

Network Directories and their Structure

Lightweight Directory Access Protocol (LDAP)

Nick Urbanik <nicku@nicku.org>

Copyright Conditions: Open Publication License (see <http://www.opencontent.org/openpub/>)

A computing department

Network Directories and their Structure

Lightweight Directory Access Protocol (LDAP)

Organising accounts in a large network

Reference book: *Understanding and Deploying LDAP Directory Services*, Second Edition, Timothy Howes, Mark Smith and Gordon Good, Macmillan, 2003.

Our library: TK 5105.595 .H69 2003
(also see references at the end of slides)

Introduction to Directories

Network Directories and their Structure

Account Information

Network Accounts

Network Accounts — 2

Methods of achieving this

Directory systems for

authentication

Proprietary application

directories

Problem with proprietary

directories

Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Account Information

- The computer uses numbers to refer to users and groups
- Humans prefer to use names (like nicku)
- When you create files in your shared network drive, the client must access them using the same numbers
- The user ID numbers and group ID numbers must be the same on all computers
- Otherwise won't be able to read own files!

Introduction to Directories
Network Directories and their
Structure

Account Information

Network Accounts

Network Accounts — 2

Methods of achieving this

Directory systems for
authentication

Proprietary application
directories

Problem with proprietary
directories

Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Network Accounts

- `$ ls -ln file`
`-rw-rw---- 1 500 500 2057 Nov 1 2000 file`
- Now nicku with user ID number 500 and group ID 500 can read and write this file
- ... But nicku with user ID number 2270 and group ID number 2270 cannot access the file at all:

```
$ id
uid=2270(nicku) gid=2270(nicku) groups=2270(nicku),14171(staff)
```

[Introduction to Directories](#)
[Network Directories and their Structure](#)

[Account Information](#)

[Network Accounts](#)

[Network Accounts — 2](#)

[Methods of achieving this](#)

[Directory systems for](#)

[authentication](#)

[Proprietary application](#)

[directories](#)

[Problem with proprietary](#)

[directories](#)

[Why not buy Microsoft AD?](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Network Accounts — 2

- The user ID numbers and group ID numbers on files on a network drive are fixed
- The user ID numbers should remain unchanged for all users who read/write the network drive.

[Introduction to Directories](#)
[Network Directories and their Structure](#)
[Account Information](#)
[Network Accounts](#)

Network Accounts — 2

[Methods of achieving this](#)
[Directory systems for authentication](#)
[Proprietary application directories](#)
[Problem with proprietary directories](#)
[Why not buy Microsoft AD?](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Methods of achieving this

- Have a *directory server* of some kind
- The directory server associates a fixed user ID number with each login ID
- ... and a fixed group ID number for each group ID
- On NT, these are called SIDs (security IDs)

Introduction to Directories
Network Directories and their
Structure
Account Information
Network Accounts
Network Accounts — 2
Methods of achieving this
Directory systems for
authentication
Proprietary application
directories
Problem with proprietary
directories
Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Directory systems for authentication

- Proprietary:
 - ◆ Novell Directory Services (NDS)
 - ◆ Microsoft Active Directory (M? AD)
 - ◆ NT 4 domain
 - ◆ NIS + (Network Information System plus)
 - ◆ NIS
- Open protocols:
 - ◆ LDAP
 - ◆ Hessiod

Introduction to Directories
Network Directories and their
Structure
Account Information
Network Accounts
Network Accounts — 2
Methods of achieving this
Directory systems for
authentication
Proprietary application
directories
Problem with proprietary
directories
Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Proprietary application directories

- Application-specific directories:
 - ◆ Lotus Notes
 - ◆ cc:Mail
 - ◆ Microsoft Exchange
 - ◆ Novell GroupWise
- These directories come bundled with, or, embedded into an application such as email.
- If add another such application, must manage one more directory (“ $N + 1$ directory problem”)
- If add another user, must add to all the directories.

Introduction to Directories
Network Directories and their
Structure
Account Information
Network Accounts
Network Accounts — 2
Methods of achieving this
Directory systems for
authentication
**Proprietary application
directories**
Problem with proprietary
directories
Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Problem with proprietary directories

- Need put the same user into many different directories
- Need maintain N times the number of user accounts, where N is the number of directories.
- This is just too much work.
- The accounts get out of sync.

- Introduction to Directories
- Network Directories and their Structure
- Account Information
- Network Accounts
- Network Accounts — 2
- Methods of achieving this
- Directory systems for authentication
- Proprietary application directories
- Problem with proprietary directories**

Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Why not buy Microsoft AD?

- Microsoft leverage their monopoly on the desktop to “embrace and extend” free software written by others
- Example:
 - ◆ Kerberos is a “Network Authentication Service”, an IETF standard (see RFC 1510)
 - ◆ Kerberos is written by cooperating programmers round the world
 - ◆ Microsoft took Kerberos, and modified the protocol very slightly (they classified this change as a “trade secret”)
 - ◆ So that MS destops can use MS Kerberos servers, but not non-MS Kerberos servers.
- Although MS claims to support standards, MS solutions are highly proprietary
- Designed to lock the user into an all-MS solution.
- Could be an expensive and insecure mistake.

Introduction to Directories
Network Directories and their
Structure
Account Information
Network Accounts
Network Accounts — 2
Methods of achieving this
Directory systems for
authentication
Proprietary application
directories
Problem with proprietary
directories

Why not buy Microsoft AD?

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

LDAP— Why?

- Non-proprietary, IETF standard
 - ◆ No vendor lock-in
 - ◆ Use standard software components
- Supports authorisation as well as authentication
 - ◆ E.g., access if “staff, or year 3, group W, CSA student”
- Very general purpose: use for email, system authentication, application authentication, . . .
- Reasonably secure
- Robust
- Extensible
- Good open source implementation available at <http://www.OpenLDAP.org/>

Introduction to Directories

LDAP

LDAP— Why?

LDAP Terminology

What is LDAP?

The LDAP Protocol

Simple Search Examples

Multiple Simultaneous Requests

LDAP Protocol Operations

Typical LDAP Exchange

LDAP Encoding: BER

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

LDAP Terminology

- LDAP model is *hierarchical*, i.e., tree-structured
- Each object in a directory is an *entry*
- Each individual item in an entry is an *attribute*
- Each entry has a unique full name called its *distinguished name* or *dn*
- Each entry has a short name that is unique under its parent, called its *relative distinguished name*, or *rdn*.
- The organisation of names in the directory is called the *namespace*
- An important initial task is *namespace design*

Introduction to Directories

LDAP

LDAP— Why?

LDAP Terminology

What is LDAP?

The LDAP Protocol

Simple Search Examples

Multiple Simultaneous Requests

LDAP Protocol Operations

Typical LDAP Exchange

LDAP Encoding: BER

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

What is LDAP?

- The LDAP *protocol*, a standard Internet protocol
- Four *models*:
 - ◆ *information model*—what you can put in directory
 - ◆ *information model*—name directory data
 - ◆ *functional model*—what you can do with data
 - ◆ *security model*—no unauthorised access
- LDAP Data Interchange Format (**LDIF**), a standard text format for representing directory data
- LDAP *server software*
- *command line utilities* (`ldapsearch`, `ldapmodify`, ...)
- LDAP API

Introduction to Directories

LDAP

LDAP— Why?

LDAP Terminology

What is LDAP?

The LDAP Protocol

Simple Search Examples

Multiple Simultaneous Requests

LDAP Protocol Operations

Typical LDAP Exchange

LDAP Encoding: BER

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

The LDAP Protocol

- LDAP is a *message-based* protocol
 - ◆ client sends one or more requests to server, one message per request
 - Each message has its own *message ID*
 - ◆ server replies with one or more replies. Each reply has message ID matching that of request.
 - ◆ Can send several messages at once; results can be out of order, no problem

Introduction to Directories

LDAP

LDAP— Why?

LDAP Terminology

What is LDAP?

The LDAP Protocol

Simple Search Examples

Multiple Simultaneous Requests

LDAP Protocol Operations

Typical LDAP Exchange

LDAP Encoding: BER

LDAP Operations

Utilities and LDIF

Schemas

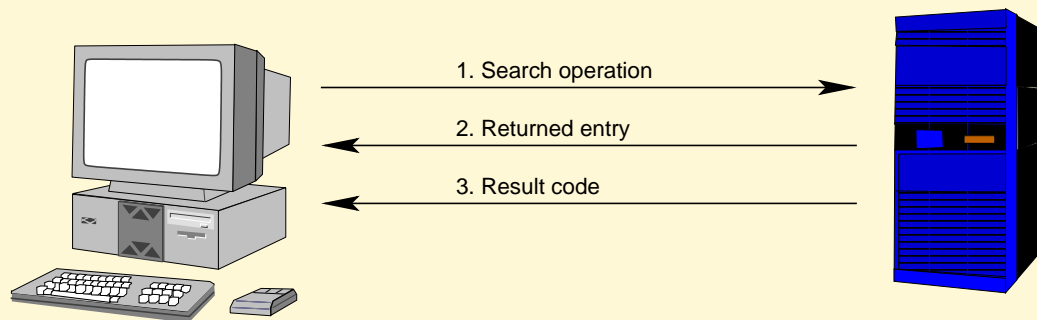
LDAP Filters & URLs

ICT Schema Design

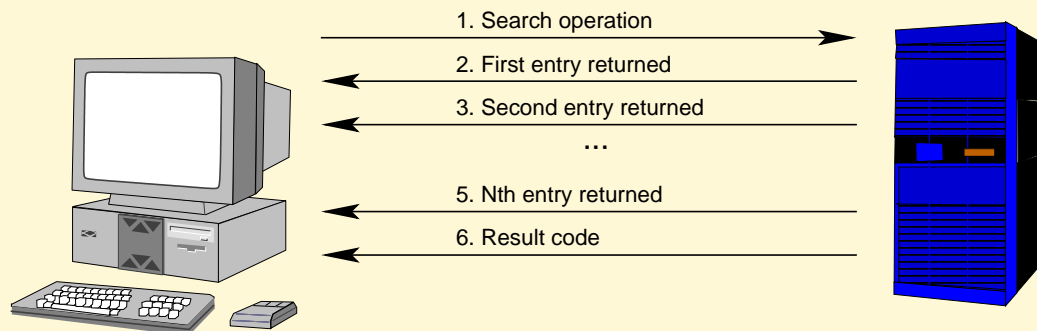
Flat, Hierarchical Structures

References

Simple Search Examples



- Here a client gets one single entry from the directory



- A client gets multiple responses from the directory

[Introduction to Directories](#)

[LDAP](#)

[LDAP— Why?](#)

[LDAP Terminology](#)

[What is LDAP?](#)

[The LDAP Protocol](#)

[Simple Search Examples](#)

[Multiple Simultaneous Requests](#)

[LDAP Protocol Operations](#)

[Typical LDAP Exchange](#)

[LDAP Encoding: BER](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

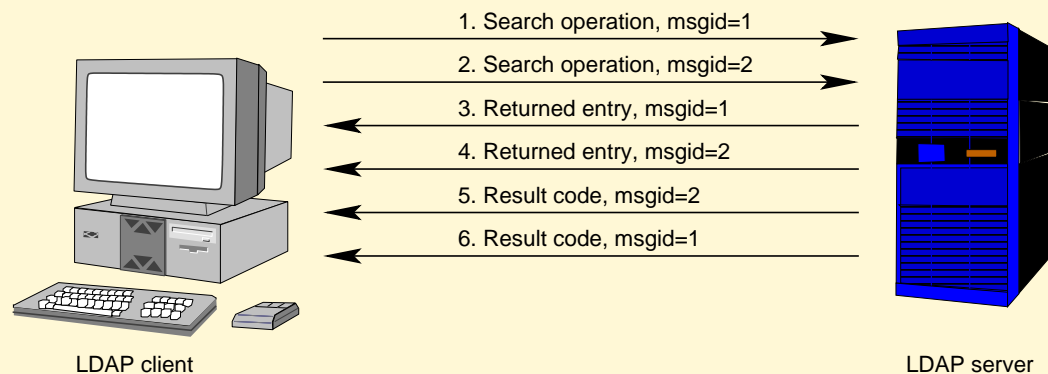
[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Multiple Simultaneous Requests



- A client sends multiple requests to the directory
- Note that each request has its own `msgid`
- Responses may come out of order (see last two result codes); that's okay.
 - ◆ These details are hidden from programmer by the SDK (software development kit)

[Introduction to Directories](#)

[LDAP](#)

[LDAP— Why?](#)

[LDAP Terminology](#)

[What is LDAP?](#)

[The LDAP Protocol](#)

[Simple Search Examples](#)

[Multiple Simultaneous Requests](#)

[LDAP Protocol Operations](#)

[Typical LDAP Exchange](#)

[LDAP Encoding: BER](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP Protocol Operations

- Interrogation operations: `search`, `compare`
- Update operations: `add`, `delete`, `modify`, `modify DN` (`rename`)
- Authentication and control operations: `bind`, `unbind`, `abandon`
 - `bind`** operation allows a client to identify itself sending identity and authentication credentials
 - `unbind`** operation allows client to terminate session
 - `abandon`** operation allows a client to tell the server it does not need the results of an operation it had requested earlier

Introduction to Directories

LDAP

LDAP— Why?

LDAP Terminology

What is LDAP?

The LDAP Protocol

Simple Search Examples

Multiple Simultaneous Requests

LDAP Protocol Operations

Typical LDAP Exchange

LDAP Encoding: BER

LDAP Operations

Utilities and LDIF

Schemas

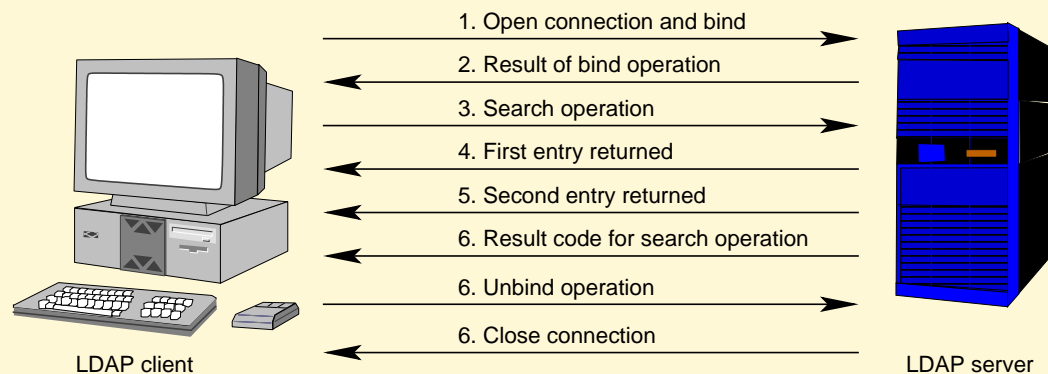
LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Typical LDAP Exchange



- The *bind operation* provides a *distinguished name* (DN) and other credentials to authenticate against the directory
- The *unbind operation* is a request to disconnect

[Introduction to Directories](#)

[LDAP](#)

[LDAP— Why?](#)

[LDAP Terminology](#)

[What is LDAP?](#)

[The LDAP Protocol](#)

[Simple Search Examples](#)

[Multiple Simultaneous Requests](#)

[LDAP Protocol Operations](#)

[Typical LDAP Exchange](#)

[LDAP Encoding: BER](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP Encoding: BER

- The LDAP protocol uses the *Basic Encoding Rules*, BER to encode various data types in a platform independent way
- These are the same rules as used in SNMP
- Therefore it is not a simple text-based protocol, like HTTP or SMTP.

[Introduction to Directories](#)

[LDAP](#)

[LDAP— Why?](#)

[LDAP Terminology](#)

[What is LDAP?](#)

[The LDAP Protocol](#)

[Simple Search Examples](#)

[Multiple Simultaneous Requests](#)

[LDAP Protocol Operations](#)

[Typical LDAP Exchange](#)

[LDAP Encoding: BER](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP Search Operation

- Used to search for entries and retrieve them
 - ◆ This is the only way to read the directory
- Takes eight parameters, including:
 - ◆ DN of base object for search — see slide §21
 - ◆ search scope — see slide §21
 - ◆ search filter — see slide §48
 - ◆ list of attributes to return

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[LDAP Search Operation](#)

[Search Scope](#)

[The Compare Operation](#)

[Add Operation](#)

[Delete Operation](#)

[Modify DN \(Rename\) Operation](#)

[Modify Operation](#)

[Bind Operation](#)

[Utilities and LDIF](#)

[Schemas](#)

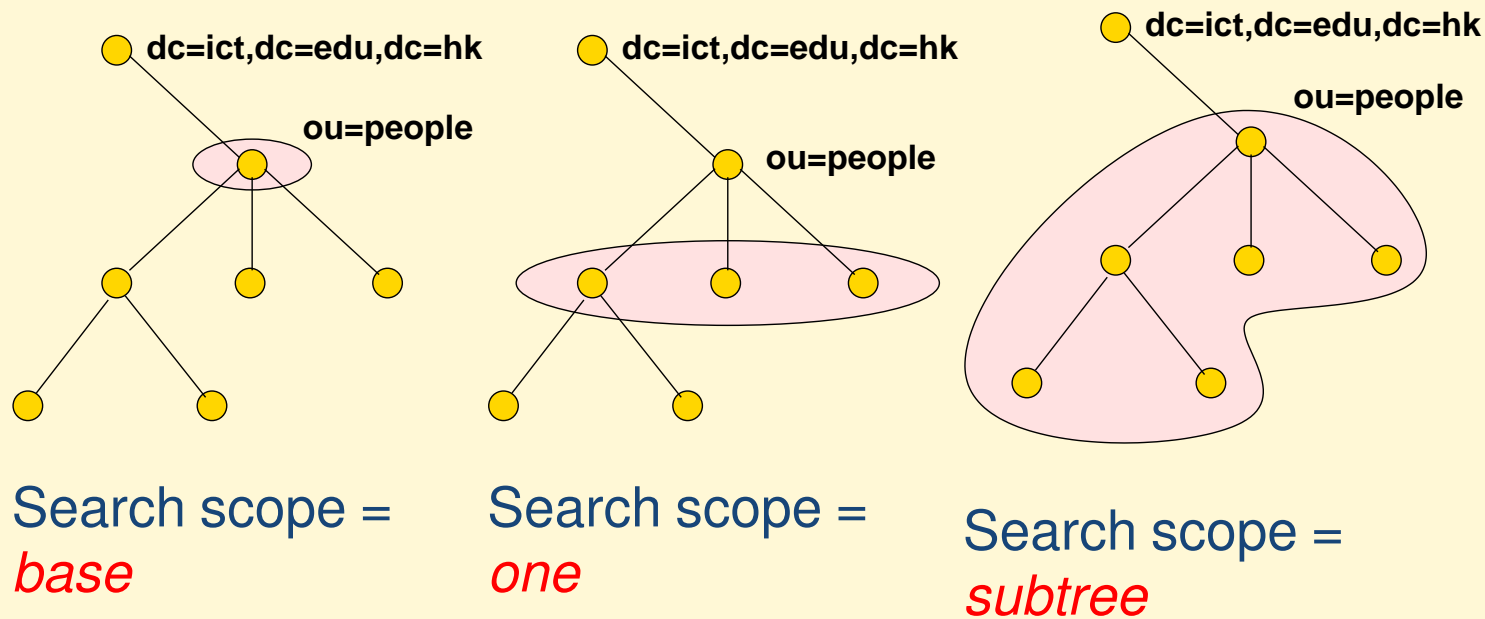
[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Search Scope



- In each case, the search base is `ou=People, dc=ict, dc=edu, dc=hk`

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[LDAP Search Operation](#)

[Search Scope](#)

[The Compare Operation](#)

[Add Operation](#)

[Delete Operation](#)

[Modify DN \(Rename\) Operation](#)

[Modify Operation](#)

[Bind Operation](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

The Compare Operation

- Not very useful
- I use it for determining if a user belongs to a particular group
- main difference from search:
 - ◆ If compare on an attribute that does not exist in a particular entry, returns code indicating this
 - ◆ If search for an attribute that does not exist in a particular entry, then get nothing returned.

Introduction to Directories

LDAP

LDAP Operations

LDAP Search Operation

Search Scope

The Compare Operation

Add Operation

Delete Operation

Modify DN (Rename) Operation

Modify Operation

Bind Operation

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Add Operation

- Creates a new entry, given two parameters:
 - ◆ DN of new entry
 - ◆ list of attributes and their values to put in the new entry
- Will succeed if and only if:
 - ◆ parent of new entry exists
 - ◆ no entry of same name exists
 - ◆ new entry matches requirements of schemas
 - ◆ access control allows operation

Introduction to Directories

LDAP

LDAP Operations

LDAP Search Operation

Search Scope

The Compare Operation

Add Operation

Delete Operation

Modify DN (Rename) Operation

Modify Operation

Bind Operation

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Delete Operation

- Deletes an entry
- Takes DN of entry to delete
- Succeeds if:
 - ◆ entry exists
 - ◆ entry has no children
 - ◆ access control allows operation

Introduction to Directories

LDAP

LDAP Operations

LDAP Search Operation

Search Scope

The Compare Operation

Add Operation

Delete Operation

Modify DN (Rename) Operation

Modify Operation

Bind Operation

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Modify DN (Rename) Operation

- Used to rename or move an entry from one place in tree to another
- Has four parameters:
 - ◆ Old DN
 - ◆ New DN
 - ◆ New RDN for entry
 - ◆ optional flag indicating whether to delete the old RDN attribute from the entry
- Succeeds if:
 - ◆ entry exists
 - ◆ new name not already used
 - ◆ access control allows operation

Introduction to Directories

LDAP

LDAP Operations

LDAP Search Operation

Search Scope

The Compare Operation

Add Operation

Delete Operation

Modify DN (Rename) Operation

Modify Operation

Bind Operation

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Modify Operation

- Allows updating existing entry
- Can add, delete or replace attributes
- Can modify many attributes in one modify operation
- Succeeds if and only if:
 - ◆ entry exists
 - ◆ all attribute modifications must succeed
 - ◆ resulting entry obeys schemas
 - ◆ access control permits modification

Introduction to Directories

LDAP

LDAP Operations

LDAP Search Operation

Search Scope

The Compare Operation

Add Operation

Delete Operation

Modify DN (Rename) Operation

Modify Operation

Bind Operation

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Bind Operation

- authenticates client to the directory
- Three bind types:
 - ◆ *simple bind*, where send DN and password in clear text to server
 - Need to use TLS to encrypt communication in this case
 - ◆ **SASL bind**
 - SASL = Simple Authentication and Security Layer
 - A standard protocol independent way of negotiating and performing authentication
 - ◆ *anonymous bind*, where send DN but no passwords
- Client can bind, perform operations, bind again, and perform other operations

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[LDAP Search Operation](#)

[Search Scope](#)

[The Compare Operation](#)

[Add Operation](#)

[Delete Operation](#)

[Modify DN \(Rename\) Operation](#)

[Modify Operation](#)

[Bind Operation](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Command Line Utilities

- With OpenLDAP, the main utilities (in RH Linux, in the package `openldap-clients`) are:
 - `ldapsearch`** Query directory
 - `ldapmodify`** Perform the modify operation on an entry — see §33
 - `ldapdelete`** Delete an entry
 - `ldapadd`** Add an entry
 - `ldapmodrdn`** Rename an entry
 - `ldapcompare`** Compare operation
 - `ldappasswd`** Change LDAP password using LDAPv3 Password Modify (RFC 3062) extended operation
- Each one has a detailed `man` page

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Command Line Utilities

Common Parameters

`ldapsearch`

LDAP Data Interchange Format

LDIF

Example LDIF

Update Operation in LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Common Parameters

- All commands use the SASL (Simple Authentication and Security Layer) protocol by default
 - ◆ But won't work here:
 - ◆ ... we use simple authentication here (we send plain text passwords over link encrypted with Transport Layer Security i.e., TLS or SSL)
- “-x” use simple authentication instead of SASL
- specify hostname of server with -h, e.g.,
`-h ldap.vtc.edu.hk`
- Specify a DN to bind with using -D (see §33)
- Specify a password on command line with -w *<password>* or interactively prompt using -W
 - ◆ See §33, §57 for examples

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Command Line Utilities

Common Parameters

ldapsearch

LDAP Data Interchange Format

LDIF

Example LDIF

Update Operation in LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

- Specify *base* of search with `-b` *<DN of search base>*
 - ◆ Default can be specified as a line in
`/etc/openldap/ldap.conf`, e.g.,
`BASE dc=tyict,dc=vtc,dc=edu,dc=hk`
`HOST ldap.tyict.vtc.edu.hk`
- Specify *scope* of search with `-s` `[base|one|sub]`
 - ◆ Default scope is subtree scope
- See §54 for more examples.

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Command Line Utilities

Common Parameters

ldapsearch

LDAP Data Interchange Format

LDIF

Example LDIF

Update Operation in LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

LDAP Data Interchange Format LDIF

- A standard defined in RFC 2849
- Used to import, export directory data in a standard way
 - ◆ A bit like how all spreadsheets understand tab-delimited text files
- Can also specify update operations to directory entries.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Command Line Utilities](#)

[Common Parameters](#)

[ldapsearch](#)

[LDAP Data Interchange Format
LDIF](#)

[Example LDIF](#)

[Update Operation in LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Example LDIF

```
dn: uid=nicku,ou=People,dc=ict,dc=vtc,dc=edu,dc=hk
uid: nicku
cn: Nick Urbanik
givenName: Nick
sn: Urbanik
mail: nicku@nicku.org
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
objectClass: posixAccount
objectClass: top
loginShell: /bin/sh
uidNumber: 1000
gidNumber: 1000
homeDirectory: /opt/nicku
mail: nicku@nickpc.tyict.vtc.edu.hk
description: Interested in free software
```

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Command Line Utilities](#)[Common Parameters](#)[ldapsearch](#)[LDAP Data Interchange Format](#)[LDIF](#)[Example LDIF](#)[Update Operation in LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Update Operation in LDIF

```
$ cat /tmp/update-nick.ldif
```

```
dn: uid=nicku,ou=People,dc=ict,dc=vtc,dc=edu,dc=hk
```

```
changetype: modify
```

```
replace: mail
```

```
mail: nicku@nicku.org
```

```
-
```

```
add: title
```

```
title: Lecturer in SNM
```

```
-
```

```
add: jpegPhoto
```

```
jpegPhoto:< file:///tmp/penguin.jpg
```

```
-
```

```
delete: description
```

```
-
```

```
$ ldapmodify -x -D 'uid=nicku,ou=People,dc=ict,dc=vtc,dc=edu,dc=hk' \  
-W -f /tmp/update-nick.ldif
```

```
Enter LDAP password:
```

```
modifying entry "uid=nicku,ou=People,dc=ict,dc=vtc,dc=edu,dc=hk"
```

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)[Command Line Utilities](#)[Common Parameters](#)[ldapsearch](#)[LDAP Data Interchange Format](#)[LDIF](#)[Example LDIF](#)[Update Operation in LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

- The directory has a set of rules that determine the allowed objectclasses and attributes
- Called the *schemas*
- Can be defined in
 - ◆ ASN.1, or
 - ◆ University of Michigan style, or
 - ◆ LDAPv3 style
- Each object, and its syntax, are both defined using OIDs, as in SNMP.

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Schemas

Attributes — Defined in Schema

LDAP objectClass — 1

Object Class and Attributes

LDAP Object Class Inheritance

LDAP Object Class Type

Structural Classes

Entries: Selecting Object Class
Types

Rules for LDAP Entries

Namespace of attributes

Example objectTypes

Want to support network login

Supporting network login
Authorisation as well as
authentication

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Attributes — Defined in Schema

- For each attribute, schema defines:
 - ◆ Name
 - ◆ Description
 - ◆ Permitted compare operations
 - ◆ Syntax (i.e., data type).
- LDAP server ensures that all added data matches the schema

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP objectClass — 1

- Each attribute belongs to one or more **objectClasses**
- objectClasses are defined in schemas
- Defines what attributes *must*, or *may* be present in an entry
- objectClass definition includes:
 - ◆ Name of objectClass
 - ◆ What subclass this is derived from
 - ◆ The type of objectClass: *structural*, *auxiliary* or *abstract*
 - ◆ Description
 - ◆ List of *required* attributes
 - ◆ List of *allowed* attributes

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Schemas

Attributes — Defined in Schema

LDAP objectClass — 1

Object Class and Attributes

LDAP Object Class Inheritance

LDAP Object Class Type

Structural Classes

Entries: Selecting Object Class
Types

Rules for LDAP Entries

Namespace of attributes

Example objectTypes

Want to support network login

Supporting network login

Authorisation as well as
authentication

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Object Class and Attributes

- The entry can use all the attributes allowed in all the objectClasses.
 - ◆ See in slide §43 how LDAP attributes differ from attributes in, say, a Java class

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP Object Class Inheritance

- LDAP implements a limited form of object oriented inheritance
- One entry may contain many objectClasses
 - ◆ We say, “an entry belongs to many classes”
- Cannot override any schema rules defined in superior class
- Example: `top` \leftarrow `person` \leftarrow `organizationalPerson` \leftarrow `inetOrgPerson`
 - ◆ In `/etc/openldap/schema`, `core.schema` defines `person`, `organizationalPerson`;
`inetorgperson.schema` defines `inetOrgPerson`
- A class derived from another class includes the attributes of its superior class(es)

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class](#)

[Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP Object Class Type

- objectClass has a type: *structural*, *auxiliary*, or *abstract*
- Default is *structural*
- **Structural** is for the fundamental, basic aspects of the object, e.g., **person**, **posixGroup**, **device**.
- **Auxiliary** classes place no restrictions on where an entry is stored, and are used to add more attributes to structural classes.
- **Abstract** classes are not usually created by users; the class **top** and **alias** are abstract.

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Schemas

Attributes — Defined in Schema

LDAP objectClass — 1

Object Class and Attributes

LDAP Object Class Inheritance

LDAP Object Class Type

Structural Classes

Entries: Selecting Object Class

Types

Rules for LDAP Entries

Namespace of attributes

Example objectTypes

Want to support network login

Supporting network login

Authorisation as well as authentication

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Structural Classes

- Rule of LDAP standards: if an entry belongs to more than one *structural* class, they must be related by inheritance
 - ◆ OpenLDAP 2.0.x does not implement this restriction, but OpenLDAP 2.1.x and later versions (including 2.2.x) do.
- To get around this, can either:
 - ◆ Implement a new objectClass that is of type auxiliary that allows the attributes you require—see <http://www.openldap.org/faq/data/cache/883.html>
 - ◆ Implement a new objectClass that inherits from both unrelated structural classes and use that—See <http://www.openldap.org/faq/data/cache/807.html>

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class](#)

[Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Entries: Selecting Object Class Types

- Entries contain one or more *objectClasses*
- Choose the attributes you need
- Select the objectClasses that provide these attributes
- Add the objectClass to your entry.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Rules for LDAP Entries

- Each entry must be a member of the objectClass `top`
- Each entry must be a member of the objectClass that provides the attributes
- Exactly **one objectClass should be structural**, the rest auxiliary (or abstract)
 - ◆ An entry may belong to more than one structural class if all structural classes are **related by inheritance**

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class](#)

[Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Namespace of attributes

- There is **only one namespace for attributes**
- The definition of the attribute `cn` (common name) is the same for all objectClasses that support the `cn` attribute.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class](#)

[Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Example objectTypes

- Here is the definition for person from core.schema:

```
objectclass ( 2.5.6.6 NAME 'person'
  SUP top STRUCTURAL
  MUST ( sn $ cn )
  MAY ( userPassword $ telephoneNumber $
    seeAlso $ description ) )
```

- This says a person entry *must* contain:
 - ◆ a surname (`sn`) and
 - ◆ common name (`cn`),
- and *may* contain a `userPassword`, a `telephoneNumber`, a `description`, and a reference to another LDAP entry.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Want to support network login

- Does the objectClass person provide what is needed for network login?
- For network accounts, need replace (at minimum):
 - ◆ `/etc/passwd`
 - ◆ `/etc/group`
 - ◆ `/etc/shadow`
- So in addition to attributes of person, need:
 - ◆ User ID name (log in name)
 - ◆ User ID number
 - ◆ Primary group ID number
 - ◆ Gecos information (fifth field of `/etc/passwd`)
 - ◆ Home directory
 - ◆ Login shell
- Also the password aging information from `/etc/shadow`

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Supporting network login

■ Use the existing objectClass posixAccount:

```
objectclass ( 1.3.6.1.1.1.2.0 NAME 'posixAccount'
  SUP top AUXILIARY
  DESC 'Abstraction of an account with POSIX
    attributes'
  MUST ( cn $ uid $ uidNumber $ gidNumber $
    homeDirectory )
  MAY ( userPassword $ loginShell $ gecos $
    description ) )
```

■ Provides fields from /etc/passwd

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Schemas

Attributes — Defined in Schema

LDAP objectClass — 1

Object Class and Attributes

LDAP Object Class Inheritance

LDAP Object Class Type

Structural Classes

Entries: Selecting Object Class

Types

Rules for LDAP Entries

Namespace of attributes

Example objectTypes

Want to support network login

Supporting network login

Authorisation as well as
authentication

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

References

Authorisation as well as authentication

- Suppose you have an online web-based quiz, want only staff, or year 3, group W, CSA student to be allowed to log in.
- For this to work:
- Each person entry has attributes including:
 - ◆ Course, e.g., 41300
 - ◆ classCode, e.g., W
 - ◆ Year, e.g., 3
 - ◆ acType, e.g., STU or STF

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Schemas](#)

[Attributes — Defined in Schema](#)

[LDAP objectClass — 1](#)

[Object Class and Attributes](#)

[LDAP Object Class Inheritance](#)

[LDAP Object Class Type](#)

[Structural Classes](#)

[Entries: Selecting Object Class Types](#)

[Rules for LDAP Entries](#)

[Namespace of attributes](#)

[Example objectTypes](#)

[Want to support network login](#)

[Supporting network login](#)

[Authorisation as well as authentication](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

- LDAP provides a standard method for selecting authenticated users who match authorisation criteria
- The filter to select staff or students in year 3, CSA, group W is:

```
( | (acType=STF) (& (year=3) (course=41300)  
  (classcode=W) ) )
```

(This line is wrapped to fit on the slide, but normally given on one line)
- All filters are enclosed in parentheses
- Filters can be combined with OR '|', AND '&'

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

LDAP filters

RFC 2254 — 1

RFC 2254 — 2

Examples of Filters from RFC 2254

More Filter Examples

Escaping Characters in a Filter

Using the command line tool

ldapsearch

Output of this `ldapsearch`
without staff

Get All the Results

`ldapsearch`

LDAP URLs: RFC 2255

`mod_auth_ldap` with Apache

ICT Schema Design

Flat, Hierarchical Structures

References

Find this in

`/usr/share/doc/openldap-2.0.27/rfc/rfc2254.txt`

```
filter      = "(" filtercomp ")"
filtercomp  = and / or / not / item
and         = "&" filterlist
or          = "|" filterlist
not         = "!" filter
filterlist  = 1*filter
item        = simple / present / substring
simple       = attr filtertype value
filtertype  = equal / approx / greater / less
equal       = "="
approx      = "~="
greater     = ">="
less        = "<="
```

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

LDAP filters

RFC 2254 — 1

RFC 2254 — 2

Examples of Filters from RFC 2254

More Filter Examples

Escaping Characters in a Filter

Using the command line tool

`ldapsearch`

Output of this `ldapsearch` without staff

Get All the Results

`ldapsearch`

LDAP URLs: RFC 2255

`mod_auth_ldap` with Apache

ICT Schema Design

Flat, Hierarchical Structures

References

```
present      = attr "=*"
substring    = attr "=" [initial] any [final]
initial      = value
any          = "*" *(value "*")
final        = value
attr         = AttributeDescription from Section 4.1.5 of [1]
value        = AttributeValue from Section 4.1.6 of [1]
[1] is RFC 2251.
Grammar is defined in RFC 822
```

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters
RFC 2254 — 1](#)

RFC 2254 — 2

[Examples of Filters from RFC
2254](#)

[More Filter Examples](#)

[Escaping Characters in a Filter](#)

[Using the command line tool](#)

[ldapsearch](#)

[Output of this ldapsearch
without staff](#)

[Get All the Results](#)

[ldapsearch](#)

[LDAP URLs: RFC 2255](#)

[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Examples of Filters from RFC 2254

Return all entries in the scope of the search with attribute `cn` having the value “Babs Jensen”:

```
(cn=Babs Jensen)
```

Return all entries in the scope of the search which do not have the attribute `cn` with the value “Tim Howes”:

```
(!(cn=Tim Howes))
```

Return all entries in the scope of the search which have the attribute

```
(&(objectClass=Person)(|(sn=Jensen)(cn=Babs J*)))
```

Return all entries having an attribute `o` (i.e., organisation) which contains the strings `univ`, `of`, `mich` with zero or more of any characters between, and with any number of any characters at the end.

```
(o=univ*of*mich*)
```

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters](#)[RFC 2254 — 1](#)[RFC 2254 — 2](#)[Examples of Filters from RFC 2254](#)[More Filter Examples](#)[Escaping Characters in a Filter](#)[Using the command line tool](#)[ldapsearch](#)[Output of this ldapsearch](#)[without staff](#)[Get All the Results](#)[ldapsearch](#)[LDAP URLs: RFC 2255](#)[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

More Filter Examples

- Note that a filter such as `(age>21)` is not allowed.
- Use `(!(age<=21))` instead.
- Similarly, instead of `(age<21)`, use `(!(age>=21))`.
- search for all students in group X, year 3, CSA course, who enrolled this year:

```
(&(year=3)(course=41300)(classcode=W)
(registrationDate=*-03))
```

Note that there is a substring match on `registrationDate` here. A substring match is like a wildcard in filename matching.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters](#)[RFC 2254 — 1](#)[RFC 2254 — 2](#)[Examples of Filters from RFC 2254](#)[More Filter Examples](#)[Escaping Characters in a Filter](#)[Using the command line tool](#)[ldapsearch](#)[Output of this ldapsearch](#)[without staff](#)[Get All the Results](#)[ldapsearch](#)[LDAP URLs: RFC 2255](#)[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Escaping Characters in a Filter

Character	Escape Sequence
* (asterisk)	\2A
((left parenthesis)	\28
) (right parenthesis)	\29
\ (backslash)	\5C
NUL (the null byte)	\00

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

LDAP filters

RFC 2254 — 1

RFC 2254 — 2

Examples of Filters from RFC 2254

More Filter Examples

Escaping Characters in a Filter

Using the command line tool

`ldapsearch`

Output of this `ldapsearch`

without staff

Get All the Results

`ldapsearch`

LDAP URLs: RFC 2255

`mod_auth_ldap` with Apache

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Using the command line tool ldapsearch

- `$ ldapsearch -x -h ldap.vtc.edu.hk \`
`-b "dc=vtc.edu.hk" \`
`" (& (department=ICT) (site=TY)`
`(| (acType=STF)`
`(& (year=3) (course=41300) (classcode=W))) " cn`
- The result is a list of all the DNs that match the filter, with the students' and staff names.
- Can filter out the DNs and blank lines by piping the command though `grep '^cn:' | sort`

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters](#)

[RFC 2254 — 1](#)

[RFC 2254 — 2](#)

[Examples of Filters from RFC 2254](#)

[More Filter Examples](#)

[Escaping Characters in a Filter](#)

[Using the command line tool ldapsearch](#)

[Output of this ldapsearch without staff](#)

[Get All the Results](#)

[ldapsearch](#)

[LDAP URLs: RFC 2255](#)

[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

Output of this `ldapsearch` without staff

```
cn: CHAN Kwok Kam
cn: CHEUK Suk Lai
cn: CHUNG Ming Kit
cn: LAI Man Chiu
cn: LAM Lai Hang
cn: LAU Siu Ying
cn: LAW Yuk Woon
cn: LI Kim Wah
cn: LI Siu Kai
cn: LI Yuet Cheung
cn: MA Hei Man
cn: MO Hoi Yu
cn: POON Chun Chung
cn: TAM Kin Fai
cn: TSO Yee Yee
cn: WONG Chi Man
cn: WONG Hoi Shan
cn: WONG Siu Fai
cn: WOO Kin Fan
```

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

LDAP filters

RFC 2254 — 1

RFC 2254 — 2

Examples of Filters from RFC
2254

More Filter Examples

Escaping Characters in a Filter

Using the command line tool

`ldapsearch`

Output of this `ldapsearch`
without staff

Get All the Results

`ldapsearch`

LDAP URLs: RFC 2255

`mod_auth_ldap` with Apache

ICT Schema Design

Flat, Hierarchical Structures

References

Get All the Results

```
$ ldapsearch -x -h ldap.vtc.edu.hk -b 'dc=vtc.edu.hk' \
"(&(department=ICT)(site=TY)(|(actype=STF)(&(year=3)
(classcode=W)(course=41300))))" cn \
| grep '^cn: ' | sed 's/^cn: //;s/^\\(.\\{15\\}\\).*\\/\\1/' | sort | column
```

Andy LAI	C M Ho	LEE HUNG KIN	SIU CHONG PUI
CHAN CHIN PANG	Curtis H.K. Tsa	LEE KOON HUNG K	SIU WAI CHEUNG
CHAN Kwok Kam	Esther YUEN	LEUNG KAM SHEK	Stella Chu
CHAN KWOK KEUNG	Eva Chung	LI Kim Wah	TAM CHI HO
CHAN SHIU CHUAN	FONG CHI KIT	LI Siu Kai	TAM Kin Fai
CHAN TAI HING	Henry Leung	LI Yuet Cheung	TSANG KWOK TUNG
CHAN TAI MING R	HO CHUN WAH	MA Hei Man	TSO Yee Yee
Charles Wu	HO KIM MAN ALBE	MA SUI WAH	WONG Chi Man
CHEUK Suk Lai	Josephine Wan	MICHAEL LEUNG	WONG Hoi Shan
CHEUNG KAM HOI	Karl Leung	MO Hoi Yu	WONG Siu Fai
CHEUNG SAI MING	Ken LI	MONTAGUE NIGEL	WONG WAI YIP FR
CHIK FUNG YING	Kit K. KO	NG HOI KOW	Wong Y.L. Lawre
CHIU SUET FAN J	LAI HING BIU	NG SZE CHIU EDD	WOO HUNG CHEUNG
Chou Siu Chuen	LAI Man Chiu	Nick Urbanik	WOO Kin Fan
CHUNG Ming Kit	LAM Lai Hang	PATRICK K.S. TO	YIM KWOK HO
CHU SHING TSU J	LAU KWOK ON	POON Chun Chung	Y.K. Leung
Clarence Lau	LAU Siu Ying	Rick Liu	
Clarence Lo	LAW Yuk Woon	SCOTT ALBERT HE	

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters](#)[RFC 2254 — 1](#)[RFC 2254 — 2](#)[Examples of Filters from RFC 2254](#)[More Filter Examples](#)[Escaping Characters in a Filter](#)[Using the command line tool](#)[ldapsearch](#)[Output of this ldapsearch without staff](#)[Get All the Results](#)[ldapsearch](#)[LDAP URLs: RFC 2255](#)[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

ldapsearch

- Needs the `-x` option to work here
- Check ssl works with the `-ZZ` option
- Can “bind” as a user to get all the info you are allowed to see after binding:

```
$ ldapsearch -x -W -D \  
"uid=nicku,ou=People,dc=tyict,dc=vtc,dc=edu,dc=hk" \  
'(uid=nicku)'
```
- Can then see own passwords

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters](#)

[RFC 2254 — 1](#)

[RFC 2254 — 2](#)

[Examples of Filters from RFC 2254](#)

[More Filter Examples](#)

[Escaping Characters in a Filter](#)

[Using the command line tool](#)

[ldapsearch](#)

[Output of this ldapsearch without staff](#)

[Get All the Results](#)

[ldapsearch](#)

[LDAP URLs: RFC 2255](#)

[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

LDAP URLs: RFC 2255

- Have the form:

- `ldap://⟨host⟩:⟨port⟩/⟨base⟩?⟨attr⟩?⟨scope⟩?⟨filter⟩`

```
ldapurl      = ldap://" [hostport] ["/"
                [dn ["?" [attributes] ["?" [scope]
                ["?" [filter] ["?" extensions]]]]]
```

- The `⟨base⟩` or `dn` is the distinguished name of the starting entry for your search.

- `⟨scope⟩` is one of `base`, `one` or `sub`

- Examples:

```
ldap://ictlab/ou=People,dc=tyict,dc=vtc,dc=edu,dc=hk?uid?one?(uid=nicku)
```

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[LDAP filters](#)

[RFC 2254 — 1](#)

[RFC 2254 — 2](#)

[Examples of Filters from RFC 2254](#)

[More Filter Examples](#)

[Escaping Characters in a Filter](#)

[Using the command line tool](#)

[ldapsearch](#)

[Output of this ldapsearch without staff](#)

[Get All the Results](#)

[ldapsearch](#)

[LDAP URLs: RFC 2255](#)

[mod_auth_ldap with Apache](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

mod_auth_ldap with Apache

- `mod_auth_ldap` is part of the `httpd` RPM package on Fedora Core 1.
- Here we allow staff or students from group W, year 3 CSA to access the web pages under `http://hostname/group-w/` if the user provides a correct password:

```
<Location "/group-w">
    AuthType Basic
    AuthName ``\LDAP authentication to class W only"
    AuthLDAPURL ldap://ldap.tyict.vtc.edu.hk/
ou=People,dc=tyict,dc=vtc,
dc=edu,dc=hk?uid?one?(|(acType=STF)(\&(course=41300)
(classCode=W)(year=3)))
    require valid-user
</Location>
```

- See http://httpd.apache.org/docs-2.0/mod/mod_auth_ldap.html, and also http://httpd.apache.org/docs-2.0/mod/mod_ldap.html for manual.

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

LDAP filters

RFC 2254 — 1

RFC 2254 — 2

Examples of Filters from RFC 2254

More Filter Examples

Escaping Characters in a Filter

Using the command line tool

`ldapsearch`

Output of this `ldapsearch` without staff

Get All the Results

`ldapsearch`

LDAP URLs: RFC 2255

mod_auth_ldap with Apache

ICT Schema Design

Flat, Hierarchical Structures

References

Authorisation of Students and Staff

- We need a new schema to support the required attributes
- We create three new objectClasses and associated attributes:
- The first is common to students and staff:

```
objectclass ( 1.3.6.1.4.1.11400.2.2.1 NAME 'institute'
  SUP top AUXILIARY
  DESC 'Any person in the institute, staff or student'
  MAY ( acOwner $ acType $ answer1 $ answer2 $
    answer3 $ batchUpdateFlag $ department $
    site $ instituteEmail ) )
```

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Authorisation of Students and Staff](#)

[Other objectTypes for IVE](#)

[The whole schema for IVE](#)

[Case Study: ICT laboratories](#)

[ICT case study](#)

[ICT case study — 2](#)

[Flat, Hierarchical Structures](#)

[References](#)

Other objectTypes for IVE

■ Then on top of this, we have attributes for students:

```
objectclass ( 1.3.6.1.4.1.11400.2.2.2 NAME 'student'
    SUP top AUXILIARY
    DESC 'A student in the institute'
    MAY ( academicYear $ award $ classCode $ course $
        courseDuration $ FinalYear $
        registrationDate $year $
        fullPartTime ) )
```

■ ...and staff:

```
objectclass ( 1.3.6.1.4.1.11400.2.2.3 NAME 'staff'
    SUP top AUXILIARY
    DESC 'A staff member of the insitute.'
    MAY ( titleDes $ employerID ) )
```

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Authorisation of Students and Staff

Other objectTypes for IVE

The whole schema for IVE

Case Study: ICT laboratories

ICT case study

ICT case study — 2

Flat, Hierarchical Structures

References

The whole schema for IVE

- The whole schema can be seen here:

<http://nicku.org/oids/institute.schema>

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Authorisation of Students and Staff](#)

[Other objectTypes for IVE](#)

[The whole schema for IVE](#)

[Case Study: ICT laboratories](#)

[ICT case study](#)

[ICT case study — 2](#)

[Flat, Hierarchical Structures](#)

[References](#)

Case Study: ICT laboratories

- Old system:
- An ancient DEC Alpha running NIS
- Hardware insufficient for demand
- *Very* expensive maintenance, stopped paying
- Technician reported a hardware failure close to first day of term
- New system:
- We were planning to introduce LDAP authentication gradually
- Failure required planning move faster
- Needed to maintain old legacy accounts, plus introduce new accounts

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Authorisation of Students and Staff](#)

[Other objectTypes for IVE](#)

[The whole schema for IVE](#)

[Case Study: ICT laboratories](#)

[ICT case study](#)

[ICT case study — 2](#)

[Flat, Hierarchical Structures](#)

[References](#)

ICT case study

- We chose OpenLDAP on Linux
- Running on an Acer Altos dual CPU P-III
- Migrated from the NIS using the migration scripts provided with OpenLDAP
- Migrated from the VTC LDAP accounts using a Perl program, written (quickly!) for the purpose,
- Uses the `Net::LDAP` Perl modules

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Authorisation of Students and Staff

Other objectTypes for IVE

The whole schema for IVE

Case Study: ICT laboratories

ICT case study

ICT case study — 2

Flat, Hierarchical Structures

References

ICT case study — 2

- After migrating the legacy accounts, and creating new accounts for staff, full and part time students, had more than 5000 accounts
- The LDAP server was using a high CPU load
- Was able to solve this using caching:
- Use `nscd` (name service caching daemon) on client
- Use memory in server to increase local cache size drastically.
- CPU load reduced to a very acceptable level.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Authorisation of Students and Staff](#)

[Other objectTypes for IVE](#)

[The whole schema for IVE](#)

[Case Study: ICT laboratories](#)

[ICT case study](#)

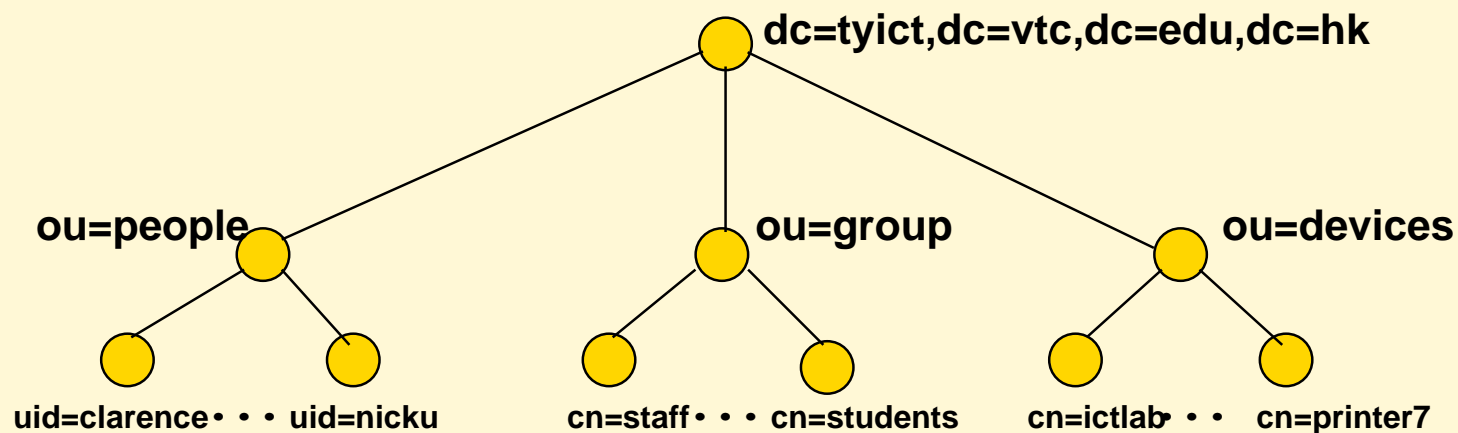
[ICT case study — 2](#)

[Flat, Hierarchical Structures](#)

[References](#)

Directory Structure — 1

■ The ICT LDAP server namespace design:



[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

Directory Structure — 2

- We chose a fairly flat directory structure
- Recommended by reference, pages 239, 249.
- Reason: flexibility:
- allows for change without major reorganisation of data.

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

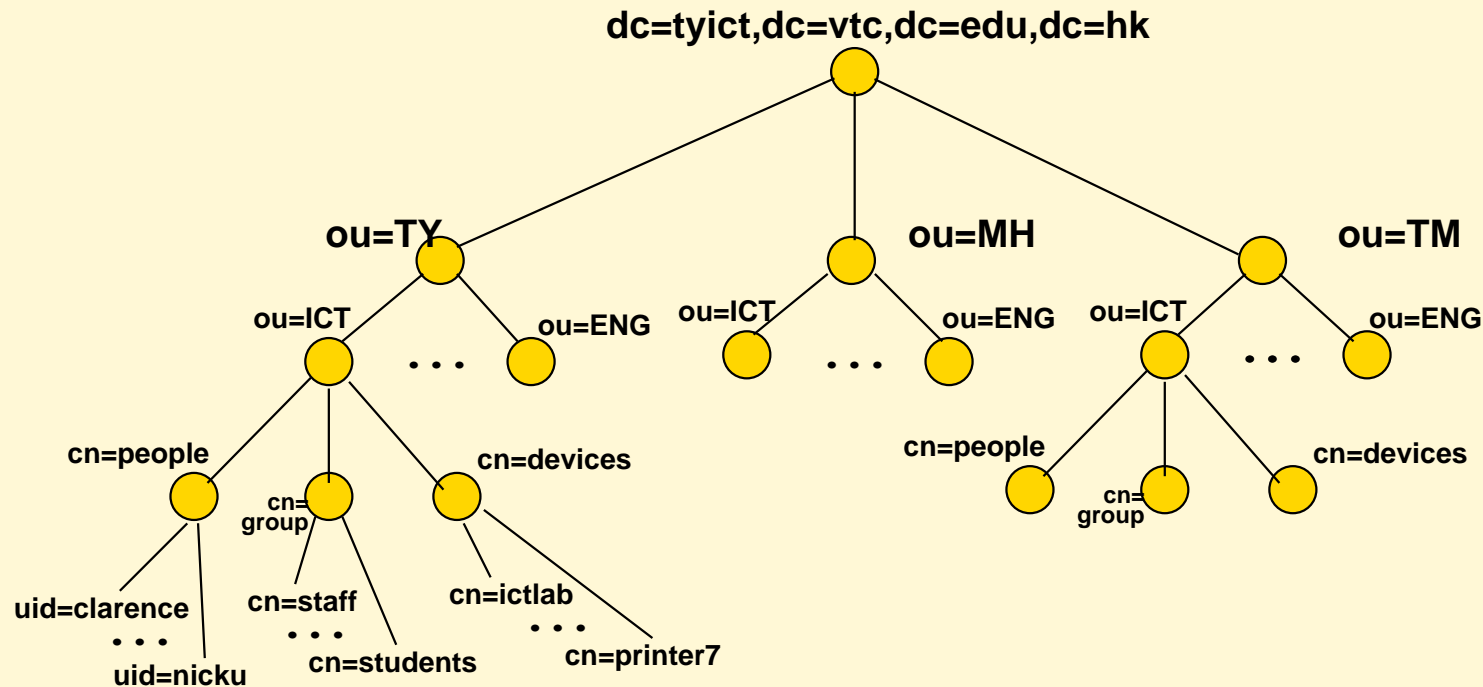
[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

Hierarchical Directory Structure

- This directory structure is hierarchical:



[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

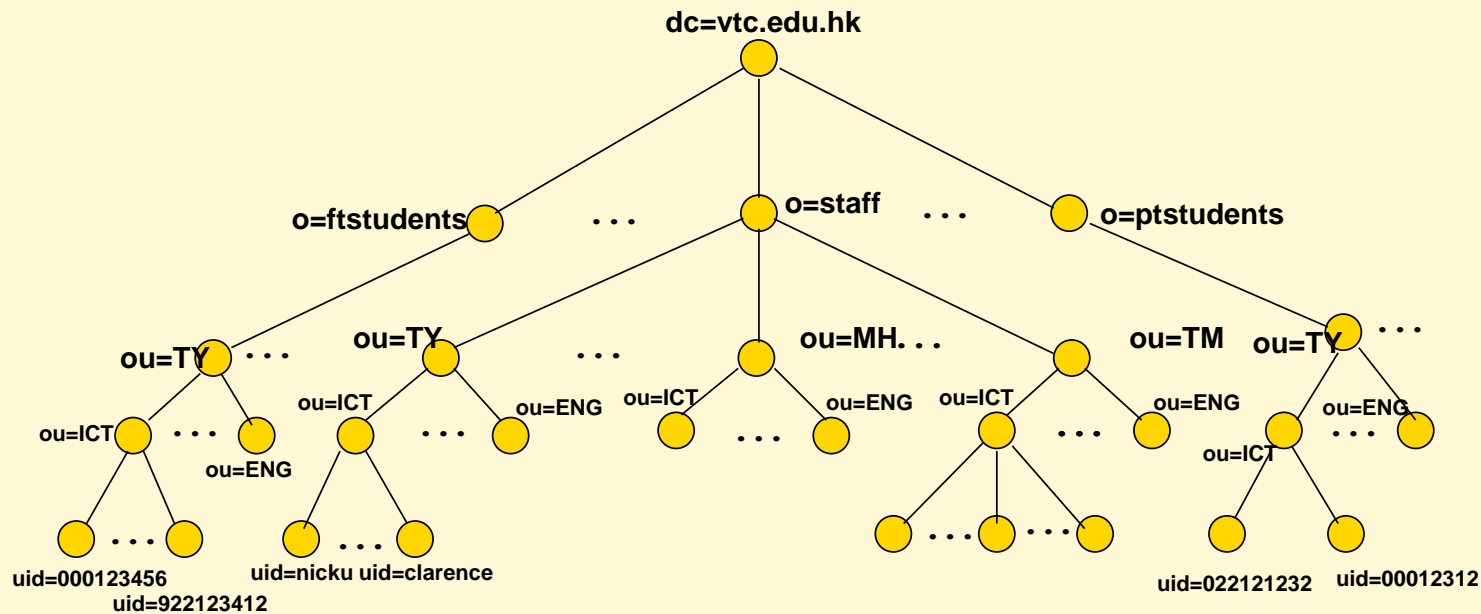
[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

New VTC LDAP Namespace

- This new VTC LDAP namespace was introduced in April 2003:



[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

Hierarchical Directory Structure

- This is an alternative data arrangement
- Divide into different campuses
- Advantage: can easily delegate management to local campus
- But: suppose ENG changes to EE?
- Suppose staff move from one department to another?
- Suppose equipment is transferred?
- Not only need change the attributes in the entry, but also move the entry.
- Overall, a flatter structure is easier to manage.

Introduction to Directories

LDAP

LDAP Operations

Utilities and LDIF

Schemas

LDAP Filters & URLs

ICT Schema Design

Flat, Hierarchical Structures

Directory Structure — 1

Directory Structure — 2

Hierarchical Directory Structure

New VTC LDAP Namespace

Hierarchical Directory Structure

Directory Design Guidelines

Designing a Schema

Designing a Schema: Example

References

Directory Design Guidelines

- Design as flat as possible given constraints:
- Replication
- Access Control
- Limitations of directory software
- Requirements of applications that use the directory

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

Designing a Schema

- After selecting the schema attributes needed for your application, you may find that not all are available with the server
- Search web for more schemas
- If none provide all you need,
- Select a suitable structural base class
- Create an auxiliary class to be used with the base class
- Define the objectClass and its attributes

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

Designing a Schema: Example

- For our ICT LDAP server, we use enough attributes to be able to log in
- But we also want to select users on the basis of course, year, class
- Want to add these attributes to the existing objectClasses
- Create three object classes:
 - Institute
 - Student
 - Staff

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[Directory Structure — 1](#)

[Directory Structure — 2](#)

[Hierarchical Directory Structure](#)

[New VTC LDAP Namespace](#)

[Hierarchical Directory Structure](#)

[Directory Design Guidelines](#)

[Designing a Schema](#)

[Designing a Schema: Example](#)

[References](#)

References

- *LDAP System Administration*, Gerald Carter, ISBN 1-565-92491-6, O'Reilly, March 2003
- *Understanding and Deploying LDAP Directory Services* (2nd Edition), Tim Howes, Timothy A. Howes, Mark C. Smith, Gordon S. Good, ISBN: 0672323168, Publisher: Addison Wesley Professional, May 2, 2003
- *Understanding and Deploying LDAP Directory Services*, Timothy Howes, Mark Smith and Gordon Good, Macmillan, 1999. Our library: TK 5105.595.H69 1999
- *LDAP Programming, Management and Integration*, Clayton Donley, ISBN: 1-930110-40-5, Manning Publications, 2003
- *LDAP Directories Explained: An Introduction and Analysis*, Brian Arkills, ISBN 0-201-78792-X, Addison-Wesley, 2003.
- *Understanding LDAP Redbook* (registration required):
<http://www.redbooks.ibm.com/abstracts/sg244986.html>
- *LDAP Implementation Cookbook Redbook* (registration required):
<http://www.redbooks.ibm.com/abstracts/sg245110.html>
- *Implementing LDAP*, Mark Wilcox, Wrox Press, 2000

[Introduction to Directories](#)

[LDAP](#)

[LDAP Operations](#)

[Utilities and LDIF](#)

[Schemas](#)

[LDAP Filters & URLs](#)

[ICT Schema Design](#)

[Flat, Hierarchical Structures](#)

[References](#)

References