Distributed Access Control of IOT Data on Agricultural Production

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Abstract
Agricultural data collection and open sharing are of great significance for promoting the interconnection, collaboration and scientific decision-making among agricultural departments. The agricultural IOT environment is composed of most resource-constrained devices with a decentralized topology. In the face of the intelligent and accurate data acquisition requirements of agricultural data, the traditional centralized access control model faces great challenges in the dynamic and distributed agricultural IOT environment. The rapid development of network technology and the development of agricultural Internet of things make the market broader. The realization of precise Control and collection of agricultural data is a research hot spot in the analysis of agricultural production data. This paper proposes a distributed access control model based on Internet of things data acquisition during crop growth, which can realize the research and analysis of accurate data collection according to the growth situation of crops. Finally, through comparison of experimental data, the accuracy of attribute-based distributed agricultural Internet of things data access control in the same experimental constraint is higher than that of traditional data access model. In the application environment of agricultural production process data acquisition, the distributed access control model based on attributes consumes less energy for obtaining the same target data.

Key words: Agricultural production, Internet of things, Access control

1. Introduction
Crop growth environment data collection refers to the collection of a large number of effective farmland environmental data and crop growth process data, in order to better study the impact of farmland environmental factors on crop growth and development. Data acquisition and analysis of crop growing environment is one of the typical applications of data acquisition technology in the field of agriculture [1]. Farmland environmental data mainly includes temperature, humidity, light intensity, wind speed, crop diseases and insect pests and other data information. The influence of these environmental factors on the yield and quality of crops is very significant. In the technical system of precision agriculture, the collection of crop growth environment data is the foundation, in most applications of precision agriculture, precise and detailed data of farmland environment should be used as data basis of biological growth and development [2]. Crop growth environment data acquisition technology is an important part of precision agriculture and the future development trend of modern agriculture.

The agricultural Internet of things can be interpreted as the use of a variety of sensor sensing devices to obtain the environmental state information, growth state information and meteorological information around agricultural production objects [3]. Similar to other IOT industry architectures, agricultural IOT architecture can also be divided into three main layers: information perception layer, communication network transmission layer and application service layer. Among them, the main task of the information perception layer is to be responsible for the collection of data. In the process of collecting, the data are collected through the induction
equipment, so as to achieve the accurate acquisition of specific agricultural related parameters. The transmission layer of the communication network is to transmit the information of the crops collected by the sensor device to the upper layer through the communication equipment in a wired or wireless way. The application service layer mainly processes and analyzes the collected data [4]. At the service layer, the data transmitted by the transport layer will be firstly fused and processed, and the redundant and outline data information will be presented to screen out the valuable data. Then through the predetermined rules to conduct a comprehensive analysis of the data, and finally get the corresponding decision control scheme, to control and guide the agricultural production management. The agricultural information level has been greatly improved through the real-time monitoring and rapid analysis and decision-making ability of the agricultural Internet of things. It provides strong technical support for the development of fine agriculture and smart agriculture, and effectively improves the level of agricultural management and production [5].

Distributed access control model based on crop attributes is used to obtain resources in the distributed Internet of things and realize intelligent control and accurate collection of crop growth data. The access right of the subject to the resource is expressed by access control policy. When the subject requests access to a resource, the acquisition equipment of the crop subject will conduct access assessment according to the growth attribute environment of the crop at that time and access control policy, to judge whether the subject has the access right to the growth data resource of the crop at this time. Traditional safety and control standards are established on the basis of introducing the trust concept of centralized trusted entities to realize unified centralized data collection, and then carry out unified analysis so that the final data does not necessarily meet the growth standards of all crops collected. In addition, the dynamic nature of IOT with a large number of devices will complicate the trust management of central entities and affect scalability. Aiming at the problems existing in the application of the above access control model in the Internet of things, we propose an access control model based on attribute distributed access control for the crop attribute information of agricultural Internet of things data, real-time monitoring and dynamic analysis of the growth information and growth environment of each crop. Distributed access control (DAC) model is a technology that successfully achieves agricultural data collection and sharing in a distributed anonymous environment where there may be malicious nodes without any intervention of trust intermediaries. In this paper, a new distributed access control model of agricultural Internet of things is constructed based on the distributed concept to overcome the defects of centralized management access control model in agricultural production environment.

Applications in agriculture compare the growth cycle of crops to the work-flow of traditional industries. The growth cycle of crops generally refers to the period from sowing to receiving. The problem of intelligent agriculture is the automatic process of precise data collection. When crop growth data is generated in the life cycle, the status and attributes of crops collected by the data collection are constantly changing, and the user's access to crops is also constantly changing. Due to the characteristics of crop growth cycle, in addition to correctly simulating the steps performed by access control, the rules and constraints followed in the control process should also be correctly simulated. Most of the traditional access controls models protect information and resources from the perspective of the system, and grant permissions and protect security are static, which makes the traditional access control model have defects in the application of the crop growth environment with dynamic characteristics. Therefore, it is necessary to study a life-cycle constrained access control model in crop environment.

2. Access Control Analyses

Access control technology that prevents unauthorized access to any resource so that the network resource can be used within a legal scope, role-based access control (RBAC) was proposed before professor Kevin Ashton first proposed the concept of the Internet of things, associating roles with a set of permissions that users would acquire based on the roles assigned to them by the system [6, 7]. With the development of the Internet of things, researchers use RBAC in the access control of the Internet of things, which can support the scalability of the Internet of things environment, cross-domain access control and heterogeneous devices and other characteristics [8]. However, as a static access control method, RBAC cannot preset the corresponding relationship between users and roles, roles and permissions in advance, so it cannot solve the problem of dynamic access of IOT nodes. The Attribute-based access control (ABAC) is a dynamic access control model, which is different from the corresponding relationship of roles and permissions that RBAC requires managers to preset in advance [9, 10]. The ABAC uses attributes as the key element of access control, and attributes are inherent in subjects and objects. Through entity attribute discovery mechanism, independent and complete attribute sets of subjects and objects can be mined. Therefore, there is no need for the administrator to input manually, and the attributes and permissions can be quickly mined through the automatic attribute-authority association relation discovery mechanism. The ABAC can not only solve the dynamic access problem of nodes in the Internet of things, but also perfectly solve the dynamic problem caused by node movement and data
access changes [11]. To realize access control in the Internet of things, not only the dynamic access of nodes, but also the variability of node attributes in the access process should be considered. The usage control (UCON) not only solves the problem of node dynamic access, but also considers two important attributes of continuity and variability in the process of access control [12, 13]. Continuity is reflected in that the access control can monitor the whole process of the requester's access to resources in real time and revoke the resource access rights at any time. Variability refers to the fact that attributes are variable in the process of access control [14, 15].

The above three access control models, RBAC, ABAC and UCON, are all made by a centralized authorization decision entity based on access control policy and another attribute information. Most of the traditional access control models protect resources and information from a centralized point of view. Therefore, the existing access control model mentioned above cannot be used in the system of customizable crop growth cycle data acquisition and access. Therefore, it is necessary to conduct in-depth research on the data acquisition process and scheme of crop growth process to propose a real-time and dynamic access control model suitable for the customizable system.

Table 1. Research on distributed control into existing access control model

<table>
<thead>
<tr>
<th>Model ideas combined with distributed</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBAC</td>
<td>The distributed theory is used to solve the cross-organization access control problem in the RBAC model and realize the cross-organization authentication of users.</td>
</tr>
<tr>
<td>ABAC</td>
<td>The distributed access control policy storage ensures that user identity attributes and control policies cannot be tampered by malicious users.</td>
</tr>
<tr>
<td>UCON</td>
<td>The distributed access control model is used to record the granting, use, circulation and other operations of permissions.</td>
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3. Model Design

According to the growth cycle of crops, the access work is decomposed into atomic tasks that cannot be further subdivided. During the execution of the task, different data access permissions are granted to visitors according to the growth environment and state assessment. In other words, access to the data is associated with the state of crop growth. The growth state of all crops in the same farm is not completely consistent, so using distributed access control model based on growth attributes is a necessary choice for precision agriculture. At the same time, if there is no real-time parameter acquisition and transmission with regular constraints, it will not achieve the most energy consumption design for the acquisition and transmission power of wireless acquisition equipment, and such a design is also unscientific. When the user requests the corresponding data acquisition permission for the crop, the crop data acquisition equipment makes attribute judgment according to the growth state parameters, and the attribute judgment analysis module. After receiving the user's permission access request, the real-time judgment is made according to the crop's own attribute, and the attribute judgment point determines whether to grant the permission to the request according to the attribute possessed by the current growth state of the task. If the access request is sent to the policy execution module by the policy judgment module, the system will recover the permission of the task immediately after the task ends.

The main function of crop growth data attributes acquisition system is to install different types of sensors on crop growth environment data. When its own attributes meet the collection standards, it allows users who implement real-time data collection to collect the growth genus data of crops. The crop growth environment data acquisition system shall meet the following requirements:

1. The crop growth environment data acquisition system can be used for both current type sensor data acquisition and voltage type sensor data acquisition, so as to adapt to various complex scenarios in the application of crop growth environment data acquisition.
2. The data acquisition system of crop growth environment needs to realize data acquisition of multiple nodes and multiple regions, so that the collected data can comprehensively show the actual situation of crop growth environment, making the data comprehensive, dynamic and accurate.
3. Distributed access control model of crop growth environment data, which can monitor the growth environment of crops in real time. When the access control attributes are satisfied, the predefined data can be collected, summarized and packaged automatically. Wait for the user to complete the property pairing to perform data collection and transmission.

Model Framework, this paper improves the permission allocation model in the model by referring to the state manager, attribute management, task manager, permission manager, access control request acceptance and
analysis, access control execution and recording, access control policy management and update. The execution flow of the distributed access control model for the data collected by the Internet of things in the agricultural production environment is shown in figure 1.

![Diagram of Distributed Access Control Model](image)

**Figure 1.** Distributed access control model based on attributes

### 3.1. Relevant Definitions

An entity in the DMBA model that has or performs operational functions on an object, relating to attributes. The basic elements of the model are given according to the access environment and the traditional access control model.

Entity represents the subject ($S$) and object ($O$) in the model. Entity can be both the subject and the object. At the same time, in a particular operation process, an entity cannot be both the subject and the object. According to the definition, the staff performing agricultural data acquisition is the subject, and the single crop to be tested is the object.

Define 1. Subject, the entity that can obtain the object resource under the condition of meeting the permission constraint, represented by Subject, abbreviated as $S$.

$$\exists entity, (entity(s) \rightarrow entity(o)) \land (entity(s) \neq entity(o)) \Rightarrow entity(s) \in S$$

Define 2. A subject attribute that describes or modifies a principal to help locate a capability or attribute on a principal that can be used in a user action, subjects attributes, short for AT ($S$).

Define 3. Object, the described as a collection of entities that can be affected by a certain operation of the subject, is represented by Objects, abbreviated as $O$.

$$\exists entity, (entity(s) \rightarrow entity(o)) \land (entity(s) \neq entity(o)) \Rightarrow entity(o) \in O$$
Define 4. Object attributes can independently describe the object characteristics or jointly influence the object with the attributes of the subject and operation to help locate the status of the object in the access control system. Attribute Objects - short for AT (O).

Define 5. Operation, the defined as a collection of actions that can be performed by a subject on an object, the Permission, abbreviated as P.

Define 6. Operation attributes, describing the modification operation, and together with the subject object attributes, locate the authority and status of the operation in the model.

Define 7. Growth state: the smallest unit of access control scheduling, where the growth cycle is composed of multiple growth states. \( T = \{t_1, t_2, ..., t_n\} \) Is a collection of user growth cycles, which \( t_i \ (1 \leq i \leq n) \) is a state in the growth cycle?

Define 8. Task state: the state of the growth task. In the life cycle of a crop, take rice as an example: seed-germination - long root - long leaf - knotting - ear - flowering - pollination - milk - yellow - mature. \( T_s = \{t_{s1}, t_{s2}, ..., t_{s11}\} \) Where \( t_{si} \ (1 \leq n \leq 11) \) is a specific task State.

Define 9. Task attributes: attributes that the growth task has. \( T_n = \{t_{n1}, t_{n2}, ..., t_{nn}\} \) is the set of task attributes, and \( t_{ni} \ (1 \leq i \leq n) \) is a specific task attribute.

Define 10. Permission: the ability of the subject to collect object growth data, including operable objects and operable operations. \( P = \{p_1, p_2, ..., p_n\} \) is a collection of all permissions, and \( p_i \ (1 \leq i \leq n) \) is a specific permission.

Define 11. Mapping relationship of user attributes (UA): the attributes of \( UA \subseteq U \times A \) users are determined by task status attributes. A user can have different attributes and a single attribute can be assigned to multiple users.

Define 12. Attribute task mapping relationship (AT): the relationship between \( AT \subseteq A^*T \) attribute and task is many-to-many. A task may require a user to have one or more attributes before it can be executed. The user of a certain attribute can complete a task or has one of the conditions for completing a task.

Define 13. Task permission mapping (TP): \( TP \subseteq T \times P \) when a task is in different states, users have different permissions for its operations. \( TP_t \) Is the operation permission that all tasks may have at \( t \) moment, \( tp_{ij} \) is the operation permission that \( t_j \) can have at \( t \) moment, and \( tp_{ui} \) is the operation permission that \( u_i \) can have at \( t \) moment.

Define 14. Task state mapping (TS): a task can only be in a certain state at a certain time, but different tasks can correspond to the same state.

Define 15. History information: historical information about the growth cycle of crops. \( HIS = \{his_1, his_2, ..., his_n\} \) is a collection of historical information about the growth cycle \( his_i \ (1 \leq i \leq n) \) is a specific historical information, which is composed of a Quaternary \( <u_i, a_j, t_n, n> \), which indicates that user \( u_i \) with attribute \( a_j \) in the growth process of crops used to be \( n \) task \( t_n \) in the growth state of crops.

3.2. Model Design

The data acquisition module in the model has an rs-485 interface. In order to improve the development speed and system stability, Jennic suite, a special development tool, is used in the communication between RFD and FFD during the design process of the data acquisition module. In the data acquisition module, each main device can communicate with 2-4 sub-devices, and each sub-device can connect up to 16 sensing devices, which can meet the practical application needs of crop growth environment information acquisition. The sub-device first collects and analyzes the crop growth status information. If the attribute data collection standard set by the main device is met, the data will be collected, transmitted and analyzed. Then the collected data will be prepared for the mobile device to control and pair the crop properties. The process of device acquisition and transmission is shown in figure 2.
In the process of data collection and access control, the data layer firstly uses Flume and Kafka components to complete the acquisition task of agricultural data resources. The data generated by various agricultural data sources were collected and read through Flume component classification. Different data channels were set up for different data in Flume component, and then different types of data Sink into the two destinations. One purpose is the HDFS file storage system, and the other is the component Kafka. In the data analysis layer, Flume component can obtain a large amount of heterogeneous data in the HDFS storage system and supply it to the Hadoop offline batch processing system for analysis and processing, and the processing results are written into the corresponding database. The Kafka component acquires the sensor network data stream and provides it to the Storm real-time data processing system for data analysis. The Storm system writes the completed data through bolt component into the corresponding database. Finally, there is the application layer, which reads the data in the database through query according to the requirements of different applications, or reads the processing analysis results of Storm in real time. The systematic analysis process of the collected data is shown in figure 3.

Figure 2. Flow chart of equipment acquisition and transmission
The system uses Flume to collect a variety of required agricultural source data. Flume is a system that can process a lot of log information. Can collect the specified mass data and the data aggregation operation after the transmission of positioning, its architecture is simple and flexible, mainly dealing with streaming data. Therefore, Flume can be used to collect heterogeneous data from different data sources and transfer the data to the subsequent Kafka and HDFS storage components. Flume mainly includes Source, Channel and Sink components, as shown in figure 4. Source is to send the data to the Channel for caching after receiving the data. Sink will verify the data in the Channel according to the distributed access control policy based on attributes and send the information to the receiver. The Channel will only delete the temporarily cached data after the Sink sends the data from the Channel successfully. Source can collect various types of data sources, and the involved data transmission will be sent to the designated Sink in the Channel pipe after passing through the temporary cache, so as to transfer to different destinations.

3.3. Experimental Analysis

In the agricultural Internet of things environment, the access control model based on RBAC and UCON is implemented by a centralized authorization decision-making entity according to access control policy and other attribute information for access control decisions, and the calculation and storage in the access control is mainly performed by the centralized server. Centralized control has corresponding advantages in the process of network communication, but in the aspect of monitoring the growth cycle parameters of fruits and vegetables, excessive energy consumption or data errors may occur in the collection of corresponding data due to individual differences. This model can accurately access the value of crop growth attribute parameters based on crop growth attributes.
The effective control of Internet of things (ion) data in crop production process by attribute-based distributed access control (DBAC) model has been widely concerned. However, at present, the main design idea of attribute-based access control model adds the corresponding distributed theory, expands the existing model by adding constraints. The specific process of authorization of access request is still that after the subject makes an access request, the object evaluates and authorizes the request according to its own growth state attribute. Therefore, these traditional attribute-based access control models naturally inherit the characteristics of centralized access request and authorization, and cannot support access control based on the status attribute of each crop, that is, prevent meaningless data collection, transmission and analysis. It ensures the accurate access and acquisition of crop growth state attribute data.

We compared the DBAAC (distributed base attribute access control) on agricultural Internet of things data proposed in this paper with the traditional access control model is called (TM) through experiments. In the experiment, we simulated different visiting experiments in the growth process of crops of the same variety. For example, three growth parameters need to be collected in one day. In traditional experiments, visitors estimate the average acquisition time according to experience and set the time threshold. Data collection was performed several times before and after the time threshold to analyze the average data. Multiple acquisition and transmission analysis of this situation will increase the pressure on the energy consumption of wireless acquisition equipment. And the traditional way is likely to miss the most accurate data acquisition. In the attribute-based distributed access control model, each growth attribute parameter that needs to be measured is first set and converted into crop attribute. When the subject makes a data acquisition request to the target object, the object acquires its own growth data and converts it into the growth attribute of the crop. According to the received attribute, judge whether the attribute is consistent with the growth attribute in the principal request at this time. If it is consistent, allow data access; if not, deny access. The acquisition method of this model can reduce the number of data acquisition and transmission of several child nodes, thus reducing the energy consumption of nodes. Through the special constraint of attributes, this model can collect agricultural data more accurately.

As shown in figure 5, the DBAAC model adopts the distributed self-judgment mode, and the attribute with the growth state as the access constraint, so as to reduce the energy consumption of useless data collection and transmission. With the increase of The Times of data access, the energy consumption for data acquisition and transmission is far less than that for the traditional access control model to complete the same data acquisition task.

Figure 6 shows the error rate of crop growth parameters in different access environments. In the simulation experiment, the two experimental platforms randomly simulated the average error rate of the data collected for 10 times for a certain crop. According to the simulation calculation, the error rate of the traditional data acquisition method is 4.03, and the error rate of the access control model based on distributed attribute autonomous control is 2.19. Through analysis, it can be concluded that in the process of large-scale application and long-term data collection, this model will improve the accuracy of application range data collection and reduce the error of data acquisition.
4. Conclusions

For the dynamic problem of nodes under the Internet of things in the agricultural production environment, the distributed attribute self-control model can solve the dynamic problem of Internet of things data collection in the growing environment of crops as far as possible. In this paper, a work-flow access control model based on attributes and tasks is proposed. Through the state attributes based on the agricultural production process, a detailed and accurate data acquisition scheme can be customized. Change the traditional centralized unified collection, comprehensive analysis of the state. Work-flow access control model based on attributes and tasks realizes dynamic management of attributes and permissions by connecting growth state with attributes and attributes with permissions. Compared with other models, this model has fine granularity, good flexibility and lower management cost. The model is applied in the agricultural production resume data processing and service system. By comparing with the traditional agricultural data, the model has more accurate data acquisition accuracy and more energy-saving data transmission scheme. These advantages are in line with the characteristics of traditional agricultural Internet of things information data collection and control.

References


