

# Installing Docker

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- OS specific instructions at [Install Docker Engine](#).
- Windows: Make sure to install Windows Subsystem for Linux version 2 (WSL 2). Install Ubuntu from Microsoft's App store and follow Docker Desktop WSL 2 backend.

# Why LDAP?

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- **Standardized** protocol like HTTP, SMB and others.
- “Glue” connecting an organization's applications and services.
  - Backend data for authentication / SSO, PKI, network FS etc.
  - Meta data repository for users, organisational units, network nodes.

# LDAP introduction

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- Read the introductory slides at Chapter 28, *LDAP* as well.

# Running a Docker container

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```
docker run --detach ❶ \  
  --name openldap ❷\  
  -p 389:389 \ ❸\  
  --env LDAP_ORGANISATION="Betrayers heaven" \ ❹\  
  --env LDAP_TLS=false ❺\  
  --env LDAP_DOMAIN="betrayer.com" ❻\  
  --env LDAP_ADMIN_PASSWORD="secret" ❼\  
  --env LDAP_CONFIG_PASSWORD="secret" ❽\  
  --volume ~/OpenLdap/Data:/var/lib/ldap ❾\  
  --volume ~/OpenLdap/Config:/etc/ldap/slapd.d ❿\  
  osixia/openldap:1.4.0 ⓫
```

# Using docker-compose

---

version: '3.7'

services:

openldap:

image: osixia/openldap:1.4.0

container\_name: openldap

restart: always

environment:

LDAP\_ORGANISATION: "Betrayers heaven"

LDAP\_TLS: "false"

LDAP\_DOMAIN: "betrayer.com"

LDAP\_ADMIN\_PASSWORD: "secret"

LDAP\_CONFIG\_PASSWORD: "secret"

ports:

- 389:389

volumes:

- ~/OpenLdap/Data:/var/lib/ldap

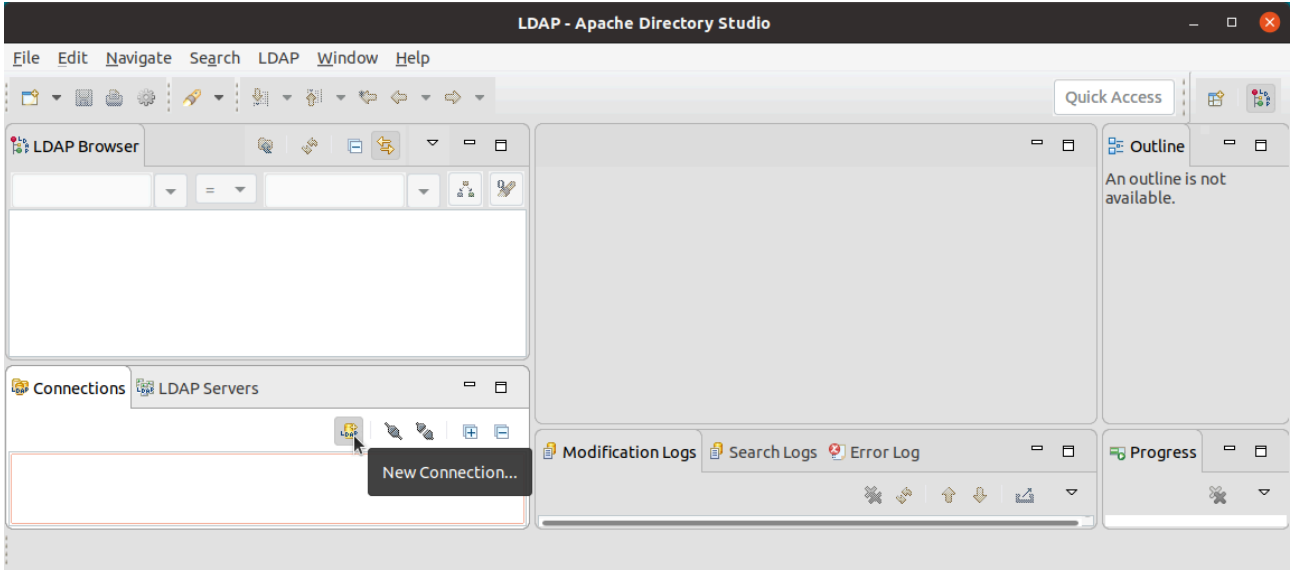
- ~/OpenLdap/Config:/etc/ldap/slapd.d

# Installing Apache Directory Studio

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- Download and install Apache Directory Studio.
- Configure access to your local docker container.

# Administrator access to your DIT



# Administrator access to your DIT

New LDAP Connection

**Network Parameter**  
Please enter connection name and network parameters.

Connection name: admin@localhost

Network Parameter

Hostname: localhost

Port: 389

Connection timeout (s): 30

Encryption method: No encryption

Server certificates for LDAP connections can be managed in the ['Certificate Validation'](#) preference page.

Provider: Apache Directory LDAP Client API

Check Network Parameter

Read-Only (prevents any add, delete, modify or rename operation)

? < Back Next > Cancel Finish



# Administrator access to your DIT

The screenshot shows the 'New LDAP Connection' wizard. The 'Network Parameter' section is active, with the following fields filled: Connection name: admin@localhost; Hostname: localhost; Port: 389; Connection timeout (s): 30; Encryption method: No encryption; Server certificates for LDAP connection: (empty); Provider: Apache Directory LDAP Client API. A 'Check Network Parameter' button is visible. A modal dialog box titled 'Check Network Parameter' is overlaid on the form, displaying an information icon and the message 'The connection was established successfully.' with an 'OK' button. At the bottom of the wizard, there are navigation buttons: '< Back', 'Next >', 'Cancel', and 'Finish'. A 'Read-Only' checkbox is also present, which is currently unchecked.

# Administrator access to your DIT

New LDAP Connection

**Network Parameter**  
Please enter connection name and network parameters.

Connection name: admin@localhost

Network Parameter

Hostname: localhost

Port: 389

Connection timeout (s): 30

Encryption method: No encryption

Server certificates for LDAP connections can be managed in the ['Certificate Validation'](#) preference page.

Provider: Apache Directory LDAP Client API

Check Network Parameter

Read-Only (prevents any add, delete, modify or rename operation)

< Back Next > Cancel Finish

# Administrator access to your DIT

New LDAP Connection

**Authentication**  
Please select an authentication method and input authentication data.

Authentication Method: Simple Authentication

Authentication Parameter

Bind DN or user: cn=admin,dc=betrayer,dc=com

Authorization ID (SASL): SASL PLAIN only

Bind password: \*\*\*\*\*

Save password

Check Authentication

▸ SASL Settings  
▸ Kerberos Settings

< Back   Next >   Cancel   Finish

# Administrator access to your DIT

The screenshot shows a 'New LDAP Connection' dialog box with the following fields and settings:

- Authentication Method:** Simple Authentication
- Authentication Parameter:** (empty)
- Bind DN or user:** cn=admin,dc=betrayer,dc=com
- Authorization ID (SASL):** SASL PLAIN only
- Bind password:** (masked with asterisks)
- Save password
- SASL Settings** (expanded)
- Kerberos Settings** (collapsed)

A 'Check Authentication' dialog box is overlaid on top, displaying the message: 'The authentication was successful.' with an 'OK' button.

At the bottom of the main dialog, there are navigation buttons: '< Back', 'Next >', 'Cancel', and 'Finish'. A 'Check Authentication' button is also present near the password field.

# Administrator access to your DIT

New LDAP Connection

**Authentication**  
Please select an authentication method and input authentication data.

Authentication Method: Simple Authentication

Authentication Parameter: Bind DN or user: cn=admin,dc=betrayer,dc=com

Authorization ID (SASL): SASL PLAIN only

Bind password: \*\*\*\*\*

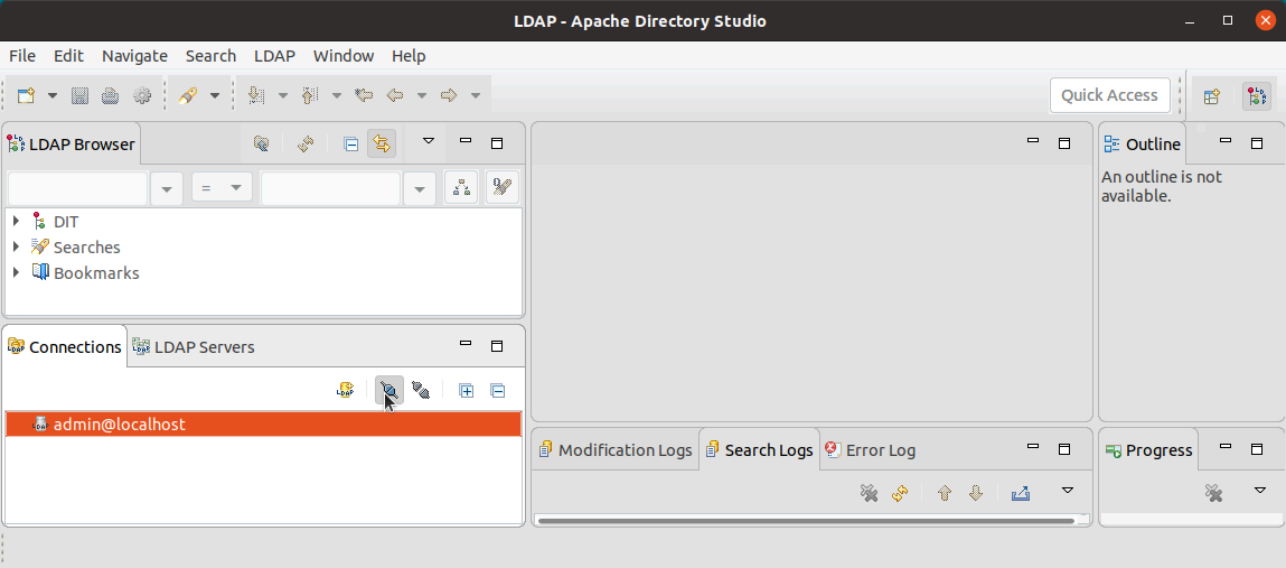
Save password

Check Authentication

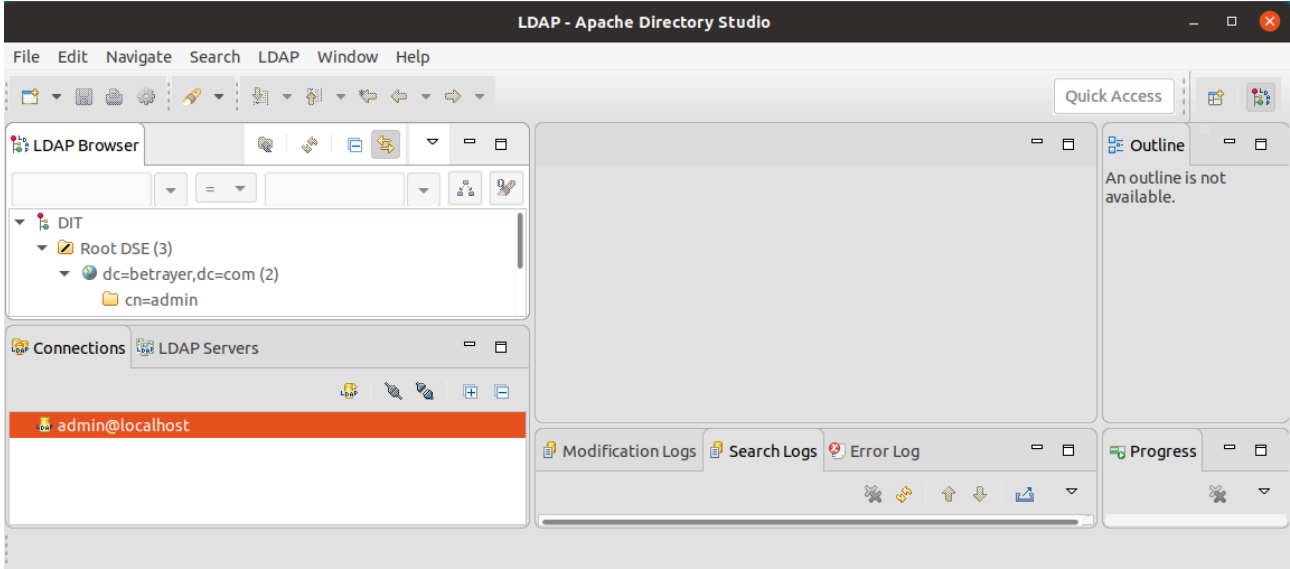
▸ SASL Settings  
▸ Kerberos Settings

< Back   Next >   Cancel   Finish

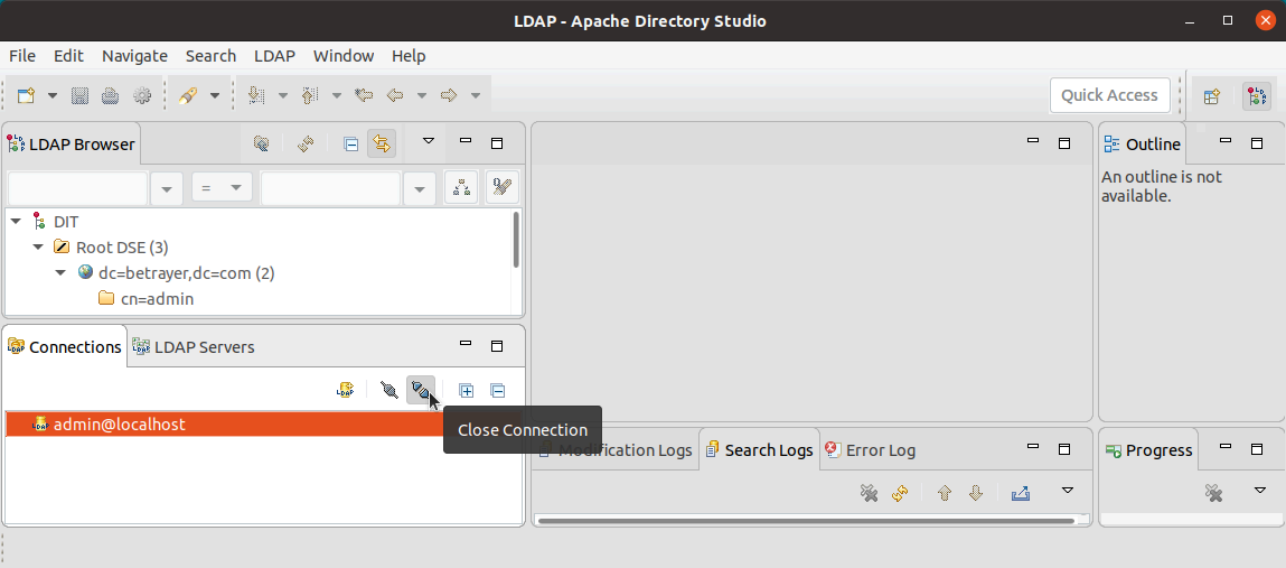
# Administrator access to your DIT



# Administrator access to your DIT

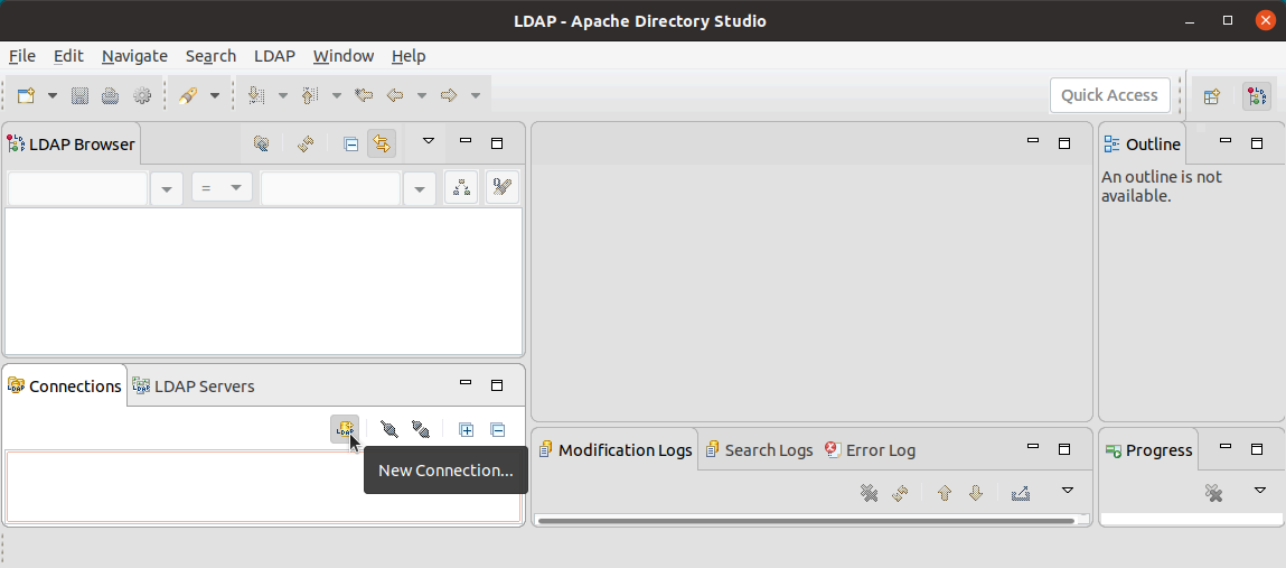


# Administrator access to your DIT





# Administrator access to your server's data tree



# Administrator access to your server's data tree

New LDAP Connection

**Network Parameter**  
Please enter connection name and network parameters.

Connection name: admin@localhost

Network Parameter

Hostname: localhost

Port: 389

Connection timeout (s): 30

Encryption method: No encryption

Server certificates for LDAP connections can be managed in the ['Certificate Validation'](#) preference page.

Provider: Apache Directory LDAP Client API

Check Network Parameter

Read-Only (prevents any add, delete, modify or rename operation)

< Back   Next >   Cancel   Finish

# Administrator access to your server's data tree

The screenshot shows a 'New LDAP Connection' dialog box with the following fields and options:

- Connection name: admin@localhost
- Network Parameter: localhost
- Port: 389
- Connection timeout (s): 30
- Encryption method: No encryption
- Server certificates for LDAP connection: (empty)
- Provider: Apache Directory LDAP Client API
- Read-Only (prevents any add, delete, modify or rename operation):

A 'Check Network Parameter' button is located at the bottom right of the dialog. An information dialog box is overlaid on top, displaying the message: 'The connection was established successfully.' with an 'OK' button.

# Administrator access to your server's data tree

New LDAP Connection

**Network Parameter**  
Please enter connection name and network parameters.

Connection name: admin@localhost

Network Parameter

Hostname: localhost

Port: 389

Connection timeout (s): 30

Encryption method: No encryption

Server certificates for LDAP connections can be managed in the ['Certificate Validation'](#) preference page.

Provider: Apache Directory LDAP Client API

Check Network Parameter

Read-Only (prevents any add, delete, modify or rename operation)

< Back Next > Cancel Finish

# Administrator access to your server's data tree

New LDAP Connection

**Authentication**  
Please select an authentication method and input authentication data.

Authentication Method: Simple Authentication

Authentication Parameter

Bind DN or user: cn=admin,dc=betrayer,dc=com

Authorization ID (SASL): SASL PLAIN only

Bind password: \*\*\*\*\*

Save password

Check Authentication

▸ SASL Settings  
▸ Kerberos Settings

< Back   Next >   Cancel   Finish

# Administrator access to your server's data tree

The screenshot shows a 'New LDAP Connection' dialog box with a 'Check Authentication' pop-up window. The main dialog box has the following fields and options:

- Authentication Method:** Simple Authentication
- Authentication Parameter:** (empty)
- Bind DN or user:** cn=admin,dc=betrayer,dc=com
- Authorization ID (SASL):** SASL PLAIN only
- Bind password:** (masked with asterisks)
- Save password
- SASL Settings** (expanded)
- Kerberos Settings** (expanded)
- Check Authentication** button

The 'Check Authentication' pop-up window displays the message: 'The authentication was successful.' with an 'OK' button.

At the bottom of the main dialog box, there are navigation buttons: '< Back', 'Next >', 'Cancel', and 'Finish'.

# Administrator access to your server's data tree

New LDAP Connection

**Authentication**  
Please select an authentication method and input authentication data.

Authentication Method: Simple Authentication

Authentication Parameter: Bind DN or user: cn=admin,dc=betrayer,dc=com

Authorization ID (SASL): SASL PLAIN only

Bind password: \*\*\*\*\*

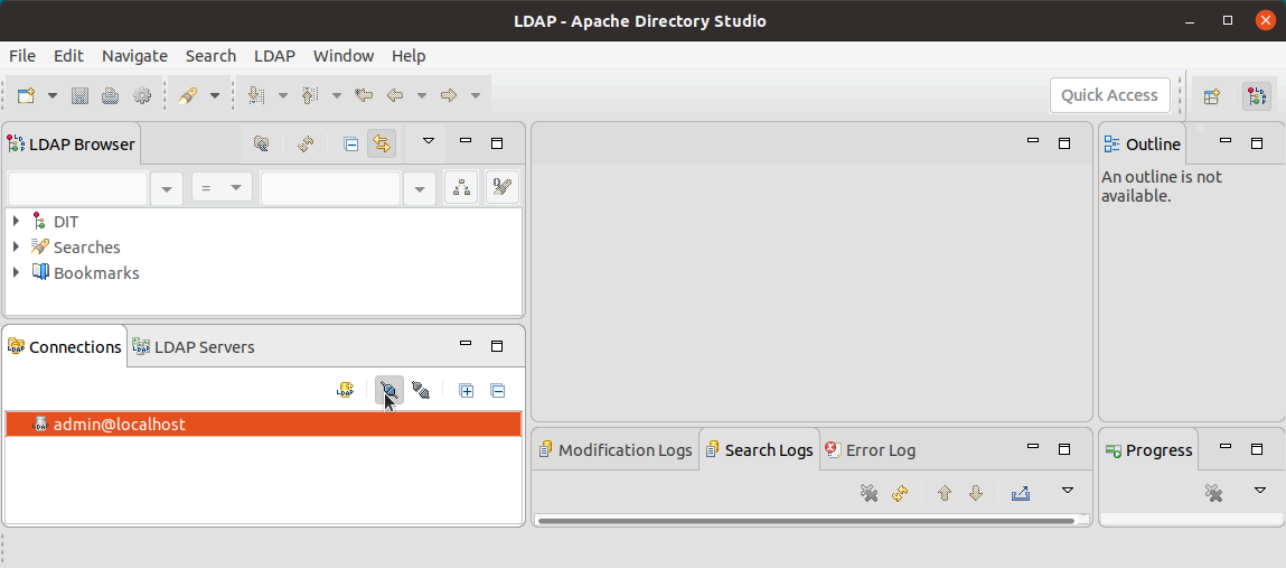
Save password

Check Authentication

▸ SASL Settings  
▸ Kerberos Settings

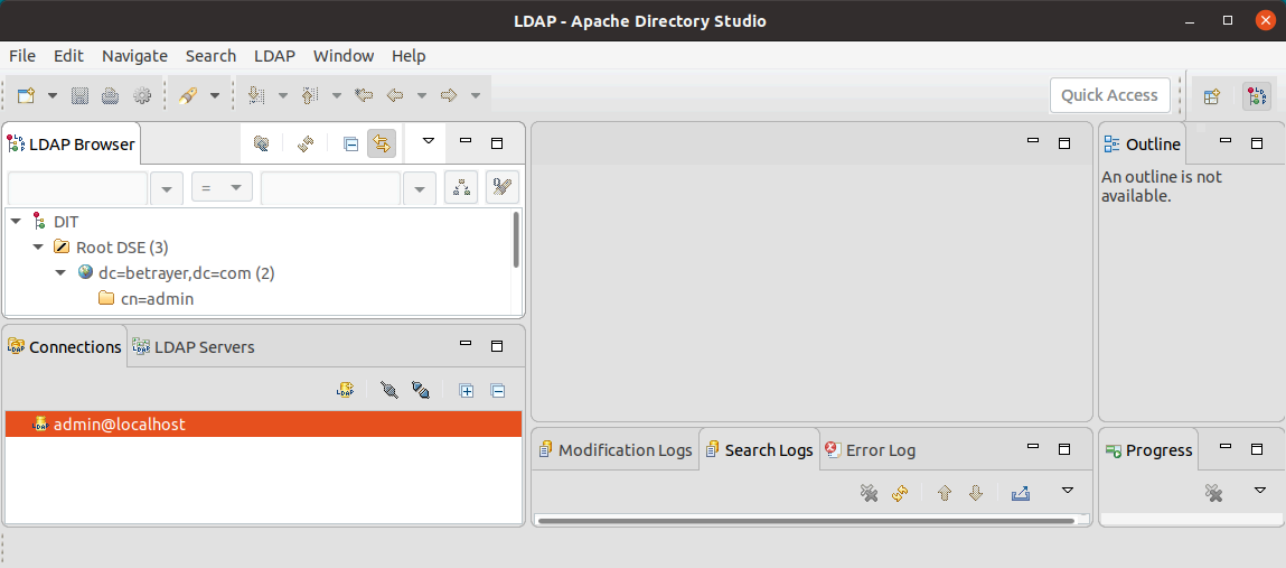
< Back   Next >   Cancel   Finish

# Administrator access to your server's data tree

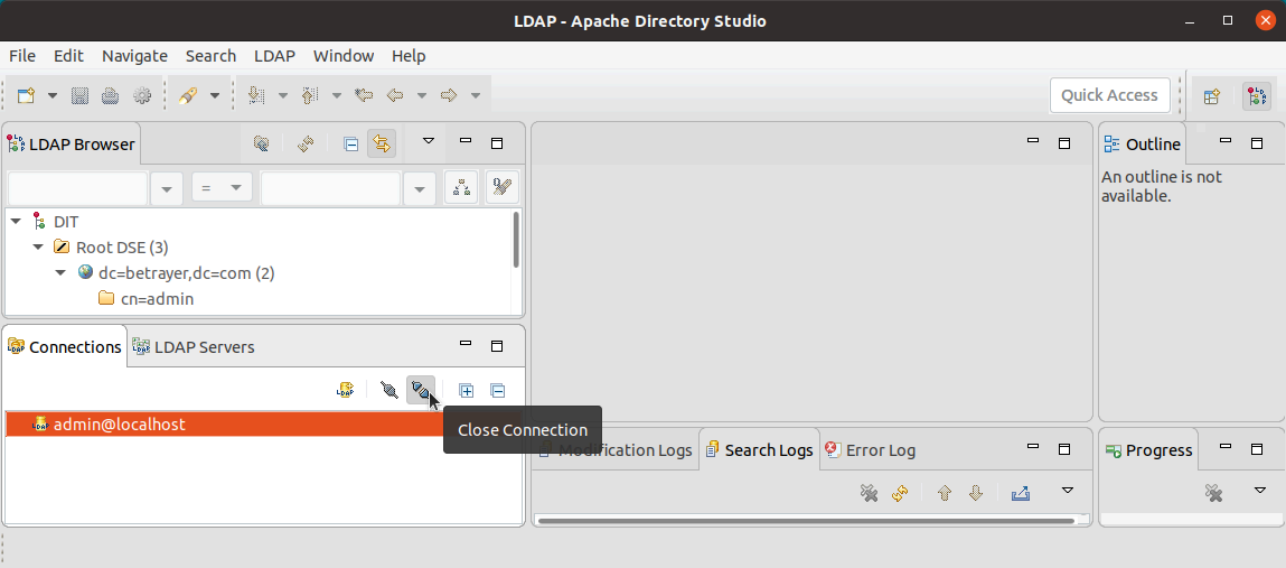




# Administrator access to your server's data tree



# Administrator access to your server's data tree



# Administrator access to your server's configuration

New LDAP Connection

**Network Parameter**  
Please enter connection name and network parameters.

Connection name: admin@config@localhost

Network Parameter

Hostname: localhost

Port: 389

Connection timeout (s): 30

Encryption method: No encryption

Server certificates for LDAP connections can be managed in the ['Certificate Validation'](#) preference page.

Provider: Apache Directory LDAP Client API

Check Network Parameter

Read-Only (prevents any add, delete, modify or rename operation)

< Back Next > Cancel Finish

# Administrator access to your server's configuration

The screenshot shows a 'New LDAP Connection' wizard window. The 'Authentication' section is active, with 'Simple Authentication' selected. The 'Bind DN or user' field contains 'cn=admin,cn=config', and the 'Authorization ID (SASL)' is set to 'SASL PLAIN only'. The 'Bind password' field is masked with asterisks, and the 'Save password' checkbox is checked. A 'Check Authentication' button is visible in the bottom right of the main window. A modal dialog titled 'Check Authentication' is displayed in the center, showing a blue information icon and the message 'The authentication was successful.' with an 'OK' button.

**New LDAP Connection**

**Authentication**  
Please select an authentication method and input authentication data.

Authentication Method: Simple Authentication

Authentication Parameter:

Bind DN or user: cn=admin,cn=config

Authorization ID (SASL): SASL PLAIN only

Bind password: \*\*\*\*\*

Save password

Check Authentication

**Check Authentication**  
The authentication was successful.

OK

< Back   Next >   Cancel   Finish

# Administrator access to your server's configuration

New LDAP Connection

**Browser Options**  
You can specify additional parameters for browsing the directory.

Base DN

Get base DN's from Root DSE

Base DN:

Fetch Base DN's

Limits

Count Limit:

Time Limit (s):

Aliases Dereferencing

Finding Base DN

Search

Referrals Handling

Follow Referrals manually

Follow Referrals automatically

Ignore Referrals

Controls

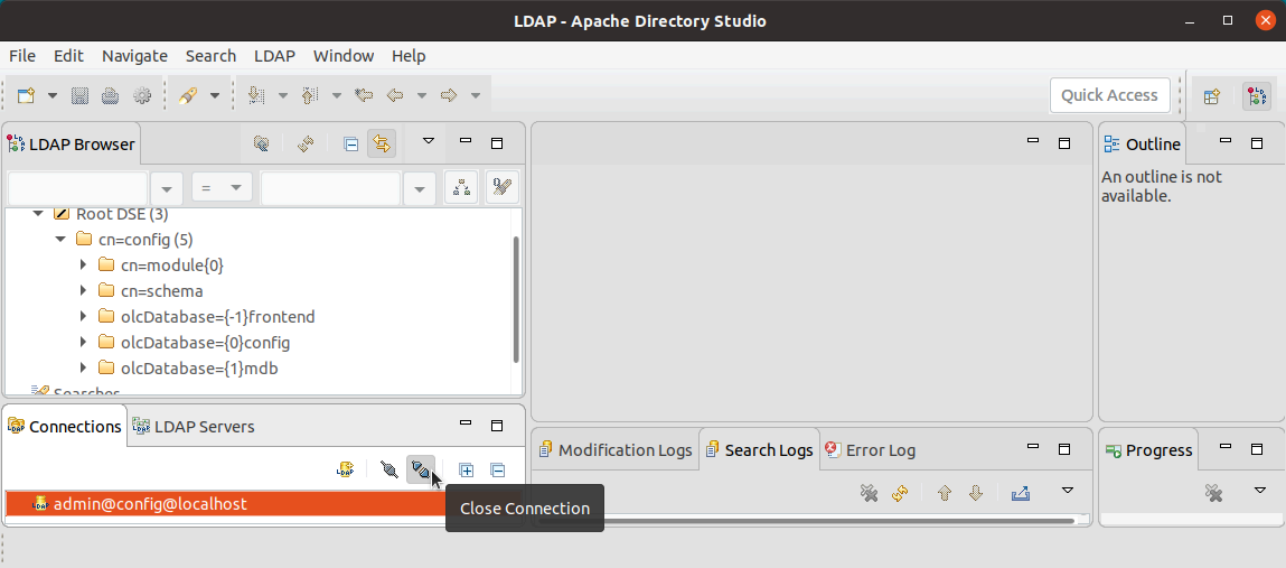
Use ManageDsaIT control while browsing

Fetch subentries while browsing (requires additional search request)

Paged Search Page Size:   Scroll Mode

< Back Next > Cancel Finish

# Administrator access to your server's configuration



# Terminology

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- DIT: Document information tree
- DN: An entries distinguished name. Unique identifier.
- RDN: Relative distinguished name. Unique identifier with respect to a given context node.
- Bind operation: Connect to an LDAP service.
  1. anonymous
  2. authenticated

# Adding an entry

---

dn: uid=smith ❶, dc=bet rayer, dc=com ❷  
changetype: add ❸  
objectClass: inetOrgPerson ❹  
objectClass: organizationalPerson ❹  
objectClass: Person ❹  
objectClass: top ❹  
uid: smith ❺  
cn: Jill Smith ❻  
sn: Smith ❻



# Adding a new attribute

Operation	Result
dn: uid=smith, dc=betraye, dc=com ❶ changetype: modify ❷ add: <b>description</b> ❸ <b>description</b> : New employee ❹	dn: uid=smith, dc=betraye, dc=com objectClass: inetOrgPerson objectClass: organizationalPerson objectClass: person objectClass: top cn: Jill Smith sn: Smith uid: smith <b>description</b> : New employee

# Replacing an attribute value

Operation	Result
dn: uid=smith, dc=betraye, dc=com ❶ changetype: modify ❷ replace: <b>description</b> ❸ <b>description</b> : Long term employee ❹	dn: uid=smith, dc=betraye, dc=com objectClass: inetOrgPerson objectClass: organizationalPerson objectClass: person objectClass: top cn: Jill Smith sn: Smith uid: smith <b>description</b> : Long term employee

# Deleting an attribute entirely

Base state	Operation	Result
dn: uid=smith, dc=betraye, dc=com ... uid: smith commonName: Jill Smith surname: Smith <b>description</b> : Long term employee	dn: uid=smith, dc=... changetype: modify delete: description	dn: uid=smith, dc=betraye, dc=com ... uid: smith commonName: Jill Smith surname: Smith

## Multi valued attributes

Operation	Result
dn: uid=smith, dc=betraye, dc=com changetype: modify add: mail ① mail: smith@company.com ② mail: jsmith@privateaccount.org ③	dn: uid=smith, dc=betraye, dc=com ... sn: Smith mail: jsmith@privateaccount.org ② mail: smith@company.com ③

# Set semantics of multivalued attributes

Base state	Operation
<p>dn: uid=smith, dc=betray, dc=com objectClass: inetOrgPerson objectClass: organizationalPerson objectClass: person objectClass: top uid: smith commonName: Jill Smith surname: Smith</p>	<p>dn: uid=smith, dc=betray, dc=com changetype: modify add: mail ❶ mail: smith@company.com ❷ mail: jsmith@privateaccount.org ❸ mail: smith@company.com ❹</p> <p>ERR_13207_VALUE_ALREADY_EXISTS ❺ The value 'smith@company.com' already exists in the attribute (mail)</p>

## Deleting selected attribute values

Base state	Operation	Result
dn: uid=smith, dc=betraye, dc=com ... cn: Jill Smith mail: jsmith@privateaccount.org mail: smith@company.com mail: anonymous@keeput.org	dn: uid=smith, dc=... changetype: modify delete: mail mail: smith@company.com mail: anonymous@keeput.org	dn: uid=smith, dc=betraye, dc=com ... cn: Jill Smith mail: jsmith@privateaccount.org

# Query scope

---

- BaseObject
- SingleLevel
- WholeSubtree
- SubordinateSubtree (not yet officially standardized)

# Query filter

---

- Presence: ( cn=\* )
- Equality: ( ui d=xy123 )
- Comparison: ( 1000 < ui dNumber )
- Substring: ( sur name=K\* )
- Approximate Match: ( sn~gok )

(matches Gack, Keck, Kubi ac, Goi k, Kabbeck, Nguyen Quoc, Gubi c , Koc)

- AND: ( &( 5 < ui dNumber ) ( sn=\*k\* ) ( gi dNumber=1000 ) )
- OR: ( | ( 5 < ui dNumber ) ( sn=\*k\* ) ( gi dNumber=1000 ) )
- NOT: ( ! ( 5 < ui dNumber ) )
- Extensible match filters, see Extensible Match Search Filter as well.



# Schema support

---

- Objectclass definitions
- Objectclass inheritance. Types:
  - Abstract
  - Structural
  - Auxiliary
- Dynamic instance schema changes
- Single and multivalued attributes
- Attribute data types
- Matching rules (Case sensitive / insensitive, string match, numeric)

# Implementations

---

access to attrs=matrikelNr

by dn="uid=goik,ou=userlist,dc=hdmstuttgart,dc=de" read

by dn="uid=kuhn,ou=userlist,dc=hdmstuttgart,dc=de" read

by self read

by \* none

access to attrs=userPassword,shadowLastChange,passwordClear

by dn="uid=Administrator,ou=people,ou=M,ou=domainlist,dc=hdmstuttgart,dc=de" read

by anonymous auth

by \* none

# Implementations

---

- JNDI
- Ldapive

# Exercises

---

1. Work through the exercises the section called “Browse an existing LDAP Server” and the section called “Populating your DIT.” to the section called “Extending an existing entry”.

## Tip

When logging in as a non-admin user i.e. using a bind DN like `uid=petra,ou=MB,ou=M,dc=beta,dc=com` you will not be able to browse your tree. This action requires a permission setting to be changed in `olcDatabase={1}mdb,cn=config` of your server's configuration tree. Follow these steps:

- a. Log in to your server's configuration using `cn=admin,cn=config` as in Figure 19.9, “Administrator access to your server's configuration”.
- b. Select your database backend node below `cn=config`.
- c. Replace:

```
to * by dn:exact=gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth manage by * break
```

By:

```
to * by dn:exact=gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth manage by * read
```

2. Find your LDAP servers database back end. Install the `lmbd-utils` package and dump your back end's data.
3. Create an application reading `ldap.hdmstuttgart.de`'s data and writing corresponding student entries back to your local LDAP server.

# Why MongoDB?

---

- Document oriented (hierarchy support).
- Horizontal scaling (Sharding)
- Large user community
- Major programming languages API support.
- Open Source

# Running a Docker container

---

```
docker run -d \  
  - name local MongoDB ❶\  
  - e MONGO_INITDB_ROOT_USERNAME=admin ❷\  
  - e MONGO_INITDB_ROOT_PASSWORD=secret ❷\  
  - e MONGO_INITDB_DATABASE=admin ❸\  
  - v ~/Data/Mongo: /data/db ❹\  
  - p 27017:27017 ❺\  
mongo: 4.4.1 ❻
```

# Using docker-compose

docker-compose.yml

version: '3.7'

services:

mongodb:

image: mongo:4.4.1  
 container\_name: mongodb  
 restart: always  
 environment:  
 MONGO\_INITDB\_ROOT\_USERNAME: admin  
 MONGO\_INITDB\_ROOT\_PASSWORD: secret

ports:  
 - 27017:27017

volumes:

- ./mongo-init.js:/docker-entrypoint-initdb.d/mongo-init.js:ro

mongo-init.js

```
db.createUser(  
  {  
    user: "explorer",  
    pwd: "secret",  
    roles: [  
      {  
        role: "readWrite",  
        db: "exploredb"  
      }  
    ],  
    passwordDigestor: "server"  
  }  
);
```

docker-compose up --build -d

## Manual user creation (mongo-init.js fail)

---

```
> mongo -u admin -p secret admin
```

```
...
db.createUser(
...   {
...     user: "explorer",
...     pwd: "secret",
...     roles: [
...       {
...         role: "readWrite",
...         db: "exploredb"
...       }
...     ],
...     passwordDigestor: "server"
...   }
... );
```

```
Successfully added user: { "user" : "explorer"...
```



# Log in as user explorer

---

```
> mongo -u explorer -p secret admin
```

```
...
```

```
> use exploredb
```

```
switched to db exploredb
```

```
> db.user.insert(
```

```
...   { cname: "Eve Gardener",
```

```
...     uid: "gardener",
```

```
...     email: "gardener@betrayer.com"
```

```
...   }
```

```
... )
```

```
WriteResult({ "nInserted" : 1 })
```

```
>
```

```
> db.user.find()
```

```
{ "_id" : ObjectId("5fa1c79d661a55242658f135"),
```

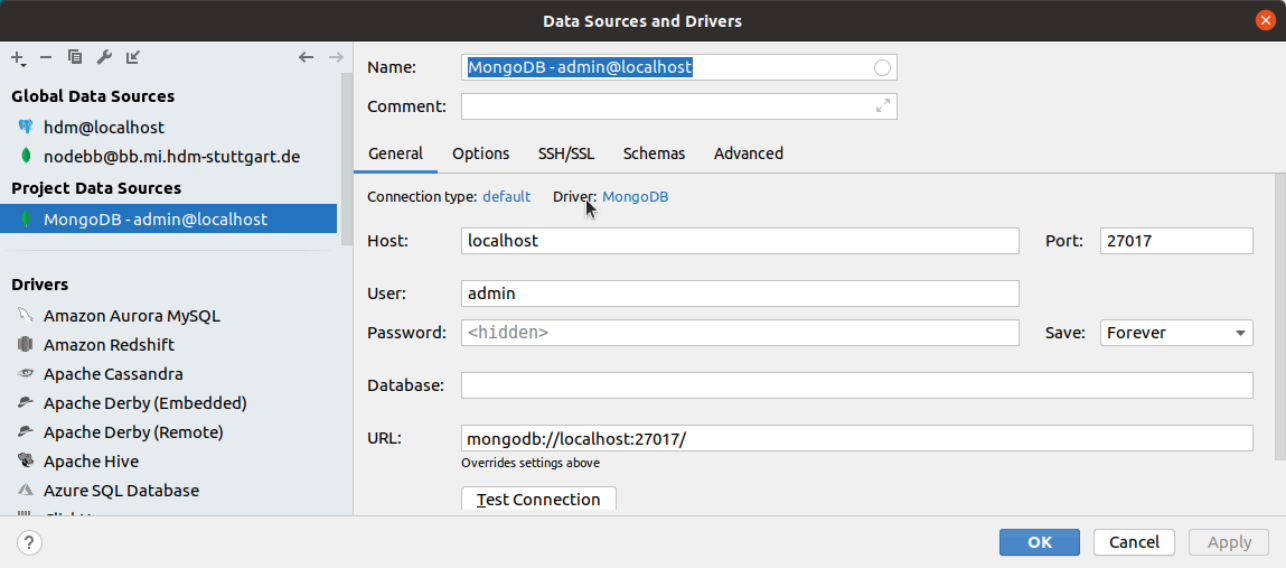
```
  "cname" : "Eve Gardener", "uid" : "gardener", "email" : "gardener@betrayer.com" }
```

# Using IntelliJ

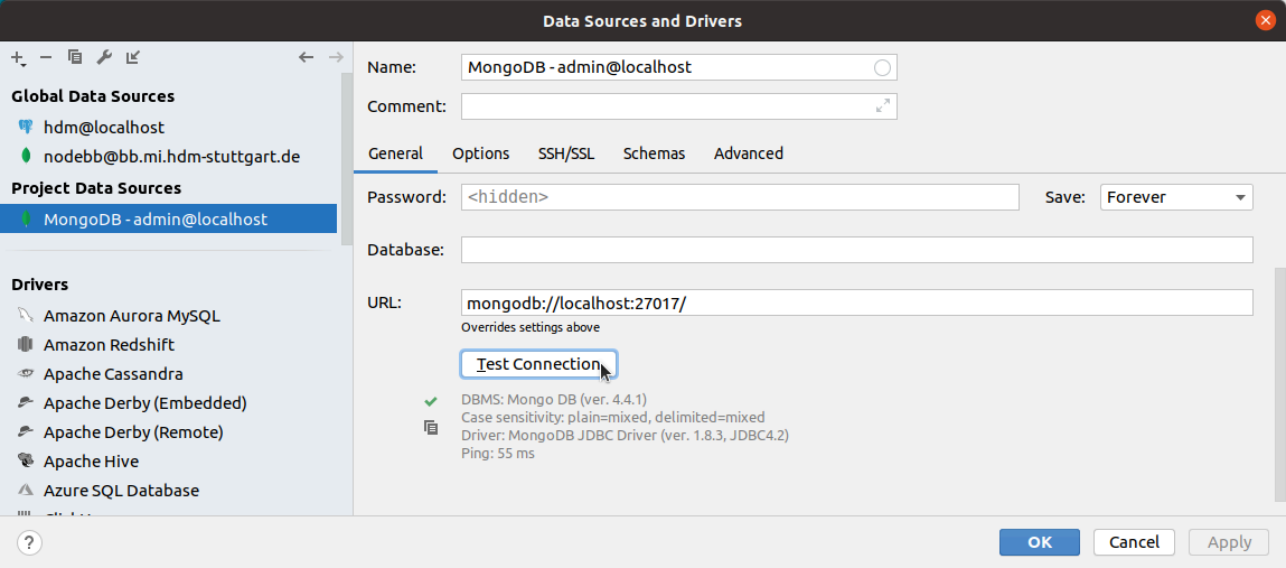
---

- View --> Tool Windows --> Database
- Data Source --> MongoDB

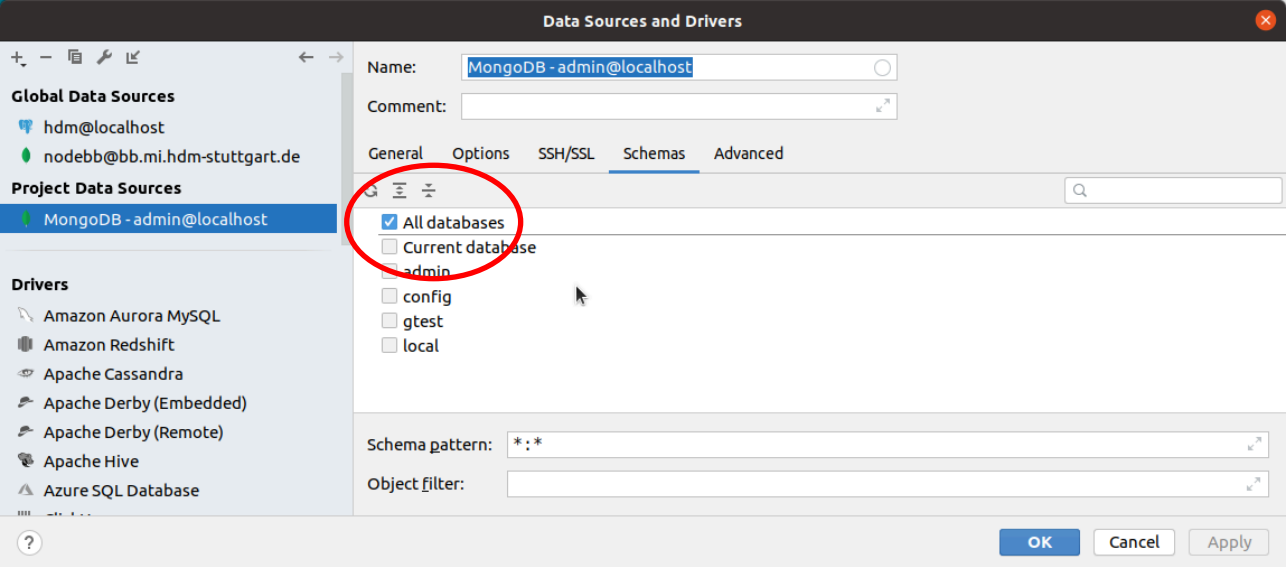
# Idea show all databases



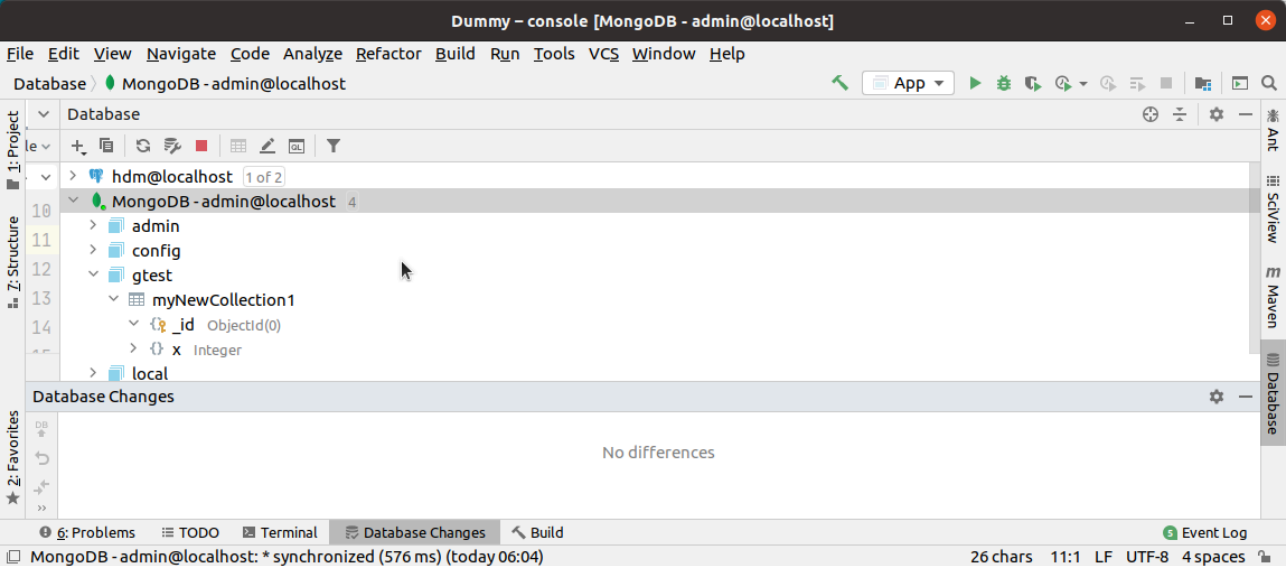
# Idea show all databases



# Idea show all databases



# Idea show all databases



# Terminology / Hierarchy

- MongoDB Server

- **Database**

- **Collection** : Similar to tables in SQL.

- **Document**: Similar to records in SQL.

```
> mongo -u explorer -p secret admin
```

```
> use exploredb
```

```
> db.user.insert(  
  { cname: "Eve Gardener",  
    uid: "gardener",  
    email: "gardener@betray.com"  
  }  
)
```

## Adding a document

Code	Result
<pre>db. group. insert (   {     cname: "All users",     gid: "users",   } )</pre>	<pre>db. group. find()  [   {     "_id": { "Soi d": "5fa3035932b87a0c60a6ed1a" },     "cname": "New users",     "gid": "users"   } ]</pre>



# Updating attributes

Code	Result
<pre>db. group. update(   {_id: ObjectId(     "5f a3035932b87a0c60a6ed1a")},   { \$set:     {       cname: "New users" ❶,       groupIdNumber: 1000 ❷     }   } )</pre>	<pre>db. group. find()  [   {     "_id": { "Soi d":       "5f a3035932b87a0c60a6ed1a"},     "cname": "New users" ❶,     "gid": "users",     "gidNumber": 1000 ❷   } ]</pre>

## Deleting a document

Code	Result
<pre>db.group.deleteOne( {"_id": ObjectId(   "5fa3035932b87a0c60a6ed1a")} );</pre>	<pre>[   {     "acknowledged": true,     "deletedCount": 1   } ]</pre>

## Deleting multiple documents

Code	Result
<pre>db.group.deleteMany({});</pre>	<pre>[   {     "acknowledged": true,     "deletedCount": 23   } ]</pre>

# Multi valued attributes

---

# Set semantics of multivalued attributes

---

# Deleting selected attribute values

---

## Deleting an attribute

Code	Result
<pre>db. group. update(   {_id: ObjectId(     "5f a3035932b87a0c60a6ed1a") },   { \$unset:     {       groupIdNumber: 42     }   } )</pre>	<pre>db. group. find()  [   {     "_id": { "Soi d":       "5f a3035932b87a0c60a6ed1a"},     "cname": "My users",     "gi d": "users"   } ]</pre>

# Query filter

---



# Schema validation support

```
db.runCommand( {
  collMod: "group",
  validator: { $jsonSchema: {
    bsonType: "object",
    required: [ "cname", "gid" ],
    properties: {
      cname: {
        bsonType: "string",
        description:
          "A group's common name"
      },
```

```
      gid: {
        bsonType: "string",
        description:
          "A group's short name"
      }
    }
  },
  validationLevel: "moderate"
})
```

## Violating required field

```
db.group.insert(  
  {  
    cname: "Extra users"  
  }  
)
```

```
... Bulk write operation error on server localhost:27017.  
Write errors: [BulkWriteError{index=0, code=121,  
  message='Document failed validation', details={}}].
```

# Schema types

---

See BSON Types for reference.

# Enforcing unique keys

```
db.group.createIndex({
  "cname": 1
},
{
  unique: true
})
```

```
db.group.insert({cname: "Extra users",
  ...
})
```

```
com.mongodb.MongoBulkWriteException:
Bulk write operation error on server localhost:27017.
Write errors: [BulkWriteError{index=0, code=11000,
message='E11000 duplicate key error collection:
exploredb.group index: cname_1 dup key:
{ cname: "Extra users" }', details={}}].
```

## On the downside

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- No way to enforce referential integrity rules.

# Implementations

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# Implementations

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# Sharding rationale

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- Problem: Large datasets / high throughput
- Two alternatives:
  - Vertical scaling: RAM, cpu,...
  - Horizontal scaling: Load distribution by multiple nodes.



# Sharding rationale

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See sharded-cluster for details.

# Exercises

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1.

2.