Research on Intelligent Service Technology of Network Electromagnetic Space Situation Cloud Based on Cloud-Edge-Terminal Synergy

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Abstract. Based on the current technology of network electromagnetic space situation awareness service by the limitations of traditional system framework and fixed working mode cannot adapt to the harsh environment within strong antagonistic conditions, limited tactical edge computing resources and intermittent network communication, the author focuses on the maintenance of traction network electromagnetic space security demand, based on the network electromagnetic situation global multi-dimensional cognition, combines with artificial intelligence machine learning and big data cloud computing of cutting edge technology for fusion development, aims at intelligent service of network electromagnetic space situation, puts forward to the network electromagnetic space situation intelligent service within edge and cloud computing synergy, builds cloud-edge-terminal regional network electromagnetic space situation cloud information service technology architecture to provide technical support for realizing the goal of network electromagnetic space security maintenance including global awareness coverage, prediction analysis, effective response and deterrence of the regional network electromagnetic space environment.

Keywords. Cloud-edge-terminal synergy; network electromagnetic space; situation cloud; intelligent service.

1. Introduction
With the rapid development and maturity of the network wireless communication and internet of things technology, the integration of cyberspace and electromagnetic space has become an inevitable trend. The security of network electromagnetic space, a vital area of national interest, directly affects civil communication, navigation, aerospace, radio positioning, remote control and telemetry, distress search and rescue and military C4ISR system and battlefield control, etc. It is closely related with national welfare and the people’s livelihood, and inseparable from the social stability and development, which has increasingly valued by all countries in the world, and gives new connotation to the national strategic security.

As the competition for the initiative in the network electromagnetic space field increasingly presents the characteristics of global penetration, continuous peace and war, convert form, fierce struggle and serious consequences, the panoramic monitoring of the network electromagnetic space environment is the key part to realize the full dimensional awareness of regional network electromagnetic space situation, and then to obtain the “control of electromagnetic power” [1]. Because of the traditional fixed electromagnetic environment monitoring methods based on wired communication infrastructure (such as cellular base stations, telephone lines, wireless access points, and fiber optic links), on the one hand, the electromagnetic signal data of all points, all frequency points and all periods of time in the target region cannot be achieved without blind traversal due to the
large amplitude of the target region, the limitation of detection equipment receiving broadband and traditional storage space. Therefore, it is difficult to generate the network electromagnetic space situation in all spatial domains, all time domains and all frequency domains by collecting the network electromagnetic space environment in the target region. On the other hand, due to the limitation of the traditional information system framework and the fixed working mode, the existing network electromagnetic situation awareness technology architecture cannot adapt to the harsh environment based on strong antagonistic conditions, limited tactical edge computing resources and intermittent network communication. Therefore, in the view of network electromagnetic space rights and interests game and the influence of the harsh environment in future conflicts, how to establish a reliable regional network electromagnetic space situation intelligent awareness system based on the global presentation to realize the network electromagnetic space intelligent hierarchical services has become the important technical bottlenecks to breakthrough for network electromagnetic space security needs.

2. Demand Analysis of Network Electromagnetic Space Situation Intelligent Service

Network electromagnetic space situation intelligent awareness service is through awareness within the target area network electromagnetic field data, analyzes and processes the acquired data and uses the cutting edge technology such as artificial intelligence and big data analysis, cloud computing, edge computing, etc., accesses to the current state of the electromagnetic environment in the target area and predicts the future trend, and then according to the situation user needs to transform the abstract data into visual expression to provide auxiliary support for decision-making [2]. In academic research, the research on electromagnetic situation mostly focuses on the visualization technology, and in the application field, it emphasizes the accurate analysis and comprehensive display of electromagnetism situation. For example, in recent years, in order to achieve effective control of the electromagnetic spectrum, the United States has conducted in-depth exploration of the theory and technology of electromagnetic situation analysis, strengthened the research and development of relevant equipment, introduced a series of policies and established corresponding command centers. In 2012, the United States Strategic Command established the Joint Electromagnetic Spectrum Control Center (JEMSCC) to fully integrate the electromagnetic spectrum management and control the electromagnetic situation in the battlefield. Combined with the application of situation awareness theory, the United States has established some relatively mature theoretical models of electromagnetic situation analysis, such as the electromagnetic situation generation model based on JDL model. The JDL model, proposed by the United States Department of Defense, regards the situation assessment as a level of data fusion, which connects the observed entity distribution in the battlefield with the activity situation, battlefield environment and knowledge base, and its ultimate goal is to form a battlefield situation map that is easy to understand, including situation analysis and estimation. At present, a lot of electromagnetic situation generation model is derived on the basis of JDL model, including the electromagnetic situation factors domain, situation understanding domain and situation show domain, through to the electromagnetic environment monitoring, perception and analysis, combining the electromagnetic situation visualization technology will make clear and forecast the electromagnetic environment of the current physical space [3]. Electromagnetic situation generation in addition to include analysis and evaluation on electromagnetic environment, using 2D and 3D or multi-dimensional visualization method of the electromagnetic signal types, properties and distribution, and so on and so forth the results of the analysis with statistical charts, spectrum and waterfall diagrams, electromagnetic map form to show, also include in a complex electromagnetic environment to provide services for decision makers to judge what form to use, which commonly known as the electromagnetic situation service [4]. The electromagnetic situation service is both the means and the goal of electromagnetic situation generation. Electromagnetic situation service belongs to the content of information service. At present, the concept of information service is changing from the original concept of users seeking and waiting resources to the concept of resources serving and waiting users, so that users can obtain the required information resources more conveniently, share all the information and innovate the way to use information resources, so as to maximize the overall efficiency. And the mainstream way to realize the
current information service is cloud service. Cloud service is a new concept derived from the “cloud concept” in the rapid development of science and technology in recent years. With its features of interconnection, efficiency and sharing, cloud service not only profoundly influences and changes our lives, but also promotes major changes in the military field. Therefore, this article proposes a synergetic idea based on cloud computing, edge computing and terminal computing, and studies the cloud-edge-terminal synergy electromagnetic space situation intelligent service algorithm.

3. The Network Electromagnetic Space Situation Intelligent Service Proposal

The purpose of network electromagnetic space situation intelligent cognition is to serve the decision makers. In view of the impact of harsh environment and the vulnerability of traditional electromagnetic situation awareness technology framework, the idea of network electromagnetic space situation cloud intelligent service is proposed [5]. By establishing network electromagnetics space situation cloud, a complex network electromagnetic space situation awareness network covering the whole target area space could be formed, in which the users of that node could contribute, receive and use network electromagnetic information, fully understand the overall network electromagnetic situation, thus speeding up the speed of command and decision-making and combat action. The proposal of network electromagnetic space situation cloud could realize from the original users seek and wait situation, and users blind repair situation into a situation for service, situation wait users and situation repair itself, so intelligent users acquire situation information resources, efficiently share operational mode of all electromagnetic information and innovative situation resources, greatly play the network electromagnetic space overall advantages [6-8]. Therefore, the following situations should be considered when researching the intelligent service of regional electromagnetic space situation cloud under harsh environment:

1) Because of traditional fixed base station communication and centralized cloud center processing mode has been severely tested, the edge resources of the harsh environment are more scarce and the reliability requirements are higher, how to combine the advantages of cloud computing and edge computing to establish the electromagnetic situation awareness cloud technology architecture that can adapt to harsh environment? [9-10]

2) When some monitoring nodes are interfered with and the detection data is incomplete or the data transmission network fails to receive data from the central node station or data transmission error occurs, how to use the information of the maneuver edge and terminal nodes to provide the regional network electromagnetic situation service?

3) Because of the influence of the harsh environment of strong interference and the existence of perception blind spots by monitoring node coverage limit and unreasonable deploy, how based on the degree of blind spots in the choose suitable intelligent optimization search algorithm to achieve high efficiency and low redundancy perception bug blind repair, to the effect of network electromagnetic situation self-healing blind area intelligent service?

4) In harsh environments, due to the high maneuver of radiation source target, intermittent fault network by strong antagonism, weak connection network, jitter network, opportunity network and other abnormal network condition frequency existence, how to combine cloud computing and edge computing to solve electromagnetic situation cloud intelligent service problems under high real-time tasks, limited computing ability and bandwidth shortage, etc. conditions?

4. Key Technology of Network Electromagnetic Space Cloud

4.1. The Network Electromagnetic Space Situation Cloud Technical Architecture Design

According to the above problems, we carry out the following technical architecture assumption. “The network electromagnetic space situation cloud” is supported by distributed network, cloud computing, edge computing and other technologies. The core is the rapid aggregation, self-blinding repair, immediate response and intelligent adjustment of all possible information in the target area space. In essence, it is a kind of network electromagnetic situation service transparent to the party itself, with
the characteristics of “self-organization, self-healing, step-down and redundancy”.

“The network electromagnetic space situation cloud” mainly has the following characteristics.

**Dynamic and virtualized network electromagnetic resource pool.** “The network electromagnetic space situation cloud” links geographically dispersed network electromagnetic resource such as platforms, sensors, systems and data, constructs a networked electromagnetic resource pool. Resource pool has the characteristics of distributed network, virtualization, dynamic self-organizing access, access on demand and so on, high maneuver in the network topology between nodes. Each node could free out cloud and in cloud and has the characteristics of input and output. Both the cloud provides information and services, and also obtains information and services from the cloud, and could dynamically allocate resources according to specific combat mission requirements. As a result, the cloud takes a virtual form, with no concrete form, but it is everywhere.

**Cross-domain fusion of network electromagnetic information.** The essence of network electromagnetic space situation cloud is fusion, the integrated control of network electromagnetic resources is realized based on cloud technology, and the collaborative detection of active and passive sensors scattered in the region, airspace and time domain is realized, so as to complete the real-time sharing of network electromagnetic situation and decision support, shorten the decision-making time, and improve the synergistic ability and overall efficiency among elements of the unit. Supported by information network technologies such as big data, cloud computing and edge computing, the network electromagnetic resources and information of combat platforms widely distributed in space, near space, air, ground, sea and underwater domains will be integrated. In the system of network electromagnetic space situation, the absence of any one or more network electromagnetic awareness nodes will not decisively affect the sharing and distribution of the network electromagnetic situation information.

**Group power distribution synergy.** Different from the traditional information system architecture which is classified and allocated according to platform attributes and combined according to administrative means, the network electromagnetic space situation cloud optimize the online configuration and combination of various network electromagnetic resource in the form of decentralized services according to the real-time task requirements to form a modular group collaborative power through the endless evolving data link and anti-interference communication system. Based on this consideration, it is proposed to establish the operation architecture of “cloud-edge-terminal” based regional network electromagnetic space situation information service (as shown in figure 1), combine the latest technology development trend of cloud computing, fog computing and edge computing, and break through the construction of cloud-edge-terminal integrated network electromagnetic space situation cloud service, provide service adaptive access based on intermittent weak connection network, achieve the purpose of rapid optimization and deployment of regional network electromagnetic space environment awareness nodes, aggregation and decentralization of independent blind repair, safe and reliable destruction resistance, and intelligent hierarchical service.
4.2. The Network Electromagnetic Space Situation Cloud-Edge Synergy Service Algorithm

One of the keys to the establishment of the network electromagnetic situation cloud is the network electromagnetic situation cloud-edge synergy service algorithm. In terms of functions, it is designed to study edge resource management, edge service management and unified scheduling, edge information fusion and synergy, and inter-cloud management and operation and maintenance management, as shown in figure 2.

![Diagram of Network Electromagnetic Space Situation Cloud-Edge Synergy Service Algorithm](image)

**Figure 1.** Network electromagnetic space situation cloud information system operation architecture based on “cloud-edge-terminal”.

**Figure 2.** Network electromagnetic situation cloud-edge synergy service function composition.

1) Network electromagnetic situation cloud-edge synergy service resource management

Research the computing, storage, network, communication resource virtualization and pooling unified management of the network electromagnetic situation awareness node, so as to realize efficient
scheduling and improve the resource utilization rate of the network electromagnetic situation awareness node, which include resource management, resource registration and discovery, resource scheduling, resource monitoring, discovery and authorization, etc.

2) Network electromagnetic situation cloud-edge synergy service information fusion

Research the information integration and sharing distribution among network electromagnetic situation awareness terminal node, maneuver margin and multiple nodes in the cloud center, decentralization in maneuver application terminal systems, provide multi-point fusion of information and data, conflict data re-judgment management, synchronization and sharing of fusion data based on narrow band weak connection of self-organized maneuver network and other problems.

3) Network electromagnetic situation cloud-edge synergy service operation schedule

According to the demand of electromagnetic situation cloud-edge-terminal fusion service, research the problems of service hosting and management capability implementation of network electromagnetic situation cloud service node and fixed terminal information service interfacing, including operational support framework for service, service classification, universal transport service, service registration and service communication component, etc.

5. Conclusion

For network electromagnetic space situation global multidimensional awareness intelligent service demand under the harsh environment, the article is based on the global awareness of regional network electromagnetic space environment, the author puts forward the network electromagnetic space situation cloud intelligent service, designs the technical architecture of network electromagnetic space situation cloud, discusses network electromagnetic space situation synergy service algorithm based on the cloud-edge-terminal synergy. Although the study of the network electromagnetic space situation itself is not a new concept, the network electromagnetic space situation awareness framework is mostly based on the traditional distributed architecture, with little consideration of the electromagnetic situation cloud service based on the new big data distributed computing such as cloud computing, edge computing and fog computing. However, the service efficiency’s quality of the traditional network electromagnetic situation service framework is not high in the intermittent network under the condition of high maneuver and strong antagonism. Therefore, it is a new and forward-looking topic for this article to continue the research on the network electromagnetic space situation intelligent service algorithm within cloud-edge synergy under harsh environment. The research results can better promote the solution of the key technical problems of “demand traction and breaking the bottleneck” of network electromagnetic space security maintenance.

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