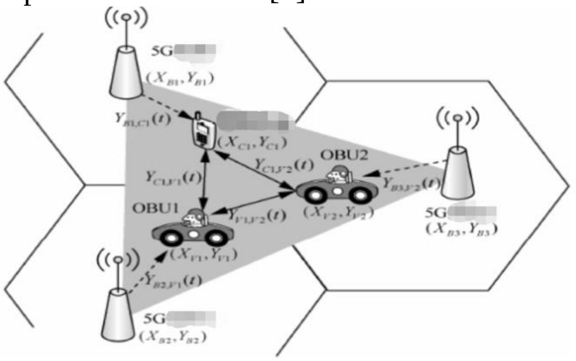

Fig. 1. 5G vehicle networking collaboration positioning system

A coordinated positioning system which based on D2D, the signal received by the vehicle terminal OBU1 from the base station 2 as follow eql.1:

$$Y_{B2,V1}(t) = \eta_{B2,V1} S_{B2}\left(t - \frac{1}{C_0}\left(C_0 T_{v1} + L_{B2,V1}\right)\right) + N_{B2,V1}(t) \quad (1)$$

The distance between vehicle terminal OBU1 and the 5G base station 2 is eql.2:

$$L_{B2,V1} = \sqrt{(X_{V1} - X_{B2})^2 + (Y_{V1} - Y_{B2})^2} \quad (2)$$

where:

$-\eta_{B2,V1}$ is scalar factor which describe decay characteristics, S_{B2} is transmitted baseband signal. C_0 is the time delay in transmisssion [4]. T_{v1} is the time offset of the vehicle terminal OBU1. $N_{B2,V1}$ is additive white Gaussian noise. The pseudo range between the vehicle terminal OBU1 and the base station 2 is eql.3:

$$\eta_{B2,V1} = C_0 T_{v1} + \sqrt{(X_{V1} - X_{B2})^2 + (Y_{V1} - Y_{B2})^2} \quad (3)$$

When the baseband signal is transmitted from the vehicle terminal OBU1 as $S_{v1}(t + T_{v1})$. The signal that can be received at OBU2 is eql.4.:

$$Y_{V1,V2}(t) = \eta_{V1,V2} S_{V1}\left(-\frac{C_0(T_{v2} - T_{v1}) + L_{V1,V2}}{C_0}\right) + N_{V1,,V2}(t) \quad (4)$$

Lv1, v2 is the distance between the vehicle terminal OBU1 and the vehicle terminal OBU2 as eql.5.

$$L_{V1,V2} = \sqrt{(X_{V1} - X_{B2})^2 + (Y_{V1} - Y_{B2})^2} \quad (5)$$

The pseudo range between OBU1 and OBU2 based on D2D is eql.6.

$$d_{V1,V2} = C_0(T_{v2} - T_{v1}) + L_{V1,V2} \quad (6)$$

TV2 is the delay of the vehicle terminal OBU2 to the network base station [5].

The terminals in 5G wireless mobile network communications will be established through self-controlled communication in future. Terminal equipment regularly broadcasts with identity information, Other neighboring terminals according to the channel state information（CSI）in adaptively select the current optimal channel [6]. Direct communication between 5G terminals and selecting appropriate relay forwarding messages enables 5G terminals to implement information exchange in an optimal way. OBU can access the Internet through multiple channels according to the diversified communication methods of 5G terminals. The OBU adaptively selects the channel quality to access the Internet through multiple channels such as nearby 5G base stations, 5G vehicle-unit OBUs, and 5G mobile terminals [7] on Fig.2.

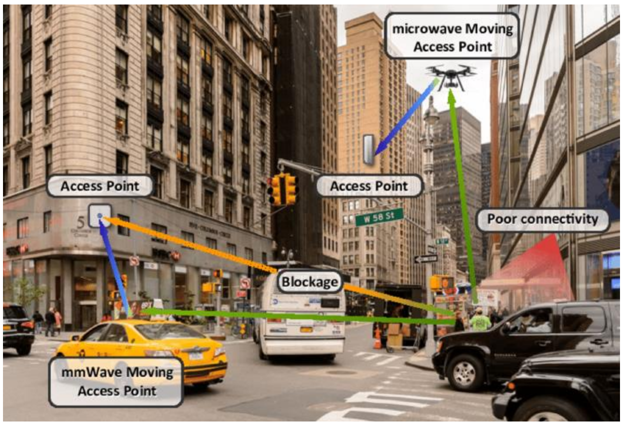

Fig. 2. The multi-channel in 5G wireless vehicle networking access internet architecture

3. The characteristics of 5G vehicle network

5G wireless mobile communications fusion cognitive radio (CR), Millimeter wave, Massive MIMO antenna array, ultra-dense networking, full-duplex communication（FD), and wireless full-duplex to significantly improved system performance [8]. The characteristics of 5G vehicle networking are mainly reflected in low delay and high reliability to compare IEEE 802.11p with spectrum utilization.

3.1 Low latency and high reliability

The sending terminal, receiving terminal and relay node of 5G vehicle networking information must ensure the privacy, security, and high transmission rate of information transmission [9]. At present, the research on vehicle networking requires very high real-time performance, However, communication delays only reach the millisecond level could support secure interconnection requirements due to the limitations of wireless communication technologies (such as bandwidth, speed, and domain name). 5G ultra-high dense structure and low equipment energy consumption will greatly reduce the network signaling overhead. The delay of 5G reached the millisecond level, which meets the requirements of low latency and high reliability to become the biggest breakthrough in the development of vehicle networking. In order to researching the link characteristics of low latency and high reliability in 5G car networking communication, the antenna have analyzed in literature in 300 km/h vehicle communication [10]. NFV (network function virtualization) and SDN (software defined network) technologies improve the flexibility of 5G network architecture [11]. The optimization of 5G network services not only needs to support the current application services, but also to adapt to the rapidly increasing amount of information and to meet the future diversity of of service requirements [12]. For example, the high reliability requirement in vehicular networking is an architecture application in 5G. The main parameter of Table 1 is D2D communication delay simulation. As the number of vehicles increases, the D2D communication delay remains basically stable in Fig.3. Delay of air interface in 5G vehicle networking less than 1ms [13].

TABLE I. The main parameter in D2D

Parameter	Value
Vehicle speed	55 km/h
Coefficient of noise	4dB
System bandwidth	5 MHz
Carrier frequency	2.6GHz
power density of Noise	-180 dBm/Hz
Base station transmission power	45 dBm
OBU transmission power	4 dBm
D2D communication distance	120 m

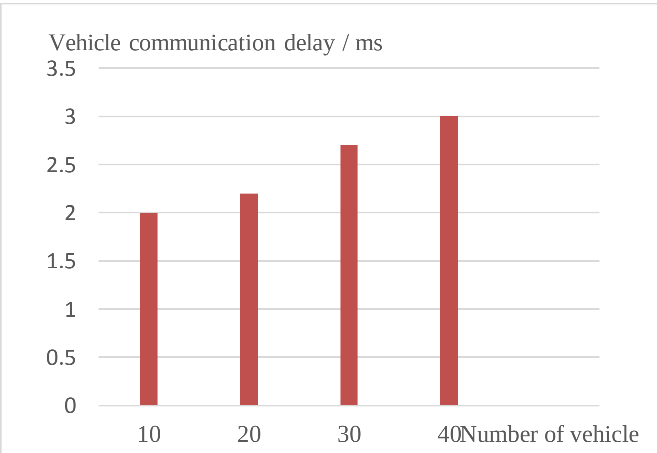

Fig. 3. Analysis of Communication Delay in Vehicle D2D Mode

3.2 The efficient use of spectrum

The efficient use of spectrum is an important feature of 5G user experience. The application of 5G communication technology will solve the problems of the current vehicle networking resources [14]. The efficient use of spectrum in 5G vehicle networking mainly in the following aspects:

1）D2D wireless communication.

D2D is achieved by multiplexing cellular resources in 5G wireless communication system. The vehicle unit based on D2D technology to communicate with adjacent vehicle unit or 5G base station to access internet. In this way, the spectrum utilization of the vehicle network communication could be significantly improved and save energy to compared with the the IEEE 802.11p standard. [15].

2）Full-duplex communication mode

5G mobile terminal equipment using full-duplex communication mode to allows messages between different terminals in sending and receiving. At this time, spectrum efficiency of the air interface improves to double time. [16].

3）Cognitive Radio technology.

Cognitive radio technology is one of the important technologies in 5G communication networks. The vehicle terminal obtains the current spectrum information through the perception of the wireless communication environment. Vehicle terminal uses cognitive radio technology to share spectrum resources with other authorized users to solve the problem of shortage of wireless spectrum resources.

3.3 Superior communication quality

5G wireless communication networks are expected to have ultra-high capacity and provide gigabit-per-second data rates for users. A millimeter-wave communication system with a frequency band of 30-300 GHz is proposed to exchange information between 5G terminals or between the base station. [17]. The millimeter waves have a very large bandwidth to provide very high data transmission rates. The interference of the environment and the probability of interruption of the connection which between the different terminals will be reduced in millimeter technology. Table II is a comparison of key technical parameters of between 5G vehicle network and IEEE 802.11p vehicle network. The result shows that 5G vehicle network has better wireless link characteristics than IEEE 802.11p vehicle networking.

TABLE II. A comparison of key technical parameters of between 5G vehicle network and IEEE 802.11p

1） Wireless communication distance

The charac-teristics of Wireless link	Current vehicle networking technology	5G vehicle networking technology
Communica tion mode	IEEE 802.11p	D2D wireless communication in 5G
Maximum transmission distance	800m	1000m
Maximum movement speed	60km/h	350km/h
Maximum data rate	27Mbit/s	1Gbit/s
Frequency Range	5.86 – 5.92 GHz	Authorized frequency band
Time Delay	>= 10ms	<= 1ms

The maximum distance for 5G vehicular D2D wireless communication is approximately 1000 m. in this situation, the short and discontinuous connection problems from the IEEE 802.11p vehicle ad hoc network communication could be extended, especially in NLOS environment.

2）Transmission rate

5G provides high-speed downlink and uplink data rates for D2D wireless communications (1Gbit/s). In this way, the high-quality video wireless communication between vehicles can be realized.

3）High-speed mobility

5G vehicle wireless networking supports faster data transmission to compared with IEEE802.11p standard wireless communication. The maximum driving speed of the supporting vehicle is approximately 350 km/h.

4) Challenge

5G technology improved the current wireless communication method and optimized the architecture of the vehicle network. However, 5G vehicle networking still has significant challenges, which are mainly reflected in the three aspects of interference management, communication security and driving safety [18].

4. Features of Millimeter Wave

The development of mobile communication networks accompanied by the rise of key technologies from 1G to LTE era. At the same time, the key technologies meet business needs and promote the network function continues to developing. Similarly, the development of 5G can not be separated from support of key technologies. Millimeter wave communication is a kind of microwave communication which length range of wave between 1 ~ 10 mm and radio frequency range between 30 ~ 300 GHz. The characteristics of millimeter wave and microwave. The radio wave dissemination distance is a few kilometers when at 30GHz. But, if the radio frequency increase to 60GHz, dissemination distance only has 0.8 km. At the same time, millimeter wave is a very high frequency electromagnetic waves. Atmospheric absorption and rainfall decline has a great interference for millimeter wave propagation [19]. Why the telecommunication organizations still researching millimeter wave communication technology all over the world, because of the characteristic which millimeter wave has a short wavelength and propagation stability is higher than decimeter microwave is suitable for dense base station layout [20]. Currently, 5G millimeter wave technology still in phase of demonstrating and piloting time, the process of developing millimeter waves exist many problems should be considered.

4.1 5G Millimeter Wave Radar Technology in Automatic Driving Control System

The frequency of the millimeter wave is high and the beam is narrow, which is more conducive to the convergence of energy [20]. 77 GHz radar sensors with digital beam forming (DBF) front ends were introduced into the market by Japanese companies in 2003. Denso built a planar patch antenna with a range capability up to 150m and a field of view of approx. ±10 degrees. The nine receiving antennas are multiplexed with four 77 GHz SP3T switches to only one base band channel, see Fig. 4.

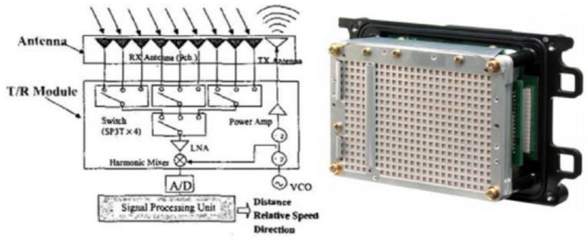

Fig. 4. Denso's 77 GHz DBF sensor [4]

The Toyota CRDL 77GHz LRR radar switches 3 equal transmitting antennas and 3 receiving antennas resulting also in one base band channel, and, after de-multiplexing in the digital domain, nine digital receiver channels for DBF on Fig. 5.

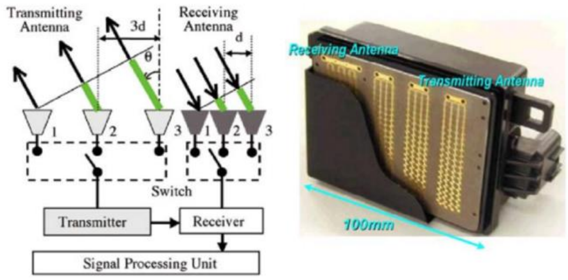

Fig. 5. Toyota CRDL Radar with DBF, 77 GHz

CRDL 77GHz LRR radar mounted on our test vehicle, see Fig 6. First results of our implementation of parameter estimation techniques on a 77 GHz DBF demonstrator are shown in Fig. 6. The markings no. 1 and 2 indicate the estimation of the Esprit algorithm.

Although the half power beam width of the virtual beams of the DBF sensor is approx [21]. 8.5 degrees, both cars with their angular separation of less than 4 degrees are detected and no ghost target between both objects does appear.

77 GHz ACC systems will be extended to be operational at low speeds including full stop capability. This will provide increased customer benefits and it will contribute significantly to the market success of ACC systems [22].

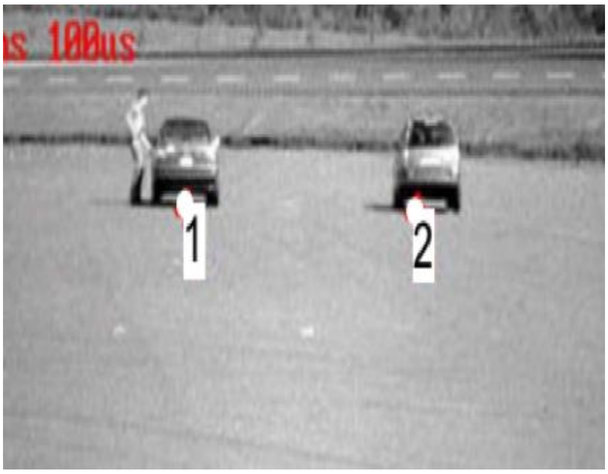

Fig. 6. CRDL 77GHz LRR radar mounted on our test vehicle

4.2 The Problem from Routing Path Loss in Propagation

Path loss is caused by the characteristics of channel. The problem from path loss is a common phenomenon in all of wireless communication systems, signals easily to be interference during propagation from adjacent wireless channel. The model of propagation from radio wave path loss could expressed, as in eql.7. d in km and f in MHz

$$P(dB) = 32.44 + 20\ln d + 20\ln f \qquad (7)$$

It can be found that the propagation path loss increasing as the radio wave frequency increasing, as in Eq. 1. Millimeter wave spectrum has greater pass loss in propagation to Compare with 300MHz-3GHz wireless mobile communication spectrum which used by LTE.

However, according to another 5G new techniques which named beam forming can concentrate energy in a small area to get a higher signal gain to solve the problem of path loss in propagation.

4.3 Signal loss from a building penetration

The ability of low-band wireless signals in penetration is more powerful to compare with high- frequency. This is the reason why wireless signal will have much energy loss when penetrating the building [23]. As the millimeter wave has a large signal penetration loss and a short transmission in distance function, the signal can not enter the room for provide users communicate. However, by establishing millimeter-wave picocell nodes indoors could guarantee the communication quality very well.

4.4 Fading of Signals on a Rainy Day

The wireless communication needs to consider what is the different characteristics of signal in propagation with different frequency band range. At the same time, the fading of signals on a rainy day is an important factor in millimeter wave communication researching.

Firstly, the length of wireless millimeter waves routing path propagation could be restricted by water molecules.

Secondly, water molecules will reduce the reliability of wireless communication system. The size of a raindrop mostly as same as the length of millimeter wave. Therefore, it will cause serious disturbances to the millimeter-wave communication system when the rainfall is heavy. Here gives a signal fading model of millimeter wave based on geographic observations which according to rainfall rate and rainfall structure [24], as in Eq. 8.9.

$$A_R = aR^b\left\{\frac{e^{udb}-1}{ub}\right\} \quad (0 \le D \le d) \qquad (8)$$

$$A_R = aR^b\left\{\frac{e^{udb}-1}{ub} - \frac{B^b e^{cdb}}{cb} + \frac{B^b e^{cdD}}{cb}\right\} \quad (0 \le D \le d) \qquad (9)$$

4.5 The Advantages of Millimeter Wave Communication

1) A Millimeter Wave Occupies Large Bandwidth to Improve the Speed of Communication. It is generally considered that the frequency range of millimeter wave is between 26.5 to 300 GHz and the peak of bandwidth could arrive to 15 GHz. The peak rate is 5 times higher than the existing microwave transmission rate even with considering the problems which from atmospheric absorption or the fading of signals on a rainy day [24]. The research of millimeter wave propagation features become very popular in the frequency resource tense time.

2) A Millimeter Wave Has a Narrow Beam. The millimeter wave beam is much narrower than the microwave beam at the same antenna size. For example, a 12 cm antenna which working at 9.4 GHz, the beam width is 18 degrees.

However, if this antenna working at 94 GHz, the beam width will become 1.8 degrees. Thus, a small target can be clearly distinguished from observation [24].

3) The Millimeter Wave Has Super Strong

Ability of Detection. The special broadband spectrum capabilities of millimeter wave can be used to suppress multipath effects. A large number of spectrum resource could be used in millimeter-wave frequency range mutual interference will be eliminated effectively. Specially, to combine in mesh network structure [25].

5. Conclusion

The specific technical standard of 5G has not been formulated yet at present, spectrum efficiency is a key developing direction for wireless communication system from the research results which released by major international organizations. Short range radar in ultra wideband operation at 24 GHz and at 79 GHz from 2013 at the latest will be used first in premium and later on in upper class models. Main applications will be ACC support, pre-crash detection, parking assistance, and blind spot surveillance. Market introduction of 24 GHz SRR will start in 2005. SRR sensors won't have angular measurement capabilities in the first generation (except the valeo-raytheon sensor), but future generations will also be able to provide angular information. Further advantages of NOMA are the very efficient spectrum usage and, with digital signal processing being cost-effective and flexible, also low complexity application of the Massive MIMO principle [26]. From this point of view, the NOMA algorithm can satisfy both the demand rate and the spectral efficiency of mobile services [27].

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