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Inventions on Integrating LDAP with Other Directories - A TRIZ Based Analysis of US Patents

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-A TRIZ based Analysis of US Patents

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1. Introduction

Lightweight Directory Access Protocol (LDAP) is an IETF open standard to provide directory services in the network. LDAP was initially developed at the University of Michigan with an objective to include most of the features of X.500, while eliminating the burdens and difficulties of the same.

The current Version of LDAP is LDAP V.3 released in December 1997 (RFC 2251). Other specifications of LDAP can be found in different RFCs on the IETF (Internet Engineering Task Force) website.

With the growing use of Internet, LDAP is becoming more and more popular to provide directory services to a wide range of applications. This led to patenting several inventions relating to LDAP operation and application. This study on LDAP data storage is a part of the main study on LDAP based on 60 selected patents on LDAP from US Patent database.

2. Study on integrating LDAP with other directories

This study on integrating LDAP with other directories is a part of the above-mentioned study “Inventions on LDAP- A study based on US Patents”. The objectives, methodology and general findings are study can be found in that article. The details of this section of study on integrating LDAP with other directories are presented below.

2.1 Objectives of the study

The objective of the study is to know:

- What are the inventions made on integrating LDAP with other LDAP and non-LDAP directories and on which aspects of it?
- What is the Ideal Final Result (IFR) in LDAP integration? Is there any trend in the series of inventions?
- Which problems on integrating multiple directories have not been solved yet? In other words which problems need to be addressed in future?
- Which aspects of LDAP integration are yet unexplored? What are the possible areas of improvements in future inventions?
2.2 Major areas of Invention

- One major area of invention is to integrate one LDAP directory with another LDAP directory, where the data in different LDAP directories may use different schemas.

- Another area of invention is to integrate LDAP directory with other Directories, where the data format and database structure can be quite different from the LDAP to be integrated.

- Another area of invention is to integrate LDAP with other directories, such as telephone directories, IP address directories, email directories etc., to get some interesting result.

- Integrating LDAP with other services to improve the performance of other services by offloading some responsibility on to LDAP.

- In almost all cases, there is a focus on data conversion, transfer, migration and data management mechanism between the two different directories.

2.3 Patents analyzed for the study


- US Patent 6154743, “Technique for accessing heterogeneous directory services in an APPN environment”,


- US Patent 6377950, “Integrated directory services” Invented by Peters,

- US Patent 6609121, “Lightweight directory access protocol interface to directory assistance systems”,

- US Patent 6778544, “Method and system for redirecting calls”,

- US Patent 6553368, “Network directory access mechanism”,

- US Patent 6614788, “Network address management”.

Inventions on integrating LDAP with other Directories, by Umakant Mishra
3. The mechanism of integrating multiple LDAP

The data model of LDAP is same as X.500 data model. The LDAP protocol assumes there are one or more servers, which jointly provide access to a Directory Information Tree (DIT). The tree is made up of entries. Entries have relative distinguished name (RDN), which must be unique among all its siblings. The concatenation of the relative distinguished names from a particular entry to an immediate subordinate of the root of the tree forms the Distinguished Name (DN) for that entry. (IETF, RFC 2251).

Thus the LDAP architecture allows multiple LDAP servers work together on the same directory tree or multiple directory trees. Besides, LDAP being built on an open architecture, it is quite possible to integrate with other directory servers. LDAP can be mapped onto any other directory system so long as the X.500 data and service model as used in LDAP is not violated in LDAP interface.

LDAP server may store data in a Flat file, in RDBMS or in any other database. The LDAP client applications can use LDAP directory interface without having knowledge on the underlying data storage mechanism.

4. Major Concerns in LDAP directory integration

- Different directories may use different schema for their directory objects. It is not possible to integrating database of one schema directly with database having another schema.

- In LDAP environment, the clients should not assume that the servers support any particular schemas without prior agreement with the servers.

- Integrating LDAP directories with other databases having very different data types and structures need special mechanism for interaction.
- Different directory servers may use different protocols, which may not be compatible to each other to communicate between themselves.

- Some directories may use proprietary protocols, which may not allow open interfaces to communicate.

5. IFR for LDAP directory integration

According to TRIZ, ideality is a function of its benefits and costs. $\text{Ideality} = \frac{\sum \text{Benefits}}{\left( \sum \text{Costs} + \sum \text{Harm} \right)}$. So the Ideal Final Result in LDAP integration can be achieved by increasing all useful functions of the LDAP integration and decreasing all harmful functions of the same. An analysis of the LDAP system may find the following as IFR for LDAP integration.

<table>
<thead>
<tr>
<th>Should have (Positive features)</th>
<th>Should not have (Negative features)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The client should use one interface and one query to request data and not multiple requests to multiple different directories.</td>
<td>• The user need not enter same data again and again in different directories.</td>
</tr>
<tr>
<td>• The client should enter and update data (say email address) only in one directory (say LDAP). The other directories containing the same data item should automatically update the data.</td>
<td></td>
</tr>
<tr>
<td>• The LDAP directory should be able to access data from other directories containing data in other formats.</td>
<td>• Accessing other directories should not require the whole data from other directories to be converted to LDAP compatible format, which would result in too much burden.</td>
</tr>
<tr>
<td>• If there is a different schema, or database structure, or different protocol, the LDAP server should automatically recognize and access accordingly.</td>
<td></td>
</tr>
<tr>
<td>• All different directories (LDAP and non-LDAP) should use the same Distinguished Name (DN) to identify an object.</td>
<td></td>
</tr>
<tr>
<td>• The LDAP directory should be XML compliant, Java compliant, CORBA CosNaming compliant, and compliant to others.</td>
<td></td>
</tr>
</tbody>
</table>
6. Inventions on LDAP directory integration

As we discussed above there are many inventions on integrating LDAP with other directories. All those inventions are analyzed in the following pages.

6.1 Method of migrating data from one LDAP directory to another

Background problem:
It is often required to migrate (e.g., copy) data from one LDAP database to another. Migrating data from one database to another database is not problematic if both databases have the same schema. However, if the databases do not have the same schema, then problems arise because of incompatibility.

Solution provided by US Patent 6915287:
US Patent 6915287 discloses a method and software tool that is useful when one is attempting to migrate data from LDAP directory to another LDAP directory where the schema for the two directories are not the same. The tool first compares the schema of a source directory to the schema of the destination directory. Then it updates the schema of the destination directory to be compatible with the source directory’s schema.

Before adding the entries, it verifies the modified schema with each entry from the source database to check whether it can allow the entry to be added to the directory. In case the destination directory’s schema does not allow any particular entry, the destination directory’s schema is modified again until it ensures that the schema is fully compatible. Finally it adds the entries to the destination directory.
TRIZ based analysis:
The method first compares the schema of the source directory to that of the destination directory and updates the schema of the destination directory to make it compatible to the schema of source directory (Principle-33: Homogeneity).

Before adding the entries, the method verifies the modified schema to ensure that it can take all entries from the source database (Principle-10: Prior Action).

In case the destination directory’s schema does not allow any particular entry, the destination directory’s schema is modified again and again until it ensures that the schema is fully compatible (Principle-20: Continuity of useful action).

6.2 Online directory service with multiple databases

Background problem
Many organizations maintain directories of users that can be accessed by other users. In such cases the data is typically maintained on the Internet and accessed through web based forms. The user submits a query through an input screen and the result is searched from the databases. This method works fine when there is one database. But when there are several databases and each having large number of records, the performance deteriorates. There is a need to improve the data management in such scenario.

Solution provided by patent 5918227
US patent 5918227 discloses a method of accessing multiple directory databases though a “gater” or intermediate computer. As per the invention there is a first processor or “gater” in between the client and the directory servers. The first processor receives requests and passes them to one of the second processors called “gaters”. The other “gaters” receive requests passed from the first “gater” but afterwards communicate directly with the user independent of the first “gater”. The “gaters” can communicate with each other to retrieve records. The invention gives an example of Switchboard directory service (and not LDAP).
TRIZ based analysis

Data searching in online directory should take no time (or minimum time) even with multiple databases each having large number of records (Ideal Final Result).

The client sends request through the first directory server (“gater”) instead of sending queries to each directory servers (Principle-24: Intermediary).

Although other “gaters” get request through the first “gater”, they communicate directly with user independent of the first “gater” (Principle-21: Skipping).

6.3 Accessing heterogeneous directory in APPN environment

Background problem

In a SNA (Systems Network Architecture) network (developed by IBM), the end stations access the network by APPN (Advanced Peer to Peer Network) functions. A CDS (Central Directory Service) provides centralized registration and search functions of all resources in an APPN network. But the APPN functions are slow and searching operations in a CDS (central directory service) consumes a significant amount of resources.

To avoid this problem, some users prefer issuing broadcast locate operations in lieu of CDS searches. However, broadcast searches consume network bandwidth and affect the performance of the network. There is a need to solve this problem.

Solutions provided by patent 6154743

US Patent 6154743 discloses a method of offloading a CDS function from a mainframe of a APPN network to a light-weight directory access protocol (LDAP) Accessible Directory Services (LADS) residing on another dissimilar network. LDAS is configured to provide CDS functionality on the dissimilar network such as TCP/IP network. This offloading of CDS services save memory and resources for mission critical applications.

The invention improves the efficiency of bandwidth usage and throughput because of reduction of unnecessary broadcast searches in the network. Besides, offloading CDS services from APPN mainframe improves server performance.
**TRIZ based analysis**

The APPN environment should make use of a centralized directory service without sacrificing bandwidth and system resources (Ideal Final Result).

The invention offloads the CDS (central directory services) function from one network to another, which improves bandwidth usage in the network (Principle-Taking out).

**6.4 Data management interoperability in heterogeneous directory structure**

**Background problem**

As the complexity of networks grow, it becomes increasingly difficult to exchange and manage data especially in networks comprising a plurality of heterogeneous components. With the inception of LDAP, corporations began using the directory services to maintain organizational data such as names, job responsibilities, telephone numbers etc. But there are various data management systems, which stores the data or documents in a traditional file system or database that are not capable of interacting with the directory service systems like Microsoft Active Directory or LDAP directory. There is a need to provide a means for interacting with Directory database in a large global enterprise.

**Solution provided by patent 6484177**

Patent 6484177 discloses a data management system that enables multiple heterogeneous systems to exchange information. The systems may be comprised of one or more networks, simple or complex file system, different types of databases or directory services like LDAP or Microsoft Active directory, they can still communicate each other. The invention uses a single virtual Data Management System (DMS) that may exist on a single homogeneous platform or distributed heterogeneous platform. The requests coming from the client are responded through this Data Management System.

The Data Management System has a plurality of data managers. The interaction between the directory services and the Data Management System is accomplished through a plurality of commonly available communication protocols. The user input is managed with a user interface through an API.
**TRIZ based analysis**

The invention uses a Data Management System (DMS) that remains between the client and the directory server (Principle-24: Intermediary).

The Data Management System (DMS) can communicate with different directory services in heterogeneous platforms by using different communication protocols (Principle-5: Merging, Principle-6: Universality).

### 6.5 Integrated directory services

**Background problem**

Traditionally a corporate enterprise has both data communication system (such as email server) and a voice communication system (such as EPABX) and directory servers, which contain some data in common. But a directory server is physically and logically separate from the telephone directory. As a result, every time a change is made to the common data, it is changed manually and independently in both the directories. This duplicate data entry increases burden on the network administrator and the PBX system administrator, besides leads to occasional errors and inconsistencies.

There is a need to have a single data entry (and administration) point for all the directories that share common data (like a telephone number).

**Solution provided by US Patent 6377950**

US patent 6377950 provides an Integrated Directory Services system (IDS) which automatically synchronizes data in a central Directory server with a telephone directory of a PBX. The IDS provides a single administration point for all additions, deletions and data changes, which are then automatically propagated to the other databases. This eliminates the need of independent entry to each existing system and ensures consistency in all the databases.
**TRIZ based analysis**

All directory databases should be updated automatically as and when a change is required (IFR). All directories should be automatically updated when the modifications are done at one central place (Desired Result).

The invention uses Integrated Directory Services (IDS) which works as an intermediary between the telephone directory and the directory database (Principle-5: Merging, Principle-24: Intermediary) and provides a single administration point to update all directory databases (Principle-6: Universality).

### 6.6 Using LDAP to interface Directory Assistance (DA) systems

**Background problem**

Directory Assistance (DA) solutions incorporate directories and directory servers, which provide phone numbers to the callers (or beneficiaries). These DA systems organize and store data different from each other. They use proprietary interface for accessing their internal information, which cannot be easily externalized directly to outside application systems. As a result the communication mechanism between different DA systems take place in closed environments.

Although LDAP is an open system that can be used to overcome the above problems, LDAP cannot be directly integrated with different DA systems, as the structure of DA systems may be incompatible to the tree-structure of LDAP. It is necessary to find a mechanism of interfacing different DA systems with LDAP interface.

**Solution provided by patent 6609121 and 6732160**

US Patent 6609121 finds a method of mapping an LDAP interface to a DA (Directory Assistance) system. According to the invention the client will send LDAP compatible search arguments, which will be converted to DA compatible search arguments. The DA will be queried using this DA compatible search arguments. The results of the query will be converted to a result set compatible with LDAP and served to the client. All these steps of conversion can be done by a plug-in to the LDAP server.
Patent 6732160 (by the same inventors) also provides a similar mechanism consisting of five steps as above. Both inventions use plug-ins for data conversion.

TRIZ based analysis

The invention comprises of five different steps to convert LDAP queries to DA system compatible queries and convert DA results to LDAP compatible results (Principle-36: Conversion).

The invention uses a plug-in to the LDAP server, which takes care of all the five steps of receiving a query from the client to serving a response (Principle-24: Intermediary).

6.7 Using LDAP to redirect telephone calls

Background problem

The calls placed in the PSTN (Public Switched Telephone Network) use offboard lookups to redirect the calls to the correct destination. For example, when a caller makes an 800 or 888 long-distance calls, the service access code (SAC) is translated into a directory number. Similarly when the caller makes a local number portability (LNP) call, the local routing number is used alongside the original directory number to route the call to its destination.

The drawback of using this system to perform SAC/LNP queries is that it consumes 30-40% more time to route the redirected calls than routing the non-redirected calls.

Solution provided by patent 6778544

US Patent 6778544 discloses a method for redirecting calls more efficiently, whereby an LDAP query is encoded with a called telephone number. The LDAP query is transmitted from a TCP/IP to an LDAP server via an IP network, and the TCP/IP awaits a response back from the LDAP server, which response identifies a corrected destination address, and may include translated digits which may be used in telephony routing.
According to the present invention, SAC and/or LNP queries and the redirecting of calls is improved by using a TCP/IP stack and LDAP protocol in lieu of an SS7/TCAP stack, SCP, and STP. This permits the use of Internet protocols, which are less expensive and faster than an SS7/TCAP stack, SCP, and STP, thereby reducing telephone line blockage and increasing the traffic capacity of telephone switches.

**TRIZ based analysis**

The invention uses TCP/IP stack (faster and cheaper) and LDAP protocol (open standard) in lieu of an SS7/TCAP stack, SCP and STP (Principle-28: Mechanics substitution).

### 6.8 Network directory access mechanism

**Background problem**

Although the popularity of LDAP is increasing as an open standard there is no known method to integrate data existing in a legacy format. Converting the data from the old format to the LDAP structure is not simple. Mapping legacy data to LDAP structure may solve the problem but there is no straightforward mechanism for this conversion. There is a need for a method, which can integrate one directory to other without needing to convert all the entries under the first format into the second format.

**Solution provided by patent 6553368**

US patent 6553368 discloses a method to integrate LDAP directory to other directories without converting the data. As per the invention, the data in the first directory remains in its own format and data in the other directories also remain in their own formats. The method stores not only access rights but also access methods for the directory entries. When the directory server is requested to access that entry, the server uses the specific access method for the entry.
The advantage of this method is that the data in different directories remain in their own format. The directory access mechanism is capable of accessing different directories without converting the entire directory.

**TRIZ based analysis**

Directories of heterogeneous structure and environment should be able to integrate and communicate with each other (Ideal Final Result).

One option is to convert the first format into second format and integrate (Principle-36: Conversion), but that will lead to a lot of unnecessary conversions.

The invention stores the access control data as well as access mechanism along with the directory entries (Principle-5: Merging).

The directory access mechanism is capable of accessing different directories through different access methods or protocols without converting the whole directory from one format to other (Principle-33: Homogeneity).

### 6.9 Using LDAP to unify RADIUS and DHCP

**Background problem:**

In a dynamic address management system, the systems request their IP (Internet Protocol) address from a common pool of addresses. The dynamic IP allocation is managed either by Remote Authentication Dial-In User (RADIUS) protocol or by Dynamic Host Configuration Protocol (DHCP). These two protocols are managed independently with separate pool of IP addresses being kept for each protocol.

This arrangement works in principle, but it is an inefficient way of managing IP addresses particularly in organizations where users may operate both on the local network and at a remote location requiring external access. There is a need to maintain a common pool in order to optimize the management of IP addresses.
Solution provided by patent 6614788

US Patent 6614788 provides a method of allocating IP addresses using LDAP. There will be a common single pool of network (IP) addresses, which will be allocated by LDAP server in response to requests by clients. LDAP also maintains a record of network address allocation to users. Thus the IP allocation under RADIUS and DHCP can be unified using a common address pool and mappings between IP addresses and centralizing the allocation by using a Directory service.

Thus the new method comprises the steps: a) receiving a request from a client for an IP address through at least one of RADIUS and DHCP; b) sending the request to a directory service for an unused IP address; c) returning a response to the client including an unused IP address allocated to the client; and d) updating the directory service for the allocated IP address--hostname/user binding.

TRIZ based analysis

The invention maintains a common network address pool to be used for both RADIUS and DHCP protocols (Principle-5: Merging).

The common address pool is maintained by LDAP directory service, which takes care of taking the request and allocating the IP address (Principle-24: Intermediary).

7. Other related inventions

7.1 Framework for LDAP operation extensibility

Patent 6665674 provides a framework for open directory extensibility that permits directory-independent information access (Principle-5: Universality). A Lightweight Directory Access Protocol (LDAP) Validation Proxy (LVP) is used to intercept and validate LDAP request messages from the clients intended for the directory (Principle-24: Intermediary). The LVP has the capability of generating LDAP requests in processing LDAP messages. The LVP also intercepts and processes LDAP responses issued by a directory and intended for clients.
7.2 Using LDAP for a CORBA Compliant Name Service:

US Patent 6578050 presents a method of using LDAP (or a directory service that is compliant to LDAP) for implementing CORBA compliant name services in distributed object systems (Principle-5: Merging). The name service can be compliant with CORBA CosNaming specification, and directory service is capable of storing persistence information in the directory database. The flexibility of LDAP can provide compliance with CORBA CosNaming Specification and it can provide an interface to interacting with the directory service for storage and retrieval of data.

7.3 Spoken name announcement feature in a messaging environment

US Patent 6810113 discloses a method of using LDAP in a messaging system which would allow messaging services to provide senders with announcements regarding the recipients. According to the invention the information on the senders and recipients will be stored in LDAP server (Principle-24: Intermediary). When a message sender’s messaging platform (MP) finds the spoken name data of the recipient from the Directory (or other sources) the MP makes a presentation to the sender (Principle-23: Feedback). With the implementation of the spoken name announcement feature, the sender becomes sure that his or her message will be made available to the recipient intended by the sender.

8. Summary and Findings of the study

8.1 Distribution of patents

- There are nine patents analyzed above under this topic of LDAP integration. The distribution of assignees of the patents are as follows:
  
<table>
<thead>
<tr>
<th>Assignee</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Novell Inc.</td>
<td>1</td>
</tr>
<tr>
<td>Switchboard Inc</td>
<td>1</td>
</tr>
<tr>
<td>Cisco technology</td>
<td>1</td>
</tr>
<tr>
<td>IBM</td>
<td>2</td>
</tr>
<tr>
<td>Mitel corporation</td>
<td>1</td>
</tr>
<tr>
<td>Nortel networks</td>
<td>1</td>
</tr>
<tr>
<td>Sun Microsystems</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
</tr>
</tbody>
</table>

- Besides the above nine patents, there are three more patents which are found to be relevant to this study. Those three are also presented above in this report.

8.2 Hot areas in LDAP integration with other directories

The analysis finds that the inventions try to improve the following aspects of LDAP system.

- Avoiding entering the same data again and again in different directories.
- The user interface to query and access multiple directories, and the administrative interface to manage and administer multiple directories.

- Method of converting data from one directory to another.

- Accessing data from different servers by issuing a single query.

- Using LDAP with other systems to offload their burdens and improve their performance.

- Integrating existing incompatible data with LDAP and access through LDAP interface.

8.3 Trends of evolution in LDAP directory integration

The following trends are prominent among the inventions on LDAP data storage.

- Boundary breakdown- inventions try multiple directories to integrate seamlessly and work together.

- Enterprise Integration- different directories with different data structures and protocols should be able to communicate with each other.

- Increasing speed in LDAP data entry, update and access- Inventions try to enter and update data only once and make use of it through different directories for different purposes.

- Increasing easiness to “configure and implement” and increasing easiness to “maintain and administer” are two obvious trends.

- Reducing conversion- inventions trying to integrate directories without converting all the data in those directories.

- Increasing scalability- the LDAP directory is aiming to manage larger volume of data.

- Action coordination- if a data item is updated in one directory, it should get updated in all directories whichever contains the same data item.

- Increasing reusability- the user should enter and update data only once in one directory (and not enter the same data again and again in different directories) and access it from any other directory.

- Reducing system complexity- The LDAP integration mechanism should be as simple as possible.
8.4 Predicting future inventions on LDAP integration

Based on the analysis we can predict more inventions on the following aspects of LDAP integration with other directories in future.


- Accessing data from any directory through LDAP server (Principle-6: Universality).

- Automatic integration of different implementations of LDAP from different vendors. (Principle- Merging, Principle- Self Service).

- Automatic replication and synchronization of multiple copies of LDAP directories. (Principle- Copying, Principle- Segmentation)

- Converting LDAP queries to access proprietary databases (Principle-36: Conversion).


- Using external clients to access LDAP data from LDAP unaware applications (Principle- Merging, Principle- Intermediary).

- Using public telephone directories in publicly accessible LDAP servers. (Principle- Parameter Change).

- Compression and storage optimization of LDAP database (Principle-Mechanics Substitution).

- Method of finding duplicate objects in LDAP by character matching (Principle- Taking out).

- Method of integrating LDAP with DNS and DHCP servers (Principle-Merging).


- Self discovering LDAP servers to communicate with each other. (Principle-Self Service, Principle- Feedback).
Reference to Patents:


Other References:


