LDAP

Lightweight Directory Access Protocol

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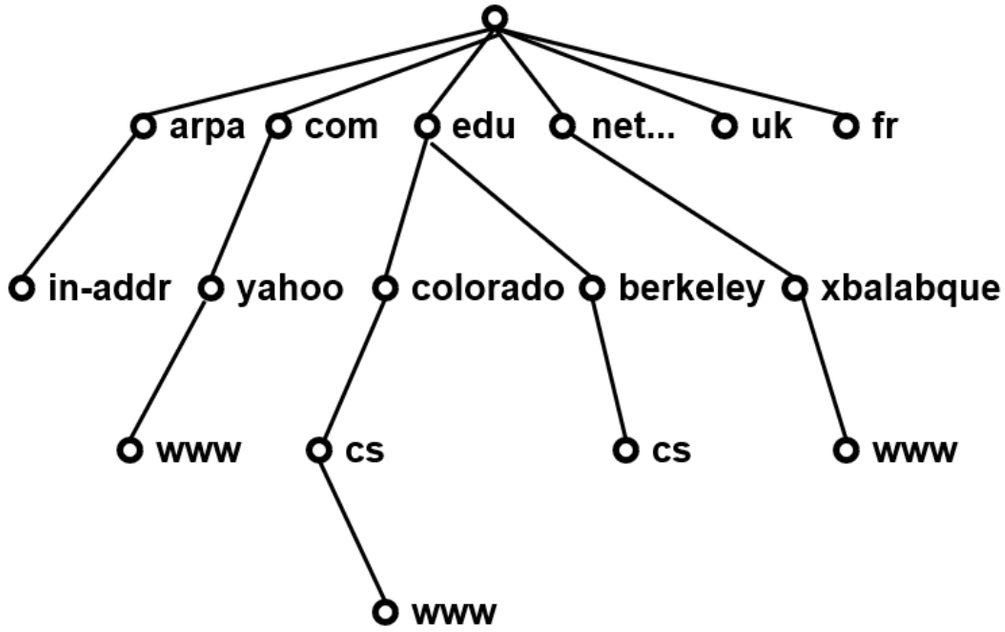
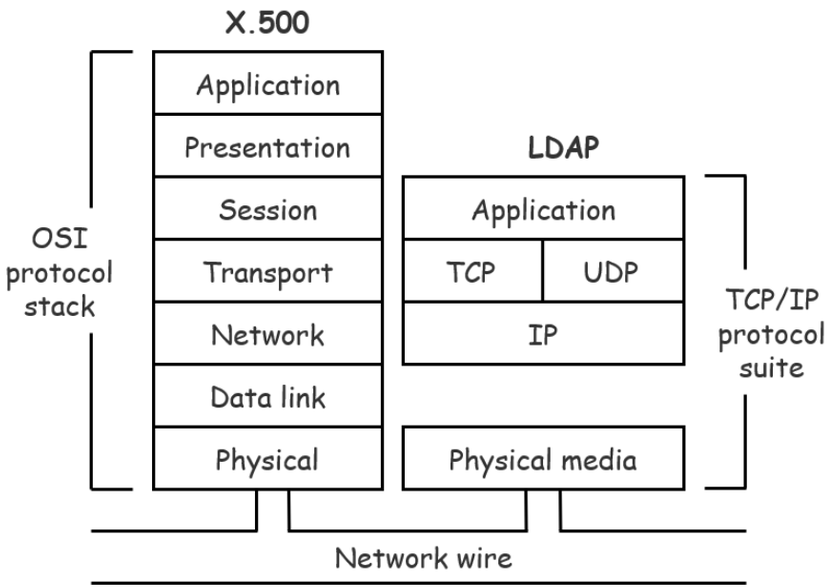
What is Directory Service?

- What is Directory Service (目錄服務)
  - Highly optimized for reads
  - Implements a distributed model for storing information
  - Can extend the type of information it stores
  - Has advanced search capabilities
  - Has loosely consistent replication among directory servers
- Domain Name Service



What is LDAP?

- The Lightweight Directory Access Protocol (LDAP) is an Internet protocol for accessing distributed directory services that act in accordance with X.500 data and service models.
- Why LDAP is lightweight
  - A subset of the X.500 standard
  - X.500 is based on OSI model
  - LDAP is based on TCP/IP model (ldap:// uses port 389, ldaps:// uses port 636)
  - LDAP omits many X.500 operations that are rarely used
  - Provides a smaller and simpler set of operations



RFCs for LDAP

- Lightweight Directory Access Protocol (LDAP)
  - LDAP: Technical Specification Road Map [RFC 4510]
  - LDAP: The Protocol [RFC4511]
  - LDAP: Directory Information Models [RFC4512]
  - LDAP: Authentication Methods and Security Mechanisms [RFC4513]
  - LDAP: String Representation of Distinguished Names [RFC4514]
  - LDAP: String Representation of Search Filters [RFC4515]
  - LDAP: Uniform Resource Locator [RFC4516]
  - LDAP: Syntaxes and Matching Rules [RFC4517]
  - LDAP: Internationalized String Preparation [RFC4518]
  - LDAP: Schema for User Applications [RFC4519]

LDAP Directory Information Tree (DIT)

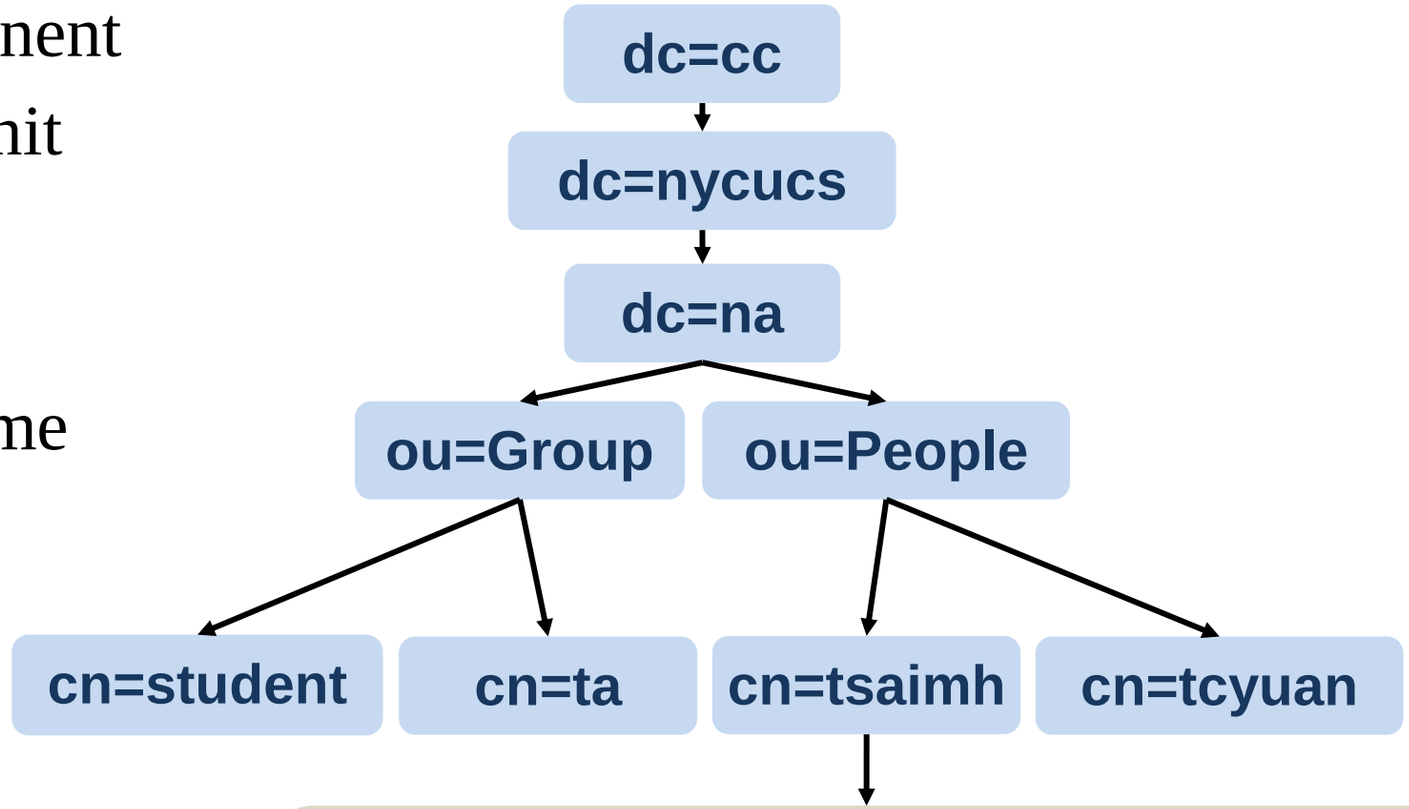
dc: domain component

ou: organization unit

cn: common name

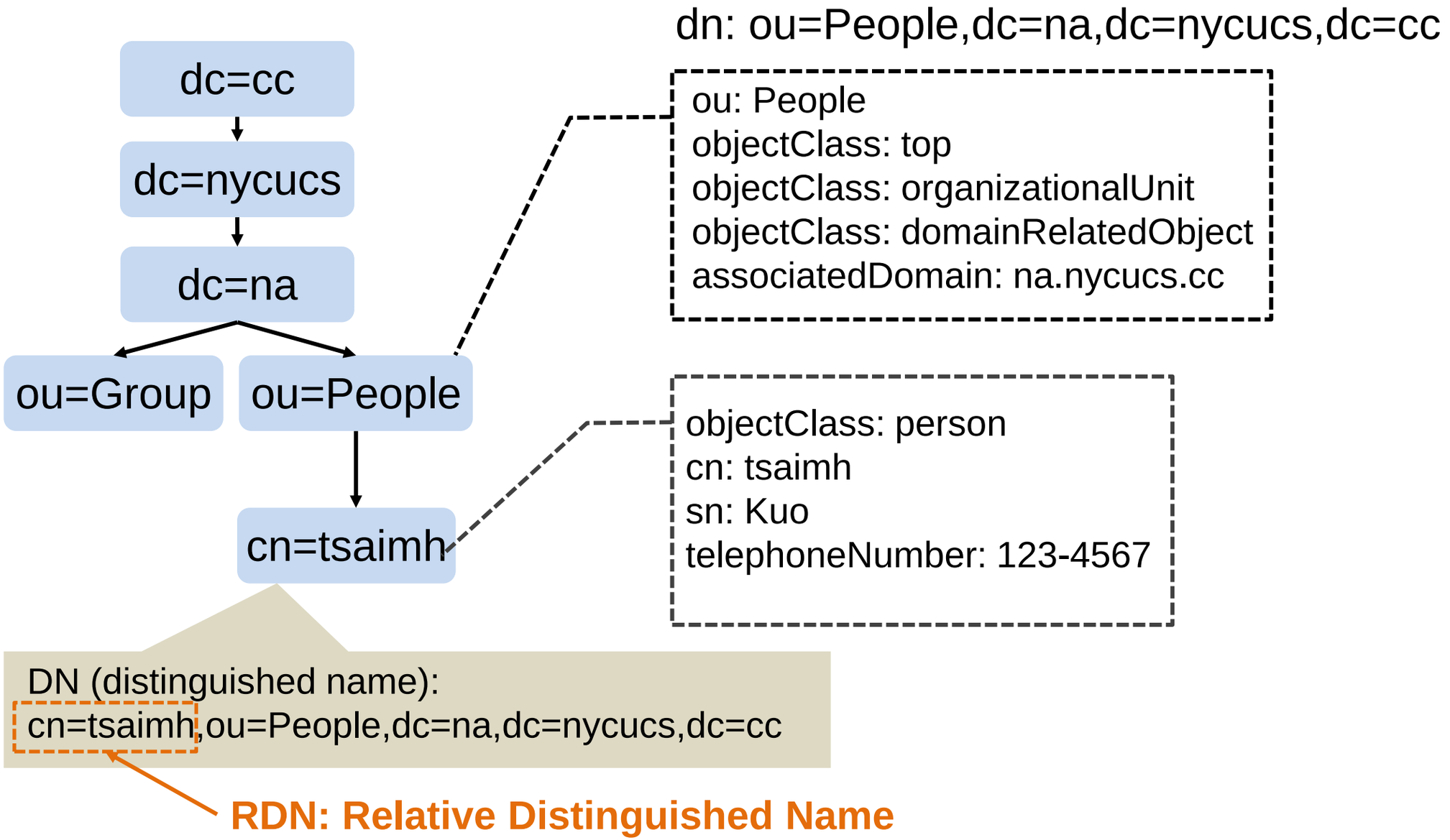
o: organizationName

c: countryName



cn=tsaimh,ou=People,dc=na,dc=nycucs,dc=cc
o="na, nycucs, cc", c=TW
o=na.nycucs.cc

LDAP Directory Information Tree (DIT)



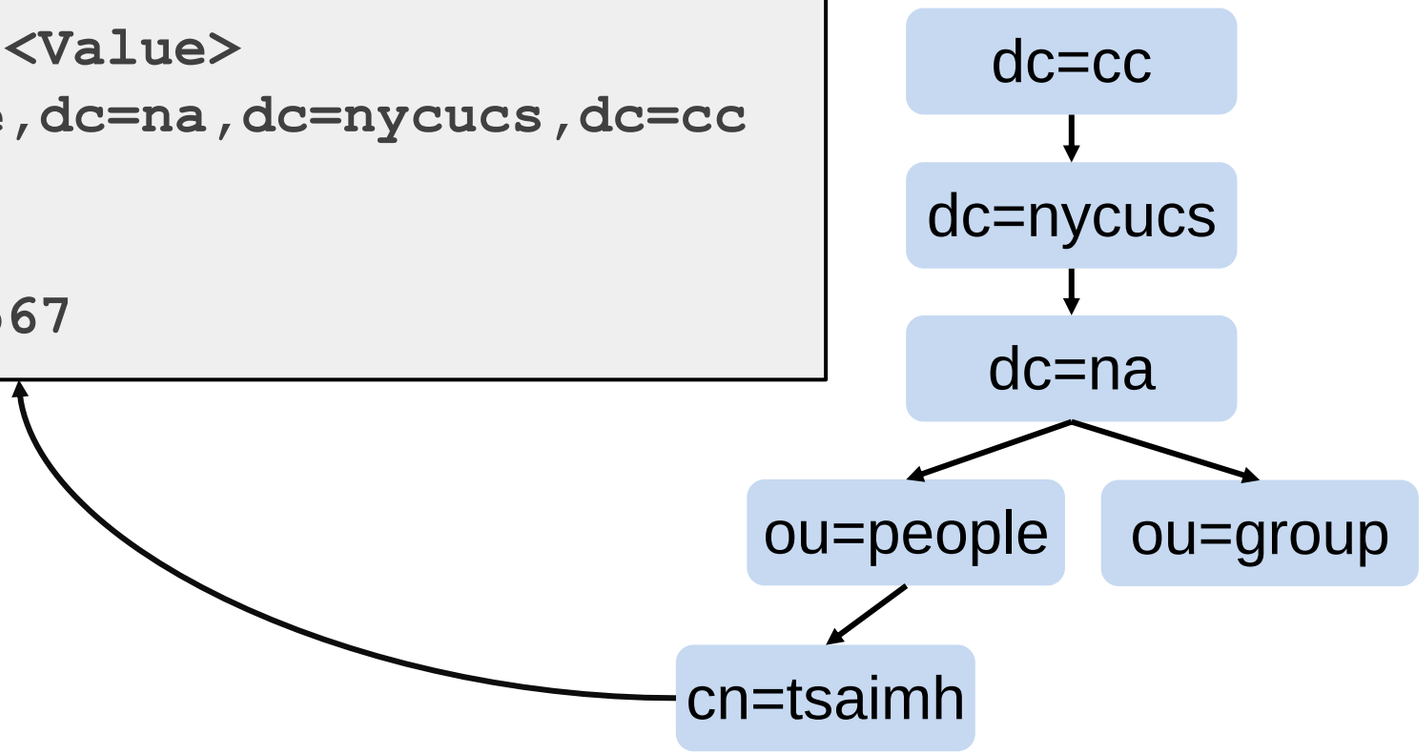
LDAPv3 Overview – LDIF (1/4)

- LDAP Interchange Format (LDIF)
  - Defined in RFC 2849
  - Standard text file format for storing LDAP configuration information and directory contents
  - An LDIF file is
    1. A collection of entries separated from each other by blank lines
    2. A mapping of attribute names to values
    3. A collection of directives that instruct the parser how to process the information
  - The data in the LDIF file must obey the schema rules of your LDAP directory

LDAPv3 Overview – LDIF (2/4)

- Sample LDIF

```
# A sample entry
# Format: <Attribute>: <Value>
dn: cn=tsaimh,ou=people,dc=na,dc=nycucs,dc=cc
objectClass: person
cn: tsaimh
telephoneNumber: 123-4567
```

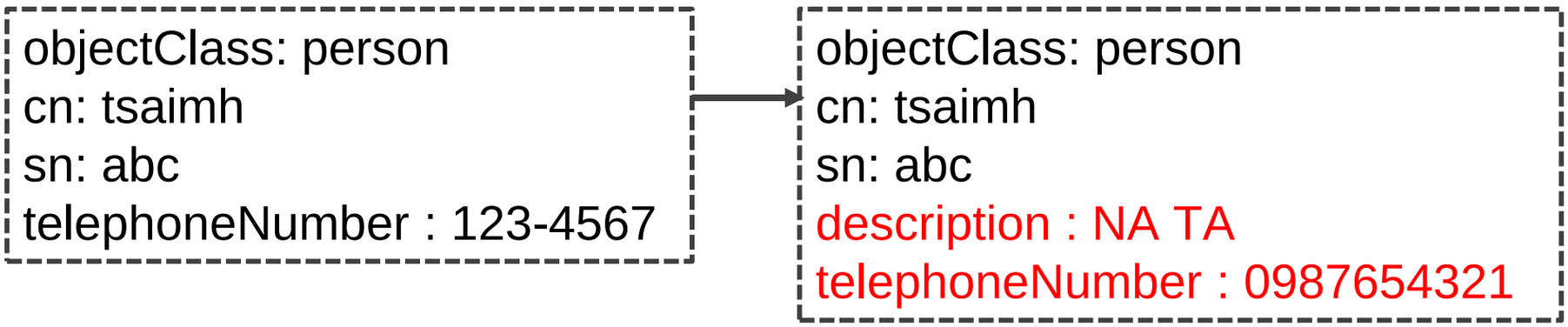


LDAPv3 Overview – LDIF (3/4)

- Sample LDIF – Modify one DN

Modify one DN

```
# Modify user info
dn: cn=tsaimh,ou=people,dc=na,dc=nycucs,dc=cc
changetype: modify
add: description
description: NA TA
-
replace: telephoneNumber
telephoneNumber: 0987654321
```



LDAPv3 Overview – LDIF (4/4)

- Sample LDIF – Modify more than one DN

Modify multiple DN

```
# Modify user info
dn: cn=tsaimh,ou=people,dc=na,dc=nycucs,dc=cc
changetype: modify
add: description
description: NA TA

dn: cn=wangth,ou=people,dc=na,dc=nycucs,dc=cc
changetype: modify
add: description
description: NA TA
```

LDAPv3 Overview – objectClass

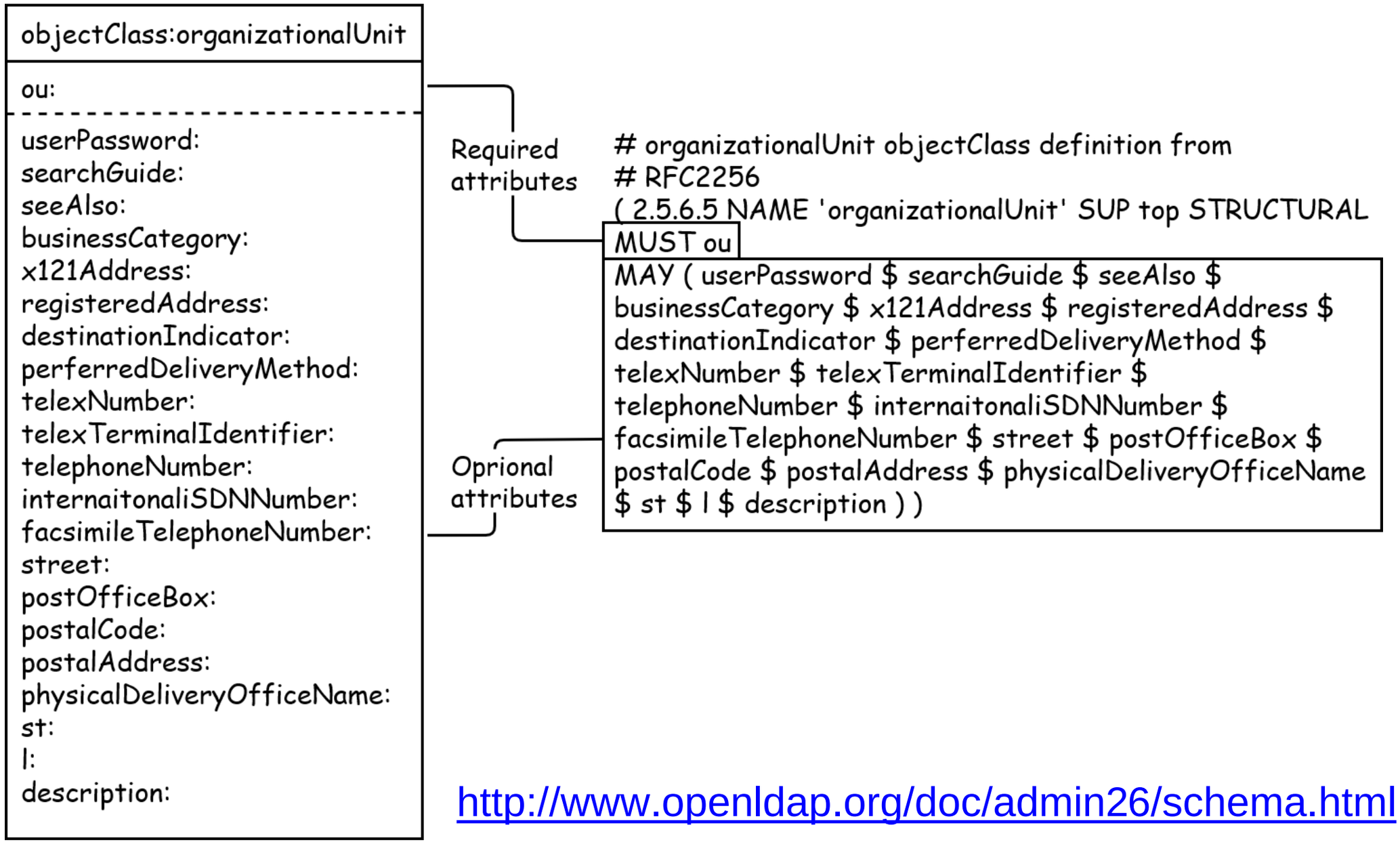
- /usr/local/etc/openldap/schema/core.schema

```
objectclass ( 2.5.6.6 NAME 'person'
      DESC 'RFC2256: a person'
      SUP top STRUCTURAL
      MUST ( sn $ cn )
      MAY ( userPassword & telephoneNumber & seeAlso & description ))
```

ObjectClassDescription = "(" whsp
numericoid whsp ; ObjectClass identifier
["Name" qdescrs]
["DESC" qdstring]
["OBSOLETE" whsp]
["SUP" oids] ; Superior ObjectClasses
[("ABSTRACT" / "STRUCTURAL" / "AUXILIARY") whsp]
; default structural
["MUST" oids] ; AttributeTypes
["MAY" oids] ; AttributeTypes
Whsp ")"

http://www.openldap.org/doc/admin26/schema.html

LDAPv3 Overview – objectClass (Cont.)



http://www.openldap.org/doc/admin26/schema.html

LDAPv3 Overview – Attribute

```
Attributetype ( 2.5.4.20 NAME 'telephoneNumber'
        DESC 'RFC2256: Telephone Number'
Matching  EQUALITY telephoneNumberMatch
Rules     SUBSTR telephobeNumberSubstringsMatch
Types     SYNTAX 1.3.6.1.4.1.1466.115.121.1.50{32} )
```

Server should support values of this length

Table 8.3: Commonly Used Syntaxes

Name	OID	Description
boolean	1.3.6.1.4.1.1466.115.121.1.7	boolean value
directoryString	1.3.6.1.4.1.1466.115.121.1.15	Unicode (UTF-8) string
distinguishedName	1.3.6.1.4.1.1466.115.121.1.12	LDAP DN
integer	1.3.6.1.4.1.1466.115.121.1.27	integer
numericString	1.3.6.1.4.1.1466.115.121.1.36	numeric string
OID	1.3.6.1.4.1.1466.115.121.1.38	object identifier
octetString	1.3.6.1.4.1.1466.115.121.1.40	arbitary octets

https://www.openldap.org/doc/admin26/schema.html

Comparison with relational databases

- It is tempting to think that having a RDBMS backend to the directory solves all problems. However, it is wrong.

- This is because the data models are very different. Representing directory data with a relational database is going to require splitting data into multiple tables.

OpenLDAP

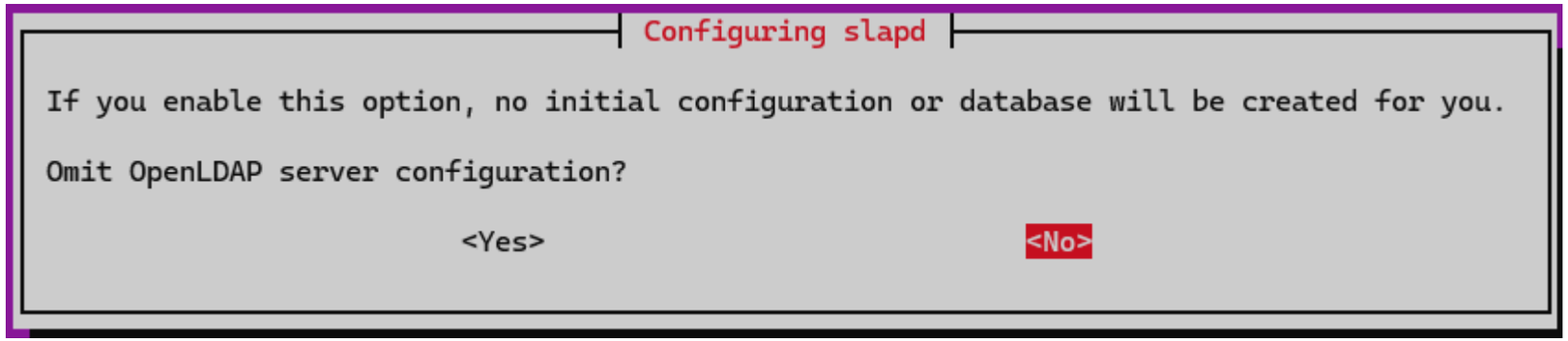
An open source implementation of the Lightweight Directory Access Protocol

國立陽明交通大學資工系資訊中心

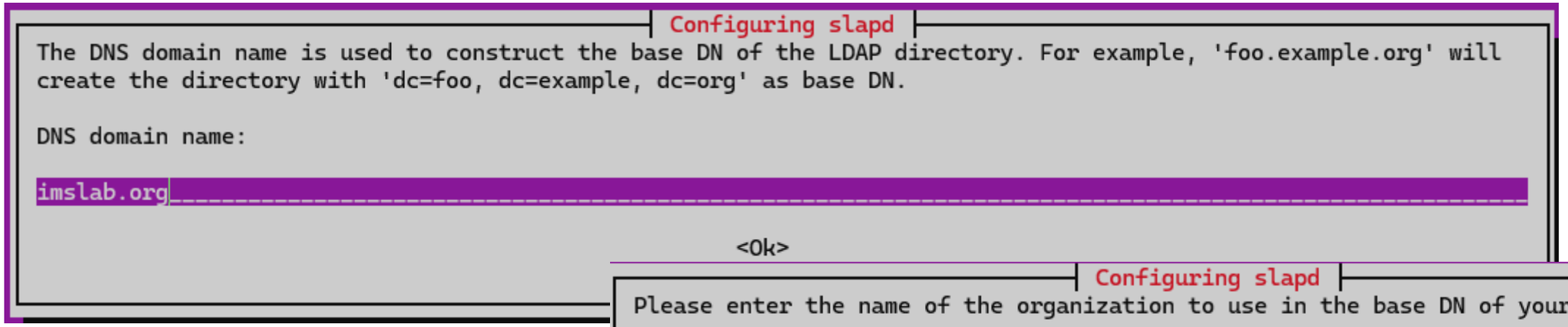
Information Technology Center of Department of Computer Science, NYCU

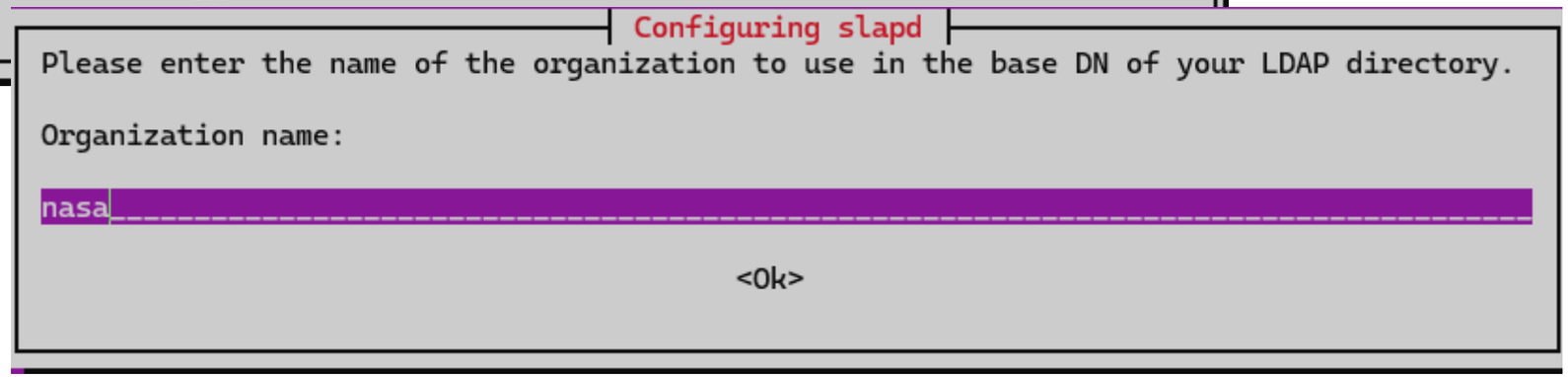
Install OpenLDAP on Linux

- Installation
  - sudo apt install slapd
  - systemctl restart packagekit.service
- Check if slapd is listening port 389
  - sudo netstat -tulnp | grep slapd
- Configure slapd
  - sudo dpkg-reconfigure slapd



Install OpenLDAP on Linux (cont.)






```
$ sudo slapcat
dn: dc=imslab,dc=org
objectClass: top
objectClass: dcObject
objectClass: organization
o: nasa
dc: imslab
structuralObjectClass: organization
entryUUID: 7105f58c-babc-103f-8a15-1305dfe8534f
creatorsName: cn=admin,dc=imslab,dc=org
createTimestamp: 20250501094312Z
entryCSN:
20250501094312.060492Z#000000#000#000000
modifiersName: cn=admin,dc=imslab,dc=org
modifyTimestamp: 20250501094312Z
```

OpenLDAP on FreeBSD

- Three main components
  - slapd – stand-alone LDAP daemon and associated modules and tools
  - libraries implementing the LDAP protocol and ASN.1 Basic Encoding Rules (BER)
  - client software: ldapsearch, ldapadd, ldapdelete, and others
- Installation
  - pkg install openldap26-server
  - cd /usr/ports/net/openldap26-server; make install clean
- slapd.conf
  - Blank lines and lines beginning with a pound sign (#) are ignored
  - Parameters and associated values are separated by whitespace characters
  - A line with a blank space in the first column is considered to be a continuation of the previous one.

slapd.conf

```
include         /usr/local/etc/openldap/schema/core.schema
pidfile         /var/run/openldap/slapd.pid
argsfile        /var/run/openldap/slapd.args
loglevel        256
modulepath      /usr/local/libexec/openldap
moduleload      back_mdb
moduleload      back_ldap

database        mdb
maxsize         1073741824
suffix          "dc=na,dc=nycucs,dc=cc"
rootdn          "cn=Manager,dc=na,dc=nycucs,dc=cc"
rootpw          <generated by slappasswd>
directory       /var/db/openldap-data

# Indices to maintain
index       objectClass eq
# ACL rules here for specific database
```

Directory ACL

```
# access to <what> [ by <who> [<accesslevel>] [<control>] ]+
access to dn.exact="cn=Manager,dc=na,dc=nycucs,dc=cc"
        by peername.ip="127.0.0.1" auth
        by users none
        by anonymous none
        by * none

access to attrs=userPassword
        by self write
        by anonymous auth
        by dn.base="cn=Manager,dc=na,dc=nycucs,dc=cc" write
        by * none

access to attrs=englishname,birthdate
        by self write
        by users read
        by anonymous read
```

If one access directive is more specific than another in terms of the entries it selects, it should appear first in the configuration

Directory ACL

http://www.openldap.org/doc/admin26/access-control.html

- Access Entity Specifiers (Who)

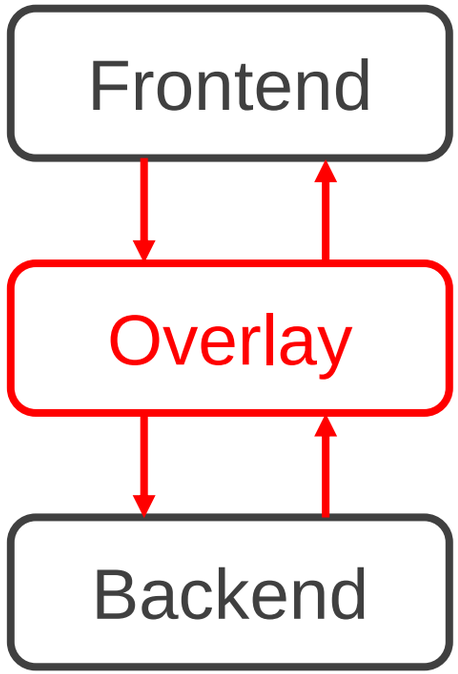
Specifier	Entities
*	All, including anonymous and authenticated users
anonymous	Anonymous (non-authenticated) users
users	Authenticated users
self	User associated with target entry
dn[.<basic-style>]=<regex>	Users matching a regular expression
dn.<scope-style>=<DN>	Users within scope of a DN

- Access Levels

Level	Privileges	Description
none =	0	no access
disclose =	d	needed for information disclosure on error
auth =	dx	needed to authenticate (bind)
compare =	cdx	needed to compare
search =	scdx	needed to apply search filters
read =	rscdx	needed to read search results
write =	wrscdx	needed to modify/rename
manage =	mwrscdx	needed to manage

Overlays

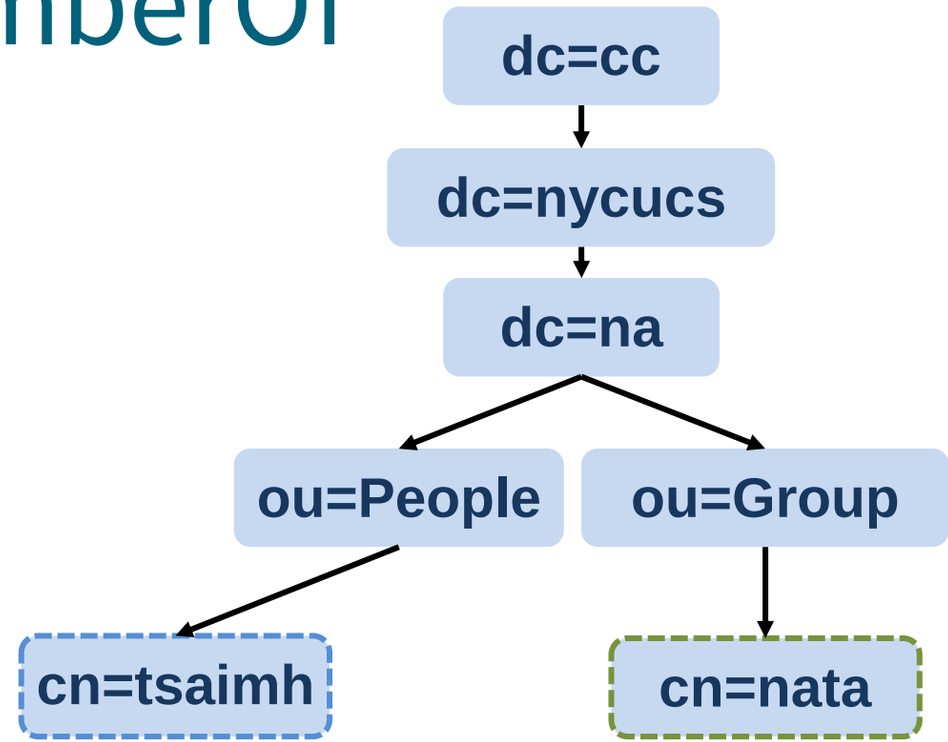
- Software components that provide hooks to functions analogous to those provided by backends, which can be stacked on top of the backend calls and as callbacks on top of backend responses to alter their behavior
- Frontend
  - handles network access and protocol processing
- Backend
  - deals strictly with data storage



https://www.openldap.org/doc/admin26/overlays.html
https://en.wikipedia.org/wiki/OpenLDAP#Overlays

Overlays – memberOf

- Membership




```
objectClass: posixGroup
objectClass: top
objectClass: posixAccount
cn: tsaimh
gidNumber: 1234
```

```
objectClass: posixGroup
objectClass: top
cn: nata
displayName: nata
description: Domain Unix group
gidNumber: 1234
```

Overlays – memberOf

- Installation
  - Ports
  - make config → enable option

```
+[ ] LMPASSWD          With LM hash password support (DEPRECATED)
+[x] MDB               With Memory-Mapped DB backend
+[ ] MEMBEROF          With Reverse Group Membership overlay
+[ ] ODBC              With SQL backend
+[ ] OUTLOOK           Force caseIgnoreOrderingMatch on name attribute
+[ ] PASSWD            With Passwd backend
+[ ] PERL              With Perl backend
+[ ] PPOLICY           With Password Policy overlay
+[ ] PROXYCACHE        With Proxy Cache overlay
+[ ] REFINT            With Referential Integrity overlay
+[ ] RELAY             With Relay backend
+[ ] RETCODE           With Return Code testing overlay
```

https://www.openldap.org/doc/admin26/overlays.html

Overlays – memberOf

- Edit /usr/local/etc/openldap/slapd.conf

```
# MemberOf
Overlay memberof
```

- restart slapd
- Query Result

```
dn: cn=nata,ou=MemberGroup,dc=na,dc=nycucs,dc=cc
objectclass: groupOfNames
cn: nata
member: cn=tsaimh,ou=People,dc=na,dc=nycucs,dc=cc
```

https://www.openldap.org/doc/admin26/overlays.html

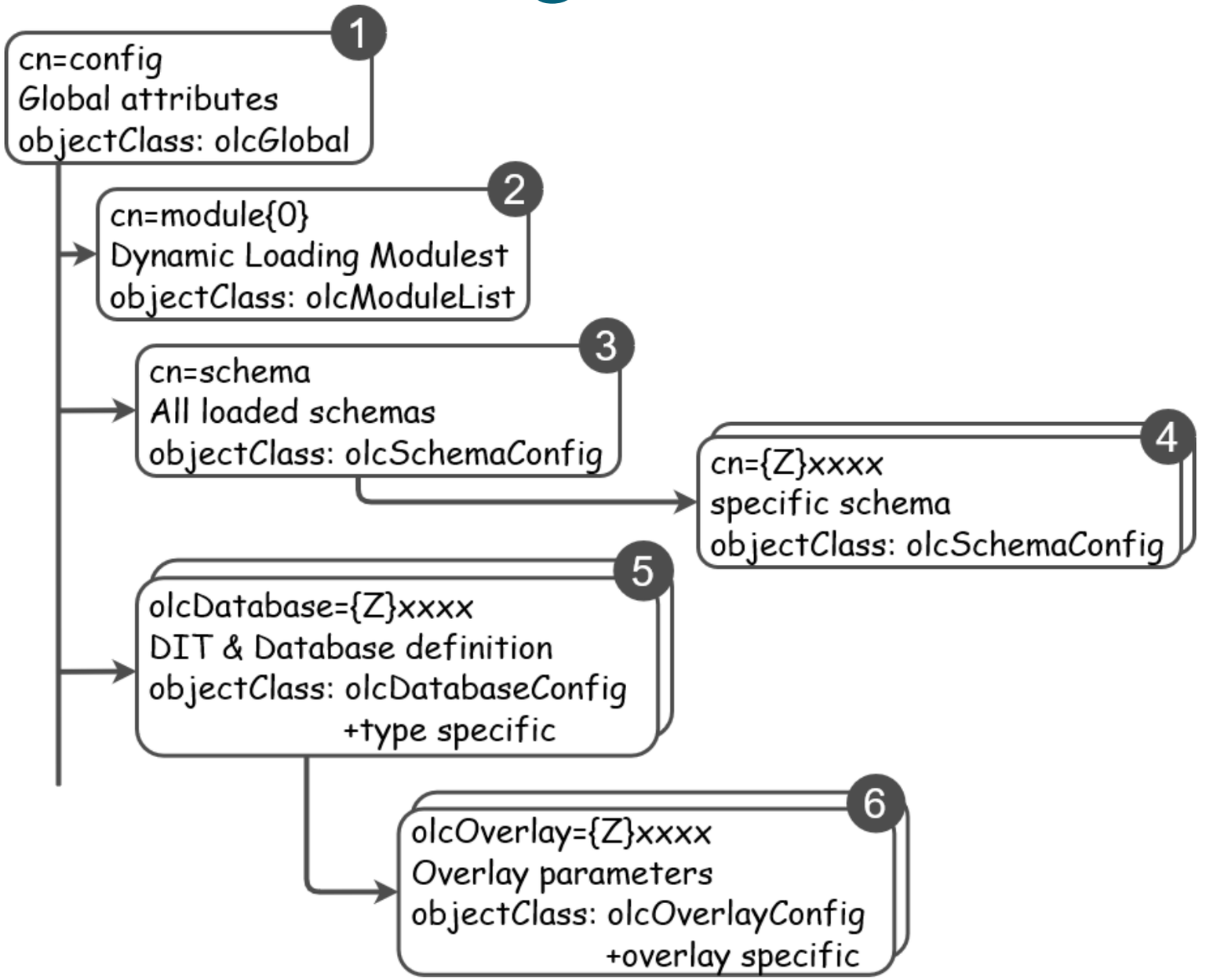
OLC – Online Configuration (1/3)

- OpenLDAP 2.3 and later have transitioned to using a dynamic runtime configuration engine

- Uses a configuration DIT to control the operational configuration
- Modifying entries in this DIT immediate changes to slapd's operational behavior
- Note: Configuration changes should be performed via LDAP operations. DON'T edit any of the LDIF files directly.

https://www.openldap.org/doc/admin26/slapdconf2.html
https://www.zytrax.com/books/ldap/ch6/slapd-config.html

OLC – Online Configuration (2/3)



OLC – Online Configuration (3/3)

```
# {1}mdb, config
dn: olcDatabase={1}mdb,cn=config
objectClass: olcDatabaseConfig
objectClass: olcMdbConfig
olcDatabase: {1}mdb
olcDbDirectory: /var/db/openldap-data/na
olcSuffix: dc=na,dc=nycucs,dc=cc
olcAddContentAcl: FALSE
olcLastMod: TRUE
olcMaxDerefDepth: 15
olcReadOnly: FALSE
olcRootDN: cn=Manager,dc=na,dc=nycucs,dc=cc
olcRootPW: secret
```

Enable slapd

- Edit /etc/rc.conf
  - slapd_enable="YES"
  - slapd_flags='-h "ldapi://%2fvar%2frun%2fopenldap%2fldapi/ ldap://0.0.0.0/"'
  - slapd_sockets="/var/run/openldap/ldapi"
- service slapd start
- slapd runs under a non-privileged user id (by default `ldap')

http://www.openldap.org/doc/admin26/runningslapd.html

slapd tools

- slapcat
  - This tool reads records from a slapd database and writes them to a file or standard output
- slapadd
  - This tool reads LDIF entries from a file or standard input and writes the new records to a slapd database
- slapindex
  - This tool regenerates the indexes in a slapd database
- slappasswd
  - This tool generates a password hash suitable for use as an Lq in slapd.conf

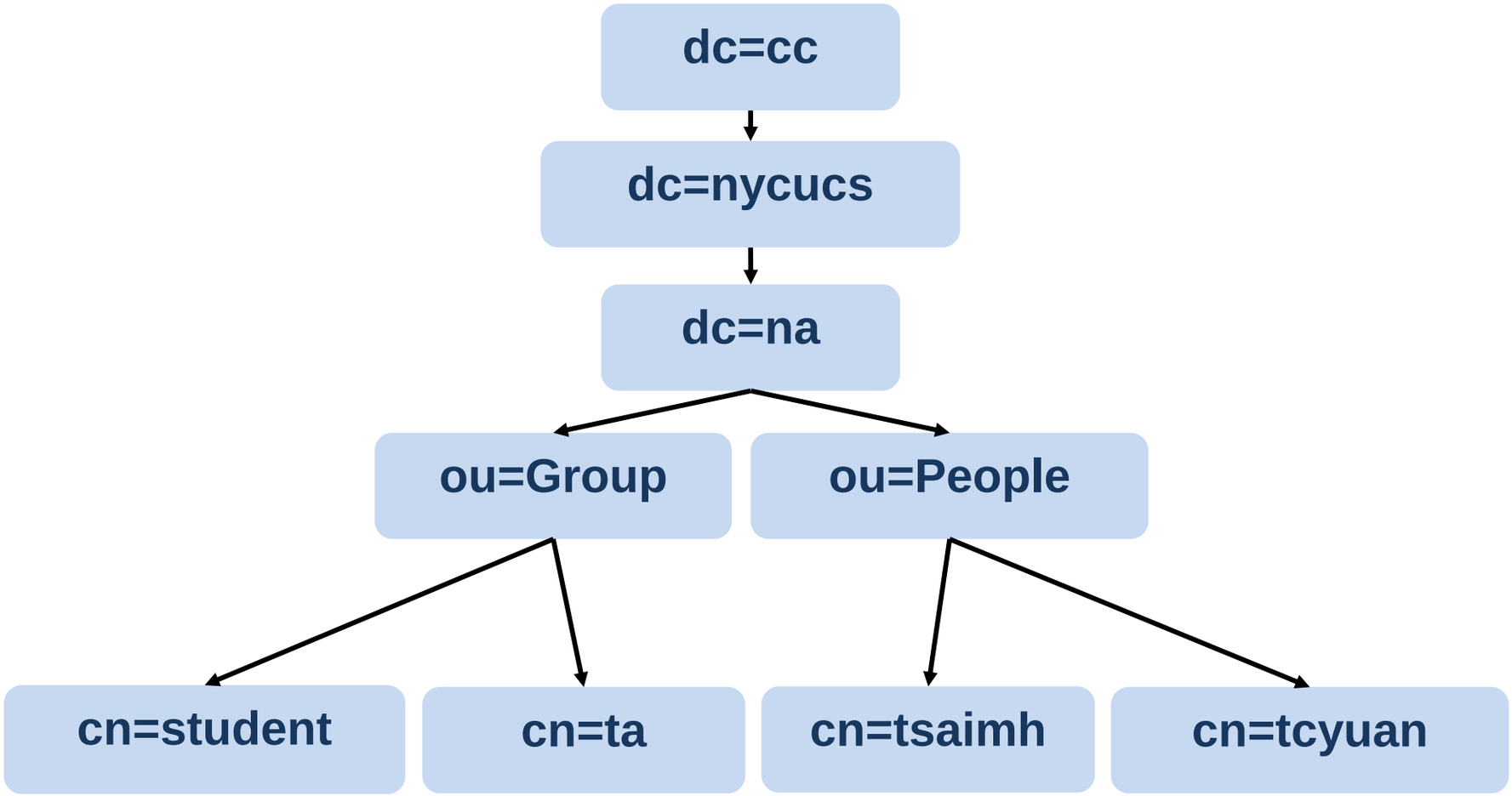
LDAP tools

- ldapsearch
  - This tool issues LDAP search queries to directory servers
- ldapadd, ldapmodify
  - These tools send updates to directory servers
- ldapcompare
  - This tool server to compare two values
- ldapdelete
  - This tool deletes entries from an LDAP directory

ldapsearch

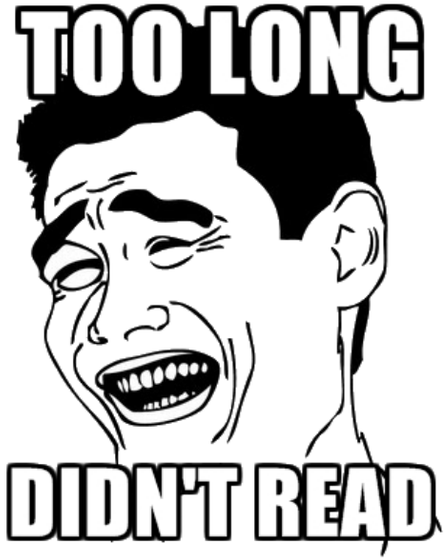
- Options
  - -b searchbase
  - -s {base|one|sub|children} # default is sub
  - -D binddn
  - -x # Use simple authentication instead of SASL
  - -W # password for simple authentication
  - -H ldapuri
- ldapsearch [options] filter
  - default filter, (objectClass=*)
  - ldapsearch -H ldap://ldap.na.nycucs.cc
    -D "cn=tsaimh,dc=na,dc=nycucs,dc=cc"
    -b "dc=na,dc=nycucs,dc=cc" -s one
- man ldapsearch

ldapsearch (Cont.)



ldap.conf

- ldapsearch -H ldap://ldap.na.nycucs.cc
  -b "dc=na,dc=nycucs,dc=cc" cn=tsaimh



- Edit /usr/local/etc/openldap/ldap.conf

```
# See ldap.conf(5) for details
# This file should be world readable but not world writable.
BASE    dc=na,dc=nycucs,dc=cc
URI     ldap://ldap.na.nycucs.cc
```

=> ldapsearch -x "cn=tsaimh"

ldapsearch – searchbase vs. filter

- Search by dn

```
# ldapsearch dn="cn=tsaimhh,dc=na,dc=nycucs,dc=cc"
```

  - It does not work!

- Use search base

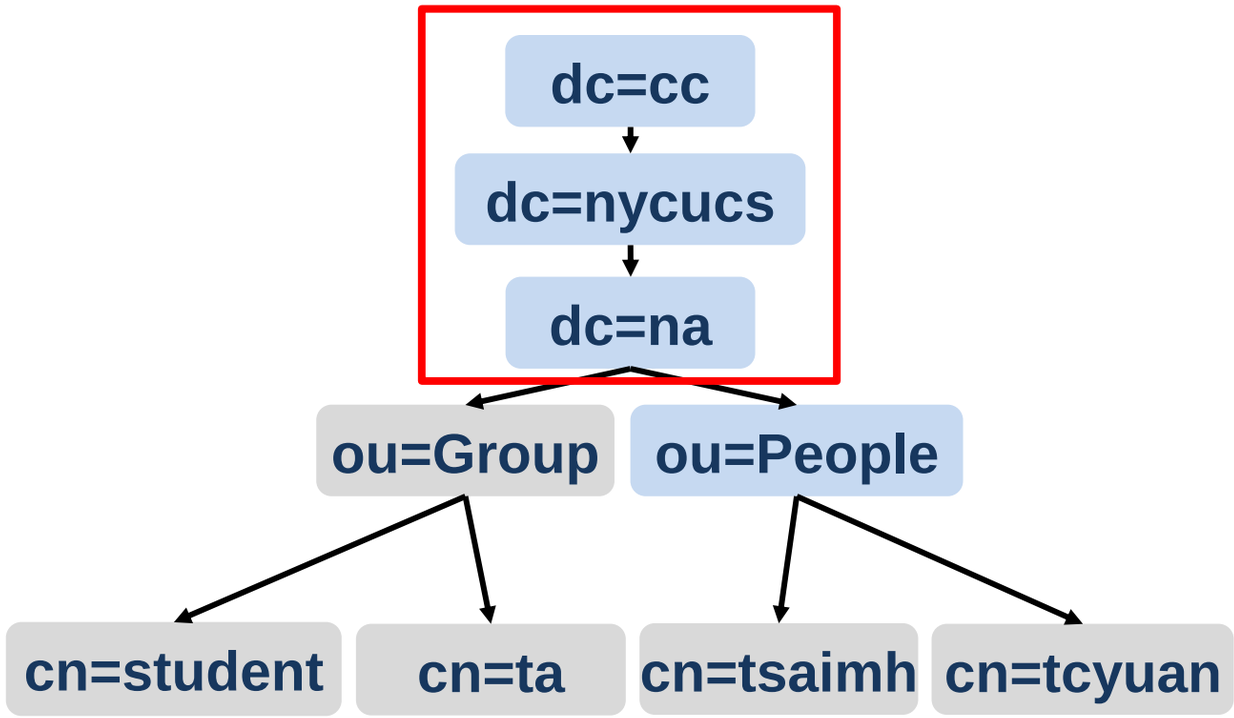
```
# ldapsearch -b "cn=tsaimh,dc=na,dc=nycucs,dc=cc" -s base
```

  - It works!

- Why?
  - You have got full dn, don’t need to search

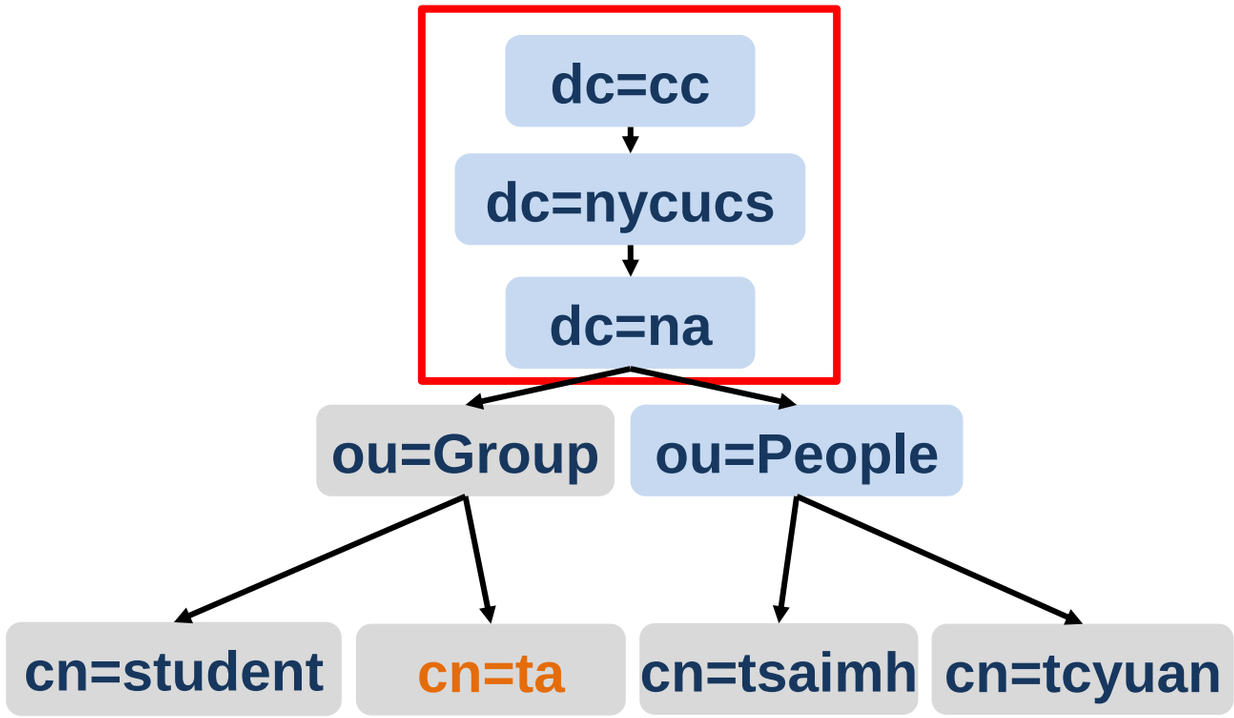
ldapsearch – searchbase vs. filter

- Example
  - Assume there are two kinds of searchbase
  - dc=na,dc=nycucs,dc=cc
  - ou=People, dc=na,dc=nycucs,dc=cc



ldapsearch – searchbase vs. filter

- Exatsaimh(Cont.)
  - filter – search for all entries that have cn=nata
  - cn=nata
  - cn=nata → Can't be found, because the cn=nata is not in this subtree



LDAP Authentication

LDAP Authentication (1/3)

- pkg install nss-pam-ldapd
- Edit /usr/local/etc/nslcd.conf
- Edit /etc/nsswitch.conf
- Edit /etc/pam.d/system

LDAP Authentication (2/3)

- Edit /usr/local/etc/nslcd.conf
  - Just like ldap.conf

```
# The user and group nslcd should run as.
uid nslcd
gid nslcd
uri ldap://ldap.na.nycucs.cc
base dc=na,dc=nycucs,dc=cc
```

LDAP Authentication (3/3)

- Edit /etc/nsswitch.conf

https://www.freebsd.org/doc/en/articles/ldap-auth/client.html

```
# nsswitch.conf(5) - name service switch configuration file
# $FreeBSD: releng/11.1/etc/nsswitch.conf
group: files ldap
passwd: files ldap
```

References

- Understanding Directory Services
  - Beth Sheresh, Doug Sheresh - Sams Publishing
- LDAP System Administration: Putting Directories to Work
  - Gerald Carter - O'Reilly Media, Inc.
- The Lightweight Directory Access Protocol: X.500 Lite
  - Timothy A. Howes
- Internet protocol suite – Wikipedia
  - https://en.wikipedia.org/wiki/Internet_protocol_suite#Comparison_of_TCP/IP_and_OSI_layering