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A Quick Query Methods for ONS System based on EPC

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Abstract

EPCGlobal proposed for the domain name (DNS) service based on the object name service (ONS) design standards, prone to slow query response ONS system, data logging, storage space, cannot meet a single product inquiry and other issues. This paper presents a separate DNS service, the use of regular expressions and match data records stored ONS system design and implementation, test results show that independent of the DNS service ONS system has a data record storage space and query response speed, meet single product inquiries and so on.

Keywords: *Object Name Service (ONS), Independent, Domain Name System (DNS), Single product queries*

1. Introduction

The internet of things (IOT) is a an important part of the new generation of information technology, through intelligent perception, recognition technology and ubiquitous computing, ubiquitous network integration application, known as the third wave after the computer and the Internet in the development of information industry in the world .The underlying source of information of IOT consists of radio frequency identification (RFID) and wireless sensor network system (WSN). With RFID technology as the representative of the EPC Network, you can build an open global network in which anything can be identified and located, which also can be referred to IOT.

EPCGlobal proposed EPC Network standards consist of five basic elements: the Electronic Product Code (EPC), radio frequency identification system (EPC tags and readers), Object Name Service (ONS), EPC Savant, and EPC Information Services (EPCIS).

At present, researches on IOT and ONS is still in its infancy, and the research results have not extended to large-scale applications. Literature [1] introduces the concept of IOT, basic characteristics and development status and the literature also discusses the key technologies. Literature [2] details of the EPC network, ONS services, ONS principles and standards. Literature [3], based on grade classification, proposes a security model of IOT. The model can analyze a topology networking application, predict their attacks and to determine the source and type of security level domain to which it belongs, give the application appropriate

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safety technical configuration. Literature [4] proposes an ONS model of two-layer P2P structure, which improves scalability and query response, avoids a single point of failure problems. Literature [5] puts forward a RFID network security solutions based on DNS Security Extensions. Literature [6] details the security problems of RFID, such as privacy disclosure, denial of service attacks and labels implantation.

Researches for the ONS can be broadly divided into three categories: (1) The structure of the ONS, such as P2P mode and hierarchy Model. (2) The ONS security solutions, such as DNSSEC protocol and PKI authentication. (3) Implementation of a simple module of ONS system based on standards proposed by EPCGlobal. These studies are mostly based on the DNS system, that is, when the client sends the request for the EPCIS server's IP address, it obtains the EPCIS server's Universal Resource Identifier (URI) through the ONS system firstly, and then gets the EPCIS server's IP address through the DNS system for domain name resolution. The design of ONS system based on DNS can make full use of the existing resources, but there are several problems.

(1) The DNS load is too large. The DNS not only provides daily inquiry service, but also provides a lot of ONS inquiry service.

(2) The reliability of the ONS system decreased .If the DNS goes wrong, the ONS system would be out of service.

(3) The request response time of ONS system is too long. ONS system returns the URI firstly, and then establishes a connection with the DNS to get the EPCIS server's IP address.

(4) ONS system cannot meet the single product queries.

As the problems mentioned above, this paper proposes a design Implementation of ONS system that independent from the DNS, and use regular expressions to match and store the data records.

2. EPC network and ONS system

At present, EPCGlobal proposed three kinds of EPC coding standards (EPC-64, EPC-96, and EPC-256). EPC-64 encoding standard is used in this paper; the format is shown in Table 1.

Table 1. EPC-64 encoding standard

EPC encoded version	Enterprise number	Item category number	Single product number
2 bits	21 bits	17 bits	24 bits

The basic working process of EPC Network is shown in Figure 1, the RFID tag reader gets the article EPC code, then sends the code to the application server, the application server sends the ONS request to the ONS system, and gets the EPCIS server's IP address where has the information of an exactly item from the ONS system. The application server connects with the EPCIS server to get the details of the item.

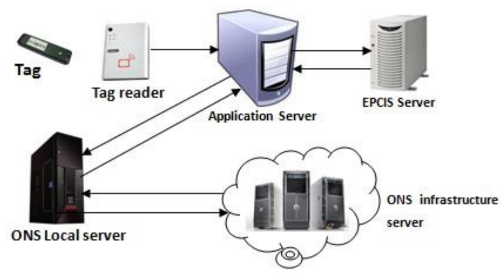

Figure 1. EPC network architecture

ONS system provides mapping between EPC encoding and EPCIS IP address. ONS system is the critical part of the EPC Network, and the important infrastructure for EPC Network services.

3. Design of ONS system independent from the DNS

This paper proposes a design of ONS system that independent from the DNS, which can return the EPCIS server's IP address directly. Taking the enterprise scale and cost into account, the following assumption is made:

(1) The item information of a large enterprise is stored in several EPCIS servers.

(2) The item information of a mid-sized enterprise is stored in an EPCIS server.

(3)The item information of several small enterprises is stored in an EPCIS server.

3.1. ONS system architecture

The architecture of ONS system is hierarchy, making the management and distribution of data records easier, the architecture is shown in Figure 2.

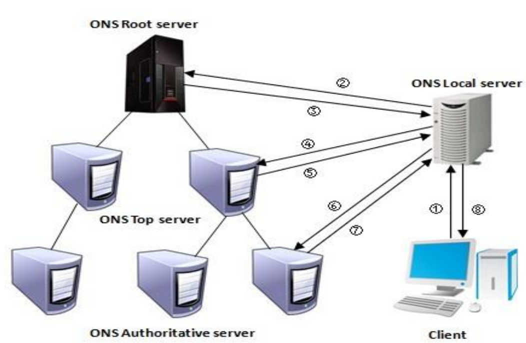

Figure 2. ONS architecture independent from the DNS

(1) Root server: When the ONS Local server sends queries, the root server returns the top server's IP address that knows the IP address of authoritative server.

(2) Top server: When the data record is very large, it is used for the expansion of infrastructure.

(3) The authoritative server: Store the mapping of EPCIS server IP address and the EPC encoding.

(4) ONS Local Server: store the frequently accessed records, in order to reduce pressure on the root server requests. ONS Local server updates records in the method of Time to Live (TTL) mode.

(5) Client: means any applications that need ONS system provide inquiry service.

3.2. Working process of ONS system

ONS analytic processes and DNS analytic processes are relatively similar; the following describes the ONS analytic processes:

Step1: Client sends EPC code to the ONS Local server.

Step2: ONS Local server seeks the record in the cache.

Step3: If the record exists in the cache and is not overdue, the ONS Local server returns EPCIS server's IP address to the client, then goes step5.

Step4: If the record do not exists in the cache or it exists but is overdue, the ONS Local server sends a request to the ONS root server, root server will send the IP address of the ONS top server which knows where the EPCIS server’s IP address stored. Then ONS Local server sends the request to the ONS top server, just as the law above, till the authoritative server returns the corresponding ONS EPCIS server's IP address, ONS Local server updates records, and returns the IP address to the client.

Step5: Clients use the returned IP address to establish a connection with the EPCIS server.

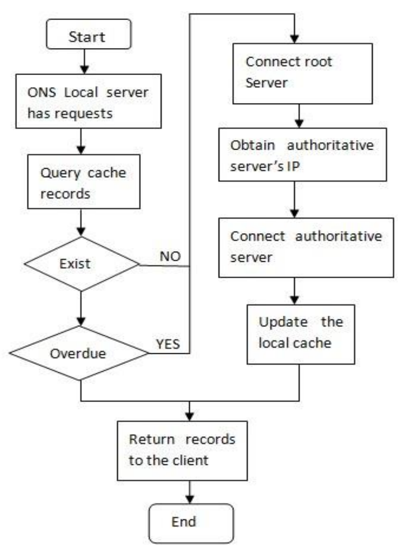

Figure 3 ONS resolution process

3.3. ONS data record distribution

In most cases, the information of a whole enterprise items stored in one EPCIS server, so the ONS server's data records cannot be divided three layers simply by the three fields (business number, item category number, item number) of EPC encoding. Otherwise, it will cause that the number of servers in enterprise number layer is too large (enterprise number has 21 bits, supports 2^21 servers), which makes it difficult for the root server to manage.

Therefore, the distribution of ONS data record should be divided by the enterprise number in EPC code, the specific partition method can be decided by the practical application. Dealing with the enterprise number in the method of Hashing module, the records will be distributed in the servers of the second layer. If the servers of the second layer overloads, you can use method of hashing modulo again to distribute the records to the servers of the third layer. This method can be flexibly extended.

3.4 Storage format of ONS data record

ONS data record stored in the database, the format described in Table 2 below.

Table 2. ONS data recording format

NO.	EPC code	IP addresses	Type
32 bits	256 bits	128 bits	32 bits

NO.: Represent that records are in the correct order to return to the client.

EPC Code: EPC coding field is 256 bits, to meet the maximum number of digits EPC coding standard requirements.

IP address: EPCIS server's IP address or ONS authoritative server's IP address which contains the EPC code mapping records, and the field "Type" in conjunction.

Type: If this field is EPCIS, the IP address in this record is EPCIS server's IP address; If this field is "ONS", the IP address in this record is ONS authoritative server's IP address. This field can be expanded to add other types of services.

3.5 ONS data record storage optimization

ONS data records are stored in the ONS authoritative server, the Table 3 is an example of ONS data records.

Table 3. ONS sample data records

No.	EPC code	IP address	Type
1	1.2151.15425.1524156	172.31.214.21	EPCI
2	1.2151.15424.1523156	172.31.214.21	EPCI
3	1.2151.15423.1524156	172.31.214.21	EPCI
4	1.2150.15420.5241562	172.31.214.20	ONS
5	1.2150.15435.1424156	172.31.214.20	ONS

By observing the data records in Table 3, it is obvious that EPCIS IP address stored in record NO. 1,2,3 is all same with 172.31.214.21, and EPC encoding enterprise number is also same with 2151, the only difference is the items category number and items single number in EPC code. So there is a big redundant data record, not only result in matching data records slow, but also result in a huge waste of storage space.

Based on the above analysis, the data storage and matching should be optimized by using regular expressions. Considering three fields in the EPC-64 coding, each field should be a collection.

Definition: A is a collection of one field, * represents the maximum value for this field.

1. $\exists\ a > 0$, For $\forall x \in A$, meet $a \le x \le *$, Then define the collection $A = \{x|x \in [a - *]\}$。

2. $\exists\ a \ge 0, a < b < *$, For $\forall x \in A$, meet $a \le x \le b$, Then define the collection $A = \{x|x \in [a - b]\}$

3. For $\forall x \in A$, meet $0 \le x \le *$, Then define the collection $A = \{x|x \in [*]\}$。

4. $\exists\ a \ge 0$, collection A has only one element x, then define the collection $A = \{x|x = a\}$。

The four cases above contain all the records. Table 4 is data record example in the use of regular expressions.

Table 4. data record sample using regular expressions

No.	EPC code expression	IP address	Type
1	1.1232.*.*	172.31.159.31	EPCIS
2	1.263.16-*.*	172.31.159.41	EPCIS
3	1.23.362.*	172.31.159.31	EPCIS
4	1.6.85-956.52-*	172.31.159.42	EPCIS

Record No.1: The information of items whose enterprise number is 1232 is all in the EPCIS server with IP address 172.31.159.31.

Record No.2: The information of items whose enterprise number is 263 and item category number is greater than or equal to 16 is all in the EPCIS server with IP address 172.31.159.41.

Record No.3: The information of items whose enterprise number is 23 and item category number is 362 is all in the EPCIS server with IP address 172.31.159.31.

Record No.4: The information of items whose enterprise number is 6, item category number is between 85 and 956 and single item number is greater than or equal to 52 is all in the EPCIS server with IP address 172.31.159.42.

3.6 ONS data records query and update

Data record query refers to an ONS Local server or an ONS authoritative server finding and matching data records after they receive a request for inquiry EPC encoding .Data record update means ONS local server update the data records if the record is not exist or the record is overdue.

(1) Single items inquiries: When ONS authoritative server receives EPC encode request, it individually checks each field of EPC encode whether they are within the scope of corresponding field in ONS authoritative server data records, if within its scope, it returns the IP address, or it returns an error message. For example request EPC encode is 1.23.32.352, Table 5 is the record in the authoritative server.

Table 5. Record in the authoritative server

No.	EPC code expression	IP address	Type
1	1.23.1-65.6-*	172.31.159.31	EPCIS

Request EPC code enterprise No. is 23, matches the record enterprise number successfully. EPC code category number is 32, within the range of the record item category code (1-65), so the item category matches successfully. Single item number is 352, within the range of the record's single item number (6 - *, greater than or equal to 6), matches all successfully in the end. Then returns the EPCIS IP address 172.31.159.31.

(2)Data record update algorithm: * marked as maximum a field, A represents the latest collection of records, B represents a collection of records that need to updated, C represents a collection of records that has updated.

Definition: collection$A = \{x|x\epsilon[a,b]\}$,$B = \{x|x \in [c,d]\}$ among it $0 \leq a \leq b \leq *$,$0 \leq c \leq d \leq *$

If $A \cap B = \emptyset$, that there is no intersection, then insert a new record C=A;

If $A \cap B \neq \emptyset$, that intersect, then update the record, the updated collection is $C = \{x|x \in [mix(a,c), max(b,d)]\}$

The following example demonstrates the update process. Suppose recorded in Table 4 are the original record. Table 6 is the latest record in authoritative server; the updated record is shown in Table 7.

Table 6. The latest data record in authoritative server

No.	EPC code expression	IP address	Type
1	1.1232.185-*.*	172.31.159.31	EPCIS
2	1.263.3-*.*	172.31.159.41	EPCIS
3	1.23.362.94-*	172.31.159.31	EPCIS
4	1.6.8-84.52-*	172.31.159.22	EPCIS

Table 7. The updated data records

No.	EPC code expression	IP Address	Type
1	1.1232.185-*.*	172.31.159.31	EPCIS
2	1.263.3-*.*	172.31.159.41	EPCIS
3	1.23.362.94-*	172.31.159.31	EPCIS
4	1.6.85-956.52-*	172.31.159.42	EPCIS
5	1.6.8-84.52-*	172.31.159.22	EPCIS

For record NO. 1 in Table 6, item category code is 185 - *, the original record item category code expression is *, they intersect. According to $C = \{x|x \in [mix(a,c), max(b,d)]\}$, so the updated record item category code is 185 - *.

For record NO. 2 in Table 6, item category code is 3-*, the original record item category code expression is 16-*.According to $C = \{x|x \in [min(a,c), max(b,d)]\}$, so the updated record item category code is 3- *.

For record NO. 3 in Table 6, item category code is 94-*, the original record item category code expression is*.According to $C = \{x|x \in [min(a,c), max(b,d)]\}$, so the updated record item category code is 94- *.

For record NO. 4 EPC in Table 6, item category code is 8-84, the original record item category code expression is 85-956.According to $C = \{x|x \in [min(a,c), max(b,d)]\}$,So the updated record item category code is 5.

4. System testing and analysis

An ONS system that independent of DNS is implemented on the Linux platform, including the ONS root server, ONS authoritative servers, ONS local server, ONS client, the data records are stored in MySQL database. For comparison, an ONS system based on DNS service on the Linux platform is also implemented, using the open source software Bind 9.5 to build DNS system.

Hardware environment: PC (CPU: Dual Core 2.3GHZ; RAM 2G, hard disk: 500G, 10M/100M adaptive network card).

Operating system: Ubuntu 10.04.

Network: local area network.

Development languages: the C language.

Table 8 and Table 9 are environment configuration for the two ONS system testing.

Table 8. ONS independent of DNS

Program name	Explanation	IP Address	Listening port
ons_client	ONS client	172.31.15.110	none
ons_local	ONS local server	172.31.15.111	8848
ons_root	ONS root server	172.31.15.112	8849
ons_server	ONS authoritative server	172.31.15.113	8849
mysql-5.1	Database server	172.31.15.114	3306

Table 9. ONS based on DNS

Program name	Explanation	IP Address	Listening port
ons_clientDNS	ONS client	172.31.15.110	none
ons_localDNS	ONS local server	172.31.15.111	8748
ons_rootDNS	ONS root server	172.31.15.112	8749
ons_serverDNS	ONS authoritative server	172.31.15.113	8749
bind 9.5	DNS client	172.31.15.114	53

We conduct comparison test on two kinds of ONS architecture from performance, application scalability, and other aspects. All tests were in the same environment, and the same initial state of the system. Time in test results is relative value.

4.1 ONS data records query and update

Performance analysis is mainly refers to the system response time for requests, scilicet the average time of process a query request completely.

Test Method: Test program sends 1,000 queries successively by cyclic, it marks time for each request and response. At last it calculates average time of 1000 queries and responses intervals. Figure 4 after both ONS were tested.

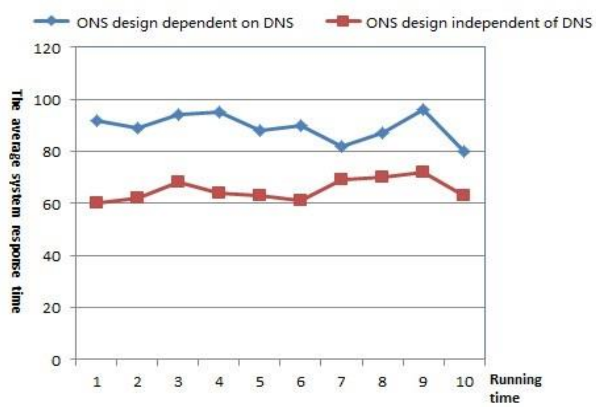

Figure 4. average response time of two kinds of ONS

Data analysis: seen from Figure 4, the average request response time of the ONS independent of the DNS service system is shorter than that of the ONS based on the DNS. This is due to that the ONS system based on DNS has to conduct DNS domain search after it finishes each query. ONS system Independent of the DNS service returns EPCIS server's IP address directly, no further DNS requests, DNS recursive queries, DNS returns the query results and other steps, so the whole system request response time is reduced.

4.2 Application Scalability Testing and Analysis

With the increasing scale of EPCGlobal, the number of queries of ONS service and records storage space will continue to grow, the system performance is also very important.

Test Description: Assume that each enterprise has 5000 Item category numbers; each category number has 1000 single product numbers. All items of each enterprise are stored in the same EPCIS server. The units of the enterprise scale are the amount of all items code record.

Test Method: Test program sends 1,000 different queries by cyclic as a test cycle, and increase all data records of the enterprise after completing a test cycle. Finally, through calculating the average time for each request response time, we obtain curves shown in Figure 5.

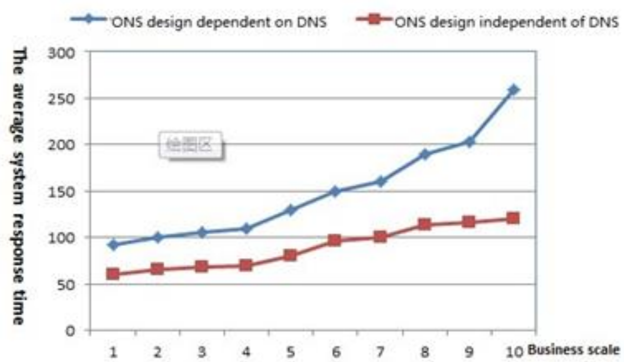

Figure 5 the system response time of the two kinds ONS with business scale increases

Data analysis: seen from Figure 5, the average request response time of ONS system independent of DNS grows logarithmically level gradually as the business scale increased while the ONS system based on DNS will grow exponentially. This is due to that the records in ONS system independent of the DNS are stored in the form of regular expressions; only need to add one record when add all item code record of an enterprise (EPC code version-Enterprise number.*.* -IP address- EPCIS).The ONS system based on DNS have to add 5000 records (assuming the enterprise category number is 5000), Therefore, the Inquiry time of ONS system independent of the DNS will greatly be reduced. Test results show that ONS system independent of the DNS stores data records in the form of regular expressions can deal well with large-scale business growth.

5. Conclusions

This paper proposed design and implementation of an ONS system that independent of DNS service. Test results show that the ONS system independent of the DNS service has characteristics such as smaller data record storage space, less query response time, success in single product inquiries. The main research work in the next phase is ONS security mechanisms, ONS standard interfaces and other aspects, which can provide better Item inquiry service in practical applications in the future.

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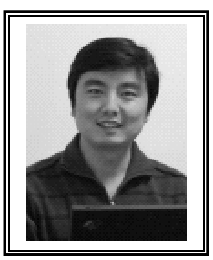

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