Journal of Electronics and Information Science (2023)
Clausius Scientific Press, Canada
DOI: 10.23977/jeis.2023.080403
ISSN 2371-9524 Vol. 8 Num. 4

# *Research on the Application of Internet of Things Private Cloud Platform in Air Material Support*

**Hao Li, Yan Liu*, Li Qiao, Jing Guo**

*Air Force Logistics Academy, Xuzhou, China*
**Corresponding author*

***Keywords:*** Air material support, Internet of Things, private cloud, informationization

***Abstract:*** Information technology has triggered profound changes in modern warfare, and the Internet of Things is the inevitable direction of the development of air material security informationization. With the current problems such as low efficiency of air material support, untimeliness of accessing to support information and slow speed of response to support, this paper combines the development of information technology such as private cloud, Internet of Things and other information technology and the actual business needs of air material support. And the article achieves the overall design and demonstration of private cloud based on Internet of Things platform for air material support. On the basis of the existing network conditions, this paper plans the platform architecture and constructs private cloud service system, and consequently it achieves real-time perception, command and control, scientific decision-making of the whole process and elements of the activities of the air material support. The development of equipment guarantee informationization and the change of equipment guarantee mode are supported strongly.

## 1. Introduction

In recent years, with the speed of new equipment development and installation, the proportion of air material reserves and turnover frequency have increased significantly, which has put forward higher standards and requirements for air material support capability. The use of information technology means such as Internet of Things for intelligent and scientific management of air material to improve the effectiveness of air material support is the key research direction and proposition of the current air material system [1]. The current state of air material support's informationization has established a network infrastructure that allows for real-time information transmission across all time and territory through the use of broadband, 4/5G networks, and BeiDou satellite short message technology. However, the current information transmission is limited to air material receipt and delivery, as well as inventory quantity, which does not allow for comprehensive and all-encompassing information management. This paper examines the application of cloud computing [2], private cloud, and IoT technology [3] in the field of air material support, and details the construction and implementation process of an IoT platform for air material support using private cloud technology, so as to provide powerful support for the construction of air material support informationization and the change of air material support mode.

## 2. Cloud computing, Private Clouds and IoT Platforms

Cloud computing has emerged as one of the most important ways of providing computing resources today, evolving from the development of distributed computing. Its architecture comprises three layers: infrastructure, platform, and application. These layers correspond to the subservices in the cloud computing collection, namely Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) [1]. IaaS provides virtual infrastructure resources in the form of services, PaaS provides application service engines, and SaaS enables users to rent software on demand through the network.

A private cloud is a cloud computing service that operates within an organization's firewall and is not accessible to the public. The organization can configure security policies specific to its needs to ensure the security and quality of its data. Private clouds offer dynamic and flexible resource allocation, which reduces the complexity of IT architecture and integrates and standardizes various IT resources. This results in reduced maintenance costs, thanks to their strong controllability and scalability, compared to traditional data centers.

An IoT platform [4] is a comprehensive software and hardware solution that enables the centralized management of a diverse range of IoT devices with varying communication methods. Given the increasing importance of big data and cloud computing, the IoT platform has emerged as a critical component in the future development of IoT. This platform leverages sensors to collect data, transmits it to the cloud, and stores it for analysis. Based on this analysis, the platform can execute specific tasks and present the results to users in a visual format [5].

## 3. Features of Private Cloud Model of Air Material Support IoT Platform

First, adaptive networking. Upon opening the air material support nodes, the IoT sensors equipped with Microcontroller Units (MCUs) utilize Bluetooth, ZigBee, and other connection methods to swiftly establish a sensor network and gain access to the LAN gateway, thus forming a local area security network. Once the safeguard nodes have accessed the private network, each air material safeguard node collectively forms a sub-node of the private cloud platform, enabling it to receive unified commands and dispatches from the command and control platform; secondly, the private cloud platform ensures high levels of data security and confidentiality, while also providing stable and reliable service. It achieves this by utilizing a private network and communication interface to offer private cloud resource services to air material support nodes and command institutions. This approach ensures that the nodes' information is protected against attacks and theft. Additionally, the cloud strictly monitors and controls the data storage location and mode; third, the deployment of nodes is effortless and can save software and hardware resources. A significant amount of data calculations will be sent to the private cloud platform for unified processing. The air material support nodes do not require complex storage equipment, servers, or software platforms. This reduces the pressure of local data processing, the difficulty of hardware deployment, and facilitates agile security during wartime. Additionally, upgrading and maintaining the system is convenient and does not affect the security process. Software upgrades and maintenance are carried out in the private cloud platform, and the MCU of each node can also be upgraded OTA. The upgrade and maintenance process is transparent to the security nodes and does not affect the work of air material.

## 4. Private Cloud-based IoT Platform Construction for Air Material Support

### 4.1 Private Cloud-based IoT Platform Architecture for Air Material Support

The architecture of the private cloud-based IoT platform for air material support primarily comprises private cloud services and IoT nodes for air material support. Figure 1 depicts the overall architecture of the platform [6].

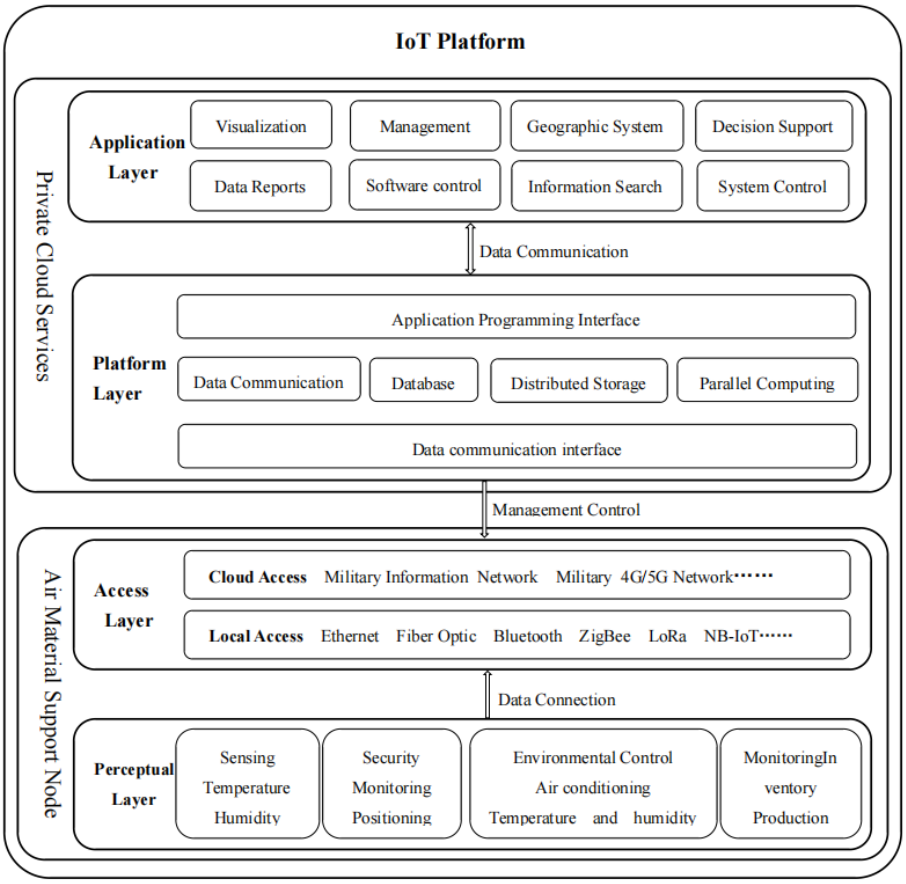


Figure 1: Private cloud-based air material support IoT platform architecture diagram.

The air material support node serves as the infrastructure of the IoT platform, responsible for the access, sensing, and data transmission of the IoT terminal. In the sensing layer, the MCU and sensors detect environmental data of the air material safeguard nodes in real-time and execute control commands based on preset rules to enable automatic control of IoT devices. The MCU's networking function quickly connects the independent sensors into a sensor network, establishing corresponding air material safeguard nodes. These nodes are accessed through suitable cloud access methods to enable private cloud services [7].

The private cloud service's platform layer enables data storage, computing, and virtualization services through the use of MQTT (Message Queuing Telemetry Transport) and RESTful/HTTP protocols [8]. It provides data communication interface and management control for air material support nodes, while also offering application interface and data communication to the application layer. The application layer, built on top of the basic hardware and data services provided by the lower layer, allows for the visualization of air material support resources, security resource management, and decision support. The application layer is capable of remotely monitoring the sensor network of air material support nodes, enabling real-time access to security resources and allocation of resources among nodes. Additionally, it provides decision support for air material support based on historical data and security situation information at the platform layer.

## 4.2 Construction of Private Cloud Service System for Aerospace Material Assurance IoT Platform

Open source IoT technology can be a solution for specific network or local area network applications that require customization. It can alleviate the strong dependence on the Internet for cloud platforms and reduce the high R&D costs for self-research platforms. This technology provides one-stop access, development, and deployment services, and supports MCU low-code flexible development as well as rapid deployment of private cloud servers. The IoT platform private cloud services mainly include data communication, data storage, system management, and system services.

The Data Communication Subsystem is the foundation of Private Cloud Services. On one hand, it provides various communication formats and access modes for different IoT hardware, storing collected data in agreed formats in corresponding databases. On the other hand, it leverages WebSocket and other protocols to push real-time data to specified clients or execute instructions to control sensor operations. The Data Storage Subsystem adopts diverse storage strategies for heterogeneous data. Structured data such as user data, application data, device data, system log data, and device configurations are all stored using different storage strategies, a relational database is utilized to store and efficiently access structured data. For unstructured data collected by sensors, a temporal database is used for compressed storage, real-time calculation [9], and efficient reading and writing. The management and system service subsystem is designed with B/S architecture, providing data analysis, device management, and application interfaces to achieve coordinated execution among communication, management, storage, and application services. This reduces the coupling between system functions and improves system scalability [10]. The technical scheme of the private cloud service of the IoT cloud platform is outlined in Table 1.

Table 1: IoT platform private cloud service technology scheme.

| Platform Subsystem | Function | Technical Solutions |
|---|---|---|
| Data communication subsystem | Device Access | MQTT/HTTP/Modbus |
| | Real-time data push | WebSocket/WebHook |
| | Communication Service Cluster | Nginx |
| Data Storage Subsystem | Relational Databases | Damon |
| | Time Series Database | InfluxDb |
| Management Subsystem | Backend Framework | ASP.NET core |
| | Front-end Framework | Bootstrap |
| System Services | Data Analysis and Visualization | Grafana |
| | Location Services | ArcGIS |
| | Open Interface | RESTful |

## 5. Private Cloud-based Air Material Support IOT Platform Application Realization

The primary objective of air material support is to provide aviation equipment and spare parts that meet quality standards and ensure aircraft are in good condition. Guarantee activities encompass the raising, storage, supply, management, and repair of aviation equipment, as well as the personnel, equipment, and suppliers involved in these activities. By utilizing an IoT sensor network, the IoT platform collects information related to air material support and uploads it to the private cloud platform. This improves real-time information and the effective utilization of information, allowing command authorities to fully understand the existing security situation and carry out dynamic security management and scientific deployment of security resources. The topology of the air material support IOT platform based on private cloud is illustrated in Figure 2.

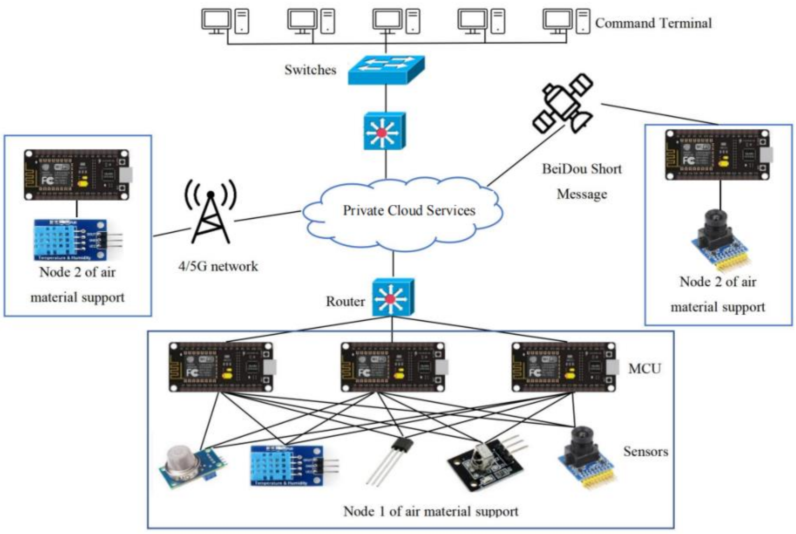


Figure 2: Topology diagram of private cloud-based IoT platform for air material support.

### 5.1 Agile Deployment of Air Material Support Nodes

The air material support nodes, which are part of a private cloud-based IoT platform, create an adaptive network that can be quickly deployed in a local area network. These nodes, numbered 1 through n, collect various types of data through sensors. The sensors work together with microprocessor units to either process simple data independently or transmit the data to LAN gateways, such as Bluetooth and LoRa gateways, to enable local networking of sensors. When cloud access is available, the local gateways upload the data to the private cloud platform for unified data collection, analysis, and processing. The LAN and cloud platforms can issue instructions, either automatically or manually, to operate the microcontroller for controlling the equipment and resources of air material support nodes. This allows for information sharing and joint security among multiple nodes.

### 5.2 Dynamic Management of Air Material Support Resources

In the air material support private cloud-based IoT platform, each node has intelligent sensing and network control capabilities and transfers data storage and processing to the cloud. The command node can obtain real-time inventory information such as quantity, quality, location, and storage volume of each security node, as well as information on security personnel, equipment, and other security capacities. The cloud computing platform processes this data to make decisions on resource allocation, such as equipment, personnel, and time, optimizing the allocation of security resources to reduce operating costs, resource losses, guarantee security, and realize intelligent, accurate, scientific and efficient security of air material, scientific and efficient guarantee. For instance, if node A is short of parts during the air material support activity, the platform can query the system's inventory to check if there are enough parts to meet the demand. If the inventory is insufficient, the platform can order from the manufacturer. On the other hand, if the inventory meets the demand, the platform can generate transfer instructions and evaluate the optimal air material support node that can be transferred. Figure 3 illustrates the process of material allocation using the private cloud air material support IoT platform.

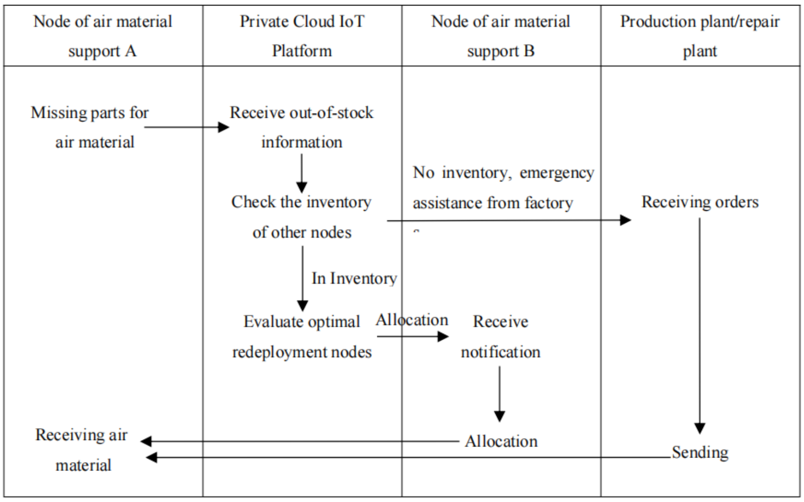


Figure 3: Private cloud-based IoT platform for air material allocation process.

## 5.3 Real-time Monitoring of air Material Support Process

In the context of air material support, the management information system has been expanded through the integration of an IOT platform. This expansion has enabled the collection of more detailed information and allows for real-time monitoring of the security status of each link. For instance, temperature and humidity sensors installed in nodes of air material support collect data and transmit it to the cloud platform. When the collected data exceeds the preset value, the cloud platform sends control instructions to automatically start the air conditioning equipment. This cloud-based security model runs throughout the entire process of air material support work, such as the capability of tracking suppliers' orders, monitoring production and repair progress, and real-time positioning of logistics and security equipment. Additionally, it can sense the status of air material storage in real-time. The MCU-based sensor network is especially useful in tracking the status of in-use air materials, enabling fault diagnosis, life warning, and other functions. This improves the efficiency of air material assurance and ensures the rapid recovery of the aircraft to its original condition.

## 5.4 Security Protection of Air Material Support Information

The support data of air material is related to the flight safety of aircraft. To ensure the security of platform data transmission, the cloud platform utilizes data encryption transmission on the security line. The access identity authentication and access security policy of the platform can deploy the access rights of different roles to ensure the security of data access. By utilizing the guarantee mode based on the cloud platform, the storage of aviation material guarantee data in each node is transformed into distributed storage in the cloud, which reduces the risk of data loss due to the destruction of security nodes and improves the disaster recovery capability of the security information. The implementation of a unified security policy and upgrade maintenance on a cloud platform has proven to be more effective in protecting data and reducing the risk of information security breaches in aviation materials, compared to traditional self-protection methods employed by individual security nodes.

## 6. Conclusion

The integration of Internet of Things and cloud computing technology in aviation material guarantee processes will revolutionize the traditional single-point guarantee process. This integration will facilitate the seamless joint guarantee of multiple nodes, leading to a significant improvement in the efficiency of aviation materials guarantee. Additionally, the automatic acquisition, transmission, and real-time monitoring of aviation materials resources and guarantee information will further promote the informationization, intelligence, and precision of aviation materials guarantee activities. This will enable scientific decision-making, reasonable deployment, and fine management, ultimately achieving the goal of scientific decision-making, rational allocation, and fine management.

In the next step, infrastructure construction such as private cloud service platform should be strengthened, while considering the application of cutting-edge technologies such as 5G and artificial intelligence to the Internet of Things, so as to achieve more efficient and accurate support for security decisions and further enhance the intelligence, informatization and scientific level of aviation material security.

## References

*[1] Ou Y. X., Xu Y. Y, Mao Y. S, et al. (2023). A Secure Retrieval Scheme for Remote Sensing Images on Cloud Computing and Blockchain Platform. Journal of Electronics and Information, 45(3), 856-864.*

*[2] Hayes B. (2008). Cloud Computing. Communications of the Acm, 51(7), 9-11.*

*[3] Kevin A. (2009). That 'Internet of Things' Thing. 8-13.*

*[4] Sun Q. B., Liu J., Li Y., et al. (2010). The Internet of Things: A Review of Concepts, Architectures and Key Technologies. Journal of Beijing University of Posts and Telecommunications, 33(3), 1-9.*

*[5] Kim Jaewoo, Lee Jaiyong, Kim Jaeho and Yun Jaeseok. (2014). M2M Service Platforms: Survey, Issues, and Enabling Technologies. IEEE Communications Surveys & Tutorials, 16(1), 61-76.*

*[6] Ruan X. J. (2018). Design and Implementation of a Private IoT Cloud Platform for Enterprises. Guangdong: Jinan University, 21-30.*

*[7] Mi Q. L., Xu T. X., Liu Y., et al. (2013). The "Cloud Security" Model of Naval Gun Equipment based on INTERNET of Things. Science and Technology Herald, 31(10), 58-61.*

*[8] Zhang X. Y., Huang Y., et al. (2023). Application of Cloud Computing and INTERNET of Things Technology in Joint Service Security. Military Automation, 42(1), 47-50, 68.*

*[9] Qin Y., Sheng Q. Z., Falkner N. J. G., et al. (2016). When Things Matter: a Survey on Data-centric Internet of Things. Journal of Network & Computer Applications, 64, 137-153.*

*[10] Zhai J. H. (2020). Design and Implementation of Data Collection Platform for Internet of Things. Shaanxi: Xi'an University of Electronic Science and Technology, 15-24.*