Research on Key Technologies of Intelligent Operation and Maintenance of Communication Network

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Abstract. Based on the analysis of the challenges faced by the operation and maintenance of communication network, this paper studies the intelligent operation and maintenance architecture of communication network. Using the accumulated massive communication network operation and maintenance data, the research explores the high-speed calculation of intelligent algorithm, rapid splicing of demand components, multi-dimensional visual interaction and other technical methods to effectively deal with the problems such as the surge of business volume, the difficulty of event handling, and the lack of personnel training. Research on key Technologies can ensure the safe and stable operation of information and communication network.

1. Introduction
Communication network is responsible for information transmission and exchange between combat entities, and is an important infrastructure [1]. Under the condition of modern high-tech, the communication coverage is wide, the information transmission is large [2], and the timeliness requirement is high. Only by ensuring the accurate cooperation of all dimensions of communication network [3], emergency disposal and strong support, we can obtain and maintain the information advantage under the fierce information confrontation.

With the rapid increase in the number of wired and wireless communication network equipments and carrying business systems, and the in-depth application of various new technologies, the communication system structure is increasingly complex, and the requirements for the reliability of the communication network are increasing, but the difficulty of operation and maintenance is increasing.

Aiming at the new problems faced by the operation and maintenance of communication network equipment, this paper explores the intelligent operation and maintenance system of communication network. Based on the integration of massive operation and maintenance data of communication network equipments, it studies the key technical methods such as high-speed calculation of data, fast assembly of algorithm components and multi-dimensional intelligent interaction, so as to improve the accuracy of positioning analysis and prediction of operation and maintenance events of communication network, and effectively guarantee the reliability of communication network.

2. Challenges of communication network operation and maintenance

2.1. Increasing variety and quantity and diversifying business
Communication network includes various types of routers, switches, servers, firewalls and other standard equipment, as well as a large number of wireless, access control and other special non-standard equipment. The communication network carries all kinds of business systems, and the
communication transmission relationship between systems and internal superior and subordinate is complex, which makes the end-to-end business support more difficult.

With the extensive and in-depth application of new technologies such as artificial intelligence, bigdata, cloud computing and virtualization, communication infrastructure has changed from traditional to dual mode of traditional and cloud IT infrastructure. In the dual mode of operation and maintenance [4], the traditional communication entity equipment, virtual equipments and bearer services have a wide range of types and different operation characteristics, and the communication organization structure is task oriented and flexible. Mixed and changeable communication network organization and operation, on the one hand, there are a lot of unknown hidden dangers, on the other hand, the difficulty of management, monitoring, accident diagnosis and emergency disposal increases, which brings new challenges to the operation and maintenance work.

2.2. Weak maintenance manpower
The operation and maintenance of communication network is complex, and the workload of operation and maintenance personnel needs to increase and master more knowledge. Some small-scale nodes are remote and scattered, lack of professional communication network maintenance force, and even unattended.

However, the existing personnel change frequently, and many skilled operation and maintenance personnel are faced with the problems of job transfer and transfer. Experienced experts need a long time of accumulation and precipitation, which is scarce and difficult to cultivate. The mobility of operation and maintenance personnel [5] will bring losses to the operation and maintenance work of communication network equipment, and it is difficult to effectively inherit a lot of valuable experience and methods accumulated in many years.

The management, economy and time cost of traditional centralized training are high, which are out of touch with the actual work and lack of pertinence. It is difficult for the new personnel to be familiar with the operation environment and event handling methods of communication network in a short time.

2.3. Inconvenient Data access and unefficient emergency response
Communication network equipment, narrow sense refers to the implementation of communication transmission services equipments and systems, broad sense refers to all the equipments and systems involved in communication transmission. Communication related equipment and system problems will affect the overall communication efficiency. Communication related units constantly produce a large number of logs and monitoring data, which is an important basis for analyzing the history, existing and potential problems of communication network equipment.

With the construction of communication management and operation and maintenance system for many years, a large amount of communication operation and maintenance data has been accumulated. The effective use of data can improve the ability of operation and maintenance personnel to recognize, analyze and solve problems. But in the face of massive communication network operation and maintenance data, the amount of data stored and processed by manual and traditional methods is very limited. For the huge amount of historical accumulated data, there is a lack of efficient and flexible access, analysis and display means, so we need to use bigdata and intelligent technology to make up for the shortcomings.

3. Intelligent operation and maintenance system of communication network equipment
The communication network data all over the network reflects the characteristics of bigdata: massive scale, complex data structure and data sources, high-speed data generation, authenticity and low value density. The rapid expansion of communication network data needs efficient and stable acquisition, storage, analysis, processing and display methods.
3.1. Architecture
The intelligent operation and maintenance architecture of communication network can be divided into five levels: basic data source, data storage, intelligent analysis, user interaction and external service interface, as shown in Figure 1.

![Architecture diagram](image)

**Figure 1. Architecture diagram**

The data source layer is responsible for communication network management, monitoring data of communication organization management system, operation and maintenance data of operation and maintenance system, service-oriented transformation of data interface of each system, and acquisition of operation and maintenance knowledge from equipment information, search engine, technical forum, etc.

The data storage layer stores the basic data in the form of file, relational database, NoSQL database and graph database to facilitate the upper layer to retrieve data for analysis and calculation.

On the one hand, the intelligent analysis layer can efficiently fuse and analyze the operation and maintenance data of communication network equipment, assist in fault diagnosis and positioning, anomaly detection, prediction analysis, and provide decision-making suggestions; on the other hand, it can construct and extract ontology to form an automatic operation and maintenance knowledge calculation model for problem solving; it can also realize the analysis and processing of input signals such as voice, image, video, etc. obtained by the interaction layer. Connect the intelligent computing modules.

In the user interaction layer, AR terminals such as smart phones, pad, glasses and helmets can obtain interactive information of scene operation and maintenance, and comprehensively display output signals such as voice, image and video, breaking the limitation of data processing and displaying physical location, realizing data access and problem handling in the communication room, and assisting personnel training.

The external service interface layer realizes the data query and analysis requirements of communication network operation and maintenance of external system.

3.2. Deployment structure
In order to run through all links and processes of communication network business, the intelligent operation and maintenance system based on bigdata of communication network is divided into two
parts: bigdata aggregation analysis center of communication network and pre-acquisition node. The overall deployment structure is shown in Figure 2.

![Deployment structure diagram](image)

**Figure 2. Deployment structure diagram**

The pre-acquisition node is a pre-acquisition device or a portable computer device installed with acquisition middleware, which can realize the nearby acquisition of communication network and status data. It can be used as a data access agent of distributed communication management operation and maintenance system, and can also make up for the blind spot of existing system acquisition and monitoring.

The communication network is equipped with bigdata aggregation analysis center. The pre-acquisition node obtains the data and sends it back to the center for comprehensive analysis and processing through various communication transmission networks.

Users can access and manage the front acquisition nodes and centers of the whole network through mobile phones, pad, terminals and other devices.

4. Key technologies

There are three main difficulties in the implementation: rapid processing and fusion analysis of big data of communication network equipment, software infrastructure, multi-dimensional data exploration and display.
4.1. Based on GPU, Hadoop, Spark hybrid computing analysis technology

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

1) Problem analysis

The analysis of massive historical and real-time operation and maintenance data of communication network can provide a strong basis for fault location and diagnosis, abnormal discovery and disposal, and event prediction of information communication network. The complex analysis model is decomposed into simple and clear real-time and off-line calculation model operators to improve the reliability, reusability and maintainability of the model.

The real-time computing model mainly focuses on the real-time and ad hoc analysis scenarios of communication network status data statistics, filtering, association search and anomaly monitoring from different angles; the offline computing model mainly focuses on the non real-time analysis scenarios of communication network such as periodic consolidation and archiving, retrospective analysis and effectiveness evaluation. The accuracy and value of analysis depend on the speed of data processing.

Most of the original communication network operation and maintenance data are stored in relational database. The amount of data accumulated for a long time is huge. After the number of single table records in relational database exceeds 100 million, the performance of data operation decreases sharply. In order not to affect the efficiency of data analysis, only a small amount of fine-grained data can be recorded, and the earlier data can only be merged by day or week, and the time granularity of the record is coarse. On the one hand, the real-time data processing speed can not meet the second level requirements, on the other hand, it is almost impossible for the long-term fine-grained backtracking of communication network equipments data, so it is necessary to find a calculation method that can quickly analyze the real-time stream data and long-time historical data.

2) Technical approach

In order to solve the above problems, a hybrid computing analysis framework based on GPU and Hadoop / spark is studied. The data analysis model of communication network is divided into atomic operators, and then the task scheduling module is assigned to the computing task to the framework operator, and the final calculation result is formed.

The task scheduling module is built in the hybrid computing framework. The CPU of the master node decomposes the computing tasks and allocates them to GPU and distributed computing nodes, and monitors the execution process of the computing tasks.

GPU real-time analysis framework preprocesses multimedia data, and the computing tasks are assigned to the corresponding recognition, training and generation operators. The GPU real-time analysis framework preprocesses the structured data file for filter filtering to remove redundant data, and then splits the data according to the set granularity to copy the CPU execution data to the GPU cache. Map operator is responsible for distributing the extracted data to different analysis kernel operators and passing them to GPU aggregation operator for calculation. The aggregated data is integrated and output to the destination GPU cache through the reduce operator. In order to adapt to different architectures of GPU, OpenCL framework is used to implement various GPU operators. GPU focuses on image, voice, question answering model training and real-time log preprocessing.

The configuration file of Hadoop offline analysis framework is Report.conf. It defines the HDFS storage path of inputpath source data, which is used to visualize the JSON file storage path of outputpath analysis results, and the information system IP address collection, unit network segment collection, key IP collection and service port collection synchronized from the communication basic resource collection module. Hadoop off-line analysis focuses on regular data processing tasks.

The configuration file of spark real-time analysis framework is used to extract the relevant time period from the history and real-time communication status according to the user's ad hoc search requirements, combine the real-time communication status calculation classes such as information system, unit and key IP that match the requirements, conduct statistical analysis according to the
requirement granularity, and return the results to MySQL database for user interaction layer display. Because the whole system is based on spark framework and uses JVM based language to implement the infrastructure, the difference of CPU architecture is transparent to the whole system. Spark real-time analysis focuses on real-time streaming structured data processing tasks.

4.2. Software architecture based on microservice

(1) Problem analysis

There are three challenges to the software architecture of communication network equipments data acquisition, aggregation storage and operation and maintenance analysis

① Distributed deployment of multiple nodes in the whole communication network

There are many fixed deployment nodes for acquisition of communication network equipment, and the requirements for comprehensive analysis of operation and maintenance are constantly changing [6]. It is necessary to study the method of rapid deployment of new acquisition points and intelligent analysis model, and rapid integration into the large system of operation and maintenance of communication network equipment.

② The functional requirements are complex and changeable

The system nodes are divided into pre-acquisition and back-end analysis, and the function points are complex. The application with "big data intelligent analysis" as the core is destined to face the growing needs and scenarios of user analysis, and the function will grow iteratively. If according to the traditional SOA architecture, the overall package release, development test online operation and maintenance cost is huge.

③ For the future cloud virtualization environment deployment.

The next step of the network management and other information system construction, its hardware infrastructure will rely on the information service center, to the development of cloud virtualization environment. How to effectively use the resources of the center to improve the system performance, how to realize the automatic deployment and operation and maintenance of the software of the traffic collection and analysis system, is a problem that must be studied in advance for the future, and also an architecture problem that must be considered by other software relying on the center to provide services.

(2) Technical approach

In view of the above problems, this paper studies the data acquisition and analysis software architecture of communication network based on micro service, and realizes fast iterative online.

Microservice architecture, including user interface, message queue and microservice components.

① The user interface layer is used to process user function requests, including:

- The judgment module is used to judge whether the function request instruction is synchronous request instruction or asynchronous request instruction;
- A synchronization processing module for directly calling the API of the microservice module corresponding to the function request instruction when the function request instruction is a synchronization request instruction;
- An asynchronous processing module for sending the function request instruction to a message queue when the function request instruction is an asynchronous request instruction.

② Message queue is used to complete the information interaction between user interface layer and micro service modules such as data acquisition, transmission, storage, analysis, visualization and self-management of communication network equipment. As a message middle layer, message queue accepts the interaction of user interface layer and various cloud micro service modules. Through advanced queue mechanism, asynchronous message, monitoring, error handling, and achieve better load balancing, scalability. The interaction between services through message middleware and the distribution of microservice architecture pattern determine its excellent scalability and deployability.

③ Microservice component, decomposes the analysis center into microservice components according to the functional boundary [7]. Each service component corresponds to a microservice
module, and each service component corresponds to a microservice module. Multiple microservice modules are used to realize application functions. The microservice architecture can realize real-time deployment, and each intelligent operation and maintenance microservice module has an independent process, so that it can be deployed independently to improve the overall upgrade efficiency.

4.3. Multidimensional exploration and interaction technology

(1) Problem analysis

Communication network and its operation and maintenance data have many dimensions, strong relevance, and change with different time granularity. On the one hand, the traditional pie chart and other two-dimensional display methods are difficult to show the multi-point and multi-faceted communication situation from the whole communication network or region. On the other hand, the computer screen area is limited. If we use projection, led and other large screen display, we can not use the mouse and keyboard for long-distance operation. We can introduce somatosensory technology to display the situation of communication resources through gestures, body movements and other operations. Secondly, in the future, we can use military CDMA, pad, glasses and other augmented reality technology and image, voice and other multi-channel recognition technology to realize terminal control, carry out communication network operation and maintenance training, machine room on-site inspection and repair, and event handling. All of these require us to think about the methods of convenient access to data and multi screen interaction in different sizes of screens.

(2) Technical approach

To solve the above problems, the project designs a multi-dimensional data multi screen somatosensory multi-channel interaction framework, as shown in the figure, including four parts: visual data organization, multi-dimensional data visualization library, multi screen adaptive, intelligent interactive operation.

① Visual data organization module

For the visual report formed by statistical analysis or intelligent calculation according to time cycle, the analysis module performs regular tasks, generates JSON files, and indexes them by file name for report reading and display.

For the intermediate data stored in the relational database, through the routine and exploration analysis module, according to the requirements of display graphics data format, the data flow is organized and generated for visualization graphics display.

② Visualization database of multidimensional data

The storage framework of built-in multidimensional data visualization library is designed to store all kinds of visualization charts and their corresponding data format requirements, and the chart styles can be defined and expanded at any time.

Users can flexibly access different data elements and select different data display dimensions.

③ Multi-screen adaptive

The display size, layout and component size are adaptively adjusted according to different screen resolution rules.

④ Intelligent interactive operation

Design data analysis somatosensory and augmented reality interactive operation instruction set, define multiple gestures, corresponding to multiple mouse and keyboard response events. Each mouse and keyboard response event corresponds to an individual gesture, which controls the operation of data analysis visualization interface through gesture or body action.
Operation and maintenance work cannot do without information, information cannot do without interaction. The traditional display and human-computer interaction are mainly computer display screen, mouse and keyboard. The interaction mode of "human adapting to machine" seriously affects the work efficiency of operation and maintenance personnel. It is urgent to study the method of information efficiently reaching front-line operation and maintenance personnel. The multi-dimensional exploration interaction framework uses the knowledge set and context map formed by the intelligent analysis of massive operation and maintenance data, realizes the communication between human and computer through multi-channel intelligent interaction technologies such as enhanced display and speech recognition, and helps to complete human instructions to the greatest extent. Through intelligent interaction, we can get through the communication network operation and maintenance information transmission and display channels, seamlessly integrate the real and virtual world information behind the communication network cluster, people and data [8], explore intelligent problem analysis and solutions, and effectively assist the communication operation and maintenance personnel to work and learn.

5. Concluding
The operation and maintenance of communication network is an important guarantee for the operation of information system, which needs to continuously improve the efficiency of operation and maintenance system and the ability and quality of operation and maintenance personnel. With the diversified application and expansion of big data, artificial intelligence, augmented reality and other technologies in the field of communication operation and maintenance, it has become the intelligent assistant of communication network operation and maintenance personnel, effectively coping with the massive surge of data and operation and maintenance tasks, shortening the time of problem discovery and disposal, doing complex logic reasoning and correlation analysis according to clues, and mining deep potential risks. The exploration of this paper also provides technical path and application method practice for big data intelligent analysis and learning in other fields.
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