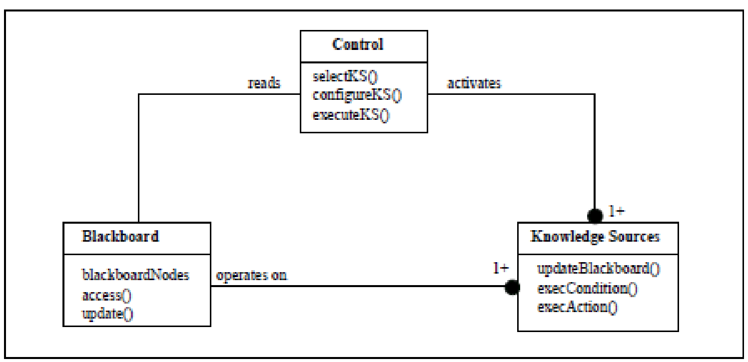
Topic 10: Model-View-Controller

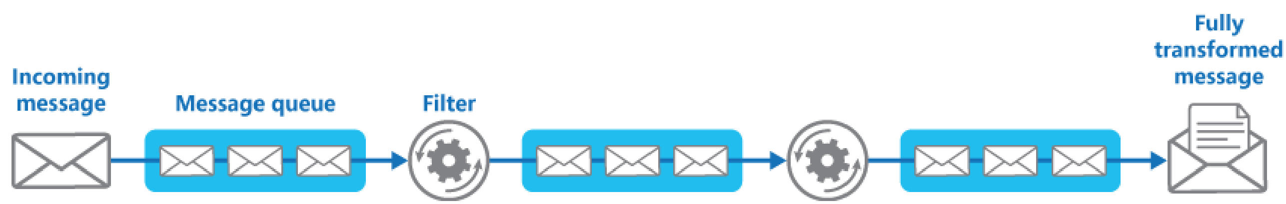
CITS3403 Agile Web Development

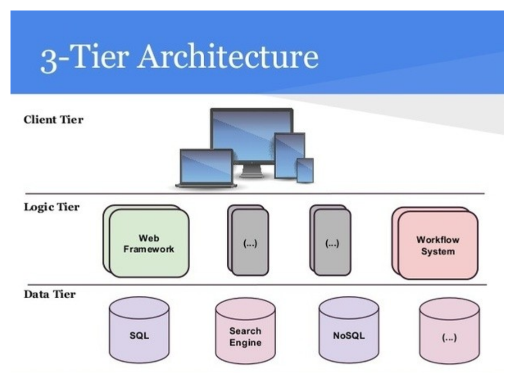
Semester 1, 2019

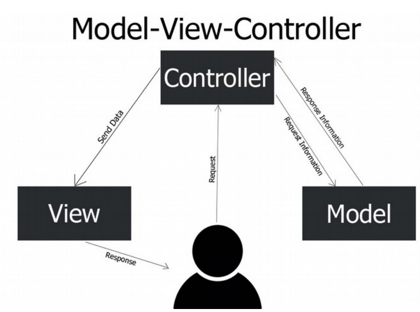
Architectural Patterns

- Design patterns describe re-useable design concepts, particularly in software. They describe how objects are organized to call each other.
- Examples are client-server architecture, pipe and filter, and blackboard architectures.
- Some specific patterns that apply to web applications are *Model View Controller*, *Boundary Control Entity*, *3-Tier Architecture* and *Model View View-Model*.



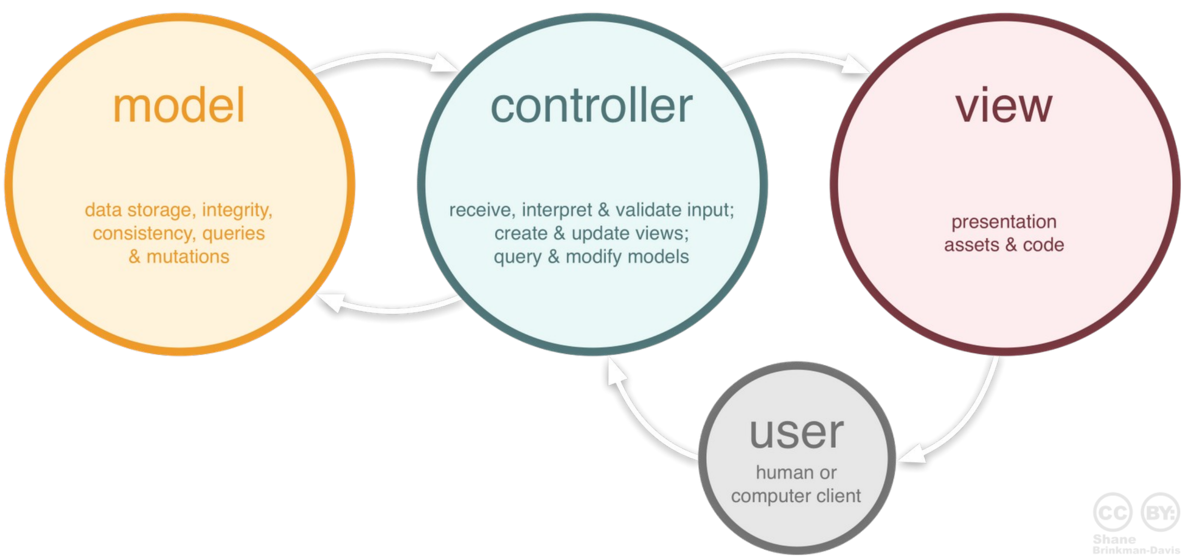






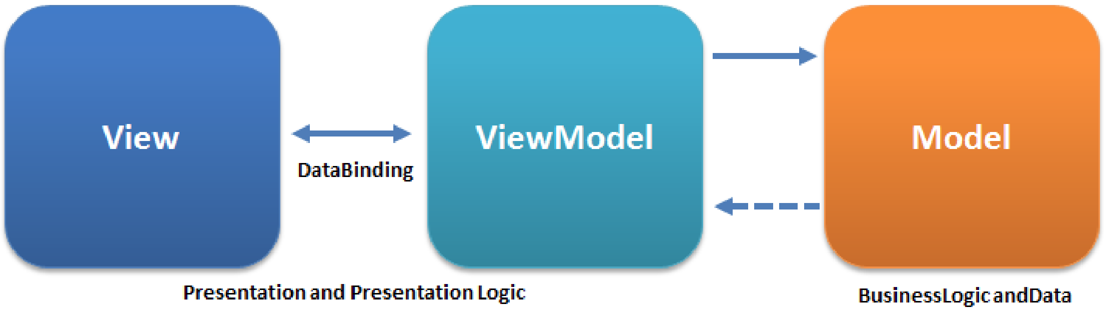
Model View Controller

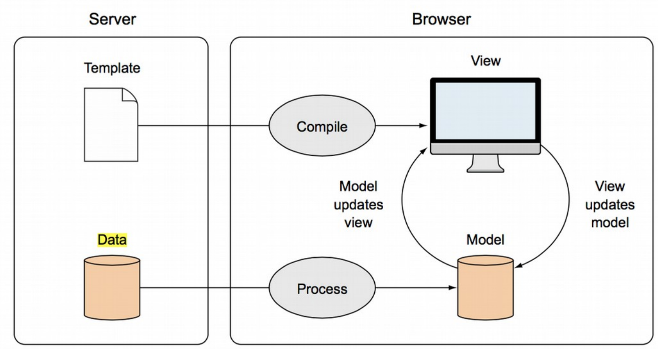
- The model view controller patter is one of the most popular for server side web applications.
- The *model* refers to an object referencing an entity in a database.
- The *view* is how that object is presented to the user.
- The *controller* is a linking class that builds the model from the database, prepares the view based on the model, and the updates and saves the models back to the database.



Model View ViewModel

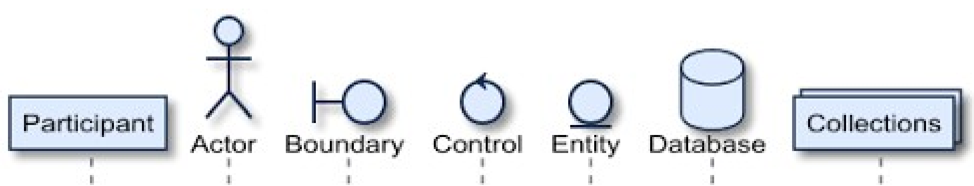
- Model View View-Model is a variation of model view controller that is tailor for client side applications and single page applications. Rather than having a controller compose the view a *binder* links the *view* to a *viewmodel*.
- The *view* presents thethe current state of the viewmodel
- The *viewmodel* exposes the data and available operations of the model, and updates the model as required.
- Two way data-binding links the *view* and *viewmodel* without need to link back to the server.

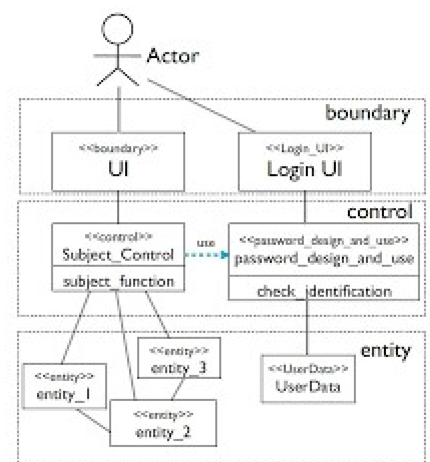




Boundary Control Entity

- Boundary Control Entity pattern is often used for enterprise systems, and doesn't have strong coupling between data and presentation.
- The *boundary* object(s) control the interface to the subsystem, and filter requests and responses to objects external to the subsystem.
- The *control* object processes the requests, update the entity objects and prepare the responses.
- The *entity* objects represent the data in the system, and link to persistent data sources, like databases.

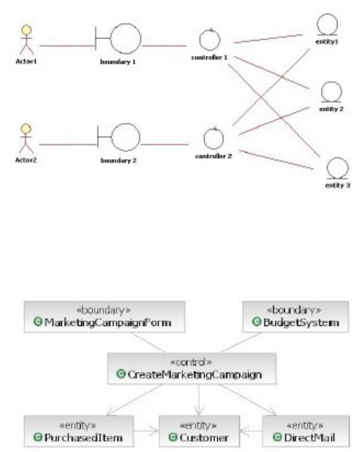
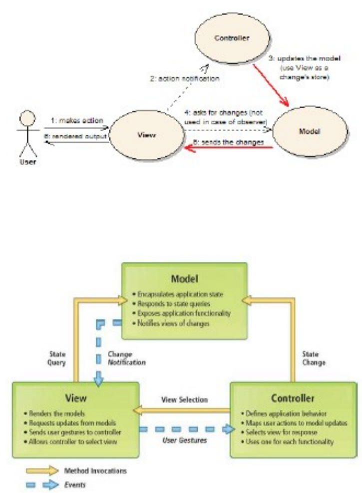
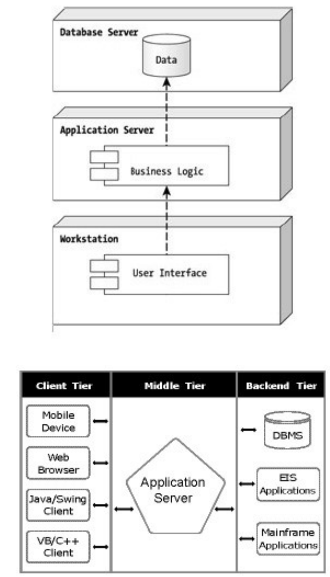




Three tier architecture

- Most of these architectures are 3-tier, in that they have middleware (e.g. flask) sitting between the client (web-browser) and the databases(s).
- 3-tier architecture have an application server to collate data from different data sources, for client applications to access.

BCE vs. MVC vs. 3-Tier

Pattern	BCE (Boundry / Control / Entity)	MVC (Model / View / Controller)	3-Tier
Sample Diagram			
Goal	Distribution of responsibilities to a set of interacting design elements	Implementing user interface Selectable View, Separated from Model and Controller	- Increase Scalability and Security - Support multiple protocols - Support different clients and Resources
Relation between elements	Linear	Triangular	Linear

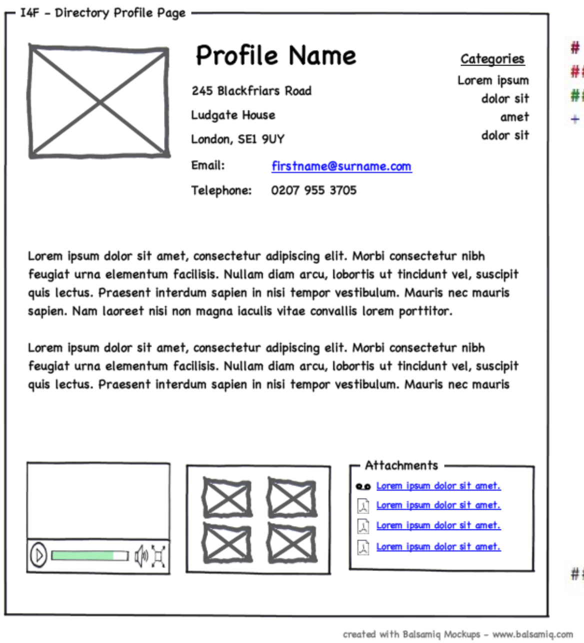
Designing an MVC structure

- We will focus on the MVC architecture as it is most suitable for web applications with server side rendering.
- To design an MVC solution architecture, you need to identify what models, views and controllers you require.
- Recall user stories are simple representations of software requirements.
- In every user story, we can identify *nouns* which could be models, *verbs* which could be routes, and associate a view for the specified user.
- We can then mock up wireframe sketches of view and mock http requests and responses.

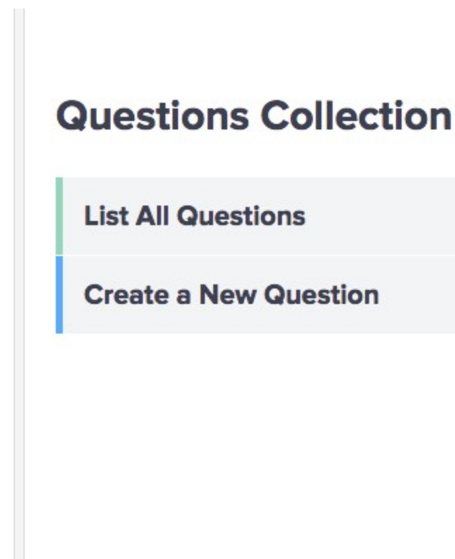
#	Backlog Item (User Story)	Story Point
1.	As a Teller, I want to be able to find clients by last name, so that I can find their profile faster	4
2.	As a System Admin, I want to be able to configure user settings so that I can control access.	2
3.	As a System Admin, I want to be able to add new users when required, so that...	2
4.	As a data entry clerk, I want the system to automatically check my spelling so that...	1

Mock Websites

- Wireframe drawing show the basic layout and functionality of a user interface.
- There are various tools for building these, or you can draw them by hand.
- A series of wire frame mocks can show the sequence of interfaces used in an application.
- You can also mock the typical http requests and responses your app will serve.
- These can be hard coded using tools like Apiary and Mocky (more on this later)

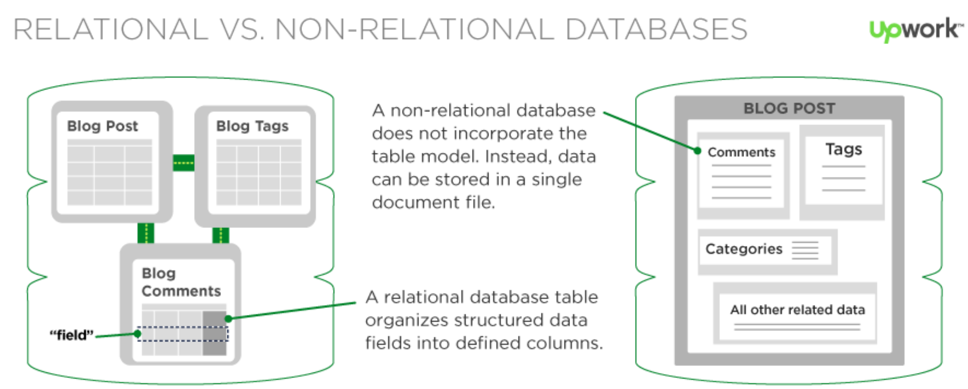



```
# Polls API
## Questions Collection [/questions]
### List All Questions [GET]
+ Response 200 (application/json)
        [
            {
                "question": "Favourite programming language?",
                "published_at": "2015-08-05T08:40:51.620Z",
                "choices": [
                    {
                        "choice": "Swift",
                        "votes": 2048
                    }, {
                        "choice": "Python",
                        "votes": 1024
                    }, {
                        "choice": "Objective-C",
                        "votes": 512
                    }
                ]
            }
        ]
### Create a New Question [POST]
```



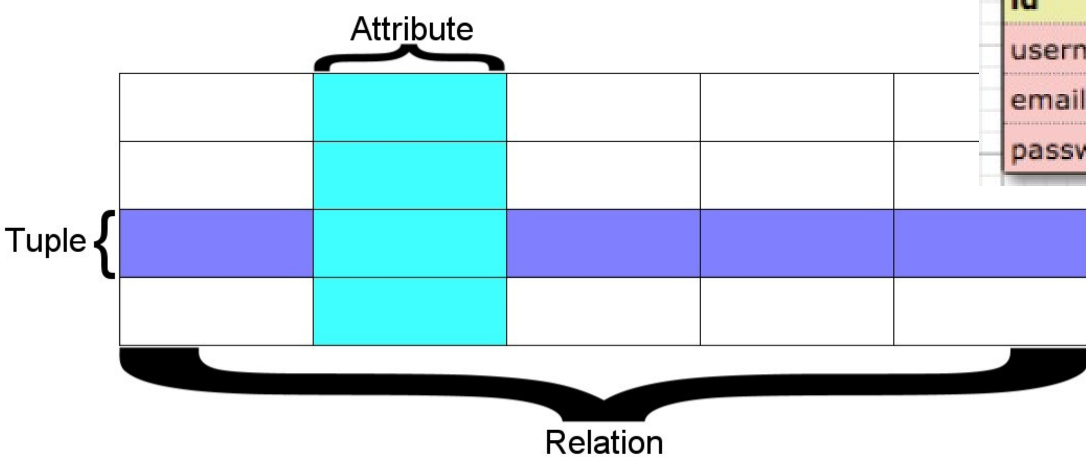
Implementing Models

- A *model* is an object that is paired with an entity in a database.
- There is an *Object Relational Mapping* (ORM) linking the data in the database to the models in the application.
- The models are only built as needed, and update the database as required. Most frameworks include ORM support.
- To build the models, we first need to set up the database.
- There are relational databases, document databases, graph databases,and others
- We will focus on relational databases and particularly SQLite, but we will discuss alternatives.



Relational Databases

- Relational databases store data as a set of relations, where each relation is represented as a table.
- Each row of the table is an *entity*, and each column of the table is an *attribute* of that entity.
- Every relation has an attribute that is unique for every entity in that relation, called the *primary key*.
- Some relations attributes that are primary keys in other relations. These are called *foreign keys*.



Setting up a database

- The DataBase Management System DBMS is an application that controls access to a database.
- A database is created, and then we set up schemas for the tables
- The schema of the database is the set of tables (relations) that are defined, the types of the attributes, and the constraints on the attributes. This is the *meta-data* of the database and is not expected to change in the normal usage of the application.
- SQLite commands start with a '.' and can display the metadata (.help to see all commands)

```
drtnf@drtnf-ThinkPad:$ sqlite3 app.db
SQLite version 3.22.0 2018-01-22 18:45:57
Enter ".help" for usage hints.
sqlite> .database
main: /Dropbox/ArePricks/Dropbox/Tim/teaching/2019/CITS3403/pair-up/app.db
sqlite> .table
alembic_version  labs             projects         students
sqlite> .schema projects
CREATE TABLE projects (
        project_id INTEGER NOT NULL,
        description VARCHAR(64),
        lab_id INTEGER,
        PRIMARY KEY (project_id),
        FOREIGN KEY(lab_id) REFERENCES labs (lab_id)
);
sqlite> .indexes
sqlite_autoindex_alembic_version_1  sqlite_autoindex_students_1
sqlite> .exit
drtnf@drtnf-ThinkPad:$
```

```
>sqlite3 c:\sqlite\sales.db
SQLite version 3.13.0 2016-05-18 10:57:30
Enter ".help" for usage hints.
sqlite>
```

```
CREATE TABLE contact_groups (
 contact_id integer,
 group_id integer,
 PRIMARY KEY (contact_id, group_id),
 FOREIGN KEY (contact_id) REFERENCES contacts (contact_id)
 ON DELETE CASCADE ON UPDATE NO ACTION,
 FOREIGN KEY (group_id) REFERENCES groups (group_id)
 ON DELETE CASCADE ON UPDATE NO ACTION
);
```

Relational Query Language

- The basic operations of any database system are ***Create***, ***Read***, ***Update*** and ***Delete*** (**CRUD**). The sequential query language (SQL) provides the syntax for performing these operations:
- Create is done using an *insert* statement
- Read is done using the *select* statement
- Update is done using an *update* statement
- Delete is done using a *delete* statement.

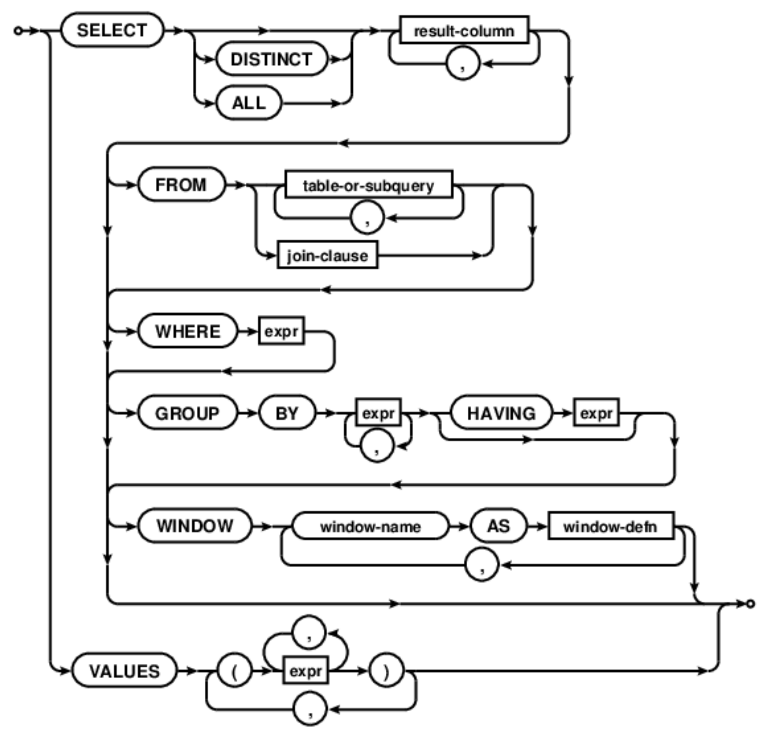
Operation	SQL	HTTP	RESTful WS	DDS
Create	INSERT	PUT / POST	POST	write
Read (Retrieve)	SELECT	GET	GET	read / take
Update (Modify)	UPDATE	PUT / POST / PATCH	PUT	write
Delete (Destroy)	DELETE	DELETE	DELETE	dispose

```
INSERT INTO table1 (
 column1,
 column2 ,..)
VALUES
 (
 value1,
 value2 ,...);
```

```
UPDATE table
SET column_1 = new_value_1,
    column_2 = new_value_2
WHERE
    search_condition
ORDER column_or_expression
LIMIT row_count OFFSET offset;
```

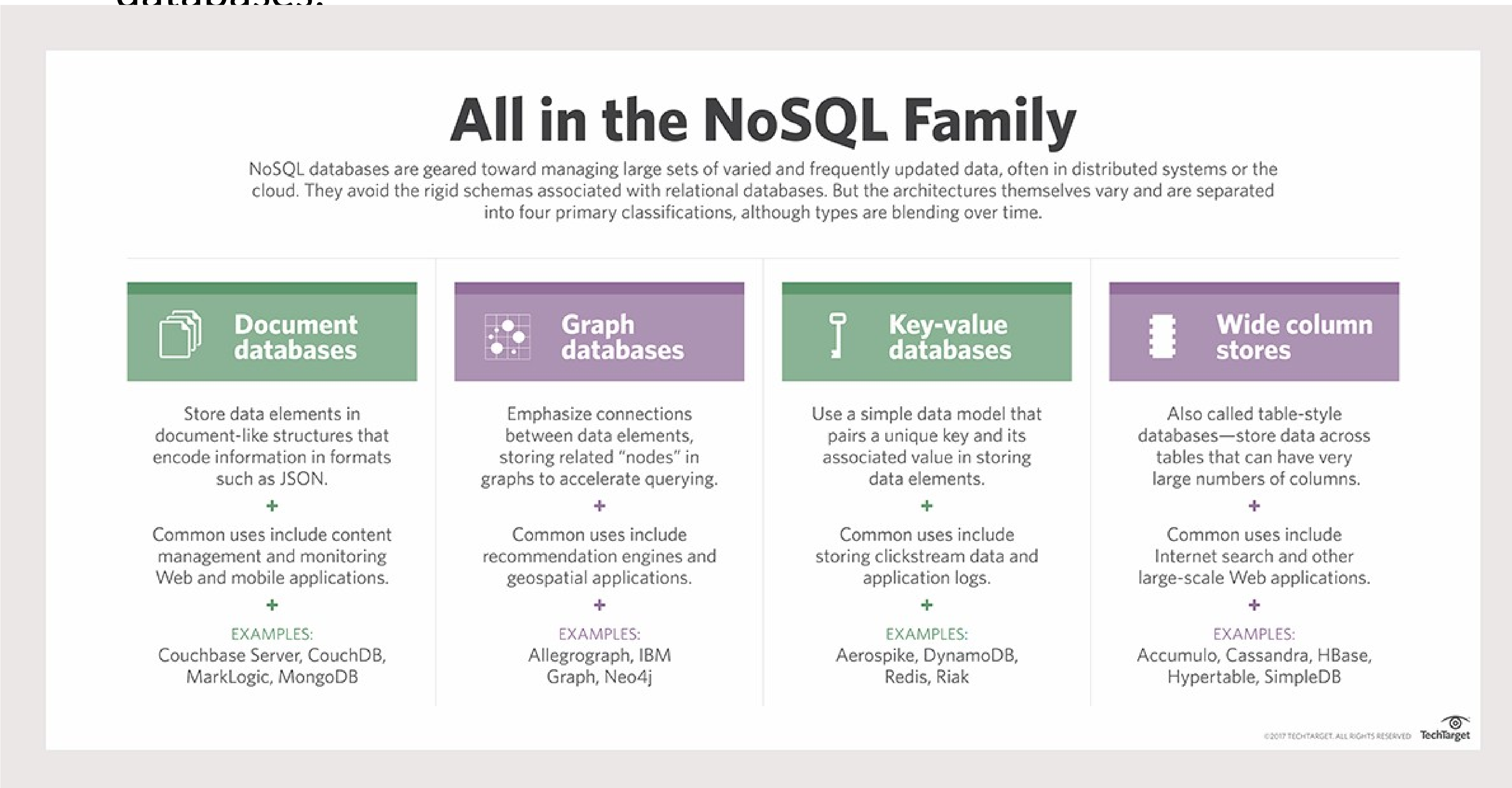
```
SELECT DISTINCT column_list
FROM table_list
  JOIN table ON join_condition
WHERE row_filter
ORDER BY column
LIMIT count OFFSET offset
GROUP BY column
HAVING group_filter;
```

```
DELETE
FROM
 table
WHERE
 search_condition;
```



NoSQL

- NOSQL standards for not only SQL, and describes non-relational databases.



Mongo DB

- MongoDB (from humongous) is a free and open-source cross-platform document-oriented database.
- Classified as a NoSQL database, MongoDB avoids the traditional table-based relational database structure in favor of JSON-like documents with dynamic schemas.
- As of July 2015, MongoDB is the fourth most popular type of database management system, and the most popular for document stores.

Document databases

Document databases don't have tables or schemas. Instead, they consist of *Collections* of *Documents.*
Each document in a collection may have different fields.
The fields of a document can be another document (a sub-document), but two documents cannot share a subdocument. i.e it is a tree. In Mongo, each document is represented as a JSON object.

- Database - Database is a physical container for collections. Each database gets its own set of files on the file system.
- Collection - Collection is a group of MongoDB documents. It is the equivalent of an RDBMS table. A collection exists within a single database. Collections do not enforce a schema.
- Document - A document is a set of key-value pairs. Documents have dynamic schema. Dynamic schema means that documents in the same collection do not need to have the same set of fields or structure.

Mongo vs RDBMS

Database	Database
Table	Collection
Tuple/Row	Document
column	Field
Table Join	Embedded Documents
Primary Key	Primary Key (Default key _id provided by mongodb itself)
Database Server and Client	
Mysqld/Oracle	mongod

Sample document

- Below is a sample document. Every document has an id.
- The document is a javascript object.
- Any relational database has a number of tables and their relationships.
- In MongoDB there is no concept of relationship

```
{
   _id: ObjectId(7df78ad8902c)
   title: 'MongoDB Overview',
   description: 'MongoDB is no sql database',
   by: 'tutorials point',
   url: 'http://www.tutorialspoint.com',
   tags: ['mongodb', 'database', 'NoSQL'],
   likes: 100,
   comments: [
      {
         user:'user1',
         message: 'My first comment',
         dateCreated: new Date(2011,1,20,2,15),
         like: 0
      },
      {
         user:'user2',
         message: 'My second comments',
         dateCreated: new Date(2011,1,25,7,45),
         like: 5
      }
   ]
}
```

Querying data

- Use db.<cName>.find() to return all documents in a collection.
- Use db.<cName>.find().pretty() for nice formatting.
  - To find particular documents, you can test fields.
  - A list of constraints will return their intersection (AND)

Operation	Syntax	Example	RDBMS Equivalent
Equality	{<key>:<value>}	db.mycol.find({"by":"tutorials point"}).pretty()	where by = 'tutorials point'
Less Than	{<key>:{$lt:<value>}}	db.mycol.find({"likes":{$lt:50}}).pretty()	where likes < 50
Less Than Equals	{<key>:{$lte:<value>}}	db.mycol.find({"likes":{$lte:50}}).pretty()	where likes <= 50
Greater Than	{<key>:{$gt:<value>}}	db.mycol.find({"likes":{$gt:50}}).pretty()	where likes > 50
Greater Than Equals	{<key>:{$gte:<value>}}	db.mycol.find({"likes":{$gte:50}}).pretty()	where likes >= 50
Not Equals	{<key>:{$ne:<value>}}	db.mycol.find({"likes":{$ne:50}}).pretty()	where likes != 50

OR in mongo

- TO find the union of two constraints use $or:

```
>db.mycol.find(
   {
      $or: [
         {key1: value1}, {key2:value2}
      ]
   }
).pretty()
```

- AND and OR can be nested.

```
>db.mycol.find({"likes": {$gt:10}, $or: [{"by": "tutorials point"},
   {"title": "MongoDB Overview"}]}).pretty()
{
   "_id": ObjectId(7df78ad8902c),
   "title": "MongoDB Overview",
   "description": "MongoDB is no sql database",
   "by": "tutorials point",
   "url": "http://www.tutorialspoint.com",
   "tags": ["mongodb", "database", "NoSQL"],
   "likes": "100"
}
>
```

“Advantages” of Mongo

- Mongo is schema-less: different documents in a collection can have different fields.
- Documents are objects: saves conversion logic.
- No complex joins. No joins at all.
- Deep query ability: doument based query language.
- Tunable and scalable.

… but

- data should be tree like.
- joins need to be done outside the database.

Linking Models into an App

- Now we have a database setup, we would like to link it into our application. We will use SQL-Alchemy for ORM with SQLite. Alternatively, we could use pymongo with Mongo or py2neo with Neo4J.
- We need to install `flask-sqlalchemy` and `flask-migrate`
- We will keep the database in a file called `app.db`, in the root of our app, and include this in `config.py`
- Next we update `__init__.py` to create an SQLAlchemy object called `db`, create a `migrate` object, and import a module called `models` (which we will write)
- The `models` classes define the database schema.

config.py: Flask-SQLAlchemy configuration

```
import os
basedir = os.path.abspath(os.path.dirname(__file__))

class Config(object):
    # ...
    SQLALCHEMY_DATABASE_URI = os.environ.get('DATABASE_URL') or \
        'sqlite:///' + os.path.join(basedir, 'app.db')
    SQLALCHEMY_TRACK_MODIFICATIONS = False
```

app/__init__.py: Flask-SQLAlchemy and Flask-Migrate initialization

```
from flask import Flask
from config import Config
from flask_sqlalchemy import SQLAlchemy
from flask_migrate import Migrate

app = Flask(__name__)
app.config.from_object(Config)
db = SQLAlchemy(app)
migrate = Migrate(app, db)

from app import routes, models
```

SQLAlchemy Models

- To build a model we import db (the instance of SQLAlchemy) and our models are then all defined to be subclasses of `db.Model`
- To see what these modules are doing, you can find the source code in the virtual environment directory.
- `db.Column` is a class used to specify the type and constraints of each column in the table.
- `db.relationship` is a function that defines attributes based on a database relationship.

```
        self.use_native_unicode = use_native_unicode
        self.Query = query_class
        self.session = self.create_scoped_session(session_options)
        self.Model = self.make_declarative_base(model_class, metadata)
        self._engine_lock = Lock()
        self.app = app
        _include_sqlalchemy(self, query_class)

        if app is not None:
            self.init_app(app)

    @property
    def metadata(self):
```

irtual-environment/lib64/python3.6/site-packages/flask_sqlalchemy/__init__.py

`Integer`	an integer
`String(size)`	a string with a maximum length (optional in some databases, e.g. PostgreSQL)
`Text`	some longer unicode text
`DateTime`	date and time expressed as Python **`datetime`** object.
`Float`	stores floating point values
`Boolean`	stores a boolean value
`PickleType`	stores a pickled Python object
`LargeBinary`	stores large arbitrary binary data

```
class Person(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(50), nullable=False)
    addresses = db.relationship('Address', backref='person', lazy=True)

class Address(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    email = db.Column(db.String(120), nullable=False)
    person_id = db.Column(db.Integer, db.ForeignKey('person.id'),
        nullable=False)
```

Database Initialisation

- This allows us to define the database schema, but we still need to link it to the database. Flask provides some utilities to do this.
- `flask db init` will initialise a database to synchronize with the models you have defined.
- `flask db migrate` will use *alembic* to create a migration script that applies changes to the datatbase.
- `flask db upgrade` applies that script to the database (and `downgrade` to roll the changes back.)
- This allows us to keep the database schema and the models in sync.

app/models.py: Posts database table and relationship

```
from datetime import datetime
from app import db

class User(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    username = db.Column(db.String(64), index=True, unique=True)
    email = db.Column(db.String(120), index=True, unique=True)
    password_hash = db.Column(db.String(128))
    posts = db.relationship('Post', backref='author', lazy='dynamic')

    def __repr__(self):
        return '<User {}>'.format(self.username)

class Post(db.Model):
    id = db.Column(db.Integer, primary_key=True)
    body = db.Column(db.String(140))
    timestamp = db.Column(db.DateTime, index=True, default=datetime.utcnow)
    user_id = db.Column(db.Integer, db.ForeignKey('user.id'))

    def __repr__(self):
        return '<Post {}>'.format(self.body)
```

```
(venv) $ flask db init
  Creating directory /home/miguel/microblog/migrations ... done
  Creating directory /home/miguel/microblog/migrations/versions ... done
  Generating /home/miguel/microblog/migrations/alembic.ini ... done
  Generating /home/miguel/microblog/migrations/env.py ... done
  Generating /home/miguel/microblog/migrations/README ... done
  Generating /home/miguel/microblog/migrations/script.py.mako ... done
  Please edit configuration/connection/logging settings in
  '/home/miguel/microblog/migrations/alembic.ini' before proceeding.
```

```
(venv) $ flask db migrate -m "users table"
INFO  [alembic.runtime.migration] Context impl SQLiteImpl.
INFO  [alembic.runtime.migration] Will assume non-transactional DDL.
INFO  [alembic.autogenerate.compare] Detected added table 'user'
INFO  [alembic.autogenerate.compare] Detected added index 'ix_user_email' on '['email']'
INFO  [alembic.autogenerate.compare] Detected added index 'ix_user_username' on '['username']'
  Generating /home/miguel/microblog/migrations/versions/e517276bb1c2_users_table.py ... done
```

```
(venv) $ flask db upgrade
INFO  [alembic.runtime.migration] Context impl SQLiteImpl.
INFO  [alembic.runtime.migration] Will assume non-transactional DDL.
INFO  [alembic.runtime.migration] Running upgrade  -> e517276bb1c2, users table
```

Alchemy Syntax

- We are now able to access the models from within the flask shell.
- `flask shell` will start the shell, and then we can import the models.
- We can create instances of the models and add them to the db object, using `db.session.add()`
- The `db.session` object will synchronize with the database when we `commit` or `flush`
- We can extract entities from the database using a query.
- `<model>.query.all()` or `session.query(<model>).all()` will return all entities of type model.

```
>>> u = User(username='susan', email='susan@example.com')
>>> db.session.add(u)
>>> db.session.commit()
```

```
>>> users = User.query.all()
>>> users
[<User john>, <User susan>]
>>> for u in users:
...     print(u.id, u.username)
...
1 john
2 susan
```

```
>>> u = User.query.get(1)
>>> p = Post(body='my first post!', author=u)
>>> db.session.add(p)
>>> db.session.commit()
```

```
>>> users = User.query.all()
>>> for u in users:
...     db.session.delete(u)
...
>>> posts = Post.query.all()
>>> for p in posts:
...     db.session.delete(p)
...
>>> db.session.commit()
```

SQL-Alchemy Queries

- The `query` object is used to wrap an SQL select statement.
- `query.get()` will extract a single element by id, and `query.all()` will return the full collection.
- We can also perform inner joins (`query.join()`), left-outer-joins (`query.outerjoin()`), and filter (`filter_by()`)and sort (`order_by()`) the results in the query syntax.

```
query = (model.Session.query(model.Entry)
         .join(model.ClassificationItem)
         .join(model.EnumerationValue)
         .filter_by(id=c.row.id)
         .order_by(model.Entry.amount) # This row :)
         )
```

```
def get_available_labs():
  labs = Lab.query.\
      outerjoin(Project, Lab.lab_id==Project.lab_id).\
      add_columns(Project.project_id,Lab.lab_id, Lab.lab, Lab.time).\
      filter(Project.project_id==None).all()
  return labs
```

```
(virtual-environment) drtnf@drtnf-ThinkPad:$ flask shell
Python 3.6.7 (default, Oct 22 2018, 11:32:17)
[GCC 8.2.0] on linux
App: app [production]
Instance: /Dropbox/ArePricks/Dropbox/Tim/teaching/2019/CITS3403/pair-up/instance
>>> Lab.get_available_labs()[0:10]
[([LID:2, Lab:CSSE 2.01 Monday, May 20, time:1605], None, 2, 'CSSE 2.01 Monday, May 20', 1605), ([LID:3, Lab:CSSE 2.01 Monday, May
SE 2.01 Monday, May 20, time:1615], None, 4, 'CSSE 2.01 Monday, May 20', 1615), ([LID:5, Lab:CSSE 2.01 Monday, May 20, time:1620],
May 20, time:1625], None, 6, 'CSSE 2.01 Monday, May 20', 1625), ([LID:7, Lab:CSSE 2.01 Monday, May 20, time:1630], None, 7, 'CSSE 2
5], None, 8, 'CSSE 2.01 Monday, May 20', 1635), ([LID:9, Lab:CSSE 2.01 Monday, May 20, time:1640], None, 9, 'CSSE 2.01 Monday, May
CSSE 2.01 Monday, May 20', 1645), ([LID:11, Lab:CSSE 2.01 Monday, May 20, time:1650], None, 11, 'CSSE 2.01 Monday, May 20', 1650)]
>>>
```

Linking in with views and controllers

- We can now respond to requests for data, by building models from the database, and then populating views with the data.
- As the code is getting complex, it is a good idea to have a Controllers.py class, rather than handling everything in routes.py

```python
class Project(db.Model):
  __tablename__='projects'
  project_id = db.Column(db.Integer, primary_key = True)
  description = db.Column(db.String(64))
  lab_id = db.Column(db.Integer,db.ForeignKey('labs.lab_id'),nullable=True)

  def __repr__(self):
    return '[PID:{}, Desc:{},LabId:{}]'.format(\
        self.project_id,\
        self.description,\
        self.lab_id)

  def __str__(self):
    return 'Project {}: {}'.format(self.project_id,self.description)

  '''returns a list of students involved in the project'''
  def get_team(self):
    return Student.query.filter_by(project_id=self.project_id).all()

  def get_lab(self):
    lab = Lab.query.filter_by(project_id=self.project_id)\
        .add_columns(Lab.lab,Lab.time).first()
    return lab
```

```python
@app.route('/edit_project', methods=['GET','POST'])
@login_required
def edit_project():
  if not current_user.is_authenticated:
    return redirect(url_for('login'))
  project=Project.query.filter_by(project_id=current_user.project_id).first()
  if project==None:
    flash(current_user.prefered_name+' does not have a project yet')
    redirect(url_for('new_project'))
  team = project.get_team()
  if not team[0].id==current_user.id:
    partner = team[0]
  elif len(team)>1:
    partner = team[1]
  else:
    partner=None
  form=ProjectForm()#initialise with parameters
  form.lab.choices= get_labs(project.lab_id)
  if form.validate_on_submit():#for post requests
      lab=Lab.query.filter_by(lab_id=form.lab.data).first()
      if lab is None or not (lab.lab_id==project.lab_id or lab.is_available()):
        flash("Lab not available")
      else:
        project.description = form.project_description.data
        project.lab_id=lab.lab_id
        db.session.add(project)
        db.session.commit()
        return redirect(url_for("index"))
  return render_template('edit_project.html', student=current_user, partner=partner, project=project,
```

```html
{% extends "base.html" %}

{% block content %}
<h2>Edit Project</h2>

<div class="container">
  <h4>{{student.prefered_name}}
    {% if not partner == None %}
        and
        {{partner.prefered_name}}
    {% endif %}'s Project Page
  </h4>

  <form name='registerProject' action='' method='post' novalidate>
    <div class='form-group'>
      {{form.hidden_tag()}}
      <p>
      {{ form.project_description.label }}<br>
      {{ form.project_description(size=20, default=project.description) }}
      {% for error in form.project_description.errors %}
      <span style="color:red;">[{{ error}}]</span>
      {% endfor %}
      </p>
      <p>
      {{ form.lab.label }}<br>
      {{ form.lab}}
      </p>
      <p> {{ form.submit() }}</p>
    </div>
  </form>
  <h6>Cannot change partner's with in a project. To dissolve a team, delete
  {% endblock %}
```