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Research and Implementation of QoS Algorithm for 230MHz Power Wireless Private Network

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Abstract. The wireless private network is a key for building an energy Internet and a full-service ubiquitous electric Internet of things (eIoT). It is an important means to get through the bottleneck of power distribution network. Quality-of-Services (QoS) management is the one of the issues that is appeared after using wireless network. With the requirements of power Internet of things, this paper studies the communication needs of different service types in the power grid, proposes a two-stage QoS algorithm based on 230MHz power wireless private network, and solves the problem of prioritizing different service types in the power grid. A new type of wireless communication equipment was developed and tested through the trial network. The test results proved that the algorithm could effectively optimize the QOS processing capacity of the system, and the results met the design expectation. The research result has positive reference value for further evolution of the electric Internet of things.

1. Introduction

With the rapid development of smart power grid, power grid companies have reached a critical stage of building energy Internet. Based on the extensive application of new Internet technologies, comprehensive perception, accurate prediction and intelligent decision-making of smart power grid can be realized. Building a strong smart power grid and ubiquitous electric Internet of things can not only solve the existing problems in the power grid, but also explore new development direction for the power grid. Wireless network has the advantages of "safe, reliable, ubiquitous and flexible", which is the key factor to build energy Internet and all-services electric Internet of things, 230MHz wireless network is the main wireless technology of power communication.

According to different security level requirements, the power grid service can be divided into several types. Different service types have different requirements on communication rate and latency, with the communication rate ranging from 1Kbps to 2Mbps and the latency from 0.05s to 5s. In order to meet the different needs of different service types, in the meanwhile to ensure overall efficiency of the power grid, a scientific QoS processing algorithm for wireless communication is required.

2. Analysis of the difference in power grid services

2.1. Service diversity

The services carried by the power wireless private network can be divided into four categories: control class, acquisition class (small particle), acquisition class (video class), and mobile class.

The control services mainly includes distribution automation and precise load control, which requires high security, high reliability and low latency, the lowest latency is about 50ms.

The acquisition services (small particles) mainly include electricity information acquisition, power transmission and transformation status monitoring, power quality monitoring, etc., which with low requirements for safety, reliability and latency, the latency requirement is not less than 15 second.

The acquisition services (video) mainly include transmission and distribution transformer machine inspection, power emergency communication, video monitoring and other services. Such services have low requirements for safety and reliability but high requirements for traffic rate.

The mobile services mainly include voice services and remote access services, which require low security and reliability but high smoothly on mobile handover. The latency requirement is no more than 300ms.

In addition, according to the reliability requirements of different services, it is necessary to prioritize the services and ensure the acquisition of channel resources by high-priority services through QoS algorithm.

2.2. QoS requirements

The communication requirements of different service types correspond to the QCI parameters (QoS Class Identifier) in the system, as shown in the following table.

Table 1. QoS Requirements of power wireless private network [a]

Priority	QCI	Rate(kbps)	Latency(s)	Service type
1	5	48.1～1130	0.05	Control class 1 (millisecond precision load control, etc.)
2	2	2.4	2	Control class 2 (distribution automation with control, etc.)
3	3	2.5～4	5	Control class 3 (load control, distributed power supply, etc.)
4	1	12.2～22.5	0.3	Voice
5	4	1.05	15	Acquisition class (electricity information collection)
6	6	512～2000	0.3	Other (video, images, etc.)

[a]: Note that data in the table is derived from specification of Q/GDW 11803.2.

3. QoS algorithm

There are differences in the communication requirements of different types of services of the power grid, and it is necessary to ensure the processing efficiency of multiple services through a scientific QoS algorithm.

3.1. Two- stage sorting algorithm

The algorithm discussed in this paper is divided into two stages, and the distance between the terminal and the base station is taken into account, so as to ensure that the throughput of each user meets the requirements while taking into account the total throughput of the cell. The first stage mainly considers the latency requirements of the services and sorts the different types of services. The second stage mainly considers the rate of services satisfaction and the ordering of different users within the same type of services to determine the scheduling order of users.

Rate satisfaction refers to the ratio between the actual rate of current service and the service rate index, which represents the difference between the actual rate and the service rate. When the actual rate is greater than or equal to the rate index, the service is considered as satisfactory. The satisfaction algorithm is as follows:

$$Satify\_factor(m) = \frac{R(m)}{R_{GBR}(m)} \tag{1}$$

(*R(m)*is actual rate for service m; $R_{GBR}(m)$ is rate required for the service m)

3.2. Priority algorithms of different service type

The 230MHz power wireless private network system prioritizes all signalling and services within the scheduler, and prioritizes the services with high priority. The specific sequencing process is: millisecond-level precision load control service>Paging service>Random access response > Signalling of the access procedure > Signalling after access > Video service, conventional load control and distribution automation service > Electricity information collection.

3.3. Priority algorithm of the same service type

When multiple services of the same level apply for resources at the same time, it needs to be further subdivided based on the superior ranking, and the gap between the current rate and the service target rate is introduced as the basis for prioritization. In each priority update period, the update process of activating each user's service priority factor is completed. The priority factor is based on factors such as service type, service QoS information, channel conditions, and rate satisfaction. The specific judgment process operates as follows:

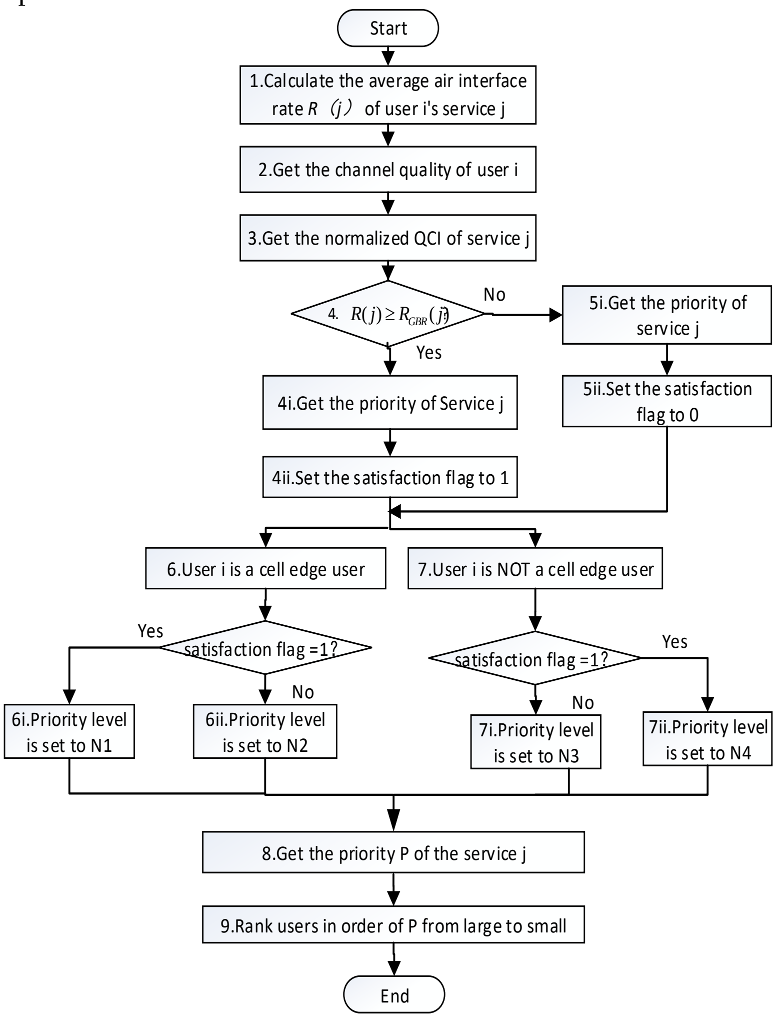

Figure 1. Priority algorithm of the same service type

(1) Find the service j of user i in the user list, and calculate the average air interface rate *R(j)* in the current period.

(2) Find the channel quality $R_{effi}(i)$ of user i in the channel quality storage space according to the user identifier.

(3) Get normalized QCI value f_{QCI} according to the priority which corresponding to the QCI level of the user service j.

i.If $R(j) \geq R_{GBR}(j)$, Calculate the priority of the service j;

$$priority_{(i,j)} = \alpha \cdot \frac{R_{effi}(i)}{Satify\_factor(j)} + \beta \cdot f_{QCI} \tag{2}$$

(α、β Is the coefficient taken as a non-zero real number.)

ii.Set the service satisfaction flag SatFlag=1, that is, the service has reached the rate requirement.

(4)Otherwise

i. Calculate the priority of the service j

$$priority_{(i,j)} = \gamma \cdot Satify\_factor(j) \tag{3}$$

(γ Is a real number with a coefficient greater than one.)

ii.Set the service satisfaction flag SatFlag=0, that is, the service has not yet reached the rate requirement.

(5) If the user i is a cell edge user

i.If SatFlag==1, the service is defined as edge-satisfying service, and set the priority level as N_1.

ii.Otherwise, the service is classified as an edge dissatisfied service, set the priority level as N_2.

(6) If the user i is not an edge user

i.If SatFlag==1, the service is determined to be a center-satisfying service, set the priority level as N_3.

ii.Otherwise, the service is classified as a center-dissatisfied service, set the priority level as N_4.

(7) get the priority of the service j，

$$P = N_k + priority_{(i,j)} \quad (K=1、2、3、4) \tag{4}$$

N_K is an adjustment factor and takes a non-negative real number.

(8) The services of each user are scheduled in the order of $\boldsymbol{P}$ from large to small.

Increasing the parameters $\boldsymbol{\alpha}$ can increase the impact of the satisfaction factor and channel environment on the priority calculation. Increasing the parameters $\boldsymbol{\beta}$ increases the impact of the type of service on the priority calculation. Adjust the parameters $\boldsymbol{\gamma}$ so that the priority of the dissatisfied user is far greater than the priority of the satisfied user, which is beneficial to increase the fairness of the rate between users. Parameters $\boldsymbol{N_K}$ are used to classify and adjust the user's topological position and the impact of satisfaction on priority.

4. Verification test

Based on the research algorithm of this paper, the corresponding wireless communication system was developed, and the trial network was built to perform verification tests for priority processing and latency.

4.1. Verification of priority processing

Test case : 1) Configure network resources to work only for one terminal, UE 1 is contracted to QCI=4, UE 2 is contracted to QCI=6; 2) FTP session is firstly set up for UE 1, software DU-Meter is used to monitor the transmission rate; 3) Attach UE 2 to network and set up FTP session; 4) It can be seen that when UE 2 starts FTP session, the transmission rate of UE 1 is reduced to 0 kbps, and resumed data transmission just after the transmission finished of UE 2

The test results are as follows:

Figure 2. Screen shot of FTP session

4.2. Verification of latency

Test case: 1) Configure the UE to be the highest priority, both QCI=5; 2) Select the good, medium, and poor spots to test, the good SINR value is 20±1, the middle SINR value is 10±1, and the worse SINR value It is 0±1, and at the same time, it is guaranteed that the RSRP is -90±5dBm, the midpoint RSRP is -100±5dBm, and the worse RSRP is -110±5dBm. 3) Using the test software to send the downlink TCP packet, the packet length is 128 bytes, the rate is 80% of the single user peak rate, and the maximum latency, the minimum latency and the average latency within 5 minutes are counted and recorded.

The latency test results are as follows:

Table 2. Latency test result

	Good spot			Middle spot			Bad spot		
	Average	Min	Max	Average	Min	Max	Average	Min	Max
Uplink Latency（ms）	34	31	44	41	34	49	42	37	49
Downlink Latency(ms)	39	31	48	43	38	49	44	39	49

4.3. Conclusion

Based on the test result, we can see that QoS algorithm meet the expected targets of different service priorities, when channel resources are limited, high-priority services can seize channel resources from low-priority services. The transmission latency can meet the latency requirement of the highest priority service such as precision load control, and the latency is less than 50ms.

5. Summary

Power grid services is diverse, different scenarios of the services lead to different communication requirements, which are reflected in priority and latency. The algorithm studied in this paper can well take into account the requirements of service latency and priority, which meet the requirements of reliability, real-time and efficiency in power grid.

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