A unified management platform for the entire network traffic of the power integrated data network based on cloud technology

Lin Yun, Guiqian Fu, Qian Wang, Yunxuan Lin, Meiqin Huang

Hainan power grid information and communication branch, Haikou 570203, China

Keywords: cloud technology, power information system, network traffic, data monitoring

Abstract: In response to the centralized deployment and multi-level application of the electric power integrated information system, a unified management platform for the flow of electric power integrated data network is proposed. First, the substation network control structure and the difference between its traffic management and the traditional network is analyzed, and the network traffic model is established. The application and architecture of cloud technology in the power grid are analyzed. Based on this, a unified management platform for the entire network flow data of the power network is established, and its platform architecture, B/S network structure and platform function modules are explained. Take traffic monitoring and trend analysis, balance management, multi-dimensional display and application performance analysis as examples, the multi-scenario functional application of the platform is illustrated.

1. Introduction

With the gradual expansion of power system network scale, the role of electronic information communication system in power network application is more and more obvious, and network information management can realize intelligent configuration of power network. In the process of power information communication, power consumption information data is stored and transmitted in the form of big data information flow. Therefore, in order to control the operation state of power system in real time and control multi-dimension in real time, it is necessary to monitor and identify network traffic data to improve the stability of power system information data. Because electric power supports many industries and covers all aspects of production and life, the traffic statistics of different businesses need to use different analysis methods and models to collect and analyze the traffic through the network security situational awareness system.

Aiming at the network traffic management, the paper [1] established a power communication network traffic balance management system based on traffic prediction. Literature [2] analyzes the necessity and realization method of network flow monitoring in power system. Document [[3] designed an automatic generation system of county-level electric power dispatching order. Literature [4] puts forward the application and algorithm improvement of abnormal flow detection in industrial control system of power grid. Literature [5] puts forward a scheme to improve the network transmission reliability of smart substation based on flow control. There are few researches on network traffic management based on cloud technology.

Firstly, this paper analyzes the control structure of substation network and the difference between it and traditional network traffic management, and explains the network traffic model. This paper analyzes the application and architecture of cloud technology in power grid, establishes a unified management platform for flow data of power network, and explains its platform architecture, B/S network structure and platform function modules. Taking traffic monitoring and trend analysis, balance management, multi-dimensional display and application performance analysis as examples, the multi-scenario function application of the platform is illustrated.

  DOI: 10.25236/isaiee.2020.023

2. Statistical analysis of information flow in power network

2.1 Substation network control structure

At present, the network structure of intelligent substation includes station control layer, interval layer and process layer. Station control layer mainly refers to the monitoring system and operator workstation in substation, which is the highest level of substation network control structure. The spacer layer is responsible for the measurement, control, protection and collection of information in the station and related electrical components. The process layer refers to the terminal system in the substation, including merging unit and intelligent terminal. Network traffic information in substation runs through the whole process of substation network control structure, and it is necessary to make statistics and analysis of network traffic from the bottom layer to the middle layer to the top layer.

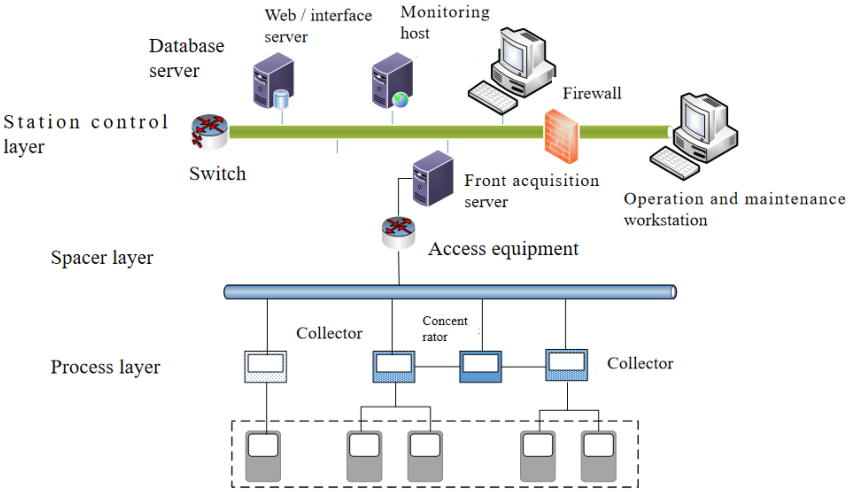

Fig 1. Architecture of substation network

2.2 Differences between substation network and traditional information network

The traditional substation information network is mainly aimed at the management data in the power system, while the data such as the direct management of the substation control network and the operation of the control terminal equipment are not in its management scope. Compared with the traditional information network, the substation control network has its unique characteristics, its traffic flow is relatively stable, and its real-time requirements are higher. In addition, the data length of substation control network is generally short, and the transmission frequency is high, which is mainly related to the configuration of protection devices and the timing length. The response control time of substation network is relatively short, and the data flow of substation control network is relatively fixed. Compared with the traditional network, these characteristics bring some special requirements to the flow management of the whole power network. The raw flow data of power information system for 2.5min sampling interval is shown in the following figure [6].

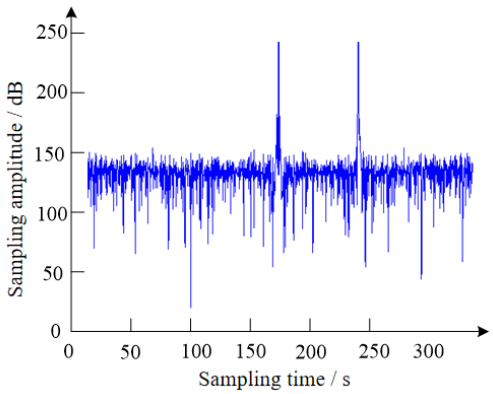

Fig 2. Waveform of real-time flow collection in power information network

2.3 Network traffic model

Electric power integrated data network traffic analysis is to find out the problems in power network operation by obtaining the data packets in the network topology, analyzing the data, analyzing its protocols and counting its traffic. Through the established network traffic analysis scheme, we can know the operation status of network business and find the abnormality of power network operation. The network traffic model is very important to analyze the network and specific traffic characteristics. The network traffic model mainly analyzes the time scale and spatial characteristics of network traffic, and establishes the corresponding model with traffic as the center. In this process, the historical traffic database is required to upload the corresponding network traffic data, and the established traffic model is used for data training to obtain the real-time traffic characteristic sequence. At present, relevant traffic models mainly include Poisson model, Markov model and regression model.

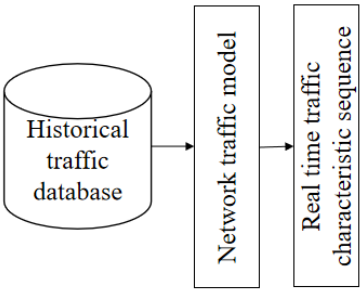

Fig 3. Model of network traffic

3. Unified management platform of power network traffic based on cloud technology

3.1 Application analysis of cloud technology

Based on cloud computing, cloud technology plays an important role in power grid planning, operation and analysis, and is also very practical in power network flow analysis. Applying cloud technology to power network traffic, management analysis can significantly improve the efficiency of network traffic analysis and reduce the problems caused by deviation caused by network traffic. Cloud technology can effectively solve the problems of low efficiency of server resource allocation and utilization in the process of traffic and analysis; Improve the application and search efficiency of power network flow database, improve the quality of power network analysis, and realize real-time interaction and dynamic update of network architecture; Power network cloud technology is a collection of various services. According to the characteristics of power network traffic analysis system, the corresponding cloud computing and cloud technology should be selected to realize accurate analysis of network traffic. At present, the overall architecture of power network cloud technology is as follows.

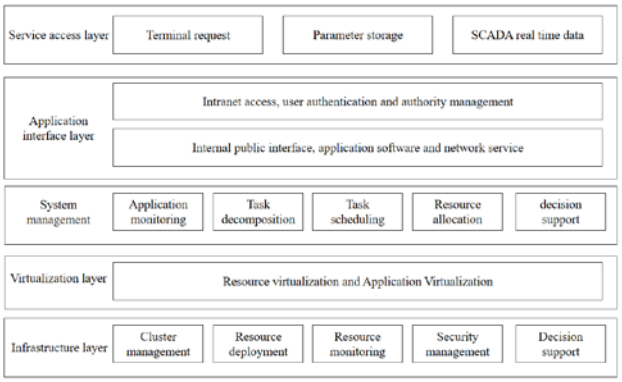

Fig 4. Architecture of clouding technology

3.2 Framework of unified management platform for network traffic

The whole network flow unified management platform of electric power integrated data network proposed in this paper is divided into data integration layer, data processing layer and application analysis layer. The data integration layer mainly includes data communication, node link data, communication system maintenance data, communication interaction coordination data and so on. This kind of data information mainly depends on the sensors configured at the front end and the flow measurement points for uploading. The data processing layer mainly carries out algorithm and management for the front-end data of the whole network traffic.

The function of this layer can mainly realize traffic balance management, and realize traffic load mapping, traffic change trend analysis, load balance management, traffic balance correction, network diversion management and so on through corresponding algorithms and database models. This layer is the central layer of the whole system architecture, and is responsible for the hub of front-end data analysis and high-end applications. Application analysis is mainly the display interface of the whole network traffic unified management platform, which can realize the visual display of front-end data collection and monitoring, traffic analysis, decision-making assistance, advanced applications and other functions.

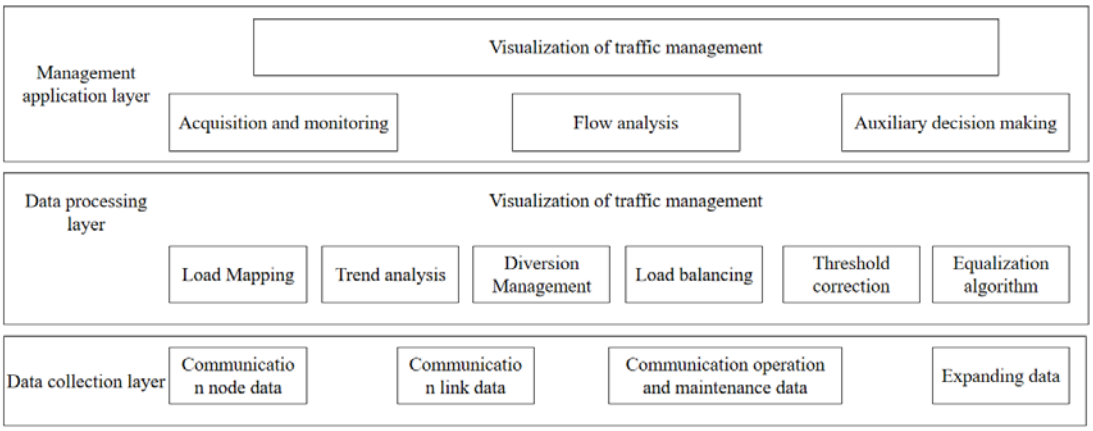

Fig 5. Architecture of traffic data management platform

The whole network traffic unified management platform proposed in this paper includes internal communication network and data integrated network. Integrated data network includes substation probe set, convergence router, traffic analysis probe, etc. It is connected with the central router of the internal communication network through optical fiber, and the central router communicates with the access switch in real time, which can provide related operations of internal application services, including traffic analysis probe, active master station probe, active dial test management platform, etc.

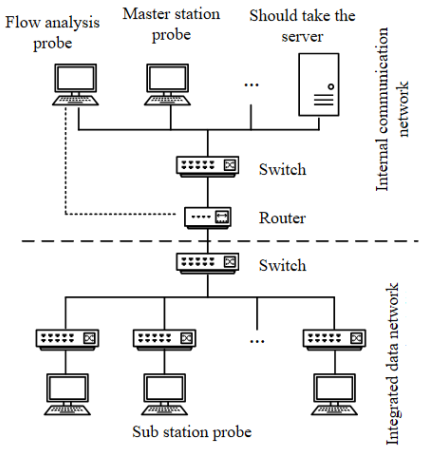

Fig 6. Network structure

This system platform adopts B/S architecture, and users can manage the system conveniently only through browser, which is easy to operate, thus reducing a lot of maintenance costs. The subsystem also adopts B/S architecture, which has independent management characteristics. The subsystem and platform are seamlessly connected through API interface, and the execution efficiency is high. The development language of the platform uses Java to meet the requirements of performance, compatibility and extensibility. The development language of the subsystem uses Java and C, the management interface is mainly realized by Java, and the bottom data processing is realized by C.

3.3 Network traffic unified management platform function module

The unified traffic management platform is divided into seven functional modules, as shown in the figure, and the interaction process between platform modules is as follows:

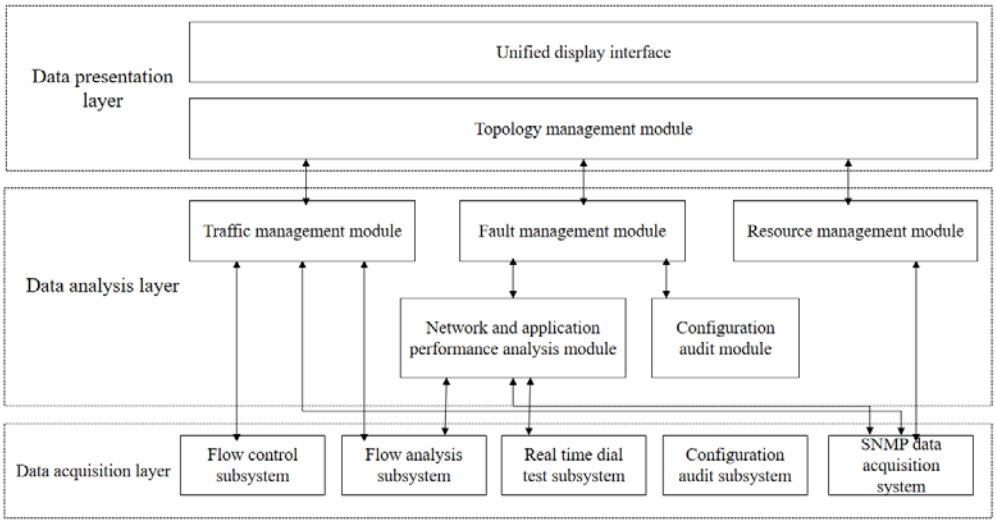

Fig 7. Platform function

Process 1: The SNMP data collection function in the traffic analysis subsystem transmits the collected network equipment resource information to the resource management module.

Process 2: The SNMP data collection function in the traffic analysis subsystem transmits the collected network equipment interface traffic information to the traffic management module.

Process 3: The SNMP data collection function in the traffic analysis subsystem transmits the collected network equipment performance information to the network and application performance analysis module.

Process 4: The network element configuration audit subsystem transmits the collected equipment configuration file to the configuration file management module.

Flow 5: The real-time dialing subsystem transmits the data tested by the dialing client to the network and application performance analysis module.

Flow 6: The probe data acquisition function in the flow analysis subsystem transmits the performance information of the probe interface to the network and application performance analysis module.

Flow 7: Netflow/ probe data acquisition function in the flow analysis subsystem transmits the interface flow information of network equipment and probe equipment to the flow management module.

Flow 8: The intelligent flow control subsystem actively receives the flow control strategy issued by the platform.

Process 9: The alarm data of "flow management module", "resource management module", "network and application performance analysis module" and "configuration file management module" will all occur to the fault management module.

Process 10: The information of "flow management module", "resource management module" and "fault management module" will appear in "topology management module".

4. Management platform function application

4.1 Traffic monitoring and trend analysis

In this paper, the whole network traffic unified management platform can decompose the real-time traffic of power system network in time domain and frequency domain, get the corresponding time series, reconstruct the series $\{x(t_0 + i\Delta t)\}$, $i = 0,1,\cdots,N-1$, and get the corresponding time domain model by filtering detection method.

The matched filter detector shown in Figure 1 is used to filter the abnormal flow [7-8].

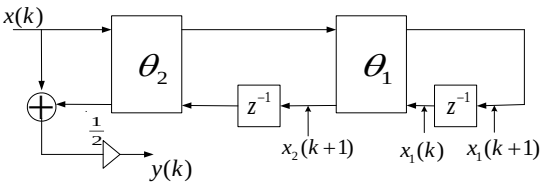

Fig 8. Matched filter detector

After filtering the abnormal flow, the accurate value of the flow can be obtained, thus optimizing the monitoring of the flow. Firstly, traffic monitoring submits the network traffic data to the data processing layer of this paper, analyzes and reconstructs the corresponding data, extracts the spectral features, monitors the traffic in different network models in real time, and improves the accuracy of network traffic monitoring by matching filter detector algorithm.

Traffic trend analysis is mainly aimed at the peak and valley values of traffic in different periods of the system, so as to judge the influence of events in the system event library on traffic, eliminate the corresponding emergencies, and judge the changes of network traffic within the range of nodes in the future.

4.2 Load balance management of the whole network

Traffic load mapping and load balance correction can calculate the internal load balance of power network, and adjust the link load threshold in real time to balance and optimize the network traffic of system links. The system proposed in this paper mainly uses the corresponding algorithm to correct the load balance.

The load balance $\mathrm{P(S(i, j))}$ of a link is defined as the ratio of the used bandwidth of the link to the bandwidth of the link. The load balance degree B_p of the whole network load is:

$$B_p = \frac{1}{N}\sqrt{\sum_{i,j(i<j)} P(S(i,j)) - \left(\frac{1}{N}\sum P(S(i,j))\right)^2} \tag{1}$$

Where N is the total number of links; $S(i,j)$ is the link between nodes i and j .

4.3 MPLS VPN service topology

In the integrated data network, each MPLS VPN corresponds to a specific service. Starting from the actual service of MPLS VPN network, targeted professional management is carried out according to the special actual use situation of MPLS VPN equipment with complex cross-regional dimension and large fluctuation of VPN changes.

Support whole network service topology view presentation and single service topology view presentation.

The service topology view intuitively shows the actual state of the service, so that users can see the equipment and connectivity in each VPN at a glance.

4.4 Topology presents multi-dimensional data information

On the topological graph, not only the basic information of network equipment, but also the information of link flow, network delay, application delay and so on can be presented. The display scheme is shown in the following figure.

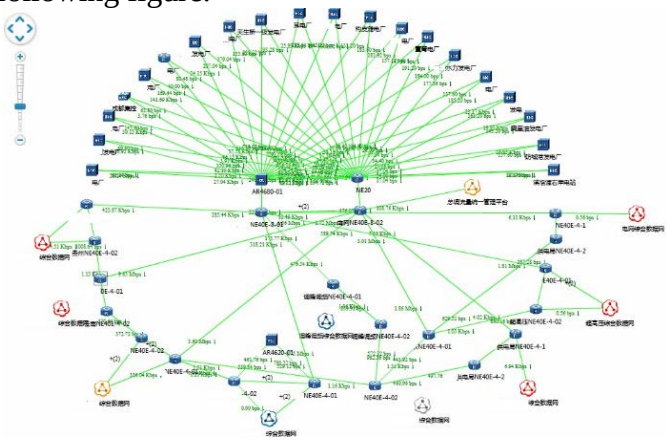

Fig 9. State of link

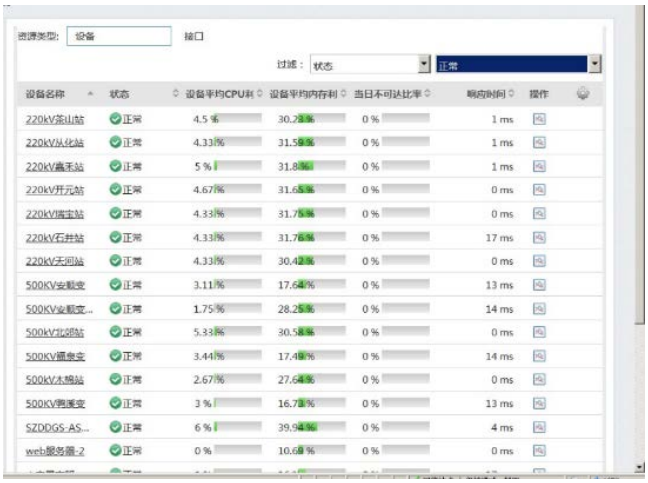

Fig 10. Delay of network

4.5 Analysis of network and application performance

The network and application performance analysis module is mainly used to realize network performance analysis, application performance analysis and network quality index evaluation, and can realize the following functions:

1. Equipment index statistics, which mainly counts and presents the CPU and memory load information of network equipment reported by SNMP data collection of traffic analysis subsystem.

2. Dial test in real time, and count and present the test results reported by the "Real-time Dial Test Subsystem".

3. Business indicator statistics, which mainly counts and presents the analysis results of network quality and business quality reported by "Probe Data Collection of Traffic Analysis Subsystem".

The network and application performance analysis module has data interaction with the fault management module and the flow management module. When the CPU and memory of the equipment analyzed by the network and application performance analysis module are overloaded and the service index exceeds the threshold, an alarm message will be triggered actively and reported to the fault management module.

The data of network and application performance analysis module are provided by network equipment, dial-up testing equipment and probe equipment.

The network equipment only provides network performance data, while the dial-up test equipment and probe provide both network performance data and application performance data.

The following table shows some indicators of network layer and application layer.

Tab 1. Analysis indicators of network application

Level	Classification	Indicator name
Network layer	CPU usage	Average utilization rate
		Peak utilization rate
		Utilization dynamic baseline
	Memory utilization	Average utilization rate
		Peak utilization rate
		Utilization dynamic baseline
	Port error packet rate	Average utilization rate
		Peak utilization rate
		Utilization dynamic baseline
	End to end IP packet loss rate	Average utilization rate
		Peak utilization rate
		Utilization dynamic baseline
	Network transmission delay	Average time delay
		Minimum delay
		Maximum time delay
		Time delay dynamic baseline
	End to end TCP error	Number of TCP retransmissions from client to server
		TCP retransmission rate from client to server
		Number of TCP retransmissions from server to client
		TCP retransmission rate from server to client
		Client to server TCP resets
		Client to server TCP reset rate
		Server to client TCP resets
		TCP reset rate from server to client
		The TCP sliding window from client to server is zero
		Client-to-server TCP sliding window has zero number rate
		The TCP sliding window from server to client is zero
		Server-to-client TCP sliding window has zero number rate
Application layer	HTTP application interaction	Average time delay
		Peak delay
		Time delay dynamic baseline
		Page download time
		Request success rate
		Reason for request failure
	FTP application interaction	Average time delay
		Peak delay
		Time delay dynamic baseline
		Account login time

5. Conclusions

In this paper, a dispatching electronic order support system based on security analysis and check is proposed. Firstly, the network control structure of substation and the difference between it and traditional network flow management are analyzed, and the network flow model is explained. This paper analyzes the application and architecture of cloud technology in power grid, establishes a unified management platform for flow data of power network, and explains its platform architecture, B/S network structure and platform function modules. Taking traffic monitoring and trend analysis, balance management, multi-dimensional display and application performance analysis as examples, the multi-scenario function application of the platform is illustrated. The system in this paper can be popularized and applied to the network traffic management application of power system, and realize the docking and supplement with the existing management mode.

References

[1] Song Hu, Yang Bo, Hao Hanyong, et al. Flow balance management system of power communication network based on flow prediction. Electric Power Informatization, 2018, 016(011):53-57.

[2] Liyao. Necessity and implementation of network flow monitoring in power system. Electrical Technology and Economics, 2018, 000(004):51-53.

[3] Liu Yali, Meng Lingyu, Ding Yunfeng. Application and algorithm improvement of abnormal flow detection in industrial control system of power grid. Computer System Application, 2018, 027(003):173-178.

[4] Chen Wen, Lv Nan, Zhou gongjian. research on electronic dispatching command system for subway. railway communication signals, v.54(5):87-90.

[5] Zhao Mingjun, Lu Hang, Yang Gui, et al. Scheme of improving network transmission reliability of intelligent substation based on flow control. Power System Protection and Control, 2019, 047(010):141-146.

[6] Hao Chengliang, Chen Ming, Sun Wei, Liu Hongbo, Liu Chao. Real-time flow monitoring analysis of network data in power information system. Electrical Measurement and Instrument, 2019,56 (8): 65-71