International Journal of Computational Intelligence Systems and Applications. Volume 10, Issue 1, (2023) 1-7
http://www.cayley-nielson.com/ijcisa/

Research on Access of Heterogeneous Sensing Devices in Agricultural Internet of Things

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Abstract

With the rapid development of the application of the agricultural Internet of Things, the characteristics of multi-source and heterogeneity of agricultural data are increasingly obvious. Due to the different types and transmission modes of heterogeneous sensing data, it is difficult to share data and service is limited. Therefore, this paper uses ontology technology to uniformly describe the semantic of heterogeneous sensing device resources, uses unified access view to design the application service interface for heterogeneous devices, realizes the sharing of heterogeneous data, and solves the access problem of heterogeneous sensing devices in agricultural Internet of Things applications. Finally, this paper uses the micro Internet of Things platform to test the access performance. The comparison shows that this scheme has obvious advantages in the time cost of heterogeneous data access, and can reduce the complexity of application implementation, and improve the ability of agricultural Internet of Things application services.

Keywords: Agricultural Internet of Things, Heterogeneous, Ontology, Semantics, Access.

1. Introduction

With the rapid development and wide application of the Internet of Things technology, the number of Internet of Things terminal connections has exploded, and the heterogeneity of access devices is obvious. Taking the application of agricultural Internet of Things as an example, the application involves various fields and links of agricultural production such as paddy fields, orchards, and settings. The access equipment covers the application links such as climate monitoring, soil monitoring, food sourcing, and agricultural logistics. Due to the diversity of data types and protocols of access devices, data sharing and reuse between applications cannot be realized, resulting in a large number of "information islands". Therefore, in the application of the agricultural Internet of Things, the fusion of multi-source heterogeneous data has become one of the fundamental issues of the application of the Internet of Things. [1-3]

In order to realize the resource sharing of heterogeneous data in the agricultural Internet of Things and put forward the service requirements of the agricultural Internet of Things with diverse needs, it is particularly important to uniformly describe the heterogeneous sensing devices in the agricultural Internet of Things and simplify the access mode of heterogeneous data. Based on this, in view of the different description methods of heterogeneous data in the agricultural Internet of Things, this paper starts with heterogeneous equipment, uses ontology technology to establish a resource description model, and designs a unified service view interface for heterogeneous data. It aims to realize the sharing of heterogeneous agricultural data, improve the access efficiency of heterogeneous data, and improve the combined service capability of agricultural Internet of Things applications.

2. State of the art

In recent years, scholars have carried out research on the unified access of heterogeneous devices in the Internet of Things and proposed relevant solutions. For example, in document [4], the semantic and Internet of Things are integrated, and the standardization of web semantics is used to integrate the semantic of Internet of Things resource discovery, interoperability, service and universality, and a unified description model of resources is built. Document [5] proposed a unified description model of equipment resources, combined with the intelligent office system based on the Internet of Things, to achieve semantic mutual understanding of heterogeneous equipment resources, and to achieve data sharing of heterogeneous resources. Literature [6] proposes a knowledge-driven method called context-aware sensor configuration model, which uses semantics to describe Internet of Things resources to simplify the process of configuring Internet of Things middleware platform, so that data consumers, especially non-technical personnel, can easily retrieve the data they need. From the perspective of resource utilization, document [7] proposes an ontology-based resource reconstruction method, and uses Web ontology language to build an intelligent equipment ontology describing intelligent manufacturing resources. The relational database is associated with the ontology of the manufacturing system to map manufacturing resources to model instances. Literature [8] provides unified access, control and management for heterogeneous sensing devices in the Internet of Things based on edge computing. Literature [9] proposes an integrated access gateway, which provides standard interfaces for supporting various applications in the home environment, from field configuration to node and service access. The sensor, camera and other devices in the home gateway are accessed through the API provided by the Internet of Things platform. The gateway provides users with great flexibility in configuring and deploying home automation networks, and supports multi-sensor networks. Document [10] designed a multi interface gateway for the Internet of Things, using Arduino to integrate multiple communication interface modules such as Wi Fi, ZigBee, Bluetooth, and infrared, which can automatically control heterogeneous devices such as traditional smart appliances.

The existing research can find that the heterogeneous data description based on the semantic web solves the access problem of heterogeneous data in the Internet of Things, but there are the following problems: first, the access of heterogeneous data is complex, and the application research of agricultural Internet of Things is less. Second, the single interface supporting the application services of the Internet of Things cannot meet the demand for service diversity in the agricultural Internet of Things. Therefore, in view of the shortcomings of the above research, according to the characteristics of heterogeneous equipment in the agricultural Internet of Things, this paper realizes the device-based heterogeneous resource description method, and realizes the resource sharing of heterogeneous data; At the same time, design the service delivery interface based on the device model to reduce the difficulty of heterogeneous data access.

3. Heterogeneous resource access method

3.1. Problem Analysis

The application of the agricultural Internet of Things involves various fields of agricultural production, such as farmland, aquatic products, facilities, logistics, etc., with a wide variety of sensors and various forms of monitoring data. For example, temperature and humidity sensors, light sensors, soil sensors and carbon dioxide sensors used to monitor the agricultural growth environment, positioning sensors, speed sensors and direction sensors used for agricultural product logistics, and water depth sensors, water temperature sensors, dissolved oxygen sensors and Ph value sensors used for aquaculture. The data types and data transmission methods detected by different sensors are quite different. In view of the

characteristics of a large number of heterogeneous agricultural data access and the convenience of the development of agricultural Internet of Things application system, the following problems need to be solved:

(1) Establish a unified access standard for agricultural Internet of Things platforms to improve the efficiency of application system development.

(2) Shield the differences of heterogeneous sensing devices, and now share data. Improve the utilization of heterogeneous device resources. For example, unify the interaction mode, data format and communication mode of heterogeneous devices.

(3) The IoT equipment needs to be continuously upgraded and improved, and the re-adaptation results in complex access and high maintenance costs.

Therefore, based on ontology technology, this paper proposes a data access method of agricultural Internet of Things based on heterogeneous sensing devices. Semantic abstraction from accessing heterogeneous resources, shielding the differences between data, and using GraphQL technology to build the API interface of agricultural Internet of Things services to realize the sharing of heterogeneous data.

A large amount of heterogeneous data in the agricultural Internet of Things requires abstraction to achieve data sharing and reuse. The resource abstraction process in this article is shown in Figure 1.

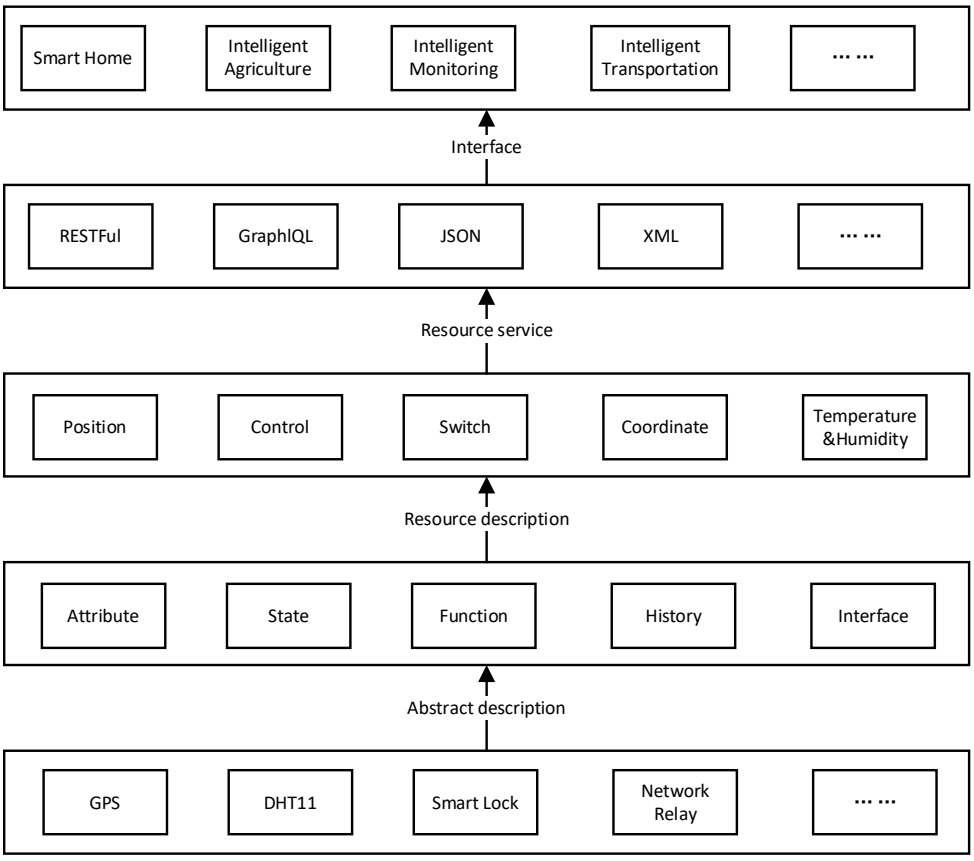

Fig. 1. System abstract model

3.2. Model establishment

Ontology is a formal specification of a conceptual model. By conceptualizing and unifying the knowledge domain, the semantic relationship between concepts is clarified, and the problem of knowledge sharing and interoperability in the domain is solved.

In the application of the agricultural Internet of Things, with the increasing number of devices connected to the Internet of Things, in order to solve the universality of the device model in the agricultural Internet of Things application system, this paper uses the classification method to establish the ontology model of the agricultural Internet of Things equipment, uses five meta-languages to standardize, and the ontology is represented by a 5-tuple, as follows:

$$O = (C, I, R, F, A) \tag{1}$$

Where, C is the collection of objects, representing classes or concepts; I is the instanced object; R represents the mutual relationship between objects, such as inclusion relationship(part-of), instantiation relationship(instance-of), inheritance relationship(kind-of) and attribute relationship(attribute-of); A stands for axiom(Axiom); F is a function, that is, the reasoning process, defined as:

$$F = C_1 \times C_2 \times \cdots \times C_{n-1} \to C_n \tag{2}$$

On the basis of the above ontology model, the characteristics of heterogeneous data of agricultural monitoring equipment are analyzed, the heterogeneous access equipment is abstractly modeled, and the resource-sharing knowledge model is established considering the attributes, states, interfaces and other factors of heterogeneous equipment. The device resource model is shown in Figure 2.

(1) The equipment attribute information describes the basic attributes of the equipment such as identification, name, type, parameter, and other attributes unique from other fields. The equipment is identified according to the combination of the equipment type, model, and number.

(2) State information, divided into public state and private state, is used to describe the parameter value of the device at a certain time. For example, the current value, location and time of the sensor.

(3) Interface information is used to provide access interfaces to the Internet of Things, including interface types and parameters.

(4) Historical information, indicating the data uploaded by the device and the operations completed.

(5) Function information, describing the category and operation mode of the equipment.

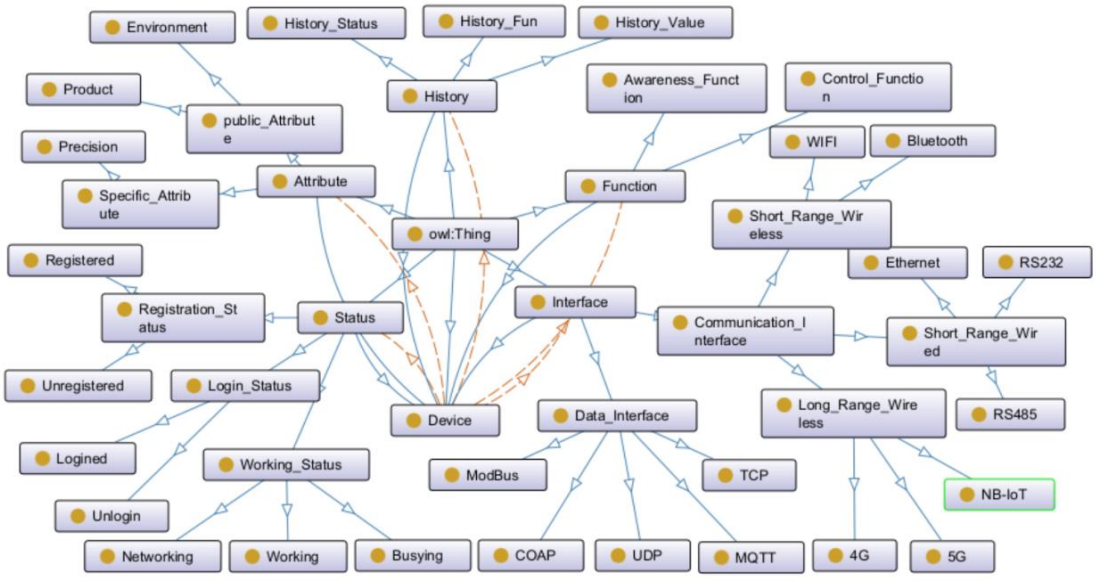

Fig. 2. Device resource description.

Taking the temperature sensor as an example, the resource description model in this paper is shown in Figure 3.

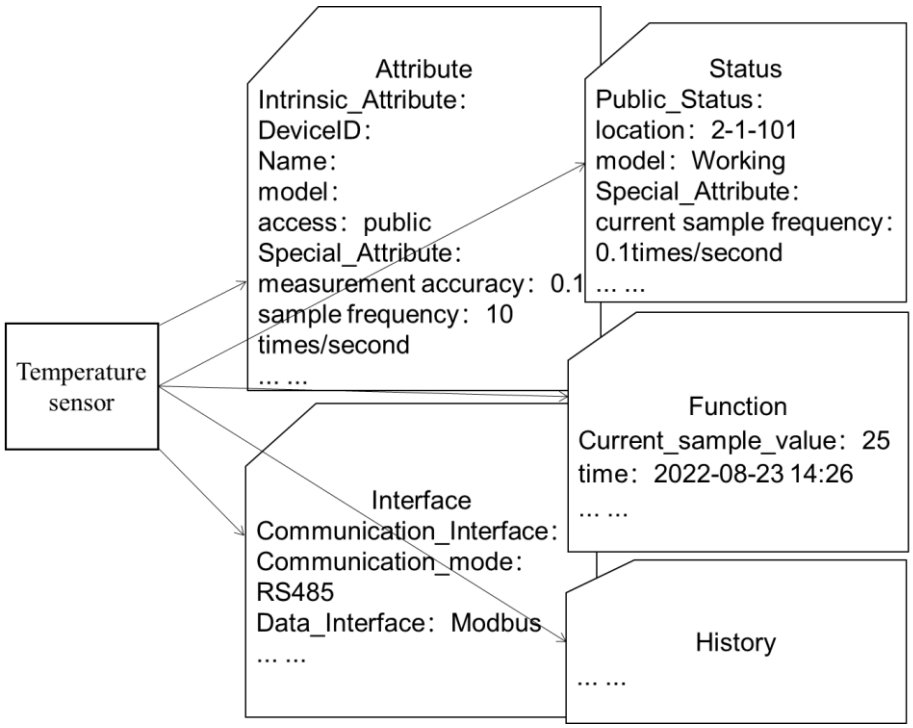

Fig. 3. Recognition rates in ORL datasets under different dimensions

3.3. Resource service based on GraphQL

GraphQL is an API standard developed by Facebook, which is simpler and more efficient than other Web Service solutions. Users use the HTTP protocol to obtain resources, and define Query to obtain resource data in the device model, such as device status, collected data, etc; Mutation users can change the status and control commands of resources by writing or publishing values; Users subscribe to the corresponding data source through the Websock protocol and GraphQL subscription operation, and complete the real-time push of sensing data according to the application scenario and requirements. Schema is an abstract collection of metadata of device information, describes the format and content of device resources, and realizes reliable data exchange with the upper layer.

4. Performance Evaluation

The agricultural Internet of Things platform needs to access a large number of heterogeneous devices to adapt to a variety of application scenarios, and a large number of data access will affect the performance of the application platform. Therefore, this paper uses the micro Internet of Things platform to access different sensor devices to test the time cost under different data access volumes, and compares it with the SDK access scheme provided by the Internet of Things platform. The test data uses common sensors in agricultural Internet of Things applications, such as temperature and humidity sensor, light sensor, soil temperature and humidity sensor, carbon dioxide concentration sensor, wind speed and direction sensor, pressure sensor, rainfall sensor, GPS sensor, speed sensor, camera, etc. In order to test the performance of

the scheme proposed in this paper, various data collected by the Internet of Things platform are fused and sorted. The time cost under different access data volumes is shown in Figure 4.

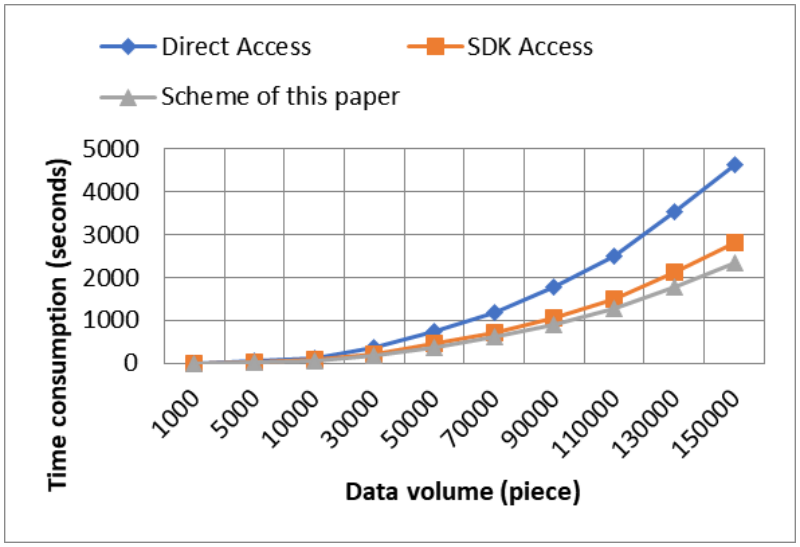

Fig. 4. Time consumption under three different schemes

It can be seen from the figure that with the increase of the amount of transmitted data, the advantages of this scheme over the other two schemes gradually appear. Because the direct access method does not support the modeling of the device model, the access time increases rapidly when the amount of access data increases due to the impact of the program time complexity; Compared to the micro Internet of Things platform SDK access method, when the amount of access data is large, the access efficiency of this scheme is gradually apparent, mainly because heterogeneous resource categories are related to the access method, and access to complex data affects system performance. According to test statistics, the access efficiency of this scheme is 46.64% and 14.88% higher than that of direct access and platform SDK access schemes. At the same time, in the development of agricultural Internet of Things application, the complexity of heterogeneous data access is reduced, the resource sharing of heterogeneous data is effectively realized, and the feasibility of this method is verified.

5. Conclusions

In order to solve the access problem of heterogeneous equipment resources in the agricultural Internet of Things, this paper analyzes the characteristics of heterogeneous equipment in agricultural information monitoring, establishes a resource description model based on ontology technology, and designs the Internet of Things service interface based on GraphQL to meet the personalized service requirements of the agricultural Internet of Things, providing a unified access view for the development of agricultural Internet of Things applications. The following research conclusions were obtained.

(1) Through the resource description model of heterogeneous equipment, knowledge sharing in the field of agricultural knowledge can be realized, and the problem of resource access of heterogeneous equipment can be solved.

(2) Designing an IoT service interface based on GraphQL to provide a unified access view for agricultural IoT application development can simplify the difficulty of agricultural IoT application systems.

Heterogeneous equipment access and application service provision are one of the key issues in the

application of the Internet of Things. In the follow-up research, we will study the differences and commonalities of the Internet of Things access equipment and different scenarios of the application system, improve the access model of heterogeneous equipment in the application of the agricultural Internet of Things, and study the universal access methods.

Acknowledgement

This work was supported by the Key Scientific Research Projects of Colleges and Universities in Henan Province(No.20A520027 and 18B520026).

References

[1] Zheng Jiye. Research on Application Architecture and Key Technologys of Agricultural Internet of Things. Chinese Academy of Agricultural Sciences, 2016.

[2] Chen Dong. Design and Implementation of Multi-source and Heterogeneous Agricultural Sensor Data Access System. Shandong Agricultural University, 2014.

[3] Gao Aman, Zhang Shuai, etc. Research on ontology-based modeling and management of IoT equipment resources. China Management Informationization, 2018, 21(10):153-154.

[4] Vandana C P, Chikkamannur A A. Semantic ontology based IoT-resource description. International Journal of Advanced Networking and Applications, 2019, 11(1): 4184-4189.

[5] Wang S, Hou Y, Gao F, et al. Ontology-based resource description model for internet of things. 2016 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery (CyberC). IEEE, 2016: 105-108.

[6] Perera C, Vasilakos A V. A knowledge-based resource discovery for Internet of Things. Knowledge-Based Systems, 2016, 109: 122-136.

[7] Wan J, Yin B, Li D, et al. An ontology-based resource reconfiguration method for manufacturing cyber-physical systems. IEEE/ASME Transactions on Mechatronics, 2018, 23(6): 2537-2546.

[8] Lan Lina. Research on Internet of Things Resource Management and Service Key Technology.Beijing University of Posts and Telecommunications, 2019.

[9] Ding F, Song A, Tong E, et al. A smart gateway architecture for improving efficiency of home network applications. Journal of Sensors, 2016, 2016.

[10] Chang C T, Chang C Y, Martinez R D B, et al. An IoT multi-interface gateway for building a smart space. Open Journal of Social Sciences, 2015, 3(07): 56.