Data Management using mongoDB® & Mongoose

Course Roadmap

Web Client

Request

Response

Web Server

Frontend development

HTML for page structure

CSS for styling

JavaScript for interaction

Backend development

Web API

Data Management

Outline

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

Introduction to

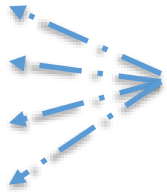
What is MongoDB?

- 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"
              }
}
```



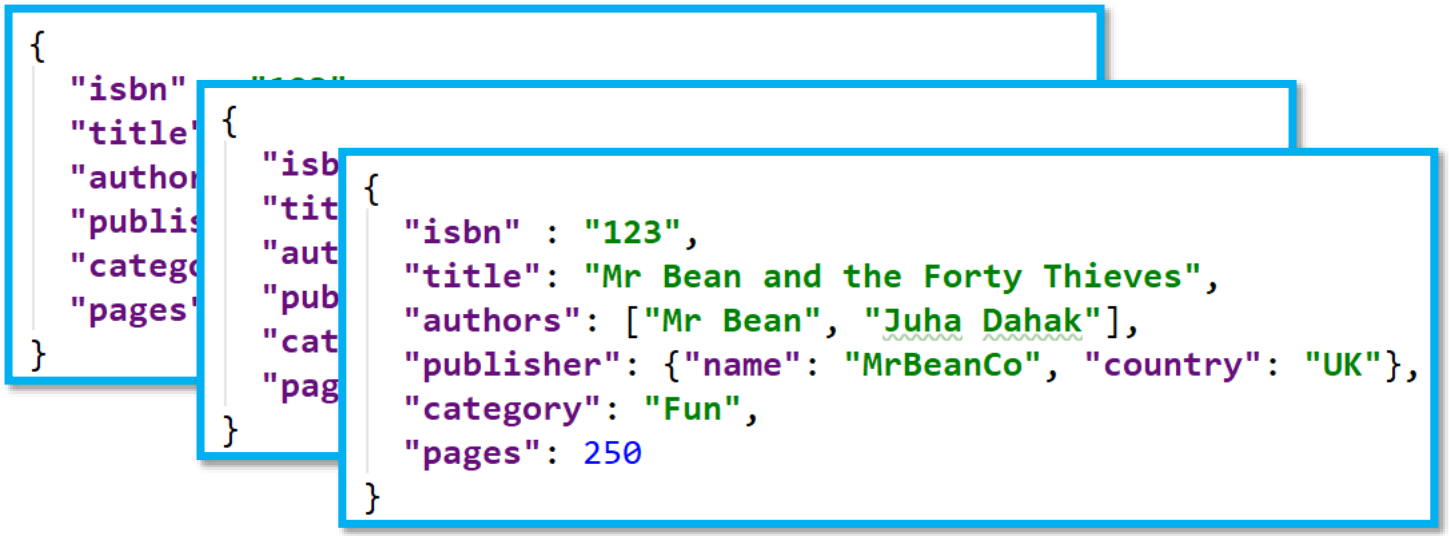
property : value

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



- **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

Programming Steps

1. Import mongoose module `import mongoose from 'mongoose';`
2. Define a **schema** for each document = **Structure doc**

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

3. Create a **model** object based

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

4. Connect to MongoDB

```
const 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

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

const bookSchema = new mongoose.Schema({
    isbn: String,
    title: String,
    authors: [String],
    publisher: {name: String, country: String}, // Embedded Doc
    category: String,
    pages: Number,
    read: {type: Boolean, default:false, required: true},
    createdOn : {
        type : Date,
        default : Date.now
    },
    reviews: [reviewSchema], // Embedded
    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, unique
- Can define custom validators

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

- Validation happens on save

Virtual Property

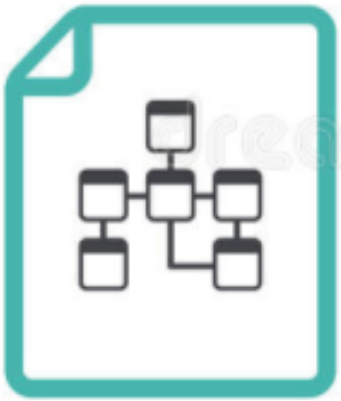
- Define a property that won't get persisted to MongoDB
  - Virtual id property for _id

```
paymentsSchema.virtual('paymentID').get(
  function (){
          return this._id
})
```

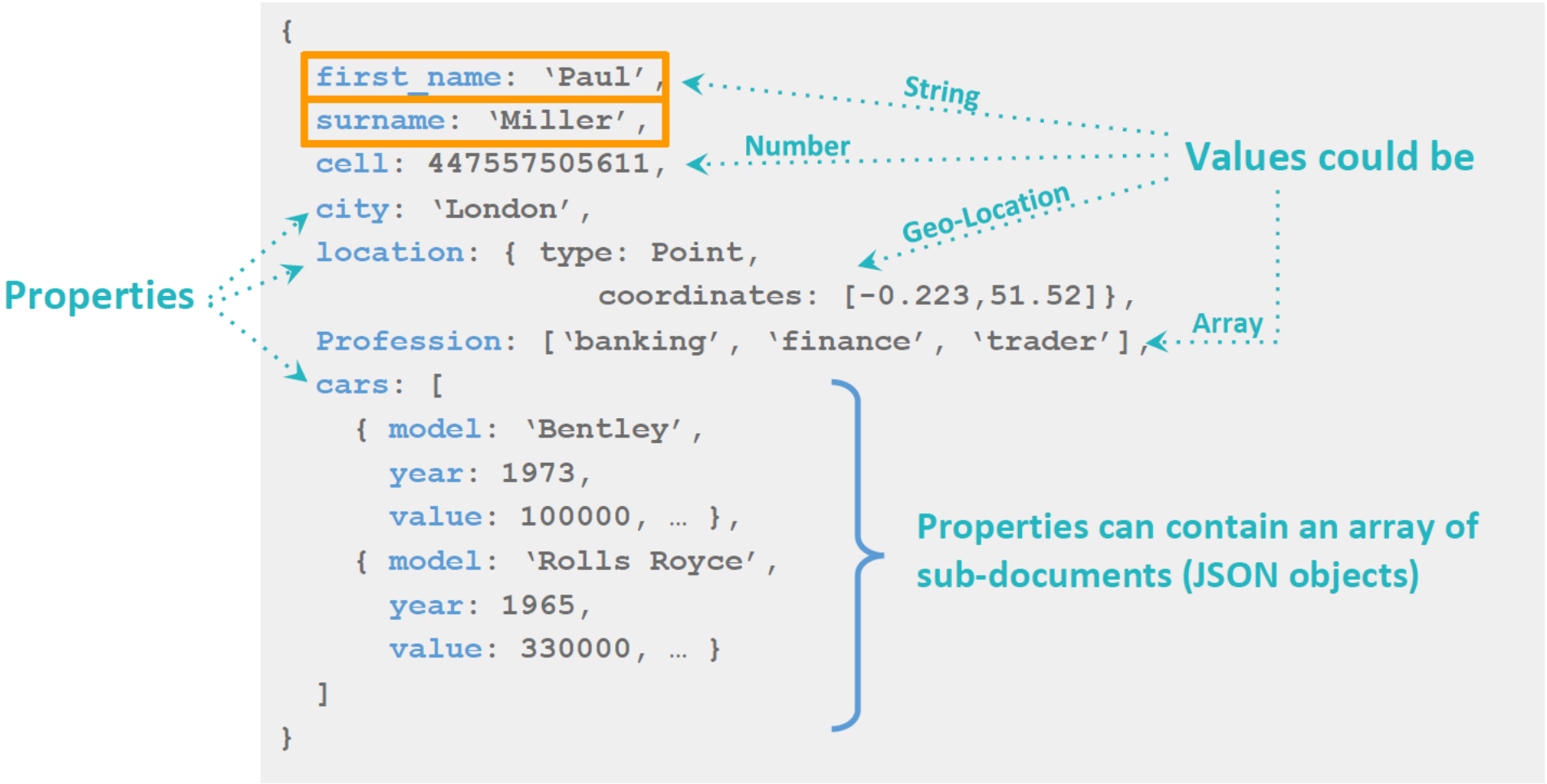
```
//define a fullName property that won't get persisted to MongoDB.
personSchema.virtual('fullName').get(function () {
    return `${this.name.first} ${this.name.last}`;
});
```

```
// 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



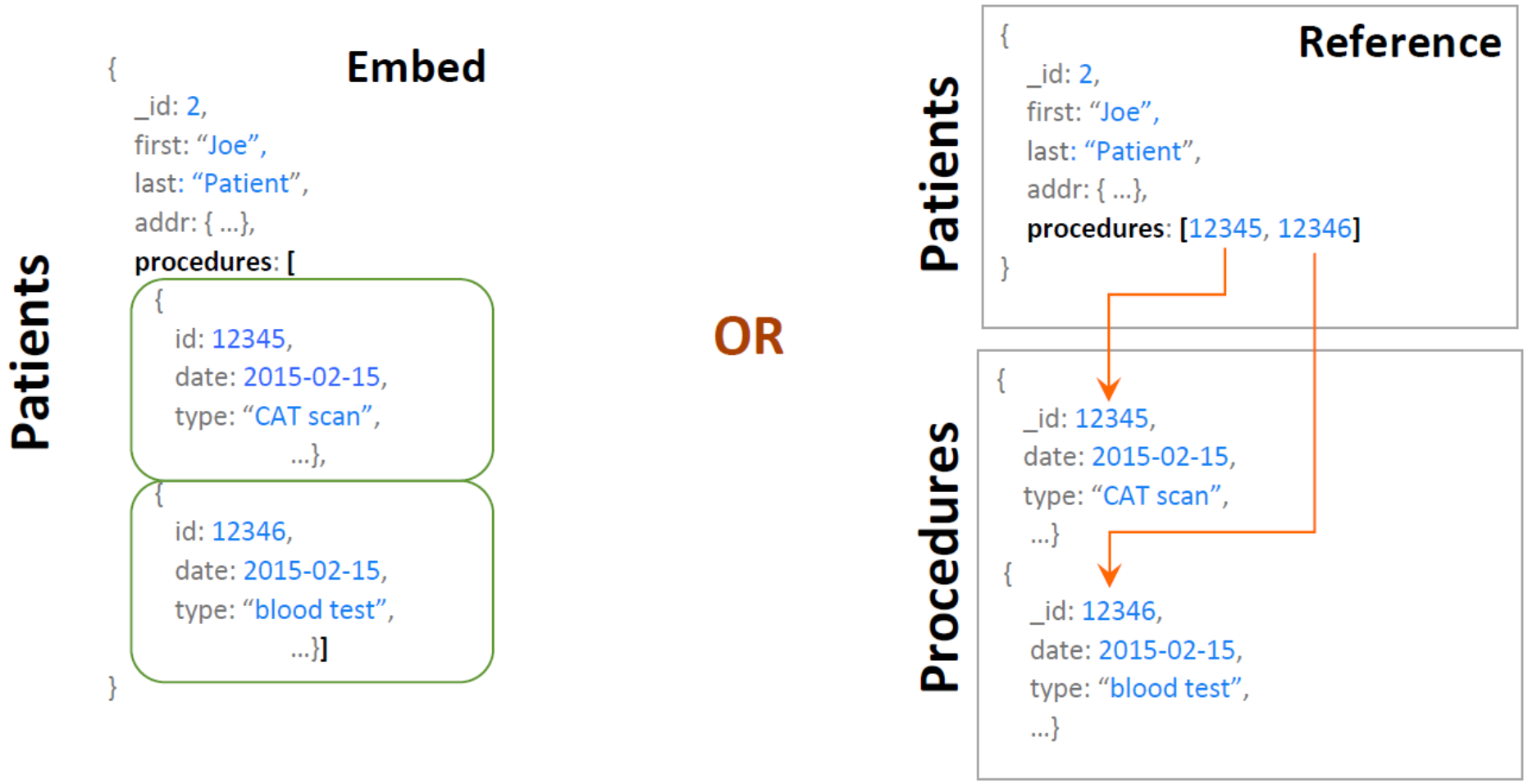
Document can have a Complex Structure



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

Embedded vs. Referenced



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 returned on every query
  - No duplication of data
- **Limitations**
  - Two queries required to retrieve information

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 : 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 properties

1 to M Example 1

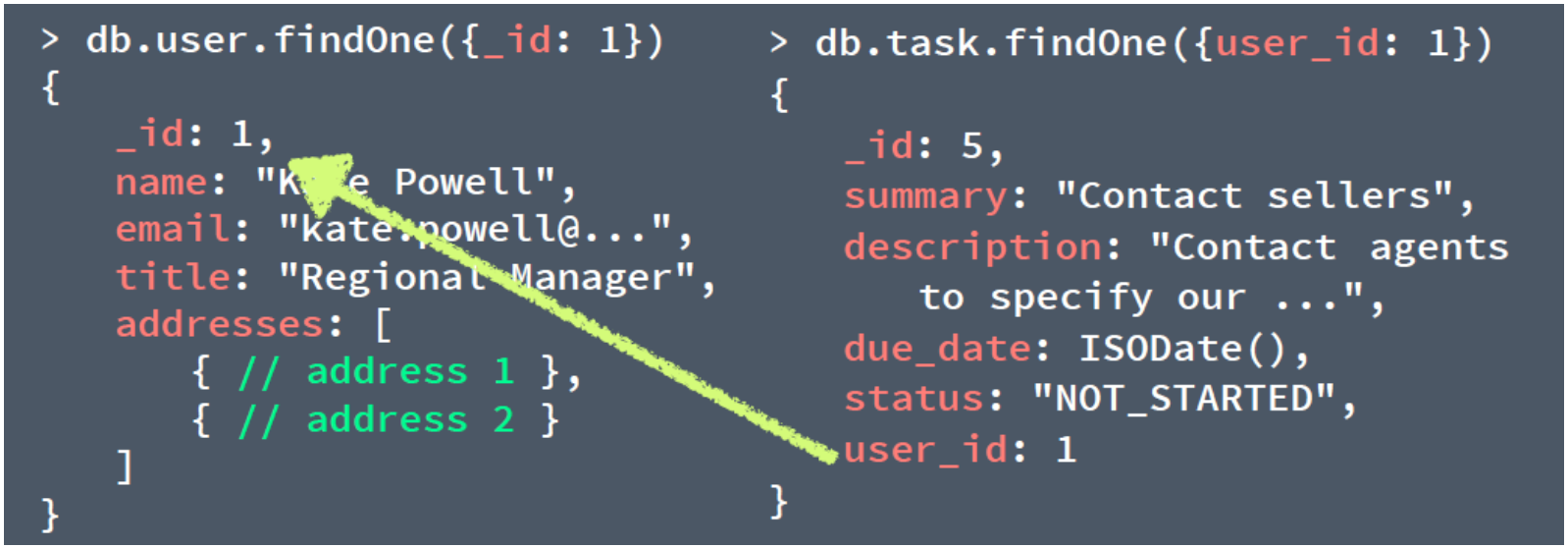
- *"We need to store user information like name, email and their addresses… a user they can have more than one address."*

```
{
    _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…"*



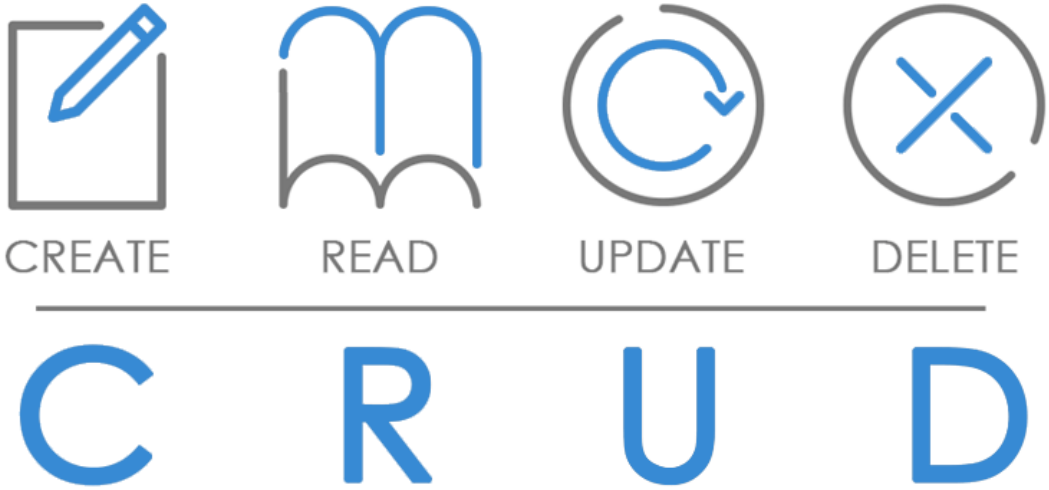
Referencing is the best design:

• **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

CRUD Operations



CRUD operations

- Create –> `Book.create(newBook)`
- Read –>
```
Book.find({})
Book.findById(bookId)
Book.findOne({isbn: '123'})
Book.find({authors: {$in: ['Mr Bean']}})
```
- Update –> `Book.updateOne({_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('price').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.countDocuments( 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

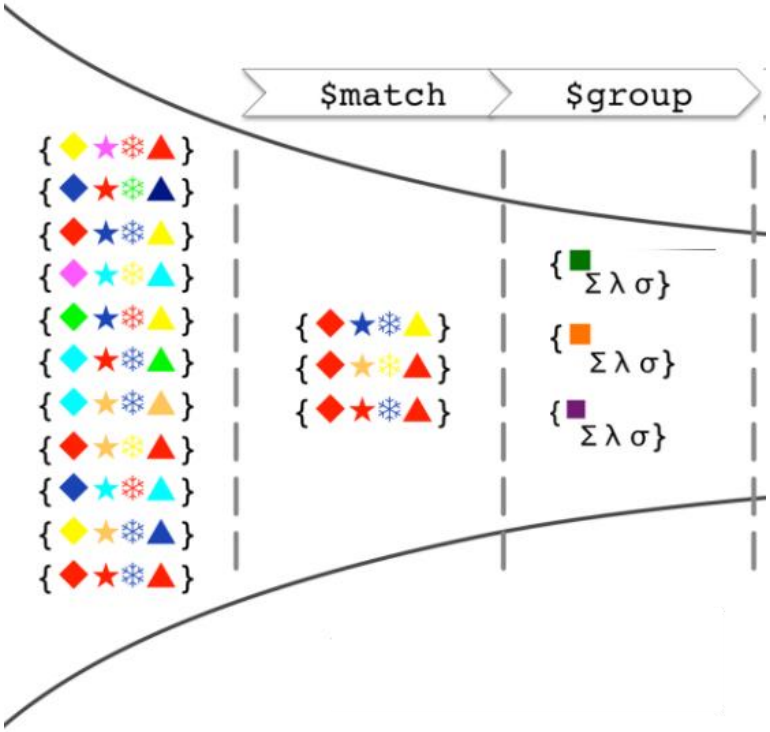
Populating a Reference Property

- Populating a reference property is the process of automatically **replacing** the reference Id is specified path in the document with document(s) from other collection(s)
- Populate sends another query for the related object

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

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

Aggregation Queries



Aggregation Queries

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

```
SELECT GROUP BY HAVING
```

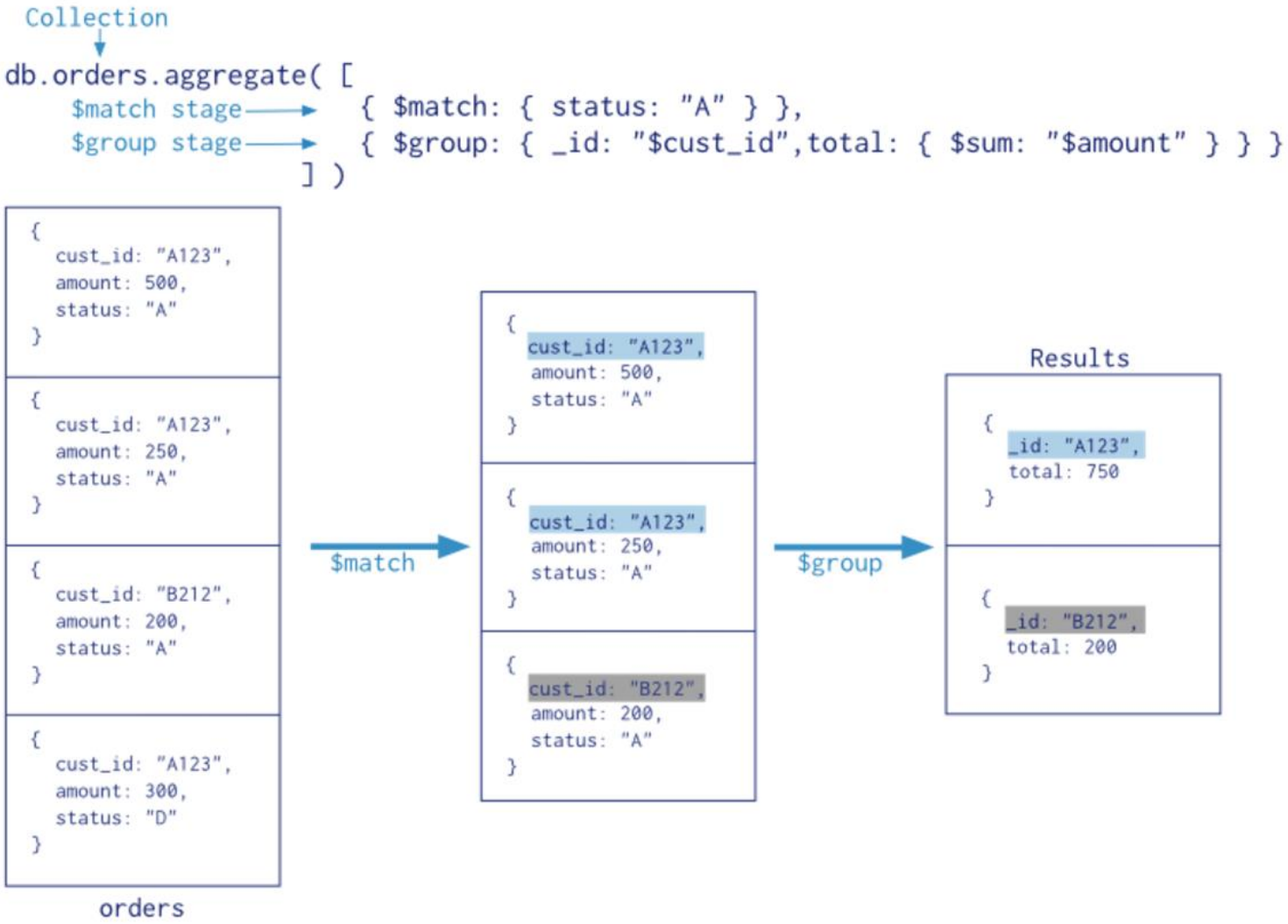
- What About MongoDB?

  => **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/