Advances in Computer, Signals and Systems (2023)
Clausius Scientific Press, Canada

DOI: 10.23977/acss.2023.071008
ISSN 2371-8838 Vol. 7 Num. 10

Time Delay Analysis of Deterministic Network 5G-A Terminals

Hu Chengsong

ASR Microelectronics Co., Ltd., Shanghai, China

Keywords: 5G network; deterministic network; time delay prediction

Abstract: The rise of 5G technology marks a revolution in the field of communication. It not only provides faster Internet connectivity for ordinary users, but also brings new opportunities for industrial, healthcare, transportation and other fields.5G networks are known for their ultra-low latency, high reliability and large capacity, providing a solid foundation for real-time communication and large-scale IoT applications.5G terminal transmission delay is a direct data performance of deterministic network capability in industrial control scenarios, and it is an important means to improve network certainty. The traditional network can only reduce the end-to-end delay to tens of milliseconds, which can no longer meet the development of industrial intelligence, so it is necessary to vigorously develop 5G network. This paper mainly starts with the advantages and limitations of 5G network and terminal equipment, and analyzes the time delay of 5G-A terminal of the deterministic network, hoping to provide reference for the development of industrial Internet.

1. Foreword

With the development of industrial intelligence, more and more scenarios need to improve the timely accuracy of communication signals and reduce the loss and distortion of signals.5G deterministic network technology is to make the network timely and accurate do the extreme, the "do" into "on time, accurate" on time, reduce the delay of signal transmission, in order to better adapt to the industrial intelligent scene, traffic regulation, autopilot, industrial automation in the field of higher requirements, improve the rapid development of industrial intelligence. In terms of network scheduling, system real-time performance and workload prediction, accurate measurement and analysis of the transmission delay of corresponding network terminal equipment are required. However, 5G air port, product characteristics, equipment parameter configuration and network environment will increase the variation and randomness of network delay, and increase the difficulty of delay prediction. As the time-series data, 5G-A terminal transmission delay, if the prediction method can be effectively mastered, it can well meet the needs of 5G network. The transmission delay of 5G-A terminal is divided into linear prediction method and nonlinear prediction method. The problem of linear prediction method is that it needs accurate modeling, which is not suitable for the network delay with large dynamic range and strong nonlinear nature. SVMs and least squares SVMs in nonlinear prediction methods have unique advantages for nonlinear and high-dimensional pattern identification and can be used to predict network delay with

strong nonlinear nature. Through the analysis of deterministic network 5G network and 5G-A terminal delay, this paper proposes the prediction method to provide reference for subsequent research work.

2. Temporal certainty of the 5-A network

5G-A is the second stage of 5G. Compared to 5G, the most intuitive is a higher level of improvement in speed and frequency band support. In terms of speed, delay, connection scale and energy consumption, 5G-A are 10 times stronger than 5G.

The most important improvement of 5G technology for the industrial Internet is to guarantee the transmission delay, reduce the transmission delay and the delay jitter, and strengthen the consistency level of the delay.

2.1. Ow latency

Through the collaborative shortening of single-domain delay and multi-domain delay of industrial connection equipment, wireless network, core network and transmission network, the end-to-end service delay is reduced. Through uRLLC technology, wireless network adopts more flexible scheduling mode (flexible scheduling interval and no authorization scheduling), smaller scheduling unit to minislot, and flexible HARQ and ARQ-ACK feedback mechanism to achieve low delay requirements. The core and transmission networks shorten the service transmission path through UPF sinking and MEC technology to reduce the service time delay; it can be deployed in MEC fully integrated with the base station, further reduce the time delay[1].

2.2. L Ow jitter

5G is combined with time-sensitive network (Ti me Sensitive Netw or king, TSN), using precise timing, traffic scheduling, QoS mapping and other technologies to achieve end-to-end deterministic services. More accurate deterministic data forwarding is realized independently in 5G, so as to meet the industrial control applications sensitive to delay jitter.

2.3. Network slice

According to the 5G service requirements, different SLAs can be realized through network slicing, providing isolation and QoS guarantee for high priority services. In addition, through the open slicing ability, the application can obtain the status information of UE, set the UE slicing strategy, so that the network can meet the requirements of vertical industry applications more finely and intelligently, and meet the time certainty.

3. Composition of deterministic network 5G-A terminals

3.1. Delivery delay

Transmission delay, also called transmission delay, refers to the time required from the first bit of the sending data frame to the completion of the last bit of the frame. The transmission delay occurs in the transmitter inside the machine and has nothing to do with the length of the transmission channel (or the distance where the signal is transmitted). The propagation delay refers to the time delay of dispatching and transmission of data signals in the transmission medium. This delay is mainly determined by the propagation speed and transmission distance of the signal in the physical medium. In 5G network, the shorter time slot scheduling than 4G network and the flexible

design of minislot make the scheduling of data transmission resources faster. Compared with the previous network standard, the propagation delay of 5G is more competitive, which helps to improve the response speed of the network. In high-density urban areas, this feature is critical to support large-scale connectivity and real-time communication, especially in intelligent transportation systems, virtual reality experiences, and industrial automation, with more important demand scenarios. Unlike propagation delay, transmission delay is the time delay of data on the transmission link, including the time required for data processing processes such as encoding, grouping and encapsulation.5G networks adopt more efficient data coding and communication protocols to reduce the transmission delay. By reducing the processing time of data packets on the transmission link, 5G ensures that the data can be transmitted from the sender to the receiver as soon as possible. This is crucial to cope with strict application scenarios with high bandwidth, large data volume and real-time requirements, such as HD video streaming, cloud gaming and telemedicine[2].

3.2. Transmission delay

5G networks introduce significant improvements in transmission delay, mainly using higher frequency millimeter bands and innovative communication technologies. Compared with the previous network standards, 5G transmission delay is more competitive, which helps to improve the real-time performance and response speed of the network. The 5G network also uses a large number of smart antenna technologies, including beamforming and multi-input and multi-output (MIMO). These technologies are able to dynamically adjust the transmission direction and intensity of the signal to ensure that the data can propagate in the shortest path, further reducing the propagation delay. This is important for real-time applications, such as remote control, virtual reality, and autonomous vehicles.

3.3. Processing time delay

Processing delay is a key performance indicator in 5G networks and represents the time required for the data to be processed on the network nodes. It involves the routing and forwarding process of the packets. In 5G networks, a data packet usually needs to be transmitted through multiple network nodes that are responsible for determining the best path of the data packet to ensure that it can reach its destination quickly. To reduce the processing delay, the optimized routing algorithms and the efficient router hardware become crucial, which helps to ensure the rapid transmission of data packets in the network. The processing delay also includes packet parsing and access control. By optimizing the protocol level design of the user data surface, the 5G network makes the packet processing more suitable for the hardware implementation, which can improve the 5G network needs to analyze the header information of the packet to determine the destination of the packet and the required processing efficiency. By improving the efficiency of parsing and access control, the processing delay can be effectively reduced, and the real-time performance and security of the network can be improved. Security also has an impact on processing delay. In 5G networks, security is crucial, so network nodes usually need to scan and check the content of packet security to prevent malicious activities and network attacks. While these security checks increase processing delays, they are critical to secure network and user data[3].

3.4. Queuing delay

Queuing delay is the time the data waits for processing in the buffer of the network device. When network congestion or data in volume, packets may need to wait in the queue, which leads to

increased queuing delay.5G networks use intelligent congestion control and load balancing to reduce queuing delays and ensure that data can be processed as soon as possible. The network slices and 5G LAN proposed by 5 G network can improve the queuing efficiency of data services.

4. Study on time delay prediction method of deterministic network 5G-A terminal

The study of time delay prediction methods is one of the key areas for deterministic network 5G-A terminals and other real-time applications. The main goal of these methods is to estimate the time required for data transmission and processing in the network to ensure that the real-time sexual requirements are met. In this field, machine learning techniques such as neural networks, decision trees, and regression models have been widely applied for time delay prediction. These methods are able to utilize historical data to train the model and then use new data for time delay estimation. Currently, researchers are actively studying how to use deep learning to improve the accuracy of time-delay prediction, especially in complex 5G network environments. Some studies also focus on the influence of network topology on time delay. By analyzing the topological information of the network, we can predict the path and transmission time of the packet in the network. These methods help to improve packet routing and queuing, thus reducing transmission delay. Many time-delay prediction methods rely on the statistical analysis of historical data, including analyzing information such as network load, packet arrival time, and processing time. By identifying the patterns and trends of data transmission, future delays can be predicted. In some applications, using sensors to measure network performance and environmental factors, such as signal strength, congestion degree, and temperature, can be used for time delay prediction. These sensor data can be used in combination with network performance indicators to improve the accuracy of time delay estimation. The researchers are also exploring how to optimize time delay prediction algorithms to consider multiple factors such as network load, device performance, and characteristics of the transmission medium. This optimization helps to improve the accuracy of time delay prediction and ensure that the requirements of real-time applications are met[4].

This paper presents a 5G-A terminal transmission delay prediction algorithm based on optimized VMD and CA-LSTM. The main data used in this method is the continuous 5G transmission terminal delay value under the industrial control scenario, which is analyzed by the random delay value in the early period of time, and then predicts the delay value of the next period of time, so as to achieve the delay prediction results. Usually, after dividing the exercise set and the test set, in order to reduce the instability and uncertainty of 5G delay, the VMD method can be adopted to decompose the original delay sequence values for the exercise set and the test set respectively, and decompose the one-dimensional data into multidimensional data, so as to realize the randomness characteristics of the data. In the decomposition algorithm, there will be three important parameters that have a great impact on the decomposition results of the transmission delay data, namely, the number of modes, the penalty factor and the fidelity coefficient. Therefore, we determined the selection of mode number by using the relevant parameter test, and used the locust optimization algorithm to complete the automatic optimal selection of parameter sum. When the data decomposition is completed, the timing data of each mode is set to standardization respectively, thus eliminating the influence of the interindex dimensions. The data correlation, nonlinearity and non-stationary of each mode can show their own characteristics. In the modal component, some components become the approximate components of the original delay sequence, with long-term correlation; others are with short-term correlation. However, due to the lack of differentiation of the delay sequence data of a certain period, it cannot accurately determine whether the data in this period of time is important enough and cannot quickly select the key information processing from a large amount of information. Therefore, it is necessary to focus on designing CA-LSTM network[5].

Convolution layer adds a layer of LSTM components by CA-LSTM, the main purpose is to extract short-term patterns on the time dimension and the local interdependence between variables. In addition, the attention mechanism is introduced for LSTM components to prioritize important information and ignore irrelevant information. At the same time, we constantly timely extract and adjust important information data, so that important information is timely selected in different time periods, with high scalability and robustness. Therefore, we need to train different CA-LSTM prediction models for the delay data of each mode, where the transmission delay feature of each mode consists of the mode delay subsequence and the original delay sequence. After the predicted value of the temporal data of the corresponding mode is obtained by the model of each mode, the data is restored to the original dimension by using anti-standardization. Finally, the predicted value of each mode is reconstructed into one-dimensional delay value to obtain the delay prediction result.

The study of time delay prediction method is a multidisciplinary field, covering many aspects, including machine learning, network topology, data analysis and edge computing. The continuous development and improvement of these methods will help to optimize the performance of 5G networks and other real-time applications to meet the increasing real-time requirements. In the future, with the continuous evolution of 5G networks and the introduction of new technologies, time-delay prediction methods will continue to play an important role.

5. Conclusion

5G networks and terminal equipment due to the advantages of fast transmission speed, low delay, large capacity and multiple connectivity, The revolutionary changes in the field of communication technology, spawned many emerging applications, especially the deterministic network 5G-A terminal in intelligent city, industrial automation, telemedicine, virtual reality and Internet of industrial control scenarios, will really benefit from 5G high-performance network, is accelerating the development of digital society. However, there are a series of potential problems and challenges in the deployment and application of 5G network from practical application. In particular, the time delay problem of 5G network is particularly important, which is related to the further development direction of industrial control scenarios. In the future, 5G networks and terminal equipment will continue to evolve and innovate, facing new challenges and opportunities. More research is needed on the prediction of 5G-A terminal delay, and close cooperation from all parties to continuously promote technological research and policy formulation to ensure that 5G can bring the greatest benefits to social and economic development.

References

[1] Zhou Chengna. Indoor scene 5G call EPSFB fall success rate improvement ideas [J]. Communication Power Supply Technology, 2021, 38 (21): 69-72.

[2] Zhong Qizhu, Wu Xiuquan, Luo Yaoman. Research and Application of LTE Wireless Interference Analysis Based on MDT Intelligence [J]. Telecommunications science. 2019, (10).

[3] Fu Yan. 5G Voice Service Solutions [J]. Communication world. 2019, (7).

[4] Tan Yushan, Zhou Wenjin, He Yan. Thinking and practice of overlapping coverage optimization based on MDT data [J]. Communication world.2019, (12).

[5] https://www.elecfans. The com / 5G / 5G-A deterministic technology system enables the industrial Internet