COMP5347 Web Application Development

Connecting to MongoDB

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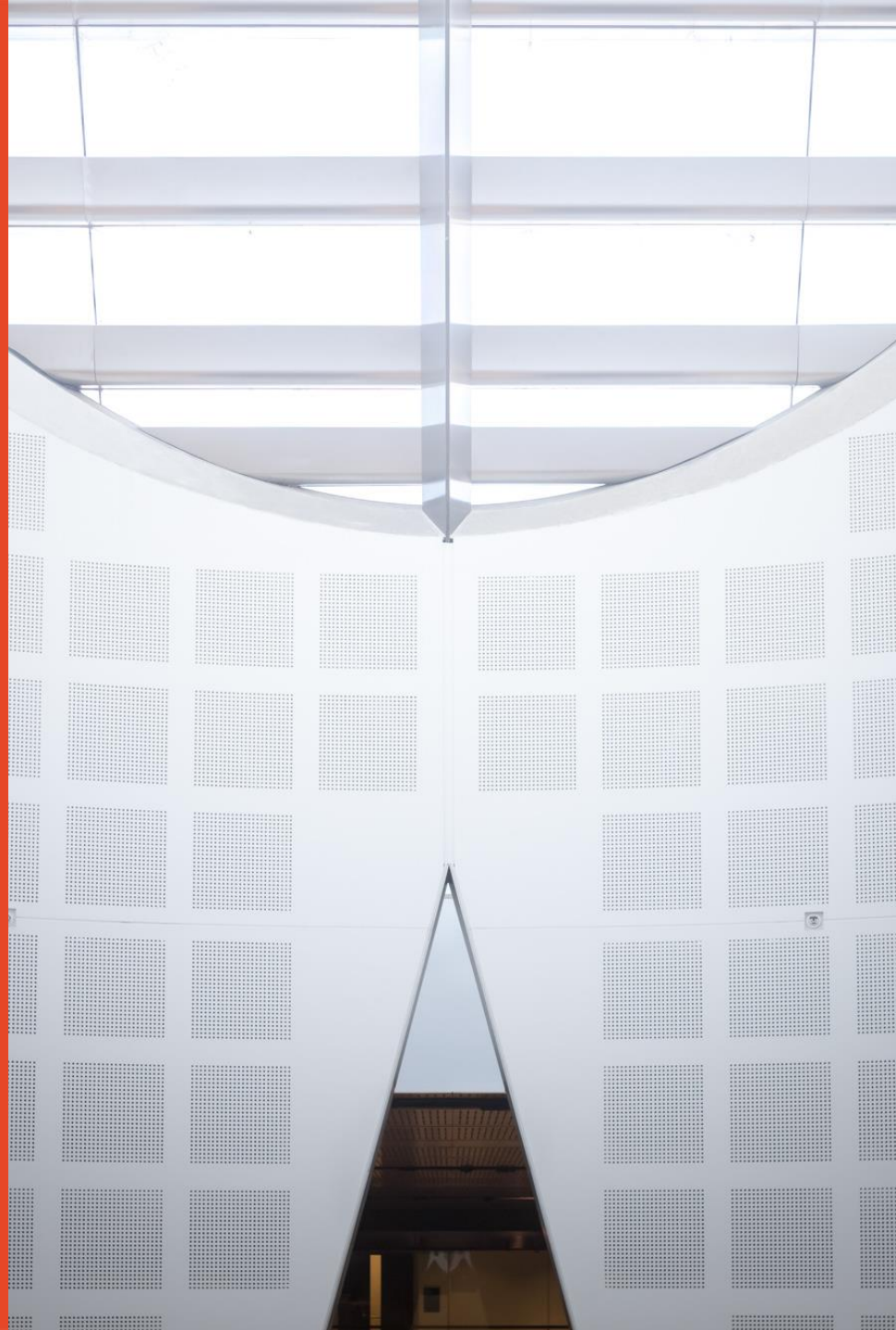

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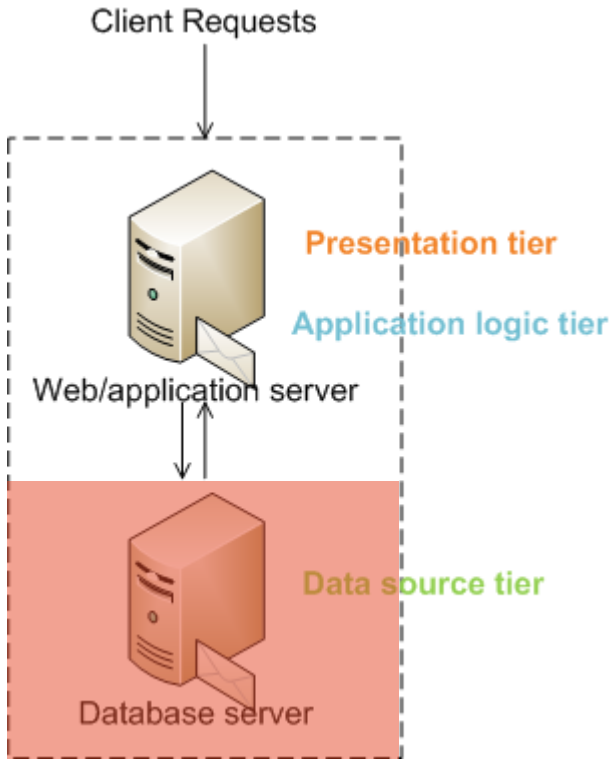
Outline

- MongoDB indexing
- Database
  - Data layer (MVC)
- Mongoose

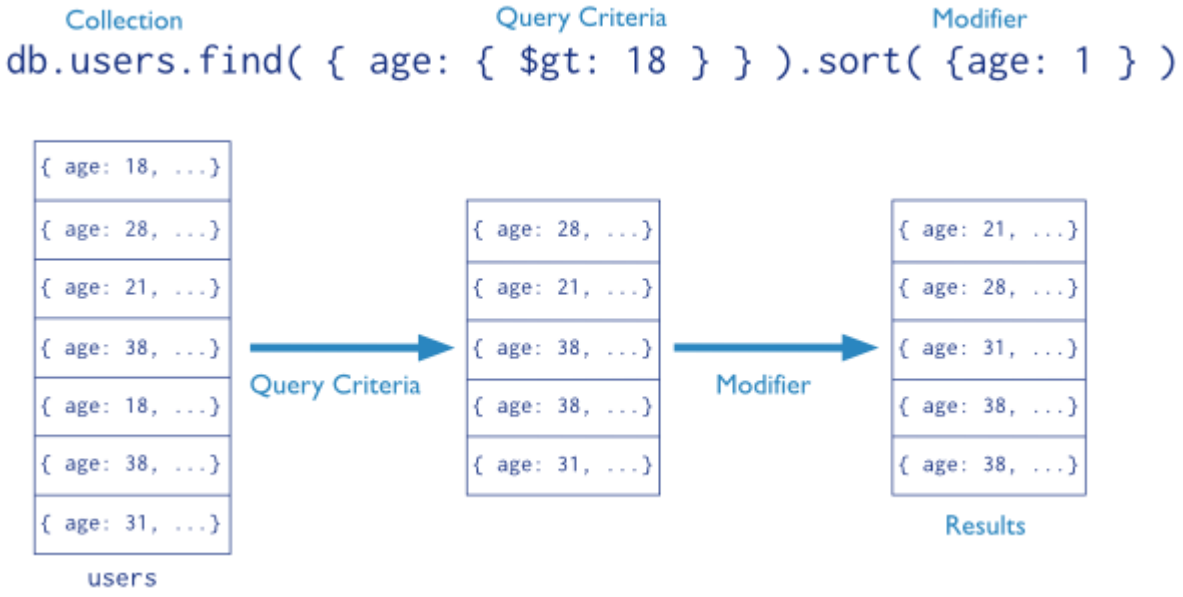
Databases Layer/Tier

- Database tier in Multi-tier (n-tier) Architecture
  - Maintain persistent data of the application
  - CRUD operations (Create, Read, Update, Delete)
- Request/query processing require network communication and server processing
- Many ways to improve performance
  - Hardware
  - Software/application
    - Database level



MongoDB Queries

Find documents in the **users** collection with **age** field greater than 18, sort the results in ascending order by **age**



- Creating an appropriate index can help to limit the number of documents it must read

Indexing

- An index is a data structure that makes it efficient to find certain rows/documents in a table/collection
- Indexes support efficient query execution
- Indexing can help to improve database performance if it is done properly
- Most DBMS providers provide facility for indexing

Indexing

- An index consists of records (called *index entries*) each of which has a value for the attribute(s)

- Index files are typically much smaller than the original file

- Most MongoDB indexes are organized as **`B-Tree`** structure

MongoDB Indexes

- The `_id` index
  - `_id` field is automatically indexed for all collections
  - The `_id` index enforces uniqueness for its keys
- The _id index cannot be dropped
- If you do not use the _id as a key, your application must maintain unique values in the _id field

https://docs.mongodb.com/manual/indexes/

MongoDB Indexes – Single Field Index

- Single-field index
  - An index that can be created on a single field of a document
  - Additional properties can be specified for an index:
    - Sparse: an index only contain entries that have the indexed field
    - Unique: MongoDB rejects duplicate values for the indexed field

- 单字段索引
- 可以在文档的单个字段上创建索引
- 可以为索引指定其他属性：
• 稀疏：仅包含具有已索引字段的条目的索引
• 唯一：MongoDB拒绝针对已建立唯一性约束条件的重复值

https://docs.mongodb.com/manual/indexes/

MongoDB – Creating Indexes

- Generic format for creating an index in MongoDB

```
db.<collectionName>.createIndex({<fieldName>:direction})
```

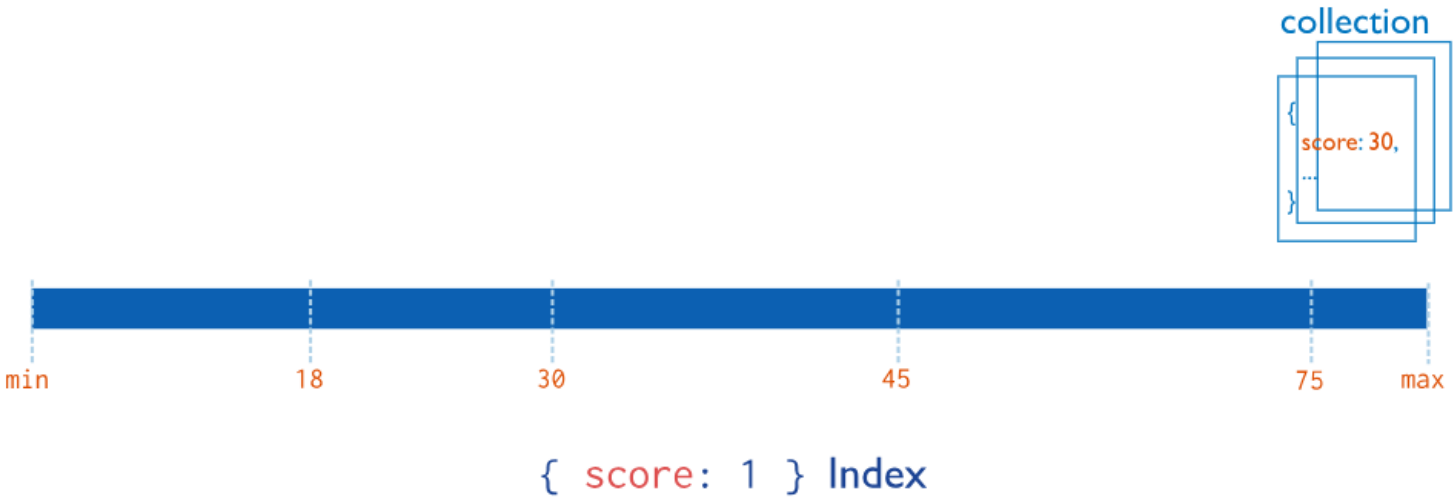
- **fieldName** can be a simple field, array field or field of an embedded document (using dot notation)
- **direction** specifies the direction of the index (1: ascending; -1: descending)

- Examples:
  - db.blog.createIndex({author:1})
  - db.blog.createIndex({tags:-1})
  - db.blog.createIndex({"comments.author":1})

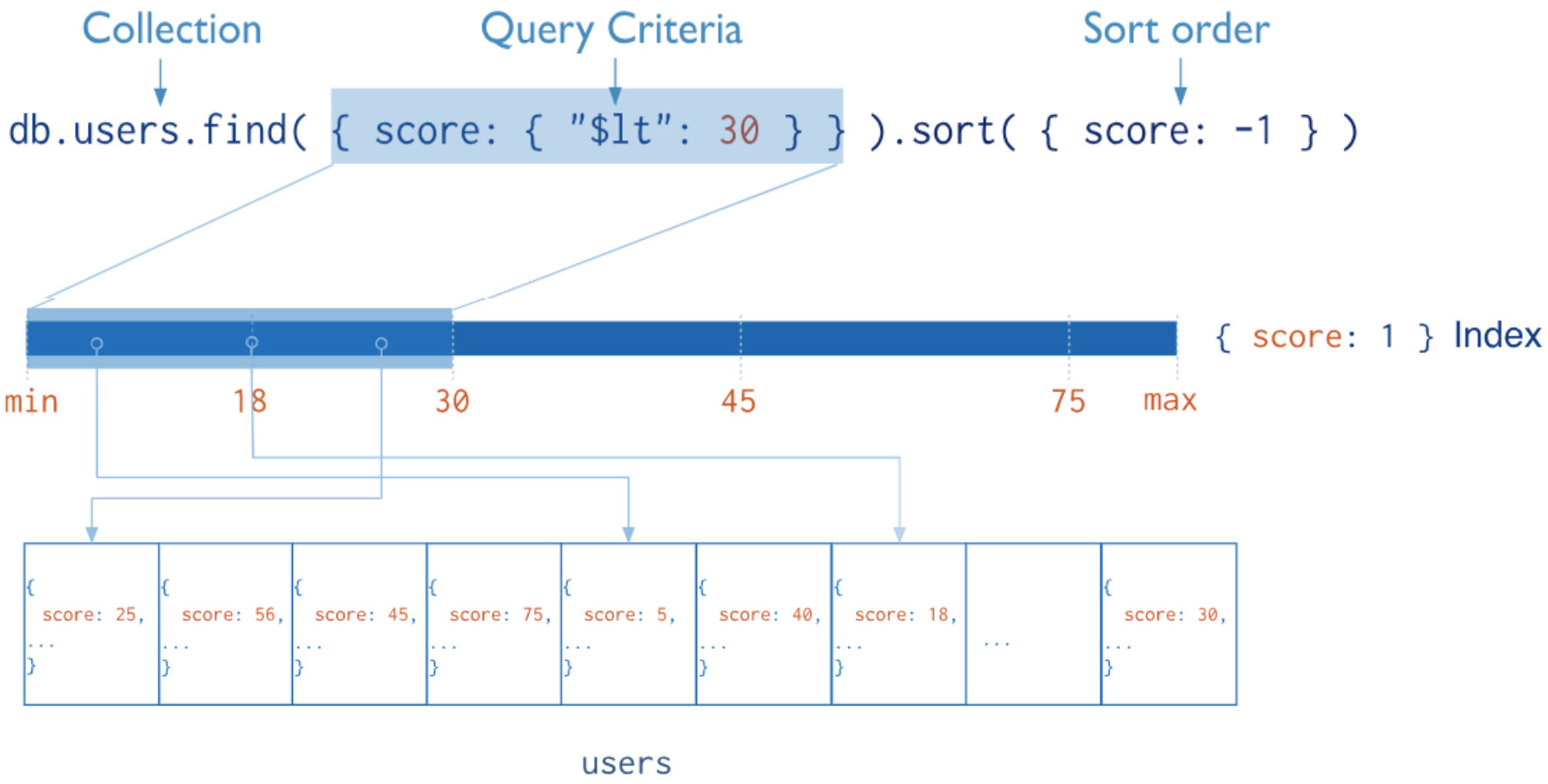
https://docs.mongodb.com/manual/indexes/

Single Field Index – Example

db.*users*.createIndex({score:1})



Single Field Index – Example



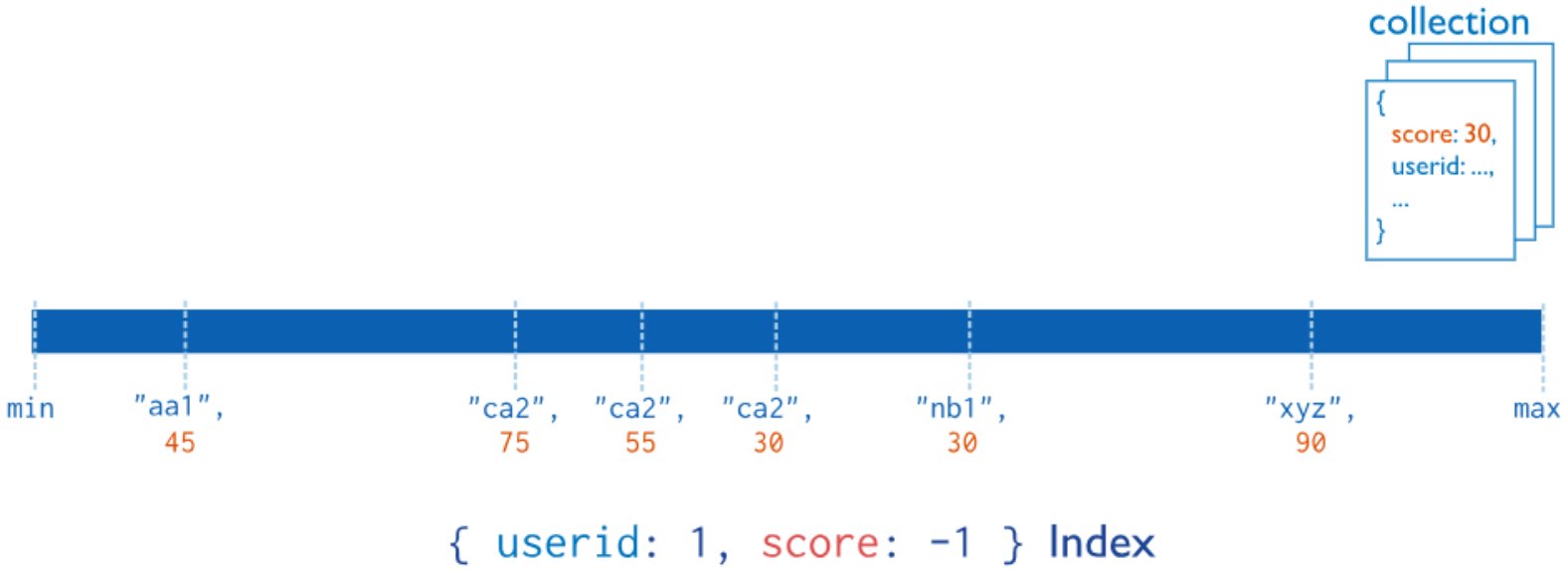
MongoDB – Compound Index

- Compound index is a single index structure that holds references to multiple fields within a collection

- The order of field in a compound index is very important
  - The indexes are sorted by the value of the first field, then second, third…
  - It supports queries like
    - db.users.find({userid: “ca2”, score: {$gt:30} })
    - db.users.find({userid: “ca2”})

Compound Index – Example

db.creatIndex({userid: 1, score: -1})



Designing Indexes

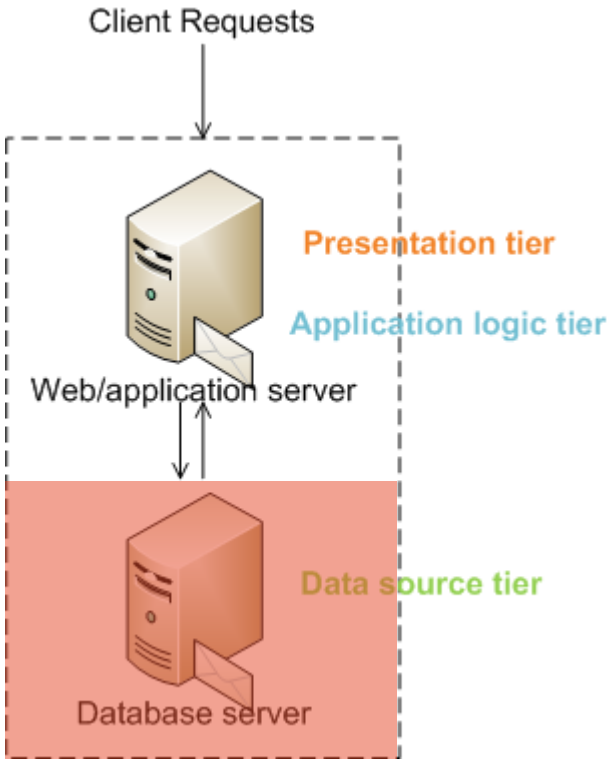
- Understand the application requirements and queries
- Identify types of queries that need to be issued to the database
  - Frequency of key queries
  - Read/write and performance implications
  - Available memory on your server
  - Compare and prioritize – trade-off analysis
- Performance profiling
  - Experiment with a variety of index configurations with data sets
  - Choose the best configuration
- Review indexes on regular basis

Outline

- MongoDB indexing
- Database
  - Data layer
- Mongoose

Web Applications – Database

- Database tier in Multi-tier (n-tier) application Architecture
  - Maintain persistent data of the application
  - CRUD operations (Create, Read, Update, Delete)
- Database Server / DBMS
  - RDBMS (MySQL, PostgreSQL)
  - NoSQL DBMS (MongoDB, Redis)
  - Choice of DBMS is crucial
- Express integrates with many DBMS
  - MySQL, PostgreSQL, MongoDB, Redis, many other*



https://expressjs.com/en/guide/database-integration.html

Database Drivers

- All database management systems work like a "server" application
  - Running on a host and waiting for connections from clients
    - Simple command line shell client
    - GUI shell client
    - Program-based client
  - There are different protocols db server used to communicate with their clients

- All database management systems provide language based drivers to allow developers to write client in various languages
  - Open/close connection to database
  - Translate between language specific construct (functions, methods) and DB queries
  - Translate between language specific data types and database defined data types

- MongoDB provides many native drivers:
  - https://docs.mongodb.com/ecosystem/drivers/

Higher level module/package

- The native DB drivers provide basic supports for client-side programming
  - Powerful, flexible
  - But usually not easy to use

- Higher level modules usually provide more convenient ways to communicate with DB servers
  - *Mongooes* is the node.js module built on top of basic mongodb node.js driver
    - Data structure to match collection "schema"
    - Validation mechanism
    - Connection management
    - Etc.

Object Data Model / Object Relational Model

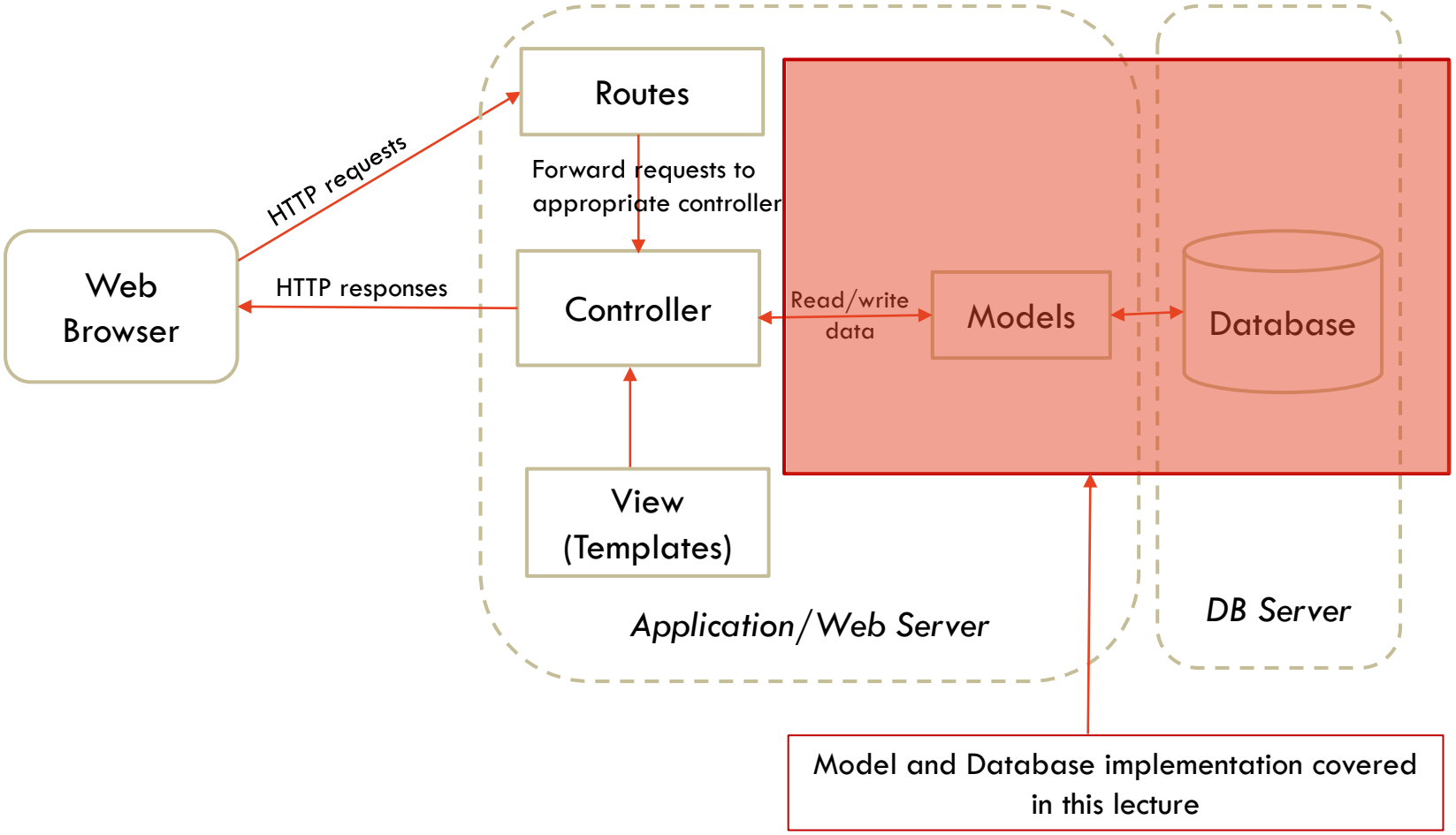
- Approaches to interact with a database
  - Database native query language (e.g., SQL)
  - Object Data Model (ODM) / Object Relational Model (ORM)

- Represents the web application data as objects, to be mapped to the DB
  - Productivity
  - Performance

- Node.js supports many ODM/ORM solutions*
  - Mongoose: a MongoDB object modeling tool for asynchronous environment
  - Others; Sequellize, Objection, Waterline
  - Consider features supported, and the community activity
  - Mongoose will be used to access data from MongoDB database

https://www.npmjs.com/search?q=keywords:odm

MVC Application Architecture



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  - Data layer
- Mongoose (MVC)

Mongoose

- All database operations should be implemented using event-driven programming style
  - Start an operation
  - Register a *callback* function to indicate what we want to do when the operation completes
  - Continue processing other parts of the program

Mongoose – Basic Concepts

- Schema
  - Schema is an *abstract* data structure defines the shape of the documents in a collection
  - Each name/value pair is a path
- Model
  - Model is a compiled version of schema, model is the schema binded with a collection
- Document
  - Document is an instance of Model, mapped to the actual document in a collection

Mongoose – Example

- A collection "**movies**" with the example document

```
{    "_id" : 1,
    "Title" : "Sense and Sensibility",
     "Year" : 1995,
     "Genres" : [ "Comedy", "Drama",
"Romance"]
}
```

Mongoose – Schema

- A collection "**movies**" with the example document

```
{    "_id" : 1,
    "Title" : "Sense and Sensibility",
     "Year" : 1995,
      "Genres" : [ "Comedy", "Drama",
"Romance"]
}
```

- Schema definition

```
var movieSchema = new Schema({
  Title: String,
   Year: Number,
  Genres: [String]
})
```

Mongoose – Schema, Model and Document

- A collection "**movies**" with the example document

```
{   "_id" : 1,
   "Title" : "Sense and Sensibility",
    "Year" : 1995,
    "Genres" : [ "Comedy", "Drama",
"Romance"]
}
```

- Schema definition

```
var movieSchema = new Schema({
  Title: String,
   Year: Number,
  Genres: [String]
})
```

- Model definition (collection name, schema, collection name)
- Save a document in a movie collection

```
var Movie = mongooes.model('Movie',
movieSchema, 'movies')

var aMovie = new Movie({
    title="Ride With the Devil"})
```

Mongoose – Queries

- All Mongodb queries run on a model
  - Including **`find`**, **`update`**, **`aggregate`**
  - Very similar syntax to the shell command query
  - A callback function needs to be specified if we want to do something with the query result
  - Two ways to run the callback function
    - Callback function is passed as a *parameter* in the query
      - The operation will be executed immediately with results passed to the callback
    - Callback function is not passed as a parameter in the query
      - An instance of the query is returned which provides a special query builder interface

Queries with Callback Function

```
Movie.find({}, function(err,movies){
   if (err){
    console.log("Query error!")
   }else{
      console.log(movies)
   }
 }
)
```

Call back function

Queries with Callback Function

- The query was executed immediately, and the results passed to the callback
  - Callback syntax in Mongoose: **callback (error, results)**
  - If successful, results will be populated with the query results, error will be null
  - If unsuccessful error will contain error document and the result will be null
  - Result depends on the operations: e.g., find() list of documents, count() number of documents, update() the number of documents affected

Query Instance – No Callback Passed

- A Query instance enables you to build up a query using chaining syntax, rather than specifying JSON object
  - A full list of Query helper functions (http://mongoosejs.com/docs/api.html#query-js)

```
Movie.find({Year: 1996})
.select({Title:1,Year:1})
.exec(function(err,movies){
  if (err){
    console.log("Query error!")
  }else{
    console.log("Movies in year 1996:")
    console.log(movies)
  }
 }
)
```

Query Instance – No Callback Passed

- A Query instance enables you to build up a query using chaining syntax, rather than specifying JSON object
  - A full list of Query helper functions (http://mongoosejs.com/docs/api.html#query-js)

```
Var query = Movie.find({Year: 1996});
query.select({Title:1,Year:1});

query.exec(function(err,movies){
  if (err){
    console.log("Query error!")
  }else{
    console.log("Movies in year 1996:")
    console.log(movies)
  }
 }
)
```

Queries – Insert Documents

- First create a document based on the model

- Use *save()* method to insert the new document
  - The model is linked to the collection, so it knows which collection to save this document to

```
var newMovie = new Movie(
{ MovieID: 292,
  Title: "Outbreak",
  Year: 1995,
  Genres: ['Action','Drama','Sci-Fi','Thriller']}
)
newMovie.save()
```

Queries – Static Methods

- To run certain queries often on some collection, we can implement those queries either as *static methods* or as *instance methods*
- *A static method* is defined on the Model (collection), any standard query/aggregation can be implemented as static method
- Better for reusability and modularity of database related code

Static Methods – Example

```
movieSchema.statics.findByYear = function(year, callback){
    return this
            .find({Year: year})
            .select({Title:1,Year:1})
            .exec(callback)
}
var Movie = mongoose.model('Movie', movieSchema, 'movies')
Movie.findByYear(1995, function(err,movies){
        if (err){
         console.log("Query error!")
        }else{
           console.log("Movies in year 1995:")
           console.log(movies)
        }
})
```

Query – Instance Methods

- Instance methods is defined on document instance
- It is often used to create queries based on a given document

Instance Methods

```
movieSchema.methods.findSimilarYear = function(cb) {
  return this.model('Movie').find({ Year: this.Year }, callback);
};

var newMovie = new Movie(
{MovieID: 292,
 Title: "Outbreak",
 Year: 1995,
 Genres: ['Action','Drama','Sci-Fi','Thriller']}
)
newMovie.findSimilarYear(function(err,movies){
  if (err){
    console.log("Query error!")
  }else{
    console.log("The movies released in the same year as " +
        newMovie.Title + " are:")
    console.log(movies)
 }
}
)
```

Database Connection

- Opening and closing connection to database is time consuming
- Let all requests share a pool of connections and only close them when application shuts down
- Mongoose manages connection pool

http://mongoosejs.com/docs/connections.html

Database Connection

- No application level open or close is required
- Mongoose.connect() prepares a number of connections. The callback can handle the success/error

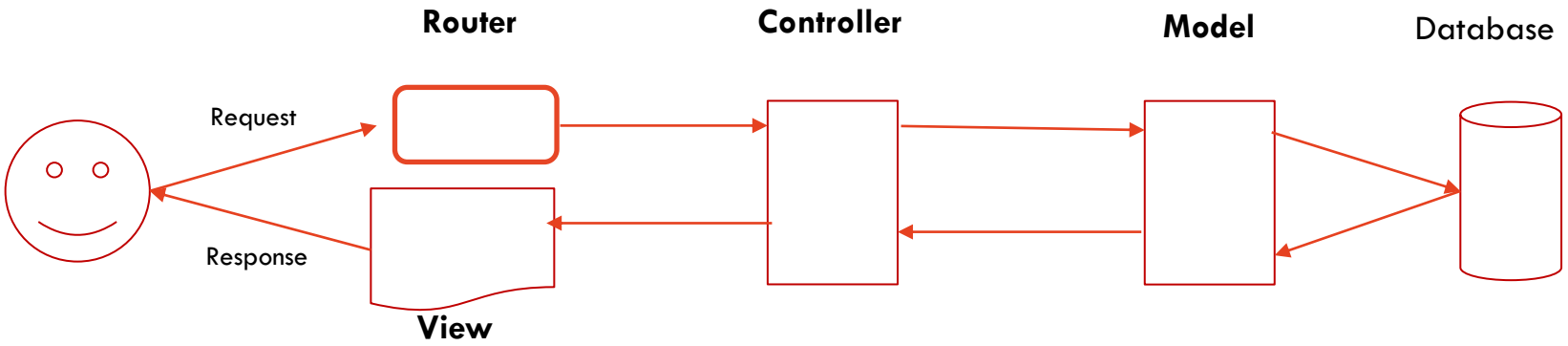
```
var mongoose = require('mongoose')

mongoose.connect('mongodb://localhost/comp5347', function
(err) {
  if (!err)
      console.log('mongodb connected')
})
```

Connection string or database URI

- You can specify more parameters, e.g., mongoose.connect('mongodb://username:password@host:port/database?options...');

http://mongoosejs.com/docs/connections.html

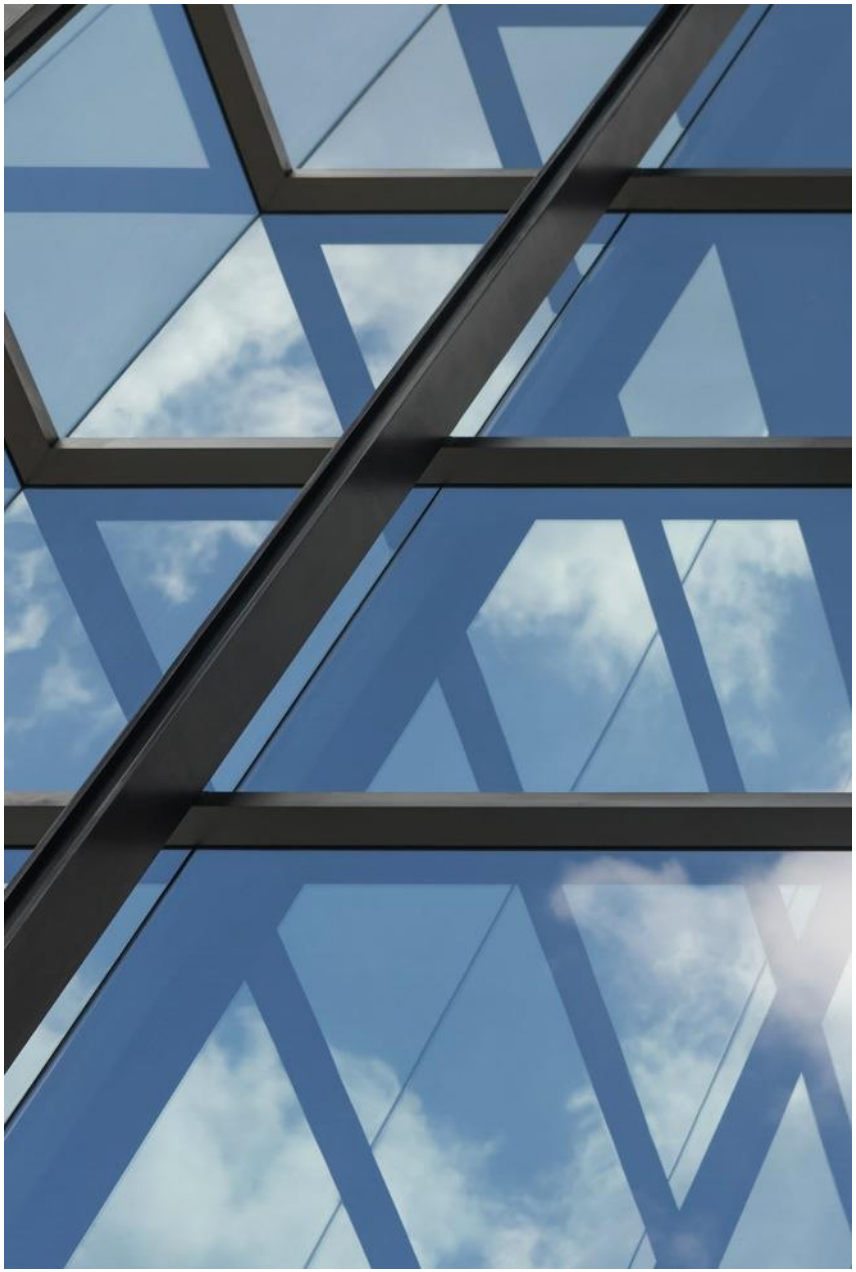
Full MVC Architecture



Resources

- Haviv, Amos Q, MEAN Web Development
- MongoDB online documents:
  - MongoDB CRUD Operations
    - http://docs.mongodb.org/manual/core/crud-introduction/
- Mongooes online documents:
  - Guide: http://mongoosejs.com/docs/guide.html

W7 Tutorial: MongoDB
W8 Tutorial: Mongoose + Promise
W8 Lecture: Client-side Libraries



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