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LDAP-based IOT Object Information Management Scheme

Li Hai[1*], Fan Chunxiao[1], Wu Yuexin[1], Liu Jie[1], Rao Lilin[1]
[1]Beijing Key Laboratory of Work Safety Intelligent Monitoring, School of Electronic Engineering, Beijing University of Posts and Telecommunications, Beijing, P.R.China, 100876.
lihaibupt@gmail.com; cxfan@bupt.edu.cn; wuyuexin@263.net; liujie@bupt.edu.cn; lilinrao@bupt.edu.cn

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Abstract. The Internet of Things (IoT) objects refer to the perceptual layer devices which are essential resources to be integrated in IoT environment. However, the integration of IoT objects is generally a challenging issue, due to the facts that the IoT objects are always managed by different application systems and there are no unified storage and management solution for the information of IoT objects. Directory is a mature solution for overcoming the interconnection of open systems and the integration of heterogeneous systems. Lightweight directory access protocol (LDAP) demonstrated the superior performance to the above issues. This paper proposes a IoT object information management scheme based on LDAP which offers a unified solution to store and manage the information of IoT objects. Through applying it in a specific application scenario "urban road environment management", this scheme is proved to be feasible and effective.

Keywords: Internet of Things • Resource Integration • LDAP • IoT Object Information Management

1. Introduction

Relative to the breakthrough of some key technologies, the heart of the development of IoT [1] industry is to establish industry standards and integrate IoT resources. As the demand for the interconnection of IoT objects increases, the "information island" problem is becoming increasingly prominent.

The IoT objects refer to the perceptual layer devices which are essential elements of IoT to be integrated and interconnected. To achieve the goal of resource integration, we must formulate unified labels for IoT objects which belong to different application systems, formulate unified storage and management solution for the information of IoT objects. However, there are no maturing solutions for this problem, nor are unified standards to follow.

Directory is a mature solution for overcoming the interconnection of open systems and the integration of heterogeneous systems [2]. Lightweight directory access protocol (LDAP) is a standard and cross-platform protocol which based on x. 500 standard. LDAP is easy to integrate different application systems and could be customized and extended based on the requirements of special applications. LDAP is one of the fundamental technical for network system and has been a widely supported standard protocol now.

Combining with a specific application scenario which called "urban road environment management", this paper proposed a LDAP-based IoT object information management scheme [3] and made a valuable research about the integration of IoT objects and the formulation of data management standard.

2. IoT Object Management

2.1. The Necessity of IoT Object Management

As a "thing-to-thing net", the IoT extends to information exchange between any goods. IoT has a similar resource addressing requirement with Internet to ensure the commodity information could be addressed, positioned and queried efficiently, accurately and safely. The IoT resource addressing system has become the center hub of global commodity information localization and cross-domain information flow [4].

In real application scenarios, we often encounter such a problem: there exist large amounts of real-time traffic monitoring cameras in system A which called "Urban road traffic video monitoring system", and large number of traffic flow information collection sensors in system B which called "Urban road traffic flow monitoring system" at the same time. Though created for the same purpose of traffic monitoring, two systems labeled objects independently, stored object information on their own way according to specific requirements and finally came to the result that objects of this two systems could not be reused. In this case, if we try to integrate resources of these two systems and create a new app which could provide multiple and accurate rode information, we would face great difficulties due to the heterogeneity problem.

Thus, it can be seen that to achieve a sustainable and stable development of IoT, unified storage and management solutions for IoT object information should be developed. Basing on this, we could promote the interconnection of IoT in general. However, there are no maturing solutions for this problem, nor are unified standards to follow yet. It has been a problem which is urgently to be solved in the current development stage of IoT.

3. LDAP-based IoT Object Information Management Scheme

Due to the reason that IoT objects have an obvious hierarchical structure, we could formulate unified labels for IoT objects according to the division of administrative areas and the application domains of IoT objects referencing to relevant existing standards. Further, we could use LDAP to set up a unified solution to store and manage the IoT object information [5].

We would represent the LDAP-based IoT object information management scheme in this chapter according to a specific application scenario which called "urban road environment management".

3.1. Sample Scenario Description

There exist two IoT app systems in a scenario which called "urban road environment":

System A: Urban road traffic video monitoring system

System B: Urban road traffic flow monitoring system

System A deployed a large number of cameras, and System B deployed a lot of traffic flow information collection sensors in the "urban road environment".

In order to provide more accurate traffic information as a reference for traffic scheduling, we hope to integrate object resources of these two existing systems and develop a new system called "urban road environment management application". The priority job is to formulate unified labels for the objects of these two systems and formulate unified storage and unified management solutions for object information.

3.2. Unified Labels of IoT objects

The code of a object consists of four sections as follows:

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The first section is the administrative division code of cities, districts, autonomous prefectures and leagues with reference to the GB/T2260 standard.

The second section is the administrative division code of the districts, counties, county-level cities, autonomous counties and banners with reference to the GB/T10114 standard.

The third section is the application domain code for IoT objects. We set encoding to 02 for the "application domain of transportation" here.

The fourth section is the information classification code for IoT objects. Code of the video class is set to 01 and code of the traffic flow class is set to 02 here.

The fifth section is the detail code for IoT objects. This code is made according to specific circumstances on the condition that it's only under the same application domain and information classification.

3.3. AttributeType Definition

LDAP directory is made up of numerous entries (Entry) according to certain structure forms, each entry has its corresponding attributes (Attribute) and each attribute has an only attribute type (AttributeType). In the application scenario above, the video objects and traffic flow information collection objects are objects of IoT, they have common attributes such as node ID, administrative, location and geographical coordinates. At the same time, they each have its unique attributes. A video object has attributes such as brand, pixels, resolution, and a traffic flow information collection object has attributes such as product supplier. Common attributes and their unique attributes were extracted and defined below:

Tab. 1: Common attributes.

Attribute name	Syntax type	Multivalued	Remark
nodeId	Directory String	N	Node code, refer to coding rules mentioned in section 3.2.
displayName	Directory String	Y	Node name, used to display, such as: Xitucheng Road - camera 1.
area	Directory String	N	Administrative area, consult *CHZ_9002_2007_Digital City Public Geographic Information Platform Geographic Name, Address Classification, Coding and Encoding Rules*, such as: Haidian District, Beijing.
street	Directory String	N	Street name, consult *CHZ_9002_2007_Digital City Public Geographic Information Platform Geographic Name, Address Classification, Coding and Encoding Rules*, such as: Xitucheng Road.
location	Directory String	N	Node location coordinates (use the same encoding rule with the Digital City Geospatial Information Public Platform), such as: x = 7020, y = 6600.
description	Directory String	N	Node description, such as: "Node of Beijing traffic flow monitoring system...".
app	Directory String	Y	IoT application the object belongs to, such as: Urban Road Traffic Video Monitoring System.
validity	Generalized Time	N	Validity date, such as: 20140101000000Z.
scope	Integer	N	Monitoring scope (m), such as: 300.

Tab. 2: Unique Attributes of Video Objects.

Attribute name	Syntax type	Multivalued	Remark
angleRange	Directory String	Y	Monitoring point range (°), such as: 0-120.
brand	Directory String	N	Brands, such as: Logitech.
model	Directory String	N	Product model, such as: C170.
pixels	Directory String	N	Pixel, such as: 500w.
resolution	Directory String	N	Resolution, such as: 1024 x 768.
maxFrames	Directory String	N	The biggest frames, such as: 30 frames / sec.

Tab. 3: Unique Attributes of Traffic Flow Information Collection Objects.

Attribute name	Syntax type	Multivalued	Remark
type	Directory String	N	Node type, such as: annular loop detector, microwave detector, etc.
supplier	Directory String	N	Product supplier, such as: Seemap.
model	Directory String	N	Product model, such as: S – 230.

3.4. ObjectClass Definition

Entries are constrained by schema in LDAP directory. Schema is a kind of class definition mechanism, each class definition is expressed in an “ObjectClass” which provides attribute constraints such as which attributes are optional (MAY) and which attributes are required (MUST) when a directory entry is created. To use LDAP for IoT object management, we need to define and abstract the “ObjectClass” of IoT objects, declare the MUST attributes, MAY attributes and other constraints. Then entries which store object information in LDAP directory could use an “objectClass” attribute to declare which “ObjectClass” the entry is constrained by.

In chapter 4.3, we have abstracted the common attributes of IoT objects, unique properties of video objects and unique properties of traffic flow information collection objects. Basing on this, we created an IoT object object class named IotNode which contains the common attributes of IoT objects, created a video object object class which named VideoNode and a traffic flow information collection object object class which named TrafficFlowNode. The VideoNode and the TrafficFlowNode both extends the IotNode class. Object classes are defined as follows:

Tab. 4: Node Object Classes.

Class name	MUST Attribute	MAY Attribute	Remark
IotNode	nodeId; displayName; area; street; location; app; validity; scope	description	Object class of IoT object.
VideoNode	angleRange	brand; model; pixels; resolution; maxFrames	Object class of Video object. Parent class: IotNode.
TrafficFlow Node	type	supplier; model	Object class of Traffic flow information collection object. Parent class: IotNode.

3.5. Data Organization Structure of LDAP Directory

The unified directory information tree of IoT objects take c=cn as the root node (RootDSE), meaning that the directory is used in mainland China. Multiple nodes are set under the c=cn node and each node represents a province, an autonomous region or a municipal.

Multiple nodes are set under the nodes of provinces/autonomous regions/municipalities (dc=<Names of provinces/autonomous regions/municipalities for short>), each node represents a county or a county-level-above area.

Multiple nodes are set under the nodes of counties or county-level-above areas (dc=<Administrative division code of counties or county-level-above areas>), each node represents an application domain of IoT and is named by the domain's English name for short.

Multiple nodes are set under the nodes of IoT application domains (dc=<Names of IoT application domains for short>), each node represents an information classification and is named by the classification's English name for short.

Multiple entries are set under the nodes of information classifications (dc=<Names of information classifications for short>), each entry store information of an IoT object which belongs to the current application domain, the current information classification and locates at the current administrative division [6].

The directory information tree formed is shown below:

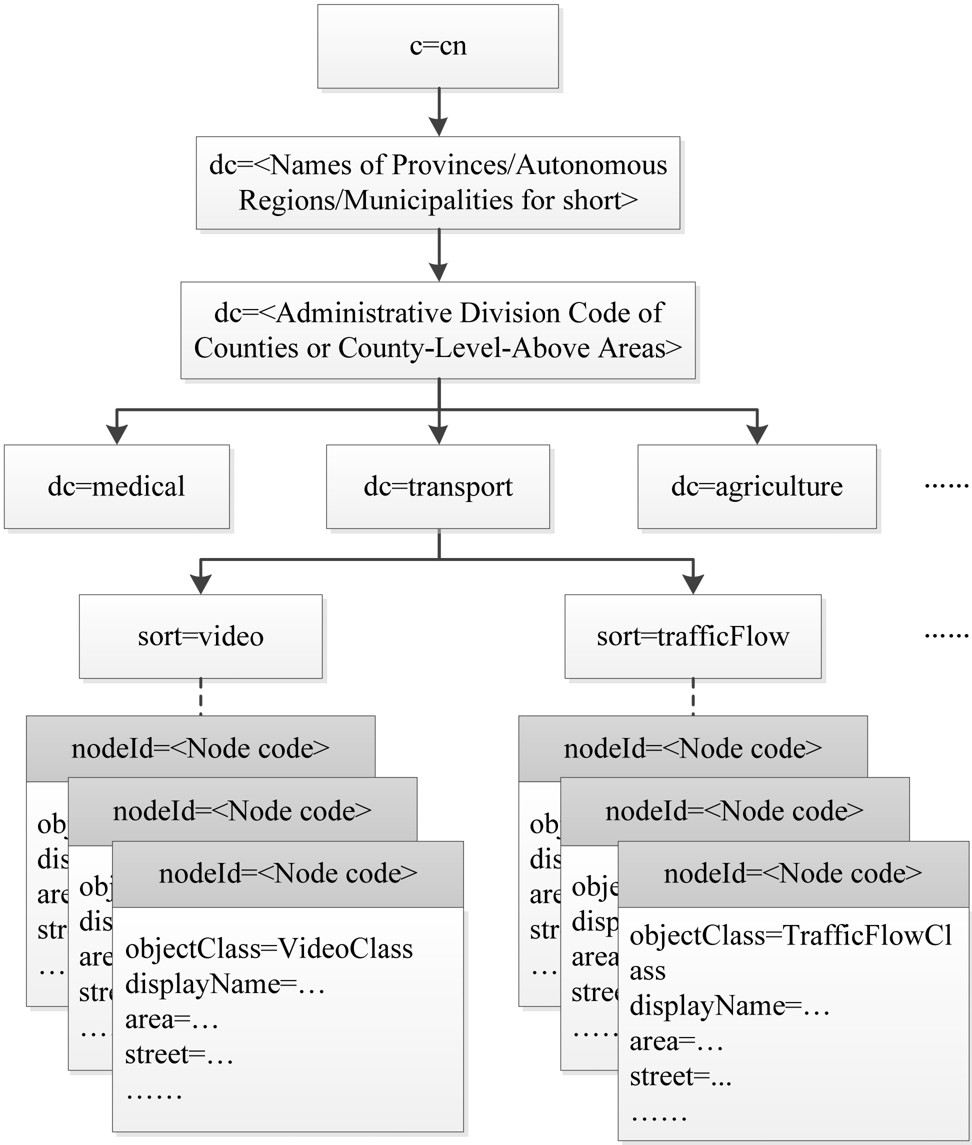

Fig. 1: IoT object Information Storage Directory Tree

3.6. Object Information Management

The management of IoT object information could be completed by using APIs provided by LDAP through Java or C programming language after the object information storage directory tree is built up. The basic operations of LADP directory is roughly divided into three categories: connection, query and change.

For example, we want to query all video objects and traffic flow information collection objects applied in "application domain of transportation" and deployed on XiTuCheng road, Haidian district, Beijing. Firstly we should go through the LDAP landing authentication with an account which has the entry-search permission and create a LDAP connection, then we could perform the query operations below: set base DN for LDAP search as "dc=transport,dc=110108,dc=BJ,c=cn", set search range as "sub" which means search all directories below the basis DN, then specify search criteria as "(&(|(objectClass=VideoNode)(objectClass=TrafficFlowNode))(street=西土城路))" and submit the query request through the entry-search API provided by LDAP. The thing left is to wait for the response from LDAP directory and get object information needed.

LDAP also provided other APIs to realize management functions such as create, modify, remove entries and attributes, etc. For example, we want to add information of a video object to the LDAP directory; we should create a LDAP connection firstly, and then submit the object information which are set according to the requirement of the "VideoNode" class through the entry-create API. Again, for instance, we want to drop object information of a video object in the LDAP directory; we just need to create a LDAP connection and submit the DN of the object to be dropped through the entry-remove API provided by LDAP.

As these APIs provided by LDAP are rich but simple enough to use, the storage and management of IoT objects in LDAP directory become quite convenient and feasible.

4. Conclusion

The integrating and interconnecting of resources are the development trend of IoT. It's extremely essential and meaningful to make a research for unified solution to store and manage the information of IoT objects. Combining with a specific application scenario which called "urban road environment management", this paper proposed a LDAP-based IoT object information management scheme, which provided a pretty good reference for promoting the integration of IoT object resources.

This paper only presents a preliminary management schema based on LDAP to manage information of IoT objects, the data models are not perfected and issues such as distributed data storage and the data migration across systems have not been figured out yet. These problems are the future research directions of this subject.

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