
The Research of Middleware Architecture of Intelligent Logistics System Based on SOA

Jie Zhu, Ruoling Zhang

School of Information, Beijing Wuzi University, Beijing, China

Email address:

zhujie@bwu.edu.cn (Jie Zhu), 422122281@qq.com (Ruoling Zhang)

To cite this article:

Jie Zhu, Ruoling Zhang. The Research of Middleware Architecture of Intelligent Logistics System Based on SOA. *American Journal of Software Engineering and Applications*. Vol. 4, No. 6, 2015, pp. 115-120. doi: 10.11648/j.ajsea.20150406.13

Abstract: Prime minister, Keqiang Li, chaired a state council executive meeting in 2014 in which the medium and long term planning of development of logistics industry was discussed and passed. It put forward to set up modern logistics service system until 2020, enhancing the level of standardization, informatization, intellectualization, intensification of logistics, improving overall efficiency and benefits of economy [1]. At present, the vigorous development of a new generation of Internet technologies and the intelligent logistics equipment technology such as the Internet of things, cloud computing, big data, mobile Internet, smart logistics and Internet plus is driving the change of China's smart logistics [2]. Internet of things technology brings convenience to the life. It also brings new problem. The data is collected by the sensors. It maps out all aspects of the physical world. At the same time, it will produce huge amounts of heterogeneous data. Aimed at the above problems, this paper puts forward the research of middleware architecture of intelligent logistics system which is based on SOA. It provides an unified and structured data for the upper application system through shielding the complex acquisition equipment and heterogeneous data.

Keywords: Intelligent Logistics Middleware, IOT Middleware, SOA Middleware Architecture

1. Introduction

Now IOT middleware software has been widely applied to each link of logistics. Because intelligent logistics system is composed of multiple subsystems collaboratively, this paper draws on the design style of SOA architecture to design this

middleware system in order to better play the role of middleware and make subsystems which work in different platforms can use middleware system. The system can be loosely coupled and can real-time update of data to adapt to the flexible dynamics of intelligent logistics system.

Table 1. The advantages of SOA.

advantages	describe
The independence of the function of the entity	Emphasize completely independent ability of the function of the entity which provides services in the framework: The traditional component technology requires a host to store and manage these function entities, when there are some problems in the host itself or other functions, other application service that run on the host will be affected. Emphasizing the ability of self management and resilience of entities: Common technologies for self-recovery, such as transaction processing, message queues, redundant deployment and cluster system, play a crucial role in the SOA [4].
A huge amount of data	Recommend exchanging information with the method of large amount of data at once. For those traditional distributed computing models, the service is carried out by means of function calls, the completion of a function often requires many times function calls between the client and server function.
Textual message passing	The influence of these calls for the response speed and stability of system is the key determinants to determine whether the system can work normally under the Internet environment. The existence of a large number of heterogeneous systems (including different languages and different platforms for data, and even some difference of basic data types defined) in the Internet determines that the SOA systems must use text messaging mode instead of binary messaging mode [5]. Based on text messaging, data processing software can only selective processing part of the data which itself understands and ignore other data, so as to get ideal compatibility.

2. An Overview of SOA

SOA (Service Oriented Architecture, SOA) a software system Architecture which can be achieved by connecting to an independent function entity that can complete specific tasks in order to solve the needs of the business integration in the Internet environment. SOA (service-oriented architecture) is a component model. It links the different functional units of application through well-defined interfaces and contracts between these services [3].

Interface is defined with the method of neutral. It should be independent of operating system, programming language and services hardware platform which can achieve services. Services which are built in different kinds of systems can interact by a unified and general way. Table 1 lists the advantages of SOA architecture.

3. IOT Middleware Architecture Design

This paper puts forward the overall architecture based on SOA middleware as shown in figure 1. Three layer structures are device access layer, the event processing layer, application interaction layer.

Device layer can collect related data of entity. It doesn't have function of simple data processing and filtration. Equipment layer is made up of IOT perception like barcode, RFID, ZigBee, sensors, PDA, wireless network and so on. These devices can make the physical world information real-time display in the computer world and information system in the form of digital. But different types, different manufacturers and different models of devices increase the difficulty of program development. Addition or decrease of all kinds of equipment can make a lot of changes of system [6].

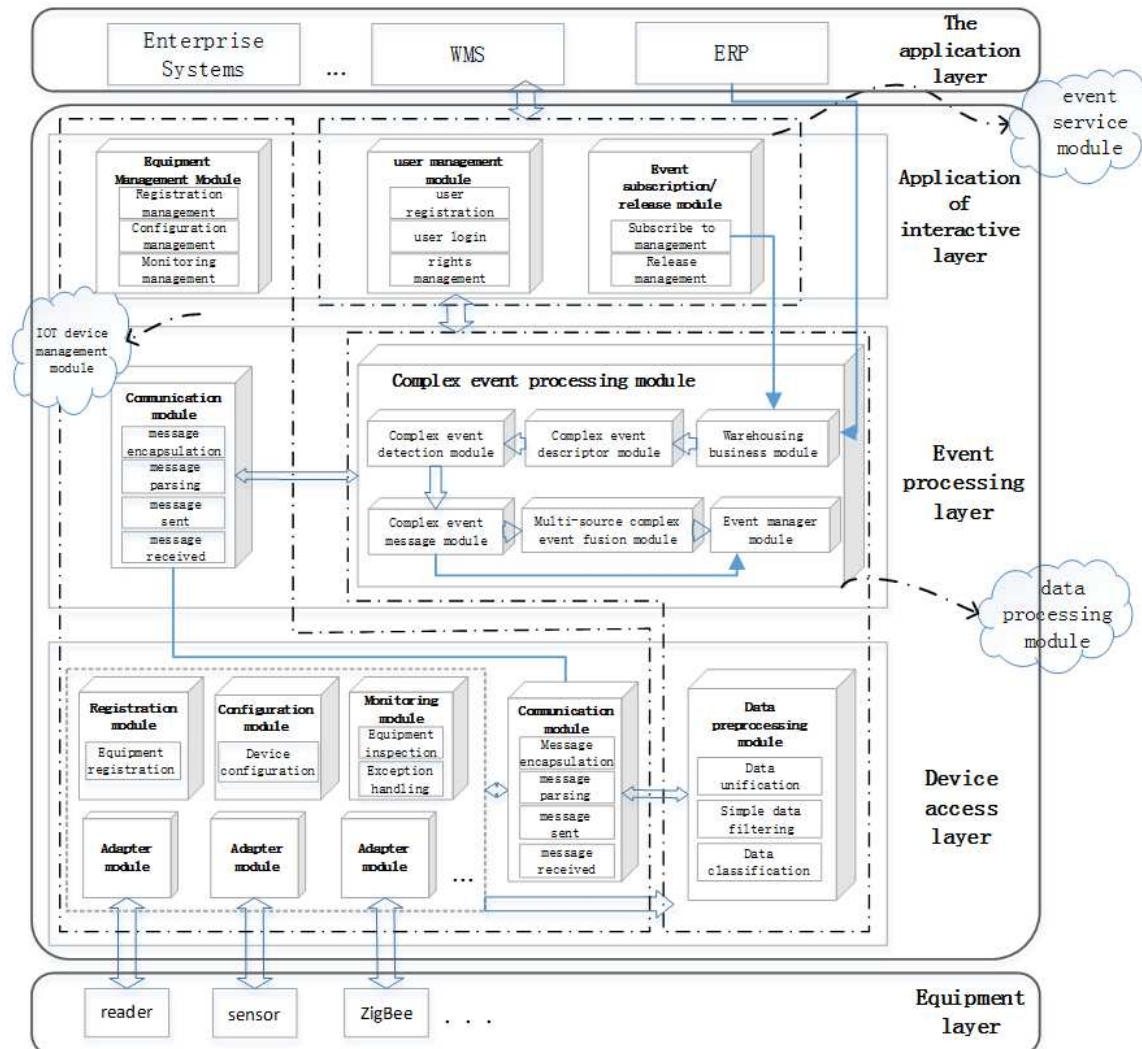


Figure 1. Middleware whole architecture.

Middleware layer can manage uniformly multiple data sets the source device and unified or block agreement between different multi-sources. At first time process collected

information of data, label and environment [7], and then process based on the application system or user requirements for secondary processing, and store information that has been

dealt for the upper application to subscribe to. The layer is made up of the device access layer, information processing layer and application interaction. It is connected by a Web interface between different layers.

Application layer is made up of ERP, the enterprise business system and each link of the subsystems of the intelligent logistics system including the intelligent management system that is based on UHF RFID technology, intelligent shelves system, storage environment monitoring system and intelligent inventory system.

ERP or other business systems provide business orders to the middleware system, each subsystem of warehouse system coordinate with each other homework, each subsystem also request and subscription business orders to the middleware system according to the different operations, middle ware system Release the corresponding incident report to the users after completing the corresponding business operations.

3.1. The Hierarchical Structure of the Middleware

Differentiate from the level, middleware system is divided into three levels include device access layer, the event

processing layer and application of interactive layer like black solid line box in the figure bellow.

(1) Device access layer

Device access layer is in the bottom of the middleware architecture. It connected with IOT acquisition devices and provides a direct dialogue with acquisition device. Device access layer is the direct undertaker of Equipment management module in Application of interactive layer .Equipment management module can manage and control the acquisition equipment .Its principle as shown in figure 2.

Device access layer contains multiple virtual devices (light gray dotted line inside, as shown in figure 1), data preprocessing and communication module. Virtual device is the mapping of the physical device in the middle tier system. It is the middle of the agent of equipment management module and the actual physical hardware device. Information world and the physical world is not in the same environment, so if the physical device wants to enter the information world to participate in work, it needs to create a virtual devices belongs to itself to each physical equipment[8].

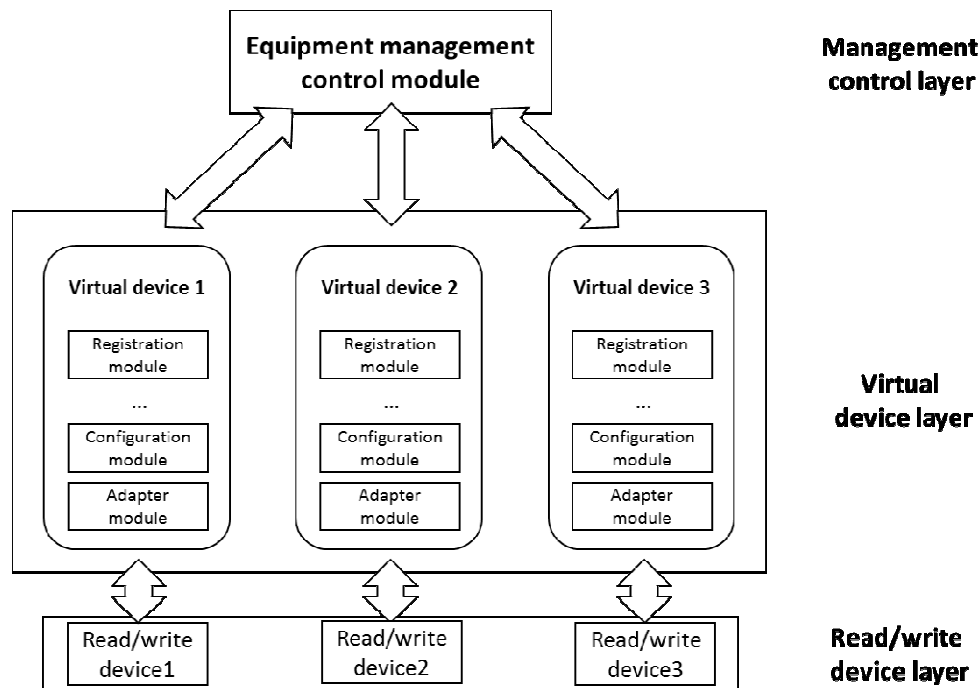


Figure 2. Equipment management principle diagram.

Each virtual devices are included in the child module of the virtual device module under the access layer. If the middleware finds that a new collection device is attempting to access to the system, the system will generate a new virtual device. This virtual equipment is the information agent in the world of the equipment. It interacts with other modules.

Equipment management module sends instruction to virtual device. Virtual device receives and executes instructions .It can also complete different operation like accessing and controlling hardware, speaking and reading labels and data collection, etc. Device access layer including

virtual module - adapter module that linked to IOT acquisition device, configuration module, monitoring module, registered module, communication module and data preprocessing module.

The main function of this layer:

- 1) To provide standard unified protocol interfaces for each type of equipment in equipment layer such as providing standard unified protocol interfaces based EPC-global reading and writing device for reading and writing equipment.
- 2) Receiving and preprocessing data that is collected by the

Internet of things devices including data standardization and simple data filtering, etc.

- 3) Receiving and executing instructions from the equipment management module and managing equipment of the equipment layer.

(2) The event processing layer

Event processing layer is the core part of the middleware system. It also is in the middle layer of middleware system at the same time. It connects device access layer below and application interaction layer above.

Event processing layer includes two modules which are event processing module and communication module. There is also a communication module in the device access layer. These two communication modules have the same meaning and function. The lower communication module sends the preprocessed data to upper communication module after encapsulating it for the message. The upper communication module parse the message received. Then it sends the message to event processing module to wait for the subsequent processing.

Communication module ensures that the instructions of equipment management module can be accurate delivery and execution at the same time. It can guarantee the normal work of the read-write equipment [9]. Communication module, as the name implies, have played an important role on communication between lower and upper.

The main features of event processing layer:

- 1) Parsing encapsulated message of different sources of data which is processed by data preprocessing module in the device access layer;
- 2) Detecting complex event information based on the business;
- 3) Meeting the needs of the user or application system, fusing events of a variety of data sources, forming a complex event information that is needed. Event information is stored in the event manager module for extracting by users.

(3) The application of interactive layer

Application interaction layer is an interfaces which middleware system keeps for system or user that can operate and manage. It is also the management center of middleware. It is one of the core component of the middleware. It contains equipment management module, user management module, event subscription and publish module. These three modules allow users and administrators to operate.

Equipment management module manages virtual equipment of equipment access layer in fact. It provides equipment registration management, equipment configuration management, equipment monitoring management and other functions. It manages the access device through ordering the virtual devices to allow multiple devices to work together. System administrators can sign up for accounts for other Application system or developer in user management module. Different users can view or add the business model through permissions management. Users can subscribe events which he needs by using event subscription and publish module.

The main functions of the application of interactive layer:

- 1) Checking the equipment registration, equipment initialization or the configuration of new equipment in the equipment layer. Ask for monitoring equipment status, etc.
- 2) Registering the identity of users include personnel, procedures and systems which need to use middleware system.
- 3) According to the needs, users subscribe for some complex event of warehousing business module. It can also distribute events.

3.2. The Functional Configuration of Middleware

From the perspective of function, the middleware system is divided into three functional modules: IOT acquisition equipment management module, data processing module and the event service module, as shown in figure 1. Three modules do their job and rely on each other, jointly complete the reserve functions of middleware.

(1) IOT collection equipment management module

Collection equipment management module is the most basic module of IOT middleware, and responsible for management of sub module and controlling the intelligent storage aspects variety of IOT heterogeneous devices.

It consists of seven sub modules, which are adapter module, the register module, configuration module, monitoring module, equipment management module, and two communication modules.

- 1) Adapter modules: collection device types differ from each other, modes of communication interface are various, such as a serial port connection, USB connection, etc. On the other hand, equipment developers will provide the corresponding development kit to decrease the difficulty of access, and due to the difference of the developers, the development kits are often different. The adapter module shoulders to provide a unified standardized protocol interface for the IoT acquisition device, convenient effective access to various acquisition devices.
- 2) Register module: when there is a new device access to the network, registration module detects the acquisition equipment, submit the information to the equipment management module, including the type of equipment, power equipment, the geographical position, etc., and then apply for registration.
- 3) Configuration module: responsible for the access to the middleware system of IOT's capture device initial configuration and real-time reconfiguration. When a new device to be connected to the network, after registration module performs a registration, the device enters configuration link, configuration module detects device configuration, then automatically configuring it. If the configuration is incorrect or need to be adjusted, it can be manually modified by the equipment management module.
- 4) Monitoring module: responsible for obtaining the equipment running status data, processing equipment failure, including equipment failure and network failures.

The equipment of the access system is monitored, and the dynamic monitoring of each specific device is carried out, and transmitted to the equipment management module during work. At the same time the problems of equipment and network, such detail information would be sent to the management module.

- 5) Equipment management module: responsible for the management and controlling the collection devices, including transmission management and control instructions to the virtual device; processing feedback information of equipment, analysis and decision; Receiving and processing the registration module's application; according to registration information and real-time running status of reading and writing equipment, coordinate multiple thing to read and write equipment working.
- 6) Communication module, communication module 1, communication module of equipment access layer, is responsible for the receiving equipment management module of the control instructions and reply the execution result; Upload different data sources that the IOT devices read; Communication module 2: in the event processing layer communication module is responsible for sending equipment management module of the management and control instructions for IOT devices read and reply the related news; Receive different data source that communication module 1 uploaded and transmit to the data processing module. Above that, each sub module mutually work together to complete the IOT collection equipment management module function.

(2) The data processing module

Data processing module is the core of middleware, it integrate all the information that comes from RFID, sensors, GPS and mobile terminal and other multi-source, to filtering, complex event detection and multisource information fusion, to realize the integration of the Internet of business information, provides the upper application based on the logistics business event service. Data processing module is composed of two sub modules, data preprocessing module and complex event processing module.

1) Data preprocessing module: responsible for preliminary processing of raw data from sampling equipment, including simple data filtering, data classification and data standardization to ensure the correctness of the data to be uploaded.

The data collected by the equipment layer has the characteristics of large amount of data and redundancy and high error rate. Firstly, the data is not reliable. In practice, it may produce a variety of acquisition error, including, tag conflict, the influence of position error, metal, water etc. Misreading, missing and repetition are RFID common phenomenon for data error. Secondly, redundancy, collected duplicate data will be great amount (sometimes reader-writer, sensor can be collected more than 1000 times a second) [10]. So filtering is very necessary and important function. The purpose of the filter is to eliminate the redundant data, which

eliminate the 'useless' in order to transmit useful information to the application.

Set up several kinds of filters:

A. de-duplication filter, filtering out the redundant data, in order to reduce system load. For example, setting a period of 10m, collect this data from 0 seconds, if equipment still not collect this data until 10 seconds, the program will determine whether the period within 10 m, because it will determine to kick out the collected information or record the information.;

B. equipment filter: equipment filter can send only one type of equipment or a specific attribute of the node information, that is to say, the filter only send the data of a certain range or mode;

C. time filter, filter events according to the time records, for example, a time filter can send only the last 10 minutes of events;

D. smoothing filter: responsible for dealing with errors, including missing and misreading information. According to the actual requirement, these filters can be used jointly.

2) Complex event processing module: It is responsible for synthesizing basic events though preprocessing the data information. These basic events combined with business to detect complex event that based on logistics business and extract these complex events;

According to the needs of the business and users, complex event processing module fuses filtering data of a variety of sources and complex events. Then it forms more complex events information and uploads to the service module.

(3) The event service module

Event service module is the module which can directly interact with the backend application. It is mainly responsible for managing and releasing the complex event information that based on storage business, providing user registration function and subscribing/publishing storage complex event. It is made up of the user management module and event subscription and publish module.

1) User management module:

Responsible for managing registration, user privileges, and user information management of middleware back-end users.

2) Event subscribe/publish module:

Subscription

It is responsible for managing storage business complex events that is required by subscribing of users and submitting the relevant business information. The system transforms business information that the user submits to the corresponding business model.

Submitted

It is responsible for publishing the complex event information which is based on storage business and submitted by data processing module.

4. Summary

Firstly, the article introduces in detail the service-oriented SOA architecture. Secondly, it analyses and designs the middleware structure which is based on SOA architecture and oriented intelligent logistics system. Middleware system

structure is divided into three levels which include device access layer, event processing layer and application of interactive layer and three functional modules which include IOT acquisition equipment management module, data processing module and service module.

Acknowledgements

This paper is supported by the Funding Project for Technology Key Project of Municipal Education Commission of Beijing (ID:TSJHG201310037036); Funding Project for Beijing Key Laboratory of intelligent logistics system(NO:BZ0211); Funding Project of Construction of Innovative Teams and Teacher Career Development for Universities and Colleges Under Beijing Municipality (ID:IDHT20130517), and Beijing Municipal Science and Technology Project (ID: Z131100005413004); Funding Project for Beijing philosophy and social science research base specially commissioned project planning (ID:13JDJGD013).

References

- [1] http://china.cnr.cn/news/201406/t20140612_515653926.shtml. cnr.cn. Keqiang Li Presiding over meetings of the state council.
- [2] Feng Liu. The Internet evolution [M]. Tsinghua university press, 2012. 9.
- [3] Yunsong Tan, Jianjun Han. A service-oriented IOT middleware model [J]. Computer science, 2011. 10(38).
- [4] Fahong Li. The research and preliminary design of digital city that is based on SOA [J]. Journal of Shanxi normal university, 2008.11(36).
- [5] Lichao Liu. Comprehensive monitoring of SOA architecture design and value analysis [J]. Telecom science, 2010(11).
- [6] Haisheng Deng. Research and implementation of the RFID middleware based on SOA [J]. Electronic technology applications, 2007(10).
- [7] Qing Hu, Yiju Shan, Xiaohu Huang. Based on Internet of things and RFID middleware technology research [J]. Micro computer information, 2009(25).
- [8] Jie Li, Using JMX and JMS technology of RFID middleware design based on SOA [J]. Electronic technology applications 2010(4).
- [9] Jincan Fang, Port logistics oriented iot technology research and design of RFID middleware [D]. Dalian university of technology, 2013.
- [10] Gonzalez H, Han J, Shen X. Cost-conscious cleaning of massive RFID data sets[C].Proc of ICED, 2007: 1268-1272.