Frequency Management Method Based on Cloud Computing, Big Data and Artificial Intelligence

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Abstract. Today's electromagnetic environment is still not optimistic enough, and spectrum resources are relatively few. In the actual allocation, unevenness will inevitably occur. In addition, the current level of intelligent monitoring is limited, and it is impossible to fully grasp the dynamics of frequency use. Spectrum monitoring emergency maneuverability still needs to be further improved, and there is a lack of refined spectrum resource management measures. In order to solve this problem as soon as possible, the article proposed a solution to the electromagnetic spectrum monitoring problem based on Cloud Computing, Big Data and Artificial Intelligence technology, proposed construction plans for various main applications and corresponding monitoring services, mainly strengthening the construction of handheld monitoring systems, electromagnetic spectrum monitoring and control systems, cloud monitoring systems, Big Data analysis systems, and intelligent monitoring and dispatching systems.

Keywords: Electromagnetic Spectrum, Efficiency, Monitoring System, Network System.

1. Introduction
The advent of the Internet era has fundamentally promoted the advancement of science and technology and the advancement of information technology. The application of wireless communication technology has become more and more extensive. However, it has brought about a relatively scarce electromagnetic spectrum resource[1]. In addition, the electromagnetic environment has gradually deteriorated[2] and there are certain shortcomings in resource allocation[3]: First, the types of communication equipment used in society have gradually increased. Therefore, the demand for the electromagnetic spectrum resources is gradually increasing[4]; secondly, in terms of spectrum utilization, its efficiency is far from the ideal effect, and even only reaches 15%~85% [5]. Faced with the above two situations, relevant technical personnel put forward the concept of cognition of radio, which is actually the management of spectrum resources through information mining technology[6]. However, some useful information cannot be fully analyzed for the first time through simple data processing and information mining[7]. Therefore, it is urgent to continuously explore the application of new technologies in the field of electromagnetic spectrum monitoring.
As a new generation of science and technology information technology, AI, Big Data and Cloud Computing (hereinafter referred to as ABC technology) have been widely used in transportation, medical treatment, Internet, and so on, which provides technical support for exploring its development and application in the electromagnetic spectrum monitoring, such as studying the application of Big Data in the storage, analysis massive spectrum monitoring data[8-11], studying the application of AI in modulation pattern recognition, signal recognition and speech recognition[12-14], and studying the application of Cloud Computing in the integration of monitoring platforms[15-17]. However, the related work still can not fully meet the needs of development:

① The electromagnetic spectrum monitoring facilities fail to form an overall network;
② There are many kinds and a large number of transmitter stations, with the lack of comprehensive knowledge of frequency usage and global real-time dynamics;
③ Frequency resources are increasingly limited, which is impossible to make a detailed analysis of massive monitoring data to form supporting capacity;
④ Intelligent monitoring needs to be improved, so it is necessary to improve the ability of signal discovery and monitoring resource scheduling;
⑤ It is necessary to improve signal discovery ability and monitoring resource scheduling ability. Therefore, it is very important to establish a perfect platform for electromagnetic spectrum monitoring, to dig into electromagnetic spectrum resources, to master the use of spectrum resources in all frequency bands, and to realize flexible, efficient, and reasonable spectrum resource planning. In this paper, ABC technology was mainly used in the process of core monitoring and application construction, and palm monitoring, electromagnetic spectrum monitoring, Cloud Monitoring, and Big Data monitoring system were equally focused on construction, so as to effectively improve the comprehensive decision-making ability and resource management ability of electromagnetic spectrum.

2. Solution system architecture and system composition

2.1. Solution system architecture
The electromagnetic spectrum monitoring solution integrating resources, platforms, services, applications, and businesses were constructed by comprehensively utilizing various monitoring facilities and hardware and software resources. Big Data was used to provide massive data access and data analysis capability for the control of monitoring equipment and monitoring Big Data analysis; Intelligent monitoring, signal recognition, speech recognition, and resource scheduling were conducted on the basis of massive electromagnetic spectrum monitoring data and AI technology; Cloud Computing was used to provide flexible resources and cloud services for Hardware resource cloud and SaaS layer cloud service.

The core of the solution consists of all kinds of services. Cluster management provides node resource management and monitoring services at all levels in the system, to form network topology and provide message communication support. Task scheduling provides task management, distribution scheduling, and operation monitoring services based on cluster network topology, with computing power and the function of data access and storage in the monitoring system.

2.2. System composition

2.2.1. Electromagnetic spectrum monitoring control system
Facing different monitoring facilities such as fixed monitoring station, mobile monitoring vehicle, movable station, grid station, and microsensor, the system enables users to control all kinds of spectrum monitoring equipment without a difference, and use and share monitoring data uniformly by standardizing the organization mode, operation mode and efficient processing of multisource information of spectrum monitoring network resources and efficient processing of multisource information, with the access of different manufacturers and types of equipment, which can realize unified management of equipment, unified monitoring of tasks, monitoring of equipment status and alarm of equipment abnormalities.
2.2.2. Spectrum monitoring Big Data analysis system
The system analyzes the spectrum resources, electromagnetic signals, radiation sources, etc., realizing the time-space frequency analysis of spectrum resources, electromagnetic signal law analysis, radiation source activity analysis, key signal prediction analysis.

2.2.3. Monitoring and scheduling system
Based on the frequency rule and resource scheduling rule of the monitoring station, the system realizes the electromagnetic environment survey, signal survey, interference source search, "black broadcast" search, and false base station search.

2.2.4. Cloud monitoring system
The system provides rich SaaS services and provides platform support for intelligent monitoring, intelligent analysis, intelligent spectrum planning, abnormal signal early warning, and other services of electromagnetic spectrum management organizations.

2.2.5. Handheld monitoring system
The system provides monitoring management and monitoring data services through mobile apps, integrates front-end applications such as electromagnetic spectrum monitoring management and control, Big Data analysis, and provides monitoring business support under maneuvering conditions.

3. Research on Key Technologies

3.1. Spectrum monitoring data processing technology
As it is shown in Fig.1, aiming at the problem of large, long-term, different kinds, fragmentation spectrum monitoring data access and mining play value-added benefits, the Real-time monitoring of multiple source data access, heterogeneous data integration, and integration processing technology is used to form the ability for Real-time analysis, off-line analysis, and multidimensional analysis, to support the spectrum monitoring business requirements.

![Fig.1 Spectrum monitoring data processing](image_url)

3.1.1. Real-time analysis of monitoring data
The data analysis, statistics, and localization of the monitoring data collected or imported by the monitoring and direction measuring equipment are carried out in time to standardize the air frequency, which supports the services of frequency band scanning measurement, discrete scanning measurement,
single frequency direction measurement, broadband direction measurement, single frequency measurement, listening and demodulation, etc. Accessed data mainly includes spectrum field strength data, direction measurement data, IQ data, and so on.

3.1.2. Heterogeneous data integration
The business data is extracted, converted, and loaded into the data warehouse, and the data mart is set up for various topics, including spectrum identity mining, spectrum resource prediction, station resource prediction, and so on, which provides services for Big Data analysis.

3.1.3. Spectrum monitoring data integration technology
Based on multi-data source, multi-dimensional analysis is carried out in the region, time domain, and frequency domain, which covers massive data such as spectrum monitoring, direction finding, radio environment, geographical data, frequency effect of equipment, etc., and adopts single-station integration, multi-station integration, regional integration, and external data integration technology to realize efficient multi-dimensional analysis ability.

3.2. Big Data analysis for spectrum monitoring
Based on the massive data, the regional electromagnetic signal information, the radiation source activity law information, the electromagnetic signal long-term frequency activity law information and so on, and the electromagnetic environment, the abnormal frequency use situation carries on the forecast, the correlation alarm, carries on the authentication to the common signal, and accurately grasps the spectrum resources, as well as carry out dynamic analysis and evaluation of spectrum resources to promote scientific utilization of spectrum resources.

3.2.1. Online transaction processing
On-line transaction processing mainly deals with routine business, which is mainly composed of spectrum sensing network management, spectrum sensing task management, spectrum sensing data processing, available frequency prediction, and spectrum monitoring data analysis and display.

3.2.2. Online analytical processing
On-line analytical processing is based on data warehouse, oriented to the business theme, extracts a subset of detailed data from multidimensional data set for analysis tool scheduling, generates multi-dimensional view, and responds quickly to user's analysis needs. Multidimensional spectrum data association analysis is realized.

3.2.3. Data mining
The integration of frontier data mining algorithms for electromagnetic situation analysis provides data heat tracking, invisible knowledge mining, trend analysis data services. It mainly includes spectrum identity mining, spectrum resource prediction, and station resource prediction.

3.2.4. Data services
Data services are based on a variety of data integration, mining algorithms. According to the integration level, the entity layer is divided into the entity layer, relationship layer, and situation layer. The entity layer obtains the entity related to the electromagnetic situation by classifying and clustering the original data. The relationship layer analyzes the relationship between various entities. The situation layer refines the application based on the relationship between entities and provides the integration result access interface for the information presentation layer.

3.3. Intelligent monitoring algorithm and model
It is mainly based on AI technology. Its research meets the monitoring resource scheduling, electromagnetic environment characteristics, signal recognition, speech recognition, and other
business requirements, which can establish different application direction models, using AI technology to serve spectrum monitoring to improve the intelligent level of monitoring work.

3.3.1. Intelligent monitoring and scheduling model
Intelligent monitoring and dispatching model monitoring network of all kinds of monitoring, direction-finding equipment comprehensive use to achieve automatic electromagnetic environment water data acquisition, electromagnetic signal acquisition. The functions of the intelligent monitoring and scheduling model mainly include: finding peripheral signals according to the requirements of acquisition tasks, supporting automatic remote control of each monitoring equipment, and monitoring, measuring, and demodulating the specified signals; being able to automatically remote control each direction measuring equipment and locating the specified signals. The process of operating the intelligent monitoring scheduling model is as follows: the monitoring center initiates the task request and calls the intelligent monitoring scheduling model, which can be executed according to the business requirements. The automatic dispatching monitoring station handles the monitoring and direction-finding task, and the model can monitor the operation of each task centrally.

3.3.2. Regional electromagnetic environment model
The model based on network and intelligent monitoring and scheduling model for regionally based characteristics of electromagnetic environment for a long time, from the time domain contrast and region contrast, artificial excavation of electromagnetic radiation, electromagnetic signals to carry out the research work, build different time, different regions of the electromagnetic spectrum feature model, and use the data fusion and data mining technology to build a typical regional electromagnetic environment characteristic., which can predict natural or man-made events from the background noise of electromagnetic environment, a load of mobile communication frequency band and electromagnetic signal variation.

3.3.3. Radiation source signal recognition model
Based on a deep learning algorithm, this model extracts the features of radiation source signals according to multiple signal parameters and is suitable for multiple signal classification. The operation process of the model is as follows: A large amount of monitoring data is obtained through a variety of means. After comprehensive analysis and processing, it is entered into the sample library, and through continuous verification, supplement and modification, the known signal technical performance and performance data are formed; Train recognition model using known signal data; The collected electromagnetic signals are classified and analyzed by the trained model, and the classification results of each signal are obtained, including signal type, use, credibility and so on.

3.3.4. Speech keyword retrieval model
The model combines machine learning and deep learning to build corresponding acoustic and language models. The operation process of the model is as follows: First, the keywords of monitoring are set, and the model is called when the monitoring task is executed; Input voice data for speech recognition and establish keyword index; Find the corresponding keyword list and conduct confidence evaluation; Return keyword search results.

3.4. Electromagnetic spectrum monitoring cloud service technology
Such technologies include software and hardware infrastructure, mass monitoring data storage and analysis, traditional and intelligent algorithms in the field of electromagnetic spectrum monitoring, which provide industry applications for the entire process of electromagnetic spectrum monitoring, to form a stable and secure cloud service ecosystem. Flexible deployment mode is adopted to meet various application scenarios and network requirements, and the problem of "the last kilometer" of electromagnetic spectrum monitoring is completely solved.
3.4.1. Cloud monitoring
Cloud monitoring provides unified equipment control, data management, and analysis interface, provide AI early warning, interference investigation, monitoring data analysis, monitoring abnormal alarm and other services, to form a cloud monitoring network with the ability of joint cooperative operation of the whole network, realizing centralized storage and unified management of spectrum monitoring data. Combined with Cloud Computing technology and Big Data application, the automation and intelligence level of the whole monitoring network management and operation can be further improved.

3.4.2. Handheld monitoring
Handheld monitoring combined with cloud monitoring strengthens mobile joint monitoring means. Monitoring business and monitoring data analysis can work in computers, mobile phones, pads, and other networking environments, providing mobile joint networking and important support tasks, which can control monitoring equipment in mobile scenes, perform various monitoring tasks uniformly, and effectively improve the ability to capture abnormal signals and investigate and deal with interference.

4. Core of construction of electromagnetic spectrum control system
Under the background of the continuous development of science and technology, it promotes the progress of information technology to a certain extent. As the premise of controlling the electromagnetic power of the battlefield system, the electromagnetic spectrum has attracted wide attention[18].

4.1. Optimize and perfect the electromagnetic spectrum control and command system
Reasonable application of electromagnetic spectrum control system can ensure its perfection to a certain extent. In addition, it is necessary to effectively ensure the high efficiency of electromagnetic control, so that its control and command system must be optimized and improved.

The first thing to do is to optimize the relevant laws and regulations and to ensure the legal nature of the command work. Under the background of the continuous development of science and technology, to a certain extent, it enhances the normality of electromagnetic spectrum control and control and is gradually moving towards the direction of legalization. However, we should also clearly realize that on the basis of the continuous progress of information construction, in the new era, the traditional laws and regulations can no longer effectively meet their needs, and lack of detail and comprehensiveness in content. In order to make the electromagnetic spectrum control work truly legal, we must optimize and perfect the relevant regulations, rules, and regulations. Among them, the construction of electromagnetic spectrum control efficiency evaluation system is its core, we must strengthen the discipline control, and give severe punishment to its illegal situation. Electromagnetic spectrum control must be supported by an effective evaluation system in the process of completing tasks, responsibilities, and exerting its effectiveness. The second is to effectively ensure the integration of command systems. It is necessary not only to effectively integrate the related forces of electromagnetic spectrum control but also to construct the electromagnetic spectrum control center. The so-called spectrum system mainly includes electromagnetic monitoring, short wave frequency detection and battlefield electromagnetic environment analysis, and other subsystems, which also produces the electromagnetic spectrum control force with the electromagnetic spectrum control center as the core. The relationship between command and computer information technology is inseparable, and the final command efficiency is determined by the degree of automation of command means. In addition, in order to effectively improve the ability of electromagnetic spectrum control and command, we must actively build a spectrum control and command information system, give priority to its corresponding command technology, and do a good job in training and popularizing command automation. Then fundamentally enhance the command level and ability of the command organization.

4.2. Improvement of electromagnetic spectrum control network system
In general, to effectively improve the control of the electromagnetic spectrum, we must rely on scientific power. At this stage, the first thing to do is to rely on the current technology to optimize and improve the technical performance of the relevant control equipment, and then effectively enhance the transformation of information, and effectively integrate the relevant technical resources. The rationality and scientificity of electromagnetic spectrum control network systems are improved effectively. First, give full attention to the relevant technical research work. The most important is that the research work of electromagnetic monitoring technology must be strengthened, so that the space of electromagnetic monitoring can be further expanded, the accuracy of positioning can be effectively improved, the independent research and development and technology introduction are combined, and effective measures such as optimization function, digestion learning and the introduction of corresponding technology are adopted to ensure that the developed electromagnetic monitoring equipment is in line with the actual electromagnetic spectrum control; Secondly, we should strengthen the analysis and study of electromagnetic compatibility, establish the mathematical model of receiving electromagnetic signal, electromagnetic coupling and equipment transmitting, analyze the frequency equipment itself and its compatibility effectively, and analyze the relevant measures to suppress electromagnetic interference to ensure the full play of the role of frequency equipment. The second is to effectively improve the information construction of control equipment. First of all, using scientific methods to improve the current electromagnetic spectrum control equipment, using the installation of network and computer processing modules, on the basis of effectively ensuring the scientific perfection of the electromagnetic spectrum control system, effectively improve the level of automation and interconnection between control equipment. The third point analyzes and integrates the related resources to make the relevant technical standards more scientific and reasonable. This paper analyzes and integrates the relevant resources to ensure the effectiveness of the connection between the electromagnetic spectrum control equipment and the system, makes the network system tend to develop in the direction of integration and gives full play to the role of each equipment and system. Make the overall control ability $1+1>2$ form. First, the lack of uniformity in the technical specifications for electromagnetic spectrum control and control preparation should be properly addressed, and the design and application of control equipment must be carried out in strict accordance with the relevant standards and technical requirements; secondly, the data link system should be optimized and perfected, and the data link system should be backed up by satellite, wireless and wired communications.

5. Conclusion
Aiming at the deterioration of the electromagnetic environment, the lack of spectrum resources, the uneven distribution and the failure of the electromagnetic spectrum monitoring facilities to realize the joint operation of the whole network, the lack of detailed management and the need to improve the ability of emergency maneuver and intelligent detection, this paper puts forward measures to solve the problem of electromagnetic spectrum monitoring based on Cloud Computing, Big Data, and AI technology. Using Big Data technology to construct an electromagnetic spectrum monitoring control system and electromagnetic spectrum monitoring Big Data analysis system, using AI technology to construct an intelligent monitoring scheduling system, Cloud Computing technology is used to construct a cloud monitoring system and handheld monitoring system. This solution is conducive to improving the ability of scientific monitoring of electromagnetic spectrum, improving the level of intelligence in the execution of monitoring tasks, strengthening the development of related applications supporting intelligent and meticulous management, perfecting the monitoring business systems and related applications such as integrated management monitoring, business management monitoring, data mining monitoring, etc. It can provide a perfect and powerful platform for the monitoring of the electromagnetic spectrum.

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