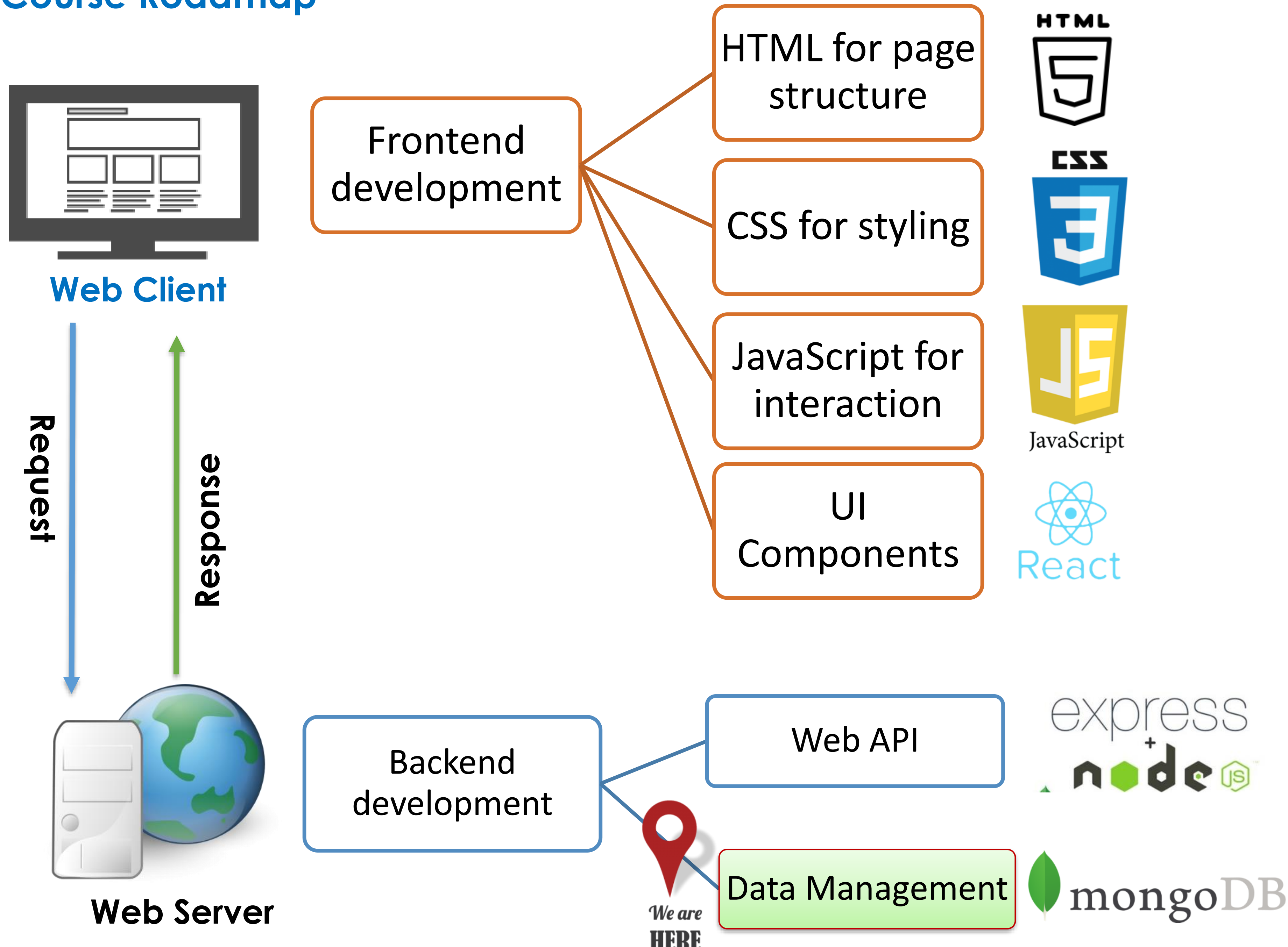
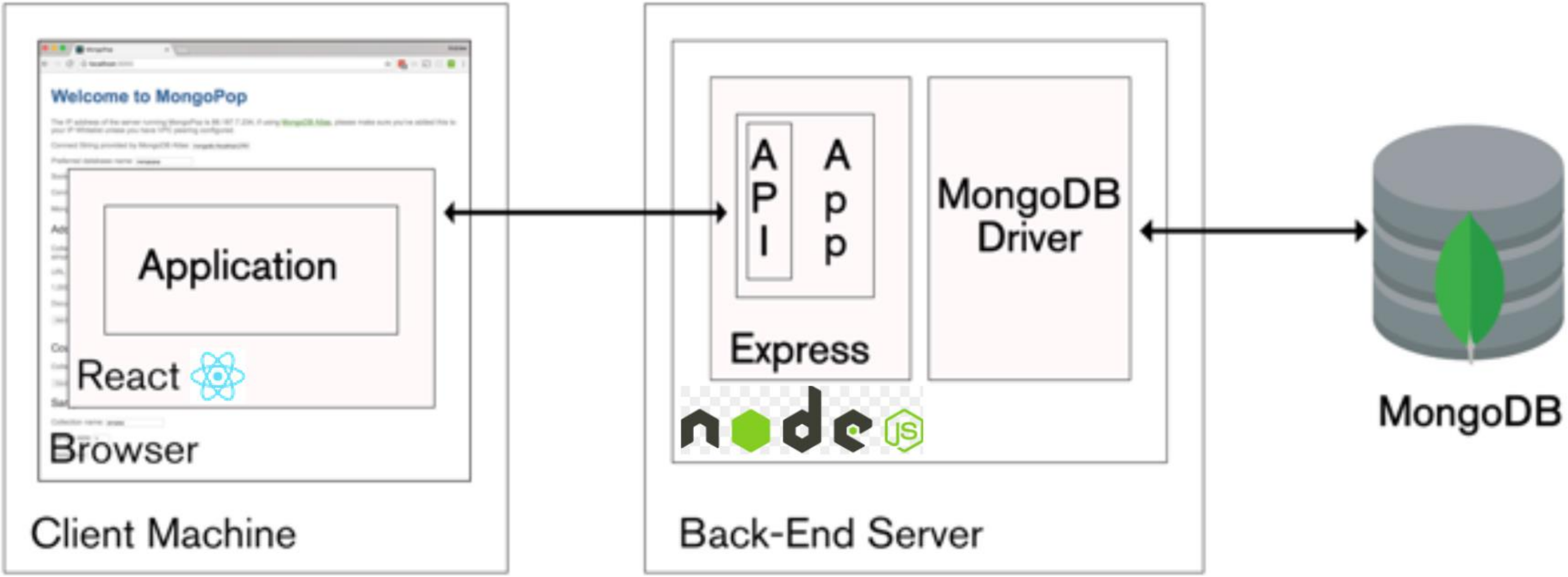
Data Management using mongoDB & Mongoose

Course Roadmap



MERN (MongoDB, Express, React, Node.js)



JavaScript is the common language throughout the MERN stack, and **JSON is the common data format**

Outline

1. Introduction to MongoDB
2. Document Schema Design
3. Introduction to Mongoose
4. CRUD Operations
5. Aggregation Queries

Introduction to

mongoDB®

What is MongoDB?

- MongoDB is an open-source **Document Oriented Database**
  - Uses a document data model: Stores data as JSON documents (instead of rows and columns as done in a relational database)
  - Arrange documents in collections (documents can vary in structure)
  - API to query and manage documents

- Better alternative data management solution for Web applications compared to using a Relational Database

Document

```
{
  "isbn" : "123",
  "title": "Mr Bean and the Forty Thieves",
  "category": "Fun",
  "pages": 250
  "authors": ["Mr Bean", "Juha Dahak"],
  "publisher": {
                 "name": "MrBeanCo",
                 "country": "UK“
               }
}
```

property : value

property : array

property : document

- **Document = JSON** object
- **Document = set of key-value pairs**
- **Basic unit of data** in MongoDB
- Analogous to **row** in a relational database

Collection

```json
{
  "isbn" : "123",
  "title": "Mr Bean and the Forty Thieves",
  "authors": ["Mr Bean", "Juha Dahak"],
  "publisher": {"name": "MrBeanCo", "country": "UK"},
  "category": "Fun",
  "pages": 250
}
```

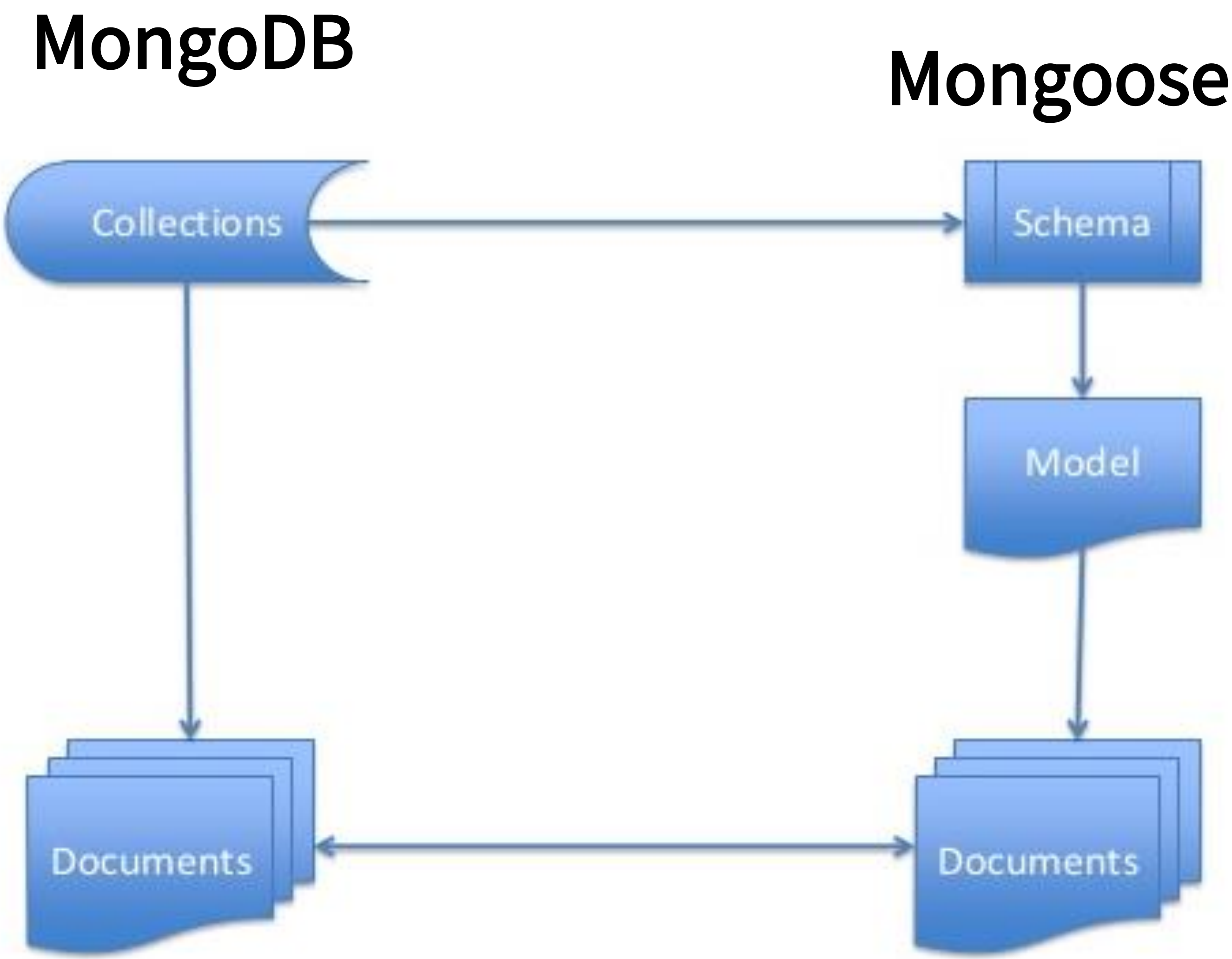
- **Collection = Group** of documents
- Analogous to **table** in a relational database
- **Does not enforce** a schema
- Documents in a collection usually **have similar purpose** but they may have slightly different schema

Introduction to Mongoose

Mongoose Overview

- Mongoose is a Node.js **Object Document Mapper (ODM)** for MongoDB
  - Allows define **schemas to model** documents. Then use the **model** to read/write documents
    - A **schema** describes a document structure in terms of properties and their types.
      - You can add validation, virtual properties
      - You can establish references to other models
    - A **model** is created based on a schema
    - A **model** maps to a MongoDB collection
    - A **model** = class used to run queries against collections
    - Instances of a model represent documents in MongoDB
  - Supports data validation on save
  - Allow rich querying of documents

MongoDB & Mongoose



Programming Steps

1. Require mongoose **module**

```
const mongoose = require('mongoose')
```

2. Define a **schema** for each document

```
let storeSchema = new mongoose.Schema({
    name: String,
    city: String
})
```

3. Create a **model** object based

```
let Store = mongoose.model('Store', storeSchema);
```

4. Connect to MongoDB

```
let dbConnection = mongoose.connect('mongodb://localhost/dbName')
```

5. Use the model to **read/write** documents

```
Store.find({})    //get all stores
```

Document Instance vs. Schema

```
{
  "firstname" : "Simon",
  "surname" : "Holmes",
  _id : ObjectId("52279effc62ca8b0c1000007")
}
```

Example MongoDB document

```
{
  firstname : String,
  surname : String
}
```

Corresponding Mongoose schema

Schema Data Types

Each property must have a type:

- String
- Number
- Date
- Boolean
- ObjectId
- Array

Example

```
let reviewSchema = new mongoose.Schema({
    author: String,
    rating: {type: Number, required: true, min: 0, max: 5},
    reviewText: String,
    createdOn: {type: Date, default : Date.now}
})

let bookSchema = new mongoose.Schema({
    isbn: String,
    title: String,
    authors: [String],
    publisher: {name: String, country: String},
    category: String,
    pages: Number,
    read: {type: Boolean, default:false, required: true},
    createdOn : {
        type : Date,
        default : Date.now
    },
    reviews: [reviewSchema],
    store : [{ type : mongoose.Schema.ObjectId, ref : 'Store' }]
})
```

_Id

- **_id** is the primary key that uniquely identifies each document in the collection
- It is automatically added when adding a document to the collection
- It is immutable (it cannot be changed)
- It is guaranteed to be unique across the whole database

Property Validation

- Built-in validators: required, min, max
- Can define custom validators

```
bookSchema.path('isbn').validate( value => value.length >= 3 )
```

- Validation happens on save

Virtual Property

- Define a property that won't get persisted to MongoDB

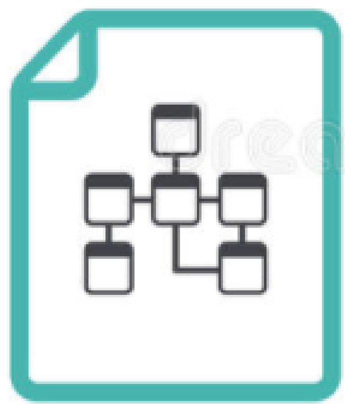
```
//define a fullName property that won't get persisted to MongoDB.
personSchema.virtual('fullName').get(function () {
    return this.name.first + ' ' + this.name.last;
});
```

```
// create a document
const student1 = new Person({
    name: { first: 'Ali', last: 'Faleh' }
});

console.log(student1.fullName); // Ali Faleh

/*
If you use toJSON() mongoose will not include virtuals by default
unless if you pass { virtuals: true }
 */
console.log(student1.toJSON({ virtuals: true }));
```

Document Schema Design



Document can have a Complex Structure

```
{
  first_name: 'Paul',
  surname: 'Miller',
  cell: 447557505611,
  city: 'London',
  location: { type: Point,
              coordinates: [-0.223,51.52]},
  Profession: ['banking', 'finance', 'trader'],
  cars: [
    { model: 'Bentley',
      year: 1973,
      value: 100000, … },
    { model: 'Rolls Royce',
      year: 1965,
      value: 330000, … }
  ]
}
```

Properties

Values could be: String, Number, Geo-Location, Array

Properties can contain an array of sub-documents (JSON objects)

Embedded vs Referenced documents

- Major design decision when designing a Document Schema is to decide **Embedded** vs **Referenced** subdocuments
- Decision should consider:
  - How the data will be used
  - Size of the document

Embedding

- **Advantages**
  - Retrieve all relevant information in a single query/document
  - Avoid implementing joins in application code => fast data retrieval
  - Update related information as a single atomic operation
- **Limitations**
  - Large documents mean more overhead if most fields are not relevant
  - 16 MB document size limit

Referencing

- **Advantages**
  - Smaller documents
  - Less likely to reach 16 MB document limit
  - Infrequently accessed information not accessed on every query
  - No duplication of data
- **Limitations**
  - Two queries required to retrieve information
  - Cannot update related information atomically (in one atomic operation)

1 to 1 Relationships => Better to Embed

Medical Procedures

```
{
  "_id": 333,
  "date": "2003-02-09T05:00:00",
  "hospital": "County Hills",
  "patient": "John Doe",
  "physician": "Stephen Smith",
  "procedure": "Glucose",
  "result": {
      "value": 97,
      "measurement": "mg/dl"
  }
}
```

← Embed – *weak entity*

Embed:

- No data duplication
- Data that are read/written together lives together

One to Many Relationships

Embed

Patients

```
{
  _id: 2,
  first: "Joe",
  last: "Patient",
  addr: { …},
  procedures: [
  {
    id: 12345,
    date: 2015-02-15,
    type: "CAT scan",
              …},
  {
    id: 12346,
    date: 2015-02-15,
    type: "blood test",
              …}]
}
```

OR

Reference

Patients

```
{
  _id: 2,
  first: "Joe",
  last: "Patient",
  addr: { …},
  procedures: [12345, 12346]
}
```

Procedures

```
{
  _id: 12345,
  date: 2015-02-15,
  type: "CAT scan",
  …}
{
  _id: 12346,
  date: 2015-02-15,
  type: "blood test",
  …}
```

One to Many : General Recommendations

- **Embed when:**
  - **One-to-few** (e.g. customer - addresses)
  - **Often queried/updated together** in a single query (e.g., book - chapters)
  - No need to access the embedded object outside the context of the parent object (e.g., order – order items)
  - No additional data duplication introduced

- **Reference when:**
  - **1 to a large number of related items** (e.g. customer orders , book – reviews, video - comments)
  - Related data changes frequently (e.g., video – viewCount)
  - Referenced entity that is used by many others (e.g., session - **room**)
  - Document size is > 16 MB
  - Subdocument has a large number of infrequently accessed fields

1 to M Example 1

- *"We need to store user information like name, email and their addresses… yes they can have more than one."*

```
{
    _id: 1,
    name: "Kate Powell",
    email: "kate.powell@somedomain.com",
    title: "Regional Manager",
    addresses: [
        { street: "123 Sesame St", city: "Boston" },
        { street: "123 Evergreen St", city: "New York" }
    ]
}
```

One-to-few : embedding is the best design

1 to M Example 2

- *"We have to be able to store tasks, assign them to users and track their progress…"*

```
> db.user.findOne({_id: 1})
{
    _id: 1,
    name: "Kate Powell",
    email: "kate.powell@...",
    title: "Regional Manager",
    addresses: [
        { // address 1 },
        { // address 2 }
    ]
}
```

```
> db.task.findOne({user_id: 1})
{
    _id: 5,
    summary: "Contact sellers",
    description: "Contact agents
        to specify our ...",
    due_date: ISODate(),
    status: "NOT_STARTED",
    user_id: 1
}
```

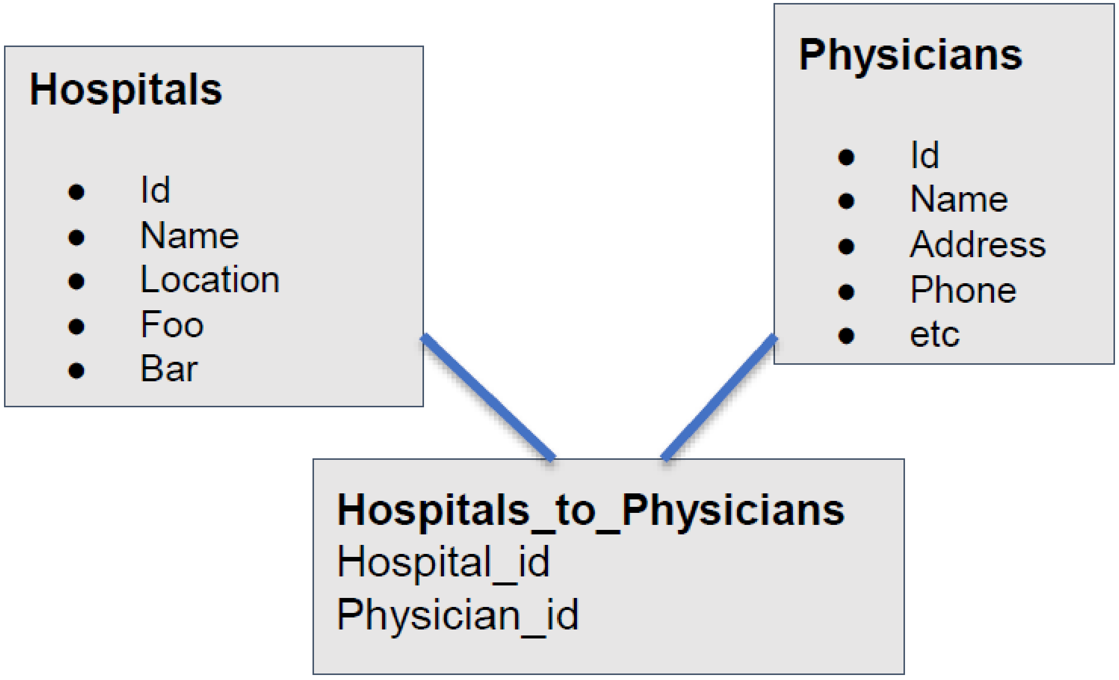
Referencing is the best design:

- Tasks are unbounded items: initially we do not know how many tasks we are going to have
    - A user can end with thousands of tasks
    - Maximum document size in MongoDB: 16 MB !
- Tasks can be queried without needing the retrieve the user details

Many to Many Relationship

- Like a One-to-Many relationship, you can embed sub-documents or reference them.
- Which approach you take depends on data access patterns and document sizes.

The relational way:



Many to Many Relationship using Embedding

Embedding **Physicians** in **Hospitals** collection

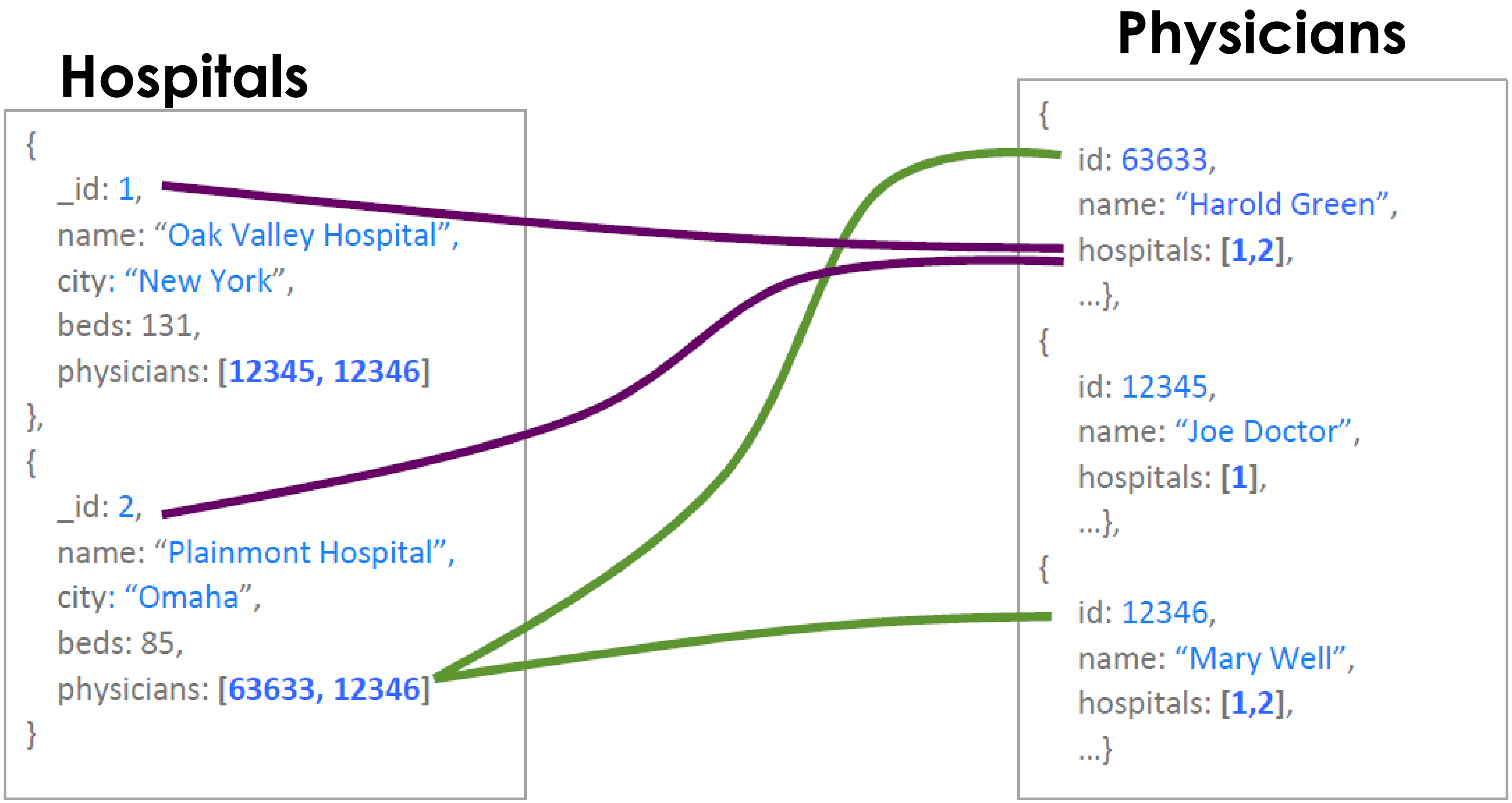
```
{
  _id: 1,
  name: “Oak Valley Hospital”,
  city: “New York”,
  beds: 131,
  physicians: [
    {
     id: 12345,
     name: “Joe Doctor”,
     address: {…},
                  …},
    {
     id: 12346,
     name: “Mary Well”,
     address: {…},
                  …}]
}
```

Data Duplication could be fine! (sometimes)

```
{
  _id: 2,
  name: “Plainmont Hospital”,
  city: “Omaha”,
  beds: 85,
  physicians: [
    {
     id: 63633,
     name: “Harold Green”,
     address: {…},
                  …},
    {
     id: 12345,
     name: “Joe Doctor”,
     address: {…},
                  …}]
}
```

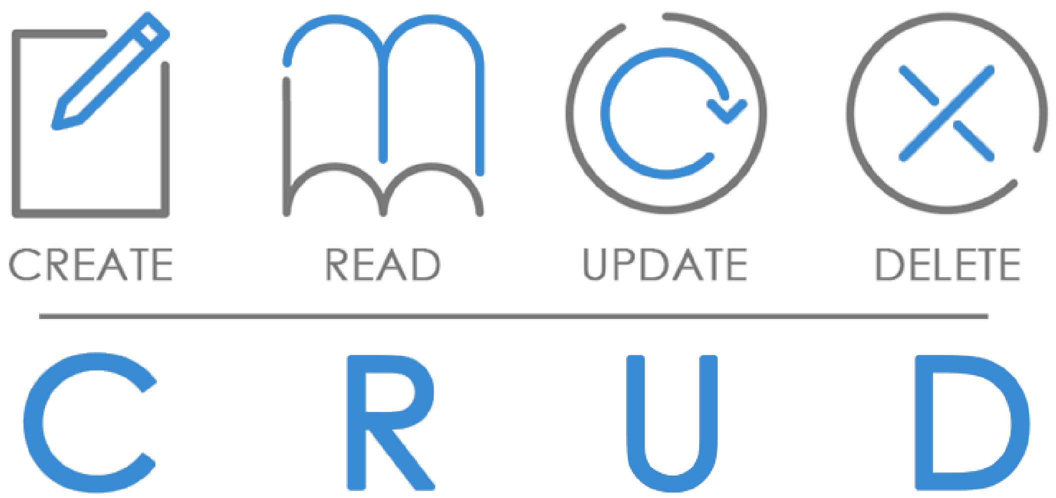
Many to Many Relationship using References

No data duplication. Hence this design is often **recommended**



Note that references can go either direction. There is no primary key/foreign key concept in MongoDB

CRUD Operations



CRUD operations

- Create -> `Book.create(newBook)`
- Read -> `Book.find({})`

  `Book.findById(bookId)`

  `Book.findOne({isbn: isbn})`

  `Book.find({authors: {$in: [author]}})`

- Update -> `Book.update({_id: bookId}, updatedBook)`
- Delete -> `Book.remove({_id : bookId});`

Mongoose Queries

- Queries are based on finding documents with any combination of fields in a collection

```
Book.find({ category: 'Fun', pages : { $lt : 200 } })
```

- You sorting and limits the number of returned documents

```
Book.find({}).sort('isbn').limit( 5 )
```

- OR condition is also supported

```
Book.find({}).where({ category: 'Fun' }).or({pages :{ $lt : 100 }})
```

- Filter on the existence of field

```
Book.find( { reviews : { $exists: true } } )
```

QueryBuilder

- The query object allows chaining methods could chained to build a complex query

```
School.find({ name: 'Iqraa'})
.where('state').equals('AZ')
.where('licenses').gt(17).lt(100)
.where('district').in(['dist1', 'dist2'])
.limit(10)
.populate ('owner', 'name')
.sort('owner.name')
.select('id name state owner.name')
```

Count and Distinct Methods

- `collection.count( query )` - returns the number of documents in the collection that match the query

- `collection.distinct( field, query )` - returns an array of all the unique values found in the passed field for the documents that match the query

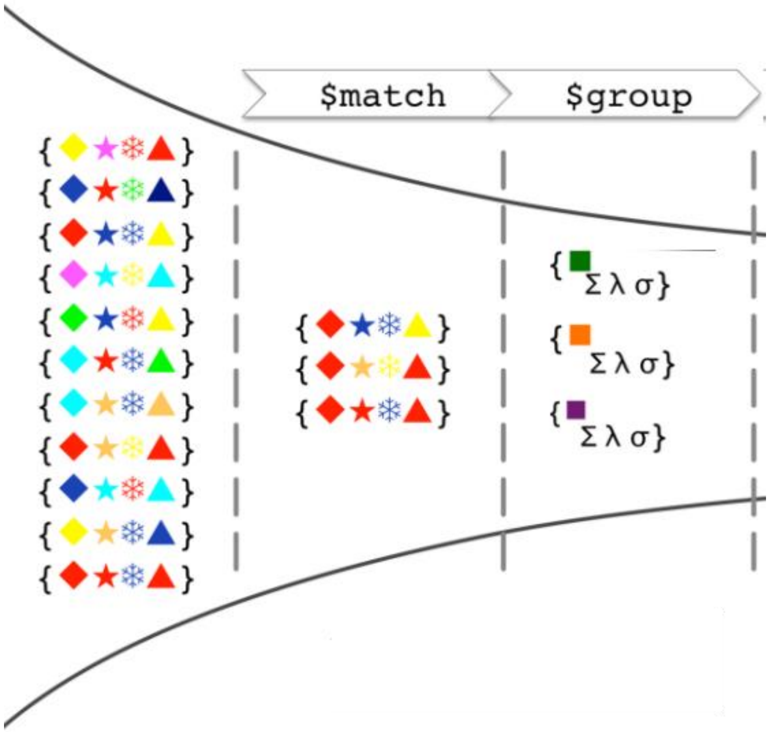
Populating Ref Property

- Population is the process of automatically replacing the specified paths in the document with document(s) from other collection(s)
- Populate sends another query for the related object

```
let bookSchema = new mongoose.Schema({
    isbn: String,
    title: String,
    ...
    store : [{ type : mongoose.Schema.ObjectId, ref : 'Store' }]
})
```

```
//populate('store') will replace the store Id with the corresponding store object
Book.find({}).populate('store')
```

Aggregation Queries



Aggregation Queries

- Summarize data typically for reports
- How would we solve this in SQL?

  `SELECT` **`GROUP BY`** `HAVING`

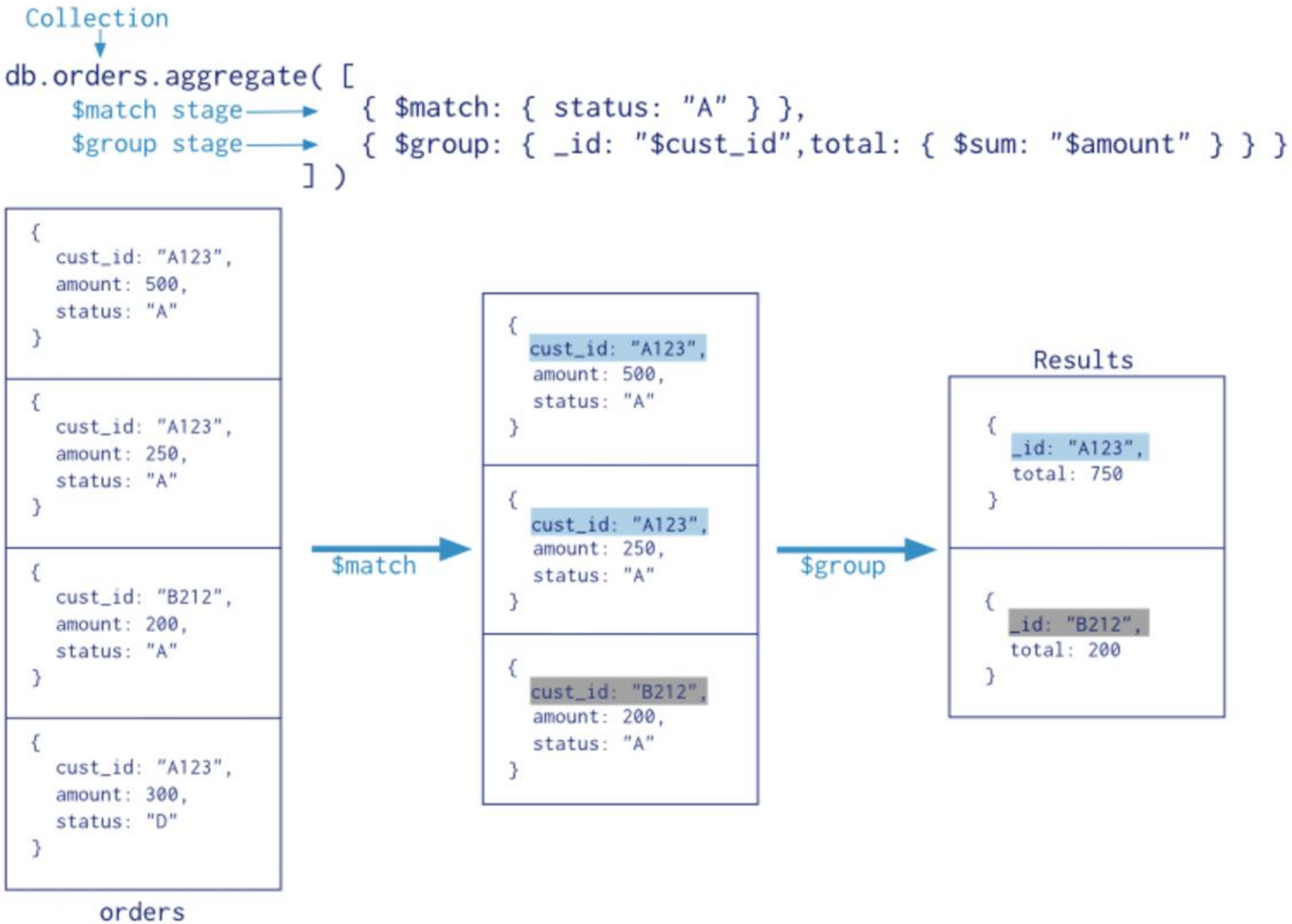
- What About MongoDB?

  => **Aggregation Pipeline**

  – Pipeline of functions to filter, group, and sort documents
  – Operations executed in sequential order
  – Output of one stage is used as an input of next

Aggregation Pipeline

- Allows filtering then grouping documents by specific fields



Pipeline Operators

- $match Filter documents
- $group Summarize documents
- $sort Order documents
- $limit Limit returned results

- **$group** specifies:

– Properties to group by

– Computed output properties using $max, $min, $avg, $sum …

$group Examples

- Return average GPA for all students

```
Student.aggregate([
    {
        "$group" : {"_id" : null,
        "avgGPA" : {$avg : "$gpa"}
    }}])
```

- Return total completed Credit Hours per student

```
StudentCourse.aggregate([
    {
        "$group" : {"_id" : studentId,
            "completedCHs" : {$sum : "$CourseCH"}
        }}])
```

Resources

- Mongoose Documentation

http://mongoosejs.com/docs/

- Queries Cheat Sheet

http://s3.amazonaws.com/info-mongodb-com/mongodb_qrc_queries.pdf

- Aggregation Queries

https://docs.mongodb.com/manual/reference/operator/aggregation/group/