ISBN: 978-981-18-5852-9
WCSE 2022 Spring Event: 2022 9th International Conference on Industrial Engineering and Applications
doi: 10.18178/wcse.2022.04.072

A Power Consumption Control Strategy for 5G Module Based on Delay and Granularity Characteristics of Electricity Mobile Communications Data

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Abstract. With the gradual spread of intelligent inspection and power automation monitoring technologies, the national power grid has a high demand for large-scale mobile communications with massive terminals, ultra-high data rates and low response latency. Compared with 4G technology, 5G technology has important features such as large bandwidth, high capacity and low latency, which can better meet the demand of electric power and has higher security. However, due to the high power consumption of 5G modules and the dramatic increase in the number of terminals, the overall power consumption of the network is higher than that of 4G power application scenarios. To address the above problems, this paper proposes a 5G module power consumption control strategy based on the data delay characteristics of power mobile communication, which can optimize the average power consumption of 5G modules by completing message reorganization for the message delay characteristics. The research in this paper can effectively reduce the power consumption of 5G modules for 5G power applications, and thus reduce the power consumption of the whole group network.

Keywords: 5G technology, electric power business, power consumption strategy

1. Introduction

5G communication technology, Big Data, Cloud Computing, Internet of Things, and artificial intelligence are integrated with electric power business [1], and diversified new electric power business such as distribution network differential protection, online storage management, and AR/VR inspection are developed. Grid control is extended to the end [2], a huge number of peripheral terminals are connected to the power system [3], and 5G modules are embedded in the terminals to realize data transmission. At the same time, the power consumption of 5G module operation is significantly higher than that of 4G module. For example, a typical 4G module consumes 3W, while a typical 5G module consumes 7W. The power consumption of a 5G module is more than twice that of a 4G module. The growth of power consumption increases the design difficulty of power supply, heat dissipation, power backup, and noise, so the power consumption of 5G module needs to be controlled. In the whole 5G network, the base station energy consumption reaches more than 80% [4], so the current research related to power control of 5G networks at home and abroad is focused on how to reduce the energy consumption of 5G base stations [5]-[8], and the research on the power consumption of 5G modules is lacking. Therefore, this paper conducts a study on the power consumption strategy for 5G modules in power service scenarios.

We divide the paper into five sections. The second section reports the diversity of power service scenarios. The third section describes the power consumption control strategies developed in this paper based on the delayed nature of the transmitted data, the particle size, and the channel quality. Then, in the forth section, we present the reduction of power consumption in the absence of policy enforcement. The fifth section concludes the whole paper.

2. Demand Analysis

There are four major application scenarios of 5G in the power industry, which are the end-of-grid control class business application scenario, the collection class business application scenario, the mobile application class business application scenario [9], and the new business application scenario of the power grid represented by multi-station convergence. The specific applications are shown in Table I.

Table 1: 5G Application Scenarios and Services in the Power Industry

Scenes	Segmented Scenes	
Application scenarios for end-of- grid control business	Existing Business	Precise load control
		Power distribution automation (three remote)
		Distributed Power
	Demand Boost	Distributed Power Monitoring
	New Business	Distribution network differential protection
Acquisition business application scenarios	Existing Business	Electricity consumption information collection
		Power distribution automation (two remote)
		Video Surveillance
		Intelligent Business Office
	Demand Boost	Electricity consumption information collection(multi-meter integration)
		Electric vehicle charging station/pile (support vehicle network)
		Intelligent Home
	New Business	Smart manhole cover
		Topology identification of station area
		Power outage reporting
		Online Warehouse Management
Mobile application class business application scenarios	Existing Business	Electricity Emergency Communications
		Transmission and Distribution Robot Inspection
	Demand Boost	Mobile Operations
		Mobile Office
	New Business	AR/VR inspection
New business application scenarios	Multi-site integration	

Grid control services involve whether the grid can operate safely and stably, and require milliseconds of delay and 99% reliability [10], which is in line with uRLLC application scenarios. There are many application scenarios for collection services, typically characterized by a large number of points (in addition to traditional user electricity information collection, new services such as charging piles are also included), involving a large number of terminals, which cannot be satisfied by wired communication, but the requirements for communication delay are not high, which is in line with the mMTC scenario. The main feature of mobile application services is the high requirement for bandwidth and security, which is in line with the eMBB application scenario. Typical services include mobile inspection. The new service of power grid is a kind of service with personalized communication requirements, which is generated with the continuous deepening and integration of smart grid and power Internet construction.

Above, it can be seen that the business of the power system is complex and diverse, and the traditional power business of electricity is constantly updated with the support of 5G technology, while new services are emerging, and a large number of peripheral terminals of the business are connected to the grid through the gateway, and Nokia predicts that by 2025, the number of terminal devices in the network will exceed 50 billion [11], 5G in power applications there is bound to be massive data transmission and The power consumption of 5G modules is closely related to the business requirements of data transmission, and the control of power consumption of 5G modules can be carried out by optimizing the data transmission rules under the premise of ensuring the safety and reliability of power services.

3. Power Consuption Control Strategy research

The research on power consumption control strategy in this paper is based on the characteristics of 5G with large bandwidth and low latency, and a comprehensive analysis of the characteristics of power services and data. In this paper, the data of power wireless communication is coarsely divided into large-granular data as well as small-granular data, while the delay requirement of data to be forwarded is divided into strong and weak according to the service type. This paper reduces power consumption by reducing the time of data transmission of 5G modules based on the same hardware conditions (e.g., supply voltage, transmit power, etc.).

3.1. Strategy for Small Granular Data with Low Latency Requirements

The latency characteristic of 5G communication differs from 4G communication in that under 4G communication, the latency of large data packets (1024MB or more) is twice as large as that of small data packets; however, 5G communication, based on its low latency characteristic, not only the overall latency are much lower than 4G communication, but also the latency between small and large data packets is not as disparate as that of 4G communication, which provides a power consumption strategy This provides a basis for the power consumption strategy. Therefore, this strategy is to combine small packets of the same type and same destination into large packets and then forward them.

Let the communication delay of the small packet be t_1 and the communication delay of the large packet be t_2 , and the difference between the two is

$$\Delta t = t_2 - t_1 < t_1 \tag{1}$$

If n small packets are merged, the overall delay of small packets before merging is

$$T_1 = nt_1 \tag{2}$$

The communication delay of large packets after merging is

$$T_2 = t_2 \tag{3}$$

The difference between the two is

$$\begin{aligned} \Delta T &= T_1 - T_2 \\ &= nt_1 - t_2 \\ &= (n-1)t_1 - \Delta t > 0 \end{aligned} \tag{4}$$

It decreases by

$$\begin{aligned} x &= \frac{\Delta T}{T_1} \\ &= \frac{1 - t_2}{nt_1} \end{aligned} \tag{5}$$

Relative to before the merge. It can be seen that x is larger when n is larger and more small packets are merged, their latency decreases proportionally more.

3.2. Strategy for Large Granular Data with Low Latency Requirements

For large particle data with low latency requirements, such as HD pictures and videos, they can be converted to 4G communication environment for transmission without occupying 5G communication environment.

The power consumption of 4G communication is lower than that of 5G communication. For power services with low latency requirements, such as large-particle acquisition-type power services, the data transmission is relatively slow after converting the communication environment, but it will not affect their services. However, the delay requirements of large particle collection class services are in the hundred millisecond level, and when the data packets are too large, the 5G communication environment is still used.

3.3. Strategy for Channel Quality in 5G Wireless Networks

For data communication with strong real-time requirements, both large and small data packets are preferred to use 5G communication mode. However, due to the high operating frequency of 5G, spatial attenuation, vulnerable to the communication environment, in the case of poor channel quality, the 5G module will increase the transmit power to improve the quality of communication transmission, power consumption increases sharply, therefore, for small particle data transmission needs, can be switched to a more stable 4G mode for data transmission. Thus, the 5G module power consumption can be reduced.

3.4. Strategy Deployment

The power consumption strategy studied in this paper will operate in a gateway with certain edge computing capability, and the architecture is shown in Fig. 1. The data is collected and sent to the gateway via peripherals, and the network protocol completes the data distribution, and the 5G module completes the forwarding of the data nulls. The power policy function is built into the main control module of the gateway, which monitors the data and controls the power consumption of the 5G module.

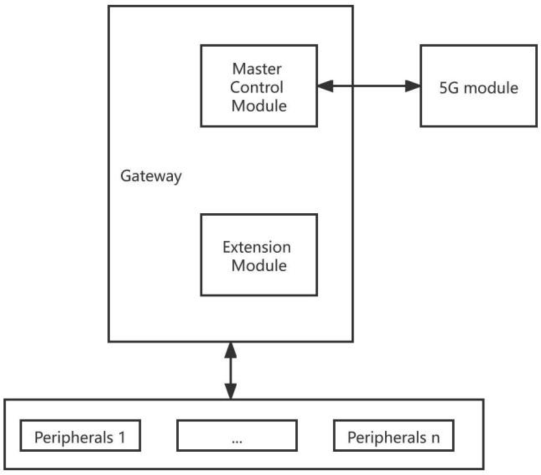

Fig. 1: 5G industrial gateway architecture.

At the same time, the power consumption control strategy can be combined with the cloud-side cooperative network system to study the module power consumption control strategy with customized and real-time characteristics for the diversification of 5G terminal application scenarios.

4. Experiment

4.1. Analysis of Experimental Data in 4G/5G Mode

The experimental server operating system is centos7.0, the platform uses springcloud microservice architecture, monitoring system, system background traffic including industrial Internet data collection and APP interaction, for 4G mode and 5G mode data transmission test. Random packets were sent at 800Mbps in 4G and 5G mode respectively, and a total of 44,875 packets were received by the server receiver in 4G mode

Table 2: 5G Application Scenarios and Services in the Power Industry

Packet size (Bytes)	4G			5G		
	Number	Percentage (%)	Average delay (ms)	Number	Percentage (%)	Average delay (ms)
0-128	28303	63.3	81.894	87408	72.58	14.487
128-256	9087	20.25	88.201	20418	16.95	15.090
256-512	4627	10.31	91.678	7409	6.15	15.895
512-1024	2232	4.97	97.315	3112	2.58	17.597
>1024	626	1.39	197.338	2055	1.70	21.882

and 120,408 packets in 5G mode. The packet size distribution and delay comparison are shown in Table 2.

Table2 shows that the communication latency of 5G is much lower than that of 4G; meanwhile, a longitudinal comparison of the data shows that the communication latency of large data packets above 1024 bytes in 4G communication environment is about twice as long as that of data packets below 1024 bytes, while the communication latency of large data packets above 1024 bytes in 5G communication environment is about 1.5 times as long as that of data packets below 1024 bytes. The communication delay is less affected by the packet size under 5G communication conditions.

4.2. Comparative Analysis with and without Strategy

In the above strategy study, the strategy for large particle data with low delay requirements and the strategy for 5G radio network channel quality are based on the downward compatibility of the 5G module with 4G mode to reduce the power consumption of the 5G module by using the feature that the power consumption of 4G mode is lower than that of 5G mode while ensuring reliable data transmission for power services.

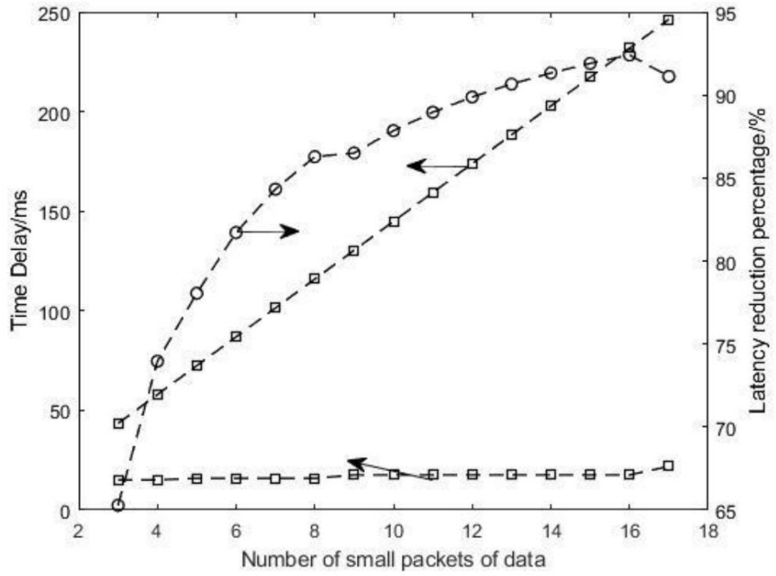

Fig. 2: Analysis and comparison of power consumption with and without strategy.

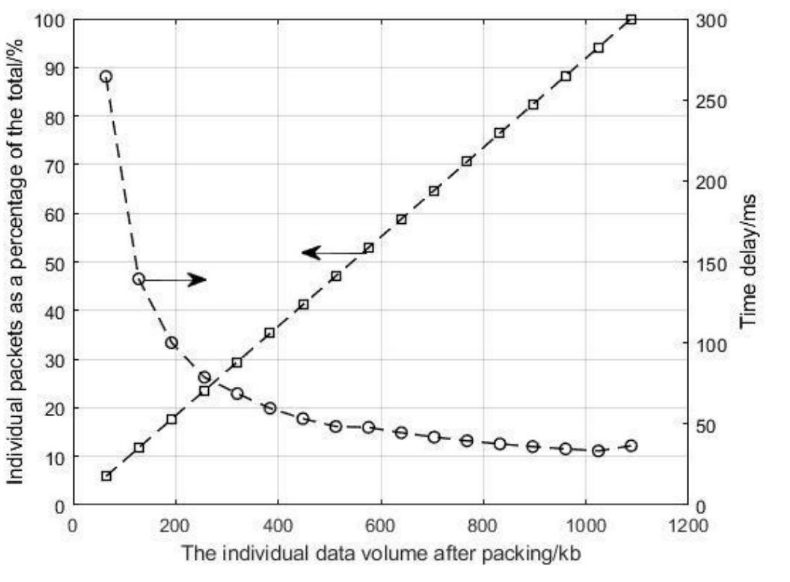

Fig. 3: Delay versus packets for small granular data policies with low latency requirements.

Therefore, this paper focuses on the small-particle data strategy with low latency requirements, and experiments are conducted in 5G mode, and the analysis is shown in Fig. 2.

As can be seen in Fig. 2, the transmission delay is significantly reduced by merging small packets of data into large packets of data for transmission. Depending on the size and number of the merged packets, the percentage of delay reduction varies, but all of them can be maintained above 60. The percentage reduction in latency increases as the number of packets packaged increases; It decreases again when the number of packets is 16, so there is no limit to the number of packets that can be packaged.

The same packets also differ in latency depending on the packing method, as shown in Fig. 3.

As can be seen in Fig. 3, the larger the individual packed data volume, the larger its percentage of the total data, then the faster the latency reduction, when 17 64kb packets are packaged. The benefits of the power control strategy are more obvious when there is a sharp increase in small particle data.

5. Conclusion

In this paper, we analyze and study that under the continuous integration of 5G technology and electric power business, the electric power business is constantly innovating, which leads to a large number of terminals with 5G modules connected to the power grid, and the power consumption of 5G modules is significantly higher than that of 4G modules. Based on the above, a targeted and adaptive power control strategy for 5G modules is proposed based on the size of the transmitted data and the requirements for latency. The packets in 4G/5G environment are collected and processed to analyze the power consumption with and without the strategy. The power consumption control strategy can significantly reduce the power consumption of 5G modules.

6. Acknowledgement

The work is funded by the science and technology project of SGCC(State Grid Corporation of China):The key technologies for “Research on Power 5G Standardization Module Technology(No. SGZJXT00JSJS2000455)”.

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