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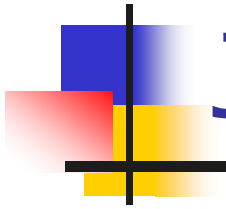

JNDI and LDAP – Part II

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DevTech®

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Session Overview

LDAP is an IETF-standardized core technology that you can use to integrate information across multiple enterprises, computing platforms, programming languages, and applications. We will discuss why and when to use a Directory Services model rather than a Relational Database model; look at published schema that standardize critical concepts; and examine how LDAP can be used to implement such things as centralized identity across operating systems, Web applications, mail servers, *etc*. We will also discuss fine-grained access control, persistent searches, and other advanced topics that highlight LDAP's advantages.

PLEASE ASK QUESTIONS! ☺

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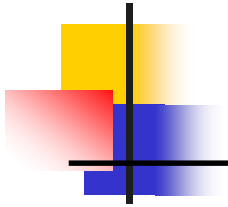

Session Prerequisites

- You will want a good understanding of Java.
- You will want an understanding of JNDI and some basic LDAP (see Part I).
- To run most of the sample code, you'll need to install a suitable LDAP server.

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Directory *vs.* RDB

Directory

- Relatively simple data model, optimized to be highly read intensive & searchable.
- Hierarchical with schema inheritance.
- Federated.
- Fine-grained, flexible, security.

Relational Database

- Larger, more complex, relational data model, optimized for lots of transactions.
- Relational tables and queries.
- Centralized.
- Relational security.

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Directory Standards Benefits

- Centralized information management of distributed, federated, multi-purposed data.
- Compared to application-specific databases, reduces:
  - Inconsistent data
  - Data redundancy
  - Administration

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LDAP Benefits

- Common, simple, fast, implementation of X.500 concepts over TCP/IP stack.
- Well-defined language bindings for many languages, wire-level protocol, and most needed schema.
- Extensible, both in terms of new schema and new directory operations.

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Common Uses for LDAP

- Identity
  - Authentication
  - Authorization
  - Profile
- Administration
  - Accounts
  - Servers
  - Services
  - …

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LDAP Aspects

- Information
  - Named *entries* composed of *object classes*, which contain named *attributes*, both of whose presence and makeup is defined by *schema.*
- Structure
  - Hierarchical structure defined by a federated namespace.
- Operations
  - Authentication: bind (to server), unbind, abandon
  - Query: search and compare
  - Update: add, delete or modify entry; modify RDN
  - Controls (modify operations) and Extended (new) Operations
- Security

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Schema Elements

- Attributes – named values. Must be defined by schema before they're used in an object class.
- Object Classes
  - Structural – used to determine the entry's location within the DIT, and group related attributes.
  - Auxiliary – group related attributes. Can be attached to entries irrespective of their place in the DIT.
    - `extensibleObject` is a special AUXILIARY object class that permits *any* attribute defined by a currently loaded schema to be used.
  - Abstract – cannot directly instantiate. See `top`.

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Sample User

- dn: uid=noel,ou=People,dc=apache,dc=org
- objectClass: top
  account
  posixAccount
  shadowAccount
  qmailUser
- uid: noel
- host: ajax
  eris
  hermes
  loki
  minotaur
  nagoya
- mailForwardingAddress: noel@devtech.com
- cn: Noel J. Bergman
- uidNumber: 711
- gidNumber: 711
- homeDirectory: /home/noel
- loginShell: /bin/bash
- userPassword: {CRYPT}...
- mail: noel@apache.org

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Sample User Structure

- `objectclass ( 2.5.6.0 NAME 'top' ABSTRACT MUST objectClass )`
- `objectclass ( 0.9.2342.19200300.100.4.5 NAME 'account' SUP top STRUCTURAL`
  `MUST userid`
  `MAY ( description $ seeAlso $ localityName $`
  `organizationName $ organizationalUnitName $ host ))`
- `objectclass ( 1.3.6.1.1.1.2.0 NAME 'posixAccount' SUP top AUXILIARY`
  `MUST ( cn $ uid $ uidNumber $ gidNumber $ homeDirectory )`
  `MAY ( userPassword $ loginShell $ gecos $ description ))`
- `objectclass ( 1.3.6.1.1.1.2.1 NAME 'shadowAccount' SUP top AUXILIARY`
  `MUST uid`
  `MAY ( userPassword $ shadowLastChange $ shadowMin $ shadowMax $`
  `shadowWarning $ shadowInactive $ shadowExpire $ shadowFlag $`
  `description ))`
- `objectclass ( 1.3.6.1.4.1.7914.1.2.2.1 NAME 'qmailUser' SUP top AUXILIARY`
  `MUST ( mail $ uid )`
  `MAY ( mailMessageStore $ homeDirectory $ userPassword $`
  `mailAlternateAddress $ qmailUID $ qmailGID $ mailQuota $`
  `mailHost $ mailForwardingAddress $ deliveryProgramPath $`
  `qmailDotMode $ deliveryMode $ mailReplyText $ accountStatus))

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What Happened to `userid`?!

- Wait! I thought that `userid` was a MUST for the `account` class!
- Yes, it is. But look at the attribute definition for `userid`:

```
attributetype ( 0.9.2342.19200300.100.1.1
   NAME ( 'uid' 'userid' )
   DESC 'RFC1274: user identifier'
   EQUALITY caseIgnoreMatch
   SUBSTR caseIgnoreSubstringsMatch
   SYNTAX 1.3.6.1.4.1.1466.115.121.1.15{256})
```

- The attribute has two names. ☺

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POSIX Group Structure

- RFC 2307 NIS Schema class for a POSIX (UNIX) Group
  - ```
    objectclass ( 1.3.6.1.1.1.2.2 NAME 'posixGroup'
      SUP top STRUCTURAL
      MUST ( cn $ gidNumber )
      MAY ( userPassword $ memberUid $ description ))
    ```
- Sample Attributes:
  - ```
    attributetype ( 1.3.6.1.1.1.1.1 NAME 'gidNumber'
      EQUALITY integerMatch
      SYNTAX 1.3.6.1.4.1.1466.115.121.1.27 SINGLE-VALUE )
    ```
  - ```
    attributetype ( 1.3.6.1.1.1.1.12 NAME 'memberUid'
      EQUALITY caseExactIA5Match
      SUBSTR caseExactIA5SubstringsMatch
      SYNTAX 1.3.6.1.4.1.1466.115.121.1.26 )
    ```
    ```

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Sample POSIX Group

- Sample Group:
  - `dn: cn=mailAdmins,ou=Group,dc=example,dc=org`
  - `objectClass: top`
    `posixGroup`
  - `cn: mailAdmins`
  - `gidNumber: 117`
  - `memberUid: aaron`
    `berin`
    `erik`
    `justin`
    `noel`
  - `Description: Mail Administrators`
- To find a user's groups, search with a filter (see RFC 2307 #5.2):

  `(&(objectClass=posixGroup)(memberUid=%s))`

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LDAP Security

- RFC 2820 specifies access control requirements for LDAP, but not a syntax.
- LDAP uses fine-grained access control.
- You could spend hours exploring OpenLDAP ACLs:
  http://www.openldap.org/doc/admin22/slapdconfig.html
  http://sapiens.wustl.edu/~sysmain/info/openldap/openldap_configure_acl.html
  - Simple example: allow users or administrators to change their password, unauthenticated users to authenticate, and deny read except to the owner or administrators.
    -
```
access        to attr=userPassword
              by self              write
              by group="cn=admins,ou=Groups,dc=apache,dc=org"
write
              by anonymous  auth
              by *                 none
```

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LDAP Integration

- Two basic approaches can be taken to integrate with LDAP.
  - Direct – the operation to be integrated is tied directly into LDAP, relying upon it in real-time. This is the most common approach.
  - Indirect – the operation to be integrated uses its "native" data stores, which are populated from LDAP by helper tools.
    - The debian project's "userdir-ldap" tools exemplify the indirect approach.
- These are <u>not</u> mutually exclusive approaches within an overall deployment.

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LDAP Integration Compared

Direct

- LDAP is accessed directly in real-time.
- Pros:
  - Real-time consistency.
  - Leverages LDAP's fine-grained access control.
- Cons:
  - Requires real-time LDAP access.
  - Requires code to be modified to use LDAP.
  - Operational reliability tied to quality of LDAP integration code and availability of LDAP.

Indirect

- Native data stores are accessed in real-time, and updated from LDAP.
  - Typically a periodic task.
  - Could use triggers (few LDAP servers support them).
- Pros:
  - Does not require change to functional code.
  - Works even when LDAP server is unavailable.
- Cons:
  - Native stores can lag LDAP.
  - Awkward, at best, to use LDAP access control when populating native stores.

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nss_ldap

- Ties the Nameservice Switch directly to LDAP.
  - IETF RFC 2307
  - Operating systems that use NSS become LDAP enabled.
- Originally developed by PADL Software. You may want to use current PADL code, but the same caveats apply as for `pam_ldap`.

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Using nss_ldap

- Edit `/etc/nsswitch.conf`, *e.g.*:

```
passwd: files ldap
shadow: files ldap
group: files ldap
```

  - Local entries will be used first, *e.g.*, `root`, followed by entries in LDAP.
- Edit `/etc/ldap.conf`, *e.g.*:

```
host ldap.apache.org
base dc=apache,dc=org
```

- See RFC 2307 for LDAP details and examples.

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pam_ldap

- Ties PAM (Pluggable Authentication Module) directly to LDAP.
  - All software that uses PAM becomes LDAP enabled.
- PAM is much more flexible than NSS, and allows us to add new authentication methods, such as OPIE.
  - See http://ldappubkey.gcu-squad.org/ to integrate OpenSSH Public Key authentication with LDAP.
- Usually derived from PADL Software's code. Could use that code, or use the version that comes with your PAM distribution.
  - Frequently updated. Check their change logs. Test for memory leaks or other issues.

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JAAS

- The Java Authentication and Authorization Service (JAAS) provides a PAM-like package to authenticate and authorize users in a Java environment.
- JAAS is intended to permit Java code to know who is executing it, regardless of whether the code is an application, applet, EJB, servlet, portlet, …
- JAAS integrates Principal-based access controls into the Java Security model.
- Can be backed by JNDI/LDAP by using the correct JAAS PAM plug-in module.
  - See: http://www.theserverside.com/articles/article.tss?l=Pramati-JAAS
  - See also: **"Security Foundations of Java"** with Simon Roberts.

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Debian's userdir-ldap Tools

- Debian manages many disparate systems.
  - http://db.debian.org/machines.cgi
  - Neither all co-located, nor always available.
- Per-user attributes include:
  - ssh authentication keys
  - vacation notices
  - xplanet coordinates
- How to manage users, groups and other info?
- Their purpose-built userdir-ldap tools use the indirect approach to provide centralized account management without code change.
- Updates performed *via* LDAP, Web Forms and e-mail.
  - Why won't using `passwd` or changing a `.forward` file work?

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Triggers

- LDAP Triggers are currently non-standard.
  - Sun: http://www.sun.com/blueprints/0204/817-5231.pdf
  - Bell Labs LTAP: http://ltap.bell-labs.com
  - The Apache Directory Server (Eve) will also have triggers.
- Pre- and post- operation interceptors.
- Can use with the indirect approach to update native stores.
- Can be used to enforce data validity and consistency.
- Can be used to integrate data across data models.
  - Operation on LDAP automatically results in an operation on another data store, such as a relational database.
- Extended operations can be used to implement triggers.

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Extended Operations

- The LDAP wire protocol is extensible, allowing new LDAP operations to be encoded as specified by RFC 2251 #4.12.
- JNDI Supports extended operations using:
  - `javax.naming.ldap.ExtendedRequest`
    - Represents the extended operation to be encoded on the request.
  - `javax.naming.ldap.ExtendedResponse`
    - Represents the response from an extended operation.
- `javax.naming.ldap` provides extended request/response objects to implement the RFC 2830 STARTTLS operation.
- An unsolicited notification is also an extended response.
- Servers are not required to support an extended operation.

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Unsolicited Notification

- RFC 2251 #4.4 defines unsolicited notification, which allows a server to send an LDAP message to a client that is not a response to a client request message.
- `javax.naming.ldap.UnsolicatedNotification` is the interface to an unsolicited notification. These will be processed as events.
- `javax.naming.ldap.UnsolicatedNotificationListener` is the contract used to listen for notification events.
- The `javax.naming.event` package is used here. In specific, we use the `javax.naming.event.EventDirContext`, which (conveniently) is implemented by the context returned by the LDAP Service Provider.
- See http://java.sun.com/products/jndi/tutorial/beyond/event/unsol.html for a simple example.

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The LdapContext

- `javax.naming.ldap.LdapContext`
- Extends `javax.naming.Directory.DirContext`
- Part of the `javax.naming.ldap` package, which adds RFC 2251 specific features:
  - LDAP Controls
  - Extended Operations
  - Unsolicited Notifications
  - LDAP specific helper classes, such as `Rdn`.
- Used when necessary to access certain, more advanced, LDAP capabilities.

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LDAP Controls

- The LDAP protocol defines parameterized operations. Operations may also have, often optional, modifiers. This extended data is known as a *control*, and defined by RFC 2251 #4.1.12.
- Controls are represented by:
  - Control Type (unique ID)
  - Criticality (must the server support it)
  - Control Value
- LDAP Persistent Searching is implemented using a control.

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Controls and HasControls

- `javax.naming.ldap.Control`
  - Specifies the basic contract for an LDAP Control.
  - Implemented by a number of `Control` sub-classes in `javax.naming.ldap`.
- `javax.naming.ldap.HasControls`
  - Used to test to see if a returned object has controls, and to access them.
  - `Controls[] getControls()`

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Persistent Search

- LDAP Persistent Searching is done using a control.
  - http://www.ietf.org/proceedings/01aug/I-D/draft-ietf-ldapext-psearch-03.txt
- A `PersistentSearch` control is attached to the `SearchRequest` message.
- The LDAP server will send `SearchResultEntry` messages until the client abandons the request or unbinds from the server. The server will not send a `SearchResultDone` message.
- The `SearchResultDone` message(s) may have attached `EntryChangeNotification` controls.

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IETF LDAP Java API

- An IETF effort to produce an RFC standardized JAVA binding to LDAP.
- Sun, Novell and Netscape are the joint authors of the draft RFC.
  - Currently: http://www.ietf.org/internet-drafts/draft-ietf-ldapext-ldap-java-api-19.txt
- Sun's LDAP Triggers paper uses this API, rather than JNDI.
- Unlike JNDI, which we used to access LDAP in part I of this presentation, this API is not a generic interface, like JNDI. It is LDAP specific, providing a much-richer, but also more complex, dialect for working with an LDAP directory.
- Novell's implementation is available through the OpenLDAP Project: http://www.openldap.org/jldap/

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WebSphere Member Manager

- The WebSphere Member Manager (WMM) stores User (Member) information in LDAP and SQL stores.
- Enterprise-wide LDAP DIT might contain the most common user information.
- WMM database can store additional, WebSphere-specific, user information.
- WebSphere Member information can be extended without changing the corporate LDAP schema.
- WMM metadata defines what to store where.

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Wrap-up

- Are there any questions?
- Please remember to turn in your speaker evaluation forms.
- Thank you for coming. I hope that you've enjoyed the session.

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Links – JNDI

- The JNDI Specification
  http://java.sun.com/j2se/1.4.2/docs/guide/jndi/spec/jndi/
- Sun's generally excellent JNDI Tutorial
  http://java.sun.com/products/jndi/tutorial
- JavaWorld articles on JNDI
  http://www.javaworld.com/javaworld/jw-01-2000/jw-01-howto.html
  http://www.javaworld.com/javaworld/jw-03-2000/jw-0324-ldap.html
- ONJava article on JNDI and LDAP
  http://www.onjava.com/pub/a/onjava/2001/05/21/jndi.html
- JNDI/LDAP: Guidelines for LDAP Service Providers
  http://java.sun.com/j2se/1.4.2/docs/guide/jndi/jndi-ldap-gl.html

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Links – LDAP

- LDAP RFC Documents
  http://www.rfc-editor.org/cgi-bin/rfcsearch.pl?searchwords=ldap&num=100
- Understanding X.500
  http://www.isi.salford.ac.uk/staff/dwc/Version.Web/Contents.htm
- IBM Redbook: *Understanding LDAP – Design and Implementation*
  http://publib-b.boulder.ibm.com/Redbooks.nsf/RedbookAbstracts/sg244986.html
- Demystifying the LDAP DIT
  http://www.sun.com/solutions/blueprints/0401/DIT.pdf
- Linux Magazine Series on LDAP
  http://dev.gentoo.org/~spyderous/articles/server/LDAP_Part1.pdf
  http://dev.gentoo.org/~spyderous/articles/server/LDAP_Part2.pdf
  http://dev.gentoo.org/~spyderous/articles/server/LDAP_Part3.pdf
- OpenLDAP
  http://www.openldap.org
- Apache Directory Project
  http://incubator.apache.org/directory

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Links – LDAP Schema

- LDAP Schema RFC Documents *(nota bene: search is a bit broad)*
  http://www.rfc-editor.org/cgi-bin/rfcsearch.pl?searchwords=schema&num=100
- IBM SecureWay Schema (w/ IETF RFC defined schema)
  http://publib.boulder.ibm.com/tividd/td/IBMDS/IDSschema52/en_US/HTML/schema.html
- Debian schema
  http://db.debian.org/userdir-ldap.schema
- qmail LDAP Schema
  http://www.bayour.com/openldap/schemas/qmail.schema
- LDAP Schema for UDDI
  http://ietfreport.isoc.org/idref/draft-bergeson-uddi-ldap-schema/

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Links – LDAP Integration

- NIS and PAM LDAP Tools
  http://www.padl.com/
- Using LDAP to Manage Unix Accounts
  http://www.samag.com/documents/s=9142/sam0405a/0405a.htm
- Securing J2EE Applications using LDAP
  http://docs.sun.com/source/817-6087/dgsecure.html#wp23244
- Security with LDAP
  http://www.skills-1st.co.uk/papers/security-with-ldap-jan-2002/
- Kerberos and LDAP
  http://www.ofb.net/~jheiss/krbldap/kerberos_and_ldap.html
- Debian userdir-ldap tools
  http://people.debian.org/~troup/userdir-ldap.tar.gz
- OpenSSH Public Key Authentication with LDAP
  http://ldappubkey.gcu-squad.org/ or http://www.b0l.org/
- mod_user_ldap
  http://horde.net/~jwm/software/mod_ldap_userdir/
- qmail and ezmlm with LDAP
  http://www.lifewithqmail.org/ldap/

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LDAP RFC List (3Q2004)

- RFC 1274 The COSINE and Internet X.500 Schema
- RFC 1804 Schema Publishing in X.500 Directory
- RFC 2079 Definition of an X.500 Attribute Type and an Object Class to Hold Uniform Resource Identifiers (URIs)

  … plus many more related to X.500
- RFC 2247 Using Domains in LDAP/X.500 Distinguished Names
- RFC 2251 Lightweight Directory Access Protocol (v3): LDAP on-the-wire protocol
- RFC 2252 Lightweight Directory Access Protocol (v3): Attribute Syntax Definitions
- RFC 2253 Lightweight Directory Access Protocol (v3): UTF-8 String Representation of DNs
- RFC 2254 The String Representation of LDAP Search Filters

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LDAP RFC List (3Q2004)

- RFC 2255 The LDAP URL Format
- RFC 2256 A Summary of the X.500(96) User Schema for use with LDAPv3
- RFC 2293 Representing Tables and Subtrees in the X.500 Directory
- RFC 2294 Representing the O/R Address hierarchy in the X.500 Directory Information Tree
- RFC 2307 An Approach for Using LDAP as a Network Information Service
- RFC 2377 Naming Plan for Internet Directory-Enabled Applications
- RFC 2587 Internet X.509 Public Key Infrastructure LDAPv2 Schema
- RFC 2589 Lightweight Directory Access Protocol (v3): Extensions for Dynamic Directory Services
- RFC 2596 Use of Language Codes in LDAP

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LDAP RFC List (3Q2004)

- RFC 2649 An LDAP Control and Schema for Holding Operation Signatures
- RFC 2696 LDAP Control Extension for Simple Paged Results Manipulation
- RFC 2713 Schema for Representing Java(tm) Objects in an LDAP Directory
- RFC 2714 Schema for Representing CORBA Object References in an LDAP Directory
- RFC 2798 Definition of the inetOrgPerson LDAP Object Class
- RFC 2829 Authentication Methods for LDAP
- RFC 2830 Lightweight Directory Access Protocol (v3): Extension for Transport Layer Security
- RFC 2849 The LDAP Data Interchange Format (LDIF) - Technical Specification

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LDAP RFC List (3Q2004)

- RFC 2891 LDAP Control Extension for Server Side Sorting of Search Results
- RFC 3045 Storing Vendor Information in the LDAP root DSE
- RFC 3062 LDAP Password Modify Extended Operation
- RFC 3088 OpenLDAP Root Service An experimental LDAP referral service
- RFC 3112 LDAP Authentication Password Schema
- RFC 3296 Named Subordinate References in Lightweight Directory Access Protocol (LDAP) Directories
- RFC 3377 LDAP(v3): Technical Specification
- RFC 3383 Internet Assigned Numbers Authority (IANA) considerations for the Lightweight Directory Access
- RFC 3384 LDAP v3 Replication Requirements

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Related Sessions

- "Federated Identity Management, the Real Story" (Anthony "Dr. Secure" Nadalin)
- "Security Foundations of Java" (Simon Roberts)
- JNDI can be used as an interface to UDDI, as well, and has some overlap with JAXR (Java API for XML Registries).
  - See the IETF Draft Schema for UDDI in LDAP: http://ietfreport.isoc.org/idref/draft-bergeson-uddi-ldap-schema/