Research on communication network operation and maintenance method based on multi-agent technology

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Abstract

The application of emerging technologies has deepened the dependence on communication networks, and the surge of access equipment and bearer services has increased the difficulty of communication network monitoring, fault diagnosis and emergency disposal. Under the hybrid technical architecture and dual mode of operation and maintenance, comprehensively comb the experience, processes and methods of various network operation and maintenance lines, form a multi-agent decision-making model system that cooperates with each other, and combine immersive interactive auxiliary operation and maintenance means to effectively cope with massive operation and maintenance scenarios and tasks, and improve the communication network planning, business support, fault emergency response and prediction capabilities.

Keywords: Dual state operation and maintenance; Multi-agent; Multi channel interaction;

1. Introduction

The wide application of emerging technologies such as meta-universe, cloud native, artificial intelligence and Internet of things has triggered a new round of disruptive innovation, which is profoundly changing the production and lifestyle of the national economy, and has become a new force of the digital revolution and a new engine for sustainable transformation. The new technology connects the active entity "things" through the communication network to achieve seamless switching between different fields and different scenarios, and the dependence on the network is deepening.

As the infrastructure base of new technologies, communication network access equipment, bearing services and data volume are increasing rapidly. Driven by innovative business applications, the communication network environment has undergone tremendous changes. The operation characteristics of traditional network physical equipment and cloud technology architecture are different, and the mixed and changeable network routing[1] and organization application modes increase the difficulty of network monitoring, fault diagnosis and emergency treatment, and bring new challenges to operation and maintenance work.

In view of the new challenges faced by the communication network, in order to achieve the goal of intelligent and visual operation and maintenance, this paper proposes a communication network operation and maintenance framework based on multi-agent decision-making technology on the basis of integrating massive communication network operation and maintenance data, and explores multi-channel interaction and multi-dimensional analysis agent technology to improve the accuracy of network problem location analysis and prediction, shorten the time of fault alarm handling, Effectively guarantee the flexible, agile, automatic and intelligent operation of innovative business transmission channels.

Multi channel interaction, integrate audio, video and other multi-channel interaction information through intelligent terminals, and improve the naturalness and operability of operation and maintenance interaction through the cooperation of on-site object recognition agents, image annotation agents and human-machine dialogue agents, and efficiently assist the execution of operation and maintenance work.

Multi-dimensional analysis, including observable information collection, transmission and storage, intelligent analysis, visual interaction, internal control and other functional agents. The core layer relies on the operation and maintenance knowledge map and knowledge base to conduct association analysis. Each agent operates in a distributed manner and cooperates with each other according to the demand of obtaining instructions to realize logical solution and information

push such as operation and maintenance fault diagnosis, event handling, on-site training and learning.

2. Difficulties in operation and maintenance of communication network

The existing communication network shows a trend of "mixed technical architecture and dual operation and maintenance mode". In the context of dual state operation and maintenance, the integration of technology and business, development and operation and maintenance in enterprise network operation and maintenance are accelerated. There are many challenges in the rapid development of user, business, development and operation and maintenance.

1) The operation and maintenance system needs to be synchronized and compatible with the traditional and dual network operation and maintenance management capabilities to realize the connection of operation and maintenance data and scenarios under the two modes, and put forward higher requirements for operation and maintenance;

2) The cloud technology architecture of communication network is adapted to the development trend of data center integration, automation and intelligent operation and maintenance management, has the ability to simplify and automate operation and maintenance management, and supports the automation of application and infrastructure delivery;

3) The new network technology architecture is widely used, the complexity of operation and maintenance management is increasing, the number of maintenance tasks of operation and maintenance personnel is increasing, and the work content is changing. It needs to master, flexibly use and track more professional knowledge.

In the face of challenges, the comprehensive network observable system and intelligent operation and maintenance decision-making tools help the system and operation and maintenance personnel to accumulate experience, track the frontier and deal with difficult problems.

3. Multi-agent communication network operation and maintenance framework

Multi-agent technology belongs to the research field of distributed artificial intelligence [2]. It is a group of autonomous agents[3] that complete complex system control and task solving process through interaction, cooperation, competition, negotiation and other behaviors in a dynamic and open environment. It has complex characteristics such as distribution, cooperation and parallelism [4].
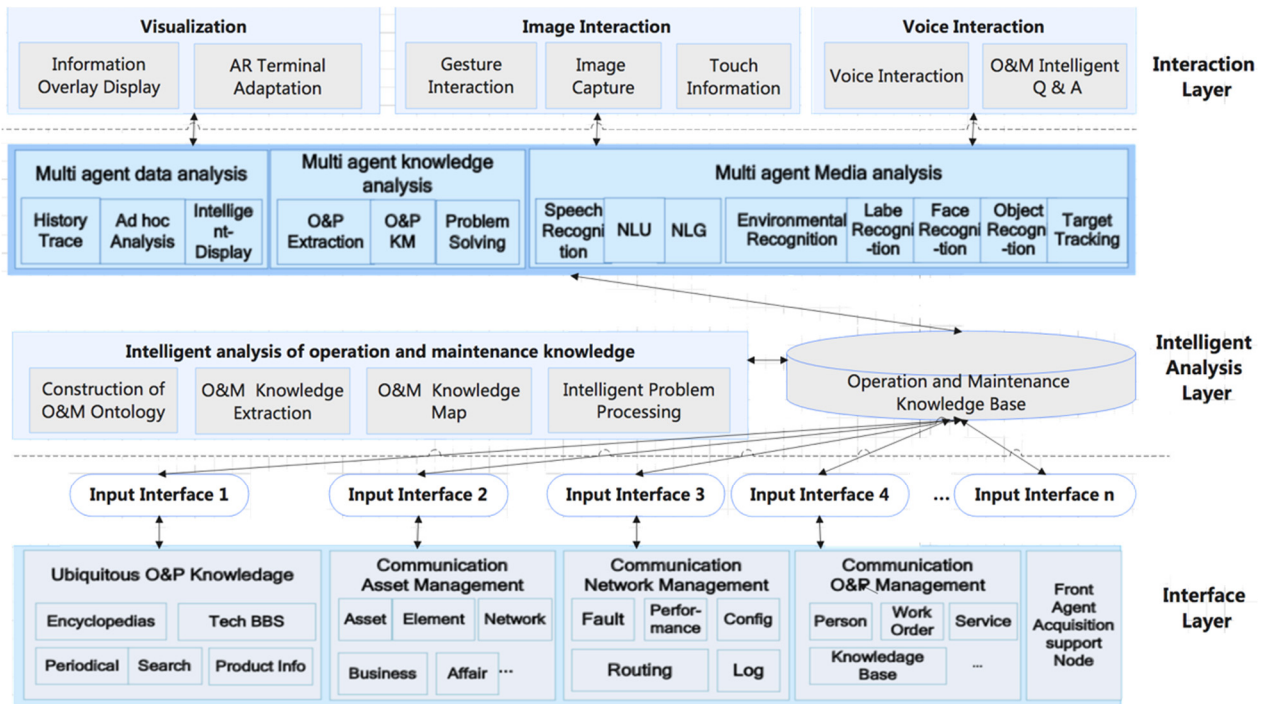

Figure 1. Multi-agent communication network operation and maintenance hierarchical framework

The multi-agent communication network operation and maintenance system is divided into interaction layer, intelligent analysis layer and data interface layer. Each layer contains several independent agents. The interface layer can push the interfaces such as the operation and maintenance problem quick query engine, graph generation and human-machine dialogue to the immersive interactive terminal, and can also realize the restful web full authorization access interface for all the result data of the operation and maintenance multi-agent decision-making.

The solution of complex problems in the operation and maintenance of large-scale communication networks requires the group intelligence of professionals, organizations and system cooperation. The work at all levels of operation and maintenance is reasonably divided and decoupled, and different agents are assigned different responsibilities. Each operation and maintenance agent has a clear goal. By sensing its internal state and environmental information in its environment, it communicates with other agents, improves its reasoning and control capabilities, and completes problem solving[5]. The operation and maintenance agent can also develop or derive new agents along its own logic according to its own functions and method iterations. At the same time, according to different business scenarios, the information content and process steps of multi-agent collaborative processing are summarized, recorded and updated.

The communication and cooperation among the communication network operation and maintenance agents can expand new planning or solving methods to deal with incomplete and uncertain knowledge, improve the ability of each operation and maintenance agent, and apply to reasoning, planning, decision-making, collaborative control and other communication network operation and maintenance problems.

4. Key technology path of multi-agent communication network operation and maintenance

The rapid solution of the communication network operation and maintenance problems requires accurate and real-time perception of the physical space of the operation and maintenance personnel, and timely understanding and meeting the information needs of the operation and maintenance personnel. Each demand of the operation and maintenance personnel is decomposed into a series of intelligent operation and maintenance interactive tasks, information is received from multiple channels, multi-dimensional operation and maintenance data sources are analyzed based on the operation and maintenance knowledge map and knowledge base, and finally the processing results of the agent are output and fed back to the operation and maintenance personnel, so as to achieve comprehensive daily operation and maintenance support and fault emergency treatment.

4.1. Multi-channel interactive agent

Multi channel interaction is a human-computer interaction mode that uses vision, language, gesture and other channels to communicate with computers, and follows the natural interaction principle of "human centered". A channel is a variety of communication methods covering the user's expressing intention, performing actions or perceiving feedback information. Multi channel interaction is applied in the field of network operation and maintenance. Through augmented reality glasses, mobile phones, pads and other intelligent terminals, the information from interactive channels such as images and voice is integrated to conduct human-machine dialogue, improve the naturalness and interactivity of interaction, and efficiently assist the execution of operation and maintenance work.

The key of multi-channel interaction is to understand the user's intention through multi-channel information fusion agent. The accuracy of intention understanding depends on the accuracy of context perception in the interaction process. Therefore, the sensitivity of context aware agents is an important way to improve the intelligence of human-computer multi-channel interaction. Whether the context information can really play a role in the computing process depends on two aspects: one is to extract and form the context [6] from the interactive environment; But coordinates and controls communication between various contexts and higher layers. The context is limited to the scope of operation and maintenance to reduce the complexity of perception.

The context information comes from the operation and maintenance task experience and the internal operation and maintenance knowledge base. The intelligent operation and maintenance interactive task of the communication network mainly includes the acquisition of the operation and maintenance environment and the communication resource status, the operation and maintenance knowledge learning, and the operation and maintenance event handling. An effective operation and maintenance domain context awareness model can eliminate ambiguity and improve the recognition rate.
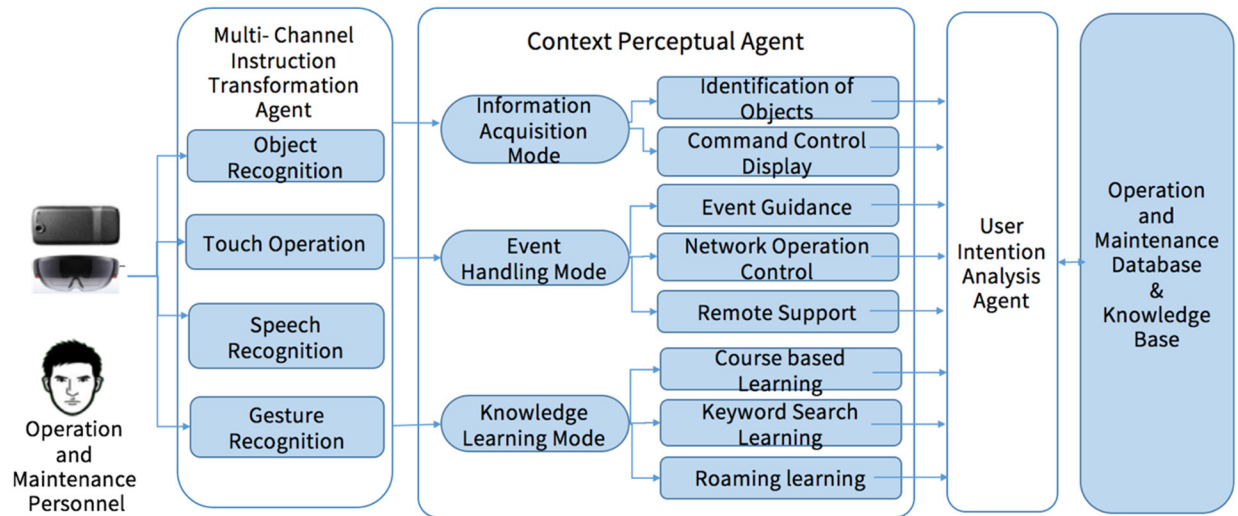
Figure 2. Multi-channel instruction transformation agent

User, system, input, output and interaction information are the interaction elements of the basic model of intelligent interaction[8]. By perceiving and recording the interaction mode and state, the interaction context is formed, and reasoning, decision-making and calculation are automatically carried out to improve the intelligence of interaction and achieve the purpose of efficient interaction. Any action of people and equipment will affect the interaction state, and the interaction mode and state will help both parties understand the interaction information, record the interaction state, and form a coherent process of operation and maintenance. Operation and maintenance personnel generate interactive information through multi-channel input. The equipment obtains interactive information, judges it as information acquisition, event disposal, knowledge learning scenario pattern, identifies the intention of the operation and maintenance personnel, generates operation and maintenance auxiliary prompt information through the operation and maintenance database and knowledge base, and feeds it back to the operation and maintenance personnel.

4.2. Multi-dimensional analysis agent

The multi-dimensional analysis system of communication network operation and maintenance covers the collection, transmission and storage of observable information, intelligent analysis, visual interaction, internal control. Distributed operation among functional modules and agents, and information collaborative processing.
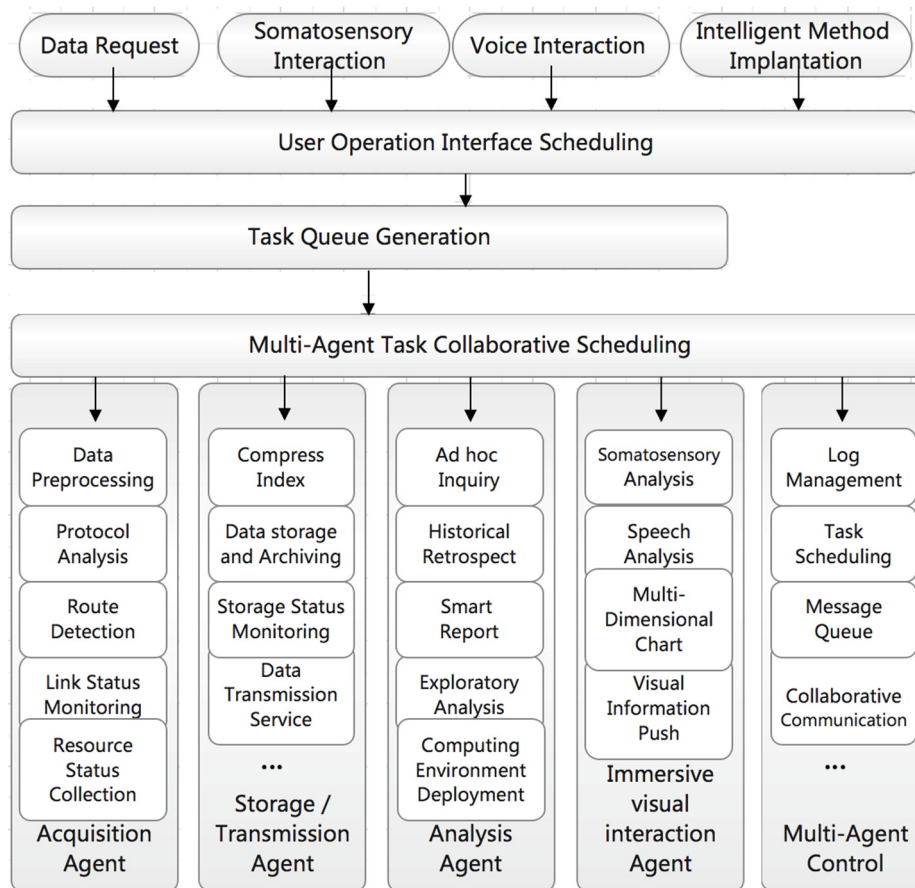
Figure 3. Multi-agent linkage framework of communication network operation and maintenance

On the one hand, the effect of multi-dimensional analysis depends on the accuracy of capturing and understanding the external environment information, on the other hand, it depends on the accuracy of collaborative processing results of task instructions by internal multi-agent. Therefore, the operation and maintenance of multi-agent communication network is not only a tool for passively executing information processing, but also needs to establish a good cooperative relationship between multi-agents and between agents and operation and maintenance personnel.

The original communication network operation and maintenance data are stored dispersedly, and there is no effective correlation analysis on the operation and maintenance related knowledge. The daily and emergency operation and maintenance work has accumulated a large amount of data, which the personnel need to consult frequently when studying and working. Multidimensional intelligent analysis relies on operation and maintenance knowledge map, knowledge base and operation and maintenance event analysis agent to solve the logic calculation process of the underlying analysis and disposal.

The operation and maintenance knowledge map can sort out the concepts, entities, attributes and relationships of the operation and maintenance field, and form the ontology database of the operation and maintenance field by using the existing communication resources, various materials in the network management operation and maintenance system, network historical status, fault rules and knowledge base data. Based on the operation and maintenance domain ontology library[9], it can automatically generate a knowledge map for the concepts of operation and maintenance, equipment operation and use, fault diagnosis methods, disposal processes and other topics, so as to facilitate the operation and maintenance personnel to quickly grasp the overall and detailed knowledge structure. Operation and maintenance personnel acquire operation and maintenance knowledge through intelligent terminals, providing a panoramic and visual domain knowledge learning framework and a convenient information query channel.

The operation and maintenance knowledge base gathers communication network data sources, including communication asset and equipment management, data access of communication network and operation and maintenance management

system, and service-oriented transformation of data interface of each system; Obtain ubiquitous operation and maintenance knowledge from massive data, search engines, technical forums, etc; The front data acquisition support node meets other data requirements of multi-agent decision-making. Multidimensional data is stored in multiple modes such as file, relational database, NoSQL database and graph database, and is analyzed and calculated according to the retrieval requirements of the upper layer.

5. Concluding remarks

Communication network operation and maintenance is an important basic guarantee for digital transformation. It needs to realize the transformation from black box to white box and then to transparency, clearly perceive the operation status of each physical / logical unit such as information and communication network equipment, links, services, etc., and quickly solve unpredictable problems. Relying on multi-agent technology and multi-channel interaction technology, research multi-intelligent operation and maintenance methods, aiming at the implementation of application scenarios, explore the solutions to the difficulties faced by operation and maintenance, and provide effective decision-making auxiliary tools and means for operation and maintenance personnel to "know the past, control the present, and insight into the future", so as to realize the leapfrog development of operation and maintenance.

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