IN4MATX 133: User Interface Software

Lecture:
Databases and Local Storage

Goals for today's lecture

By the end of this lecture, you should be able to…

- Differentiate relational from non-relational databases
- Explain the advantages of each style of database
- Use Firebase to implement a non-relational database

Today is a crash course in databases

CS 122A and 122B provide substantially more depth

Data storage

- What happens when we refresh the A4 sleep tracking app?
  - We lose all of the data we logged
- This is obviously not ideal
  - We have to tell the browser, app, etc. to store it

Data storage

- Data can be stored locally on a device
  - Android and iOS allow apps to store some data
  - Ionic Native provides (good) libraries for using local storage

Local Storage

- In Ionic, can store key-value pairs
  - Keys must be strings, values can be any type
- This is actually a non-relational database!
  - More on this in a few slides

https://ionicframework.com/docs/building/storage#ionic-storage

Local Storage

```
ionic cordova plugin add cordova-sqlite-storage

npm install --save @ionic/storage
```

- Don’t forget to add it to your module and inject it!

```
storage.set('name', 'Max');

  // Or to get a key/value pair
  storage.get('age').then((val) => {
    console.log('Your age is', val);
  });
```

https://ionicframework.com/docs/building/storage#ionic-storage

Local Storage

If we can store data on devices, why do we need databases?

Databases

- Provide reliability
  - You can get your data back if your phone dies or you get a new phone
- Provide cross-device support
  - Allow you to see and modify the same data across a phone and a desktop, for example

Databases

- Are more than files stored in the cloud
  - Can be “queried” efficiently to get subsets of data
- Two main approaches to making databases
  - Relational databases: MySQL, Postgres
  - Non-relational databases: MongoDB, Firebase
- Transaction: any add/delete/update/etc. made to a database

Databases

Relational databases

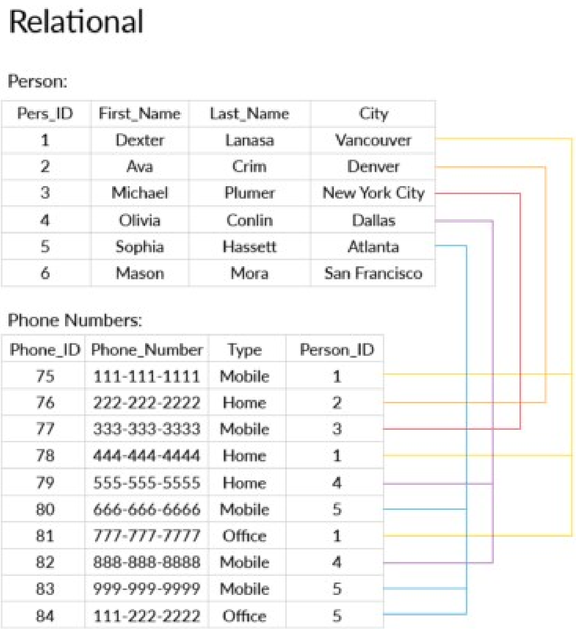
- Everything is organized into tables
- Tables contain columns with predefined names and data types
- Tables "relate" to one another by having overlapping or similar columns
  - Minimizes redundancy and keeps order
- Every data entry is a row of a table

https://www.neonrain.com/blog/mysql-vs-mongodb-looking-at-relational-and-non-relational-databases/

https://www.mongodb.com/scale/relational-vs-non-relational-database

Databases

Relational databases



Relational

Person:

Pers_ID	First_Name	Last_Name	City
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3	Michael	Plumer	New York City
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Databases

Relational databases

```sql
CREATE TABLE IF NOT EXISTS tasks (
    task_id INT AUTO_INCREMENT,
    title VARCHAR(255) NOT NULL,
    start_date DATE,
    due_date DATE,
    status TINYINT NOT NULL,
    priority TINYINT NOT NULL,
    description TEXT,
    PRIMARY KEY (task_id)
)  ENGINE=INNODB;
```

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https://www.mongodb.com/scale/relational-vs-non-relational-database

Databases

Non-relational databases

- Everything is organized into objects
- There are no restrictions on how objects are structured
- Every data entry is an object, or "document"
    - Documents may be structured differently from one another

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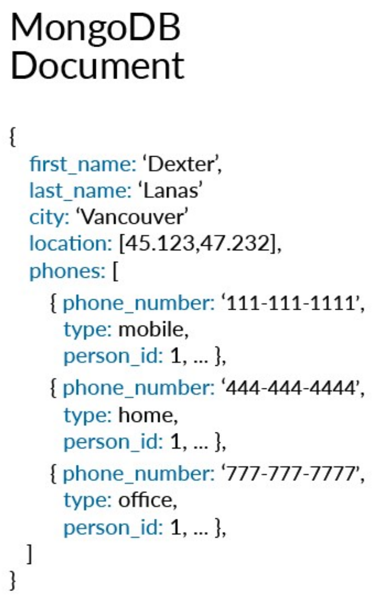
Databases

Non-relational databases



MongoDB
Document

```
{
  first_name: ‘Dexter’,
  last_name: ‘Lanas’
  city: ‘Vancouver’
  location: [45.123,47.232],
  phones: [
    { phone_number: ‘111-111-1111’,
      type: mobile,
      person_id: 1, ... },
    { phone_number: ‘444-444-4444’,
      type: home,
      person_id: 1, ... },
    { phone_number: ‘777-777-7777’,
      type: office,
      person_id: 1, ... },
  ]
}
```

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Databases

Non-relational databases

- There is no well-defined enforced structure
- That said, flatter structures are generally better

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https://www.mongodb.com/scale/relational-vs-non-relational-database

Databases

Non-relational databases

```
{
  // This is a poorly nested data architecture, because iterating the children
  // of the "chats" node to get a list of conversation titles requires
  // potentially downloading hundreds of megabytes of messages
  "chats": {
    "one": {
      "title": "Historical Tech Pioneers",
      "messages": {
        "m1": { "sender": "ghopper", "message": "Relay malfunction found. Cause: moth." },
        "m2": { ... },
        // a very long list of messages
      }
    },
    "two": { ... }
  }
}
```

https://firebase.google.com/docs/database/ios/structure-data

Databases

Non-relational databases

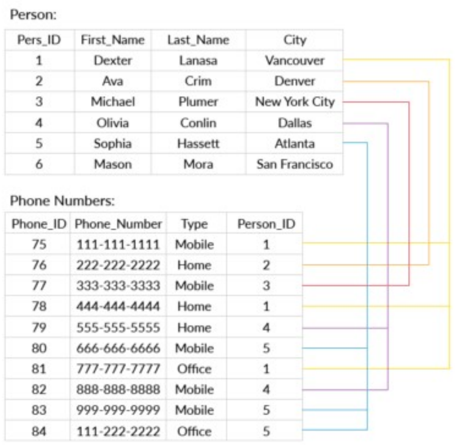
```
{
  // Chats contains only meta info about each conversation stored under the chats's unique ID
  "chats": {
    "one": {
      "title": "Historical Tech Pioneers",
      "lastMessage": "ghopper: Relay malfunction found. Cause: moth."
    },
    "two": { ... }
  },
  // Messages are separate from data we may want to iterate quickly but still easily paginated and queried,
  // and organized by chat conversation ID
  "messages": {
    "one": {
      "m1": {
        "name": "eclarke",
        "message": "The relay seems to be malfunctioning."
      },
      "m2": { ... }
    },
    "two": { ... }
  }
}
```

https://firebase.google.com/docs/database/ios/structure-data

Which database structure will be best for retrieving all first names?

- Ⓐ The relational database
- Ⓑ The non-relational database
- Ⓒ They will be about the same
- Ⓓ I’m not sure
- Ⓔ [space intentionally left blank]

Relational



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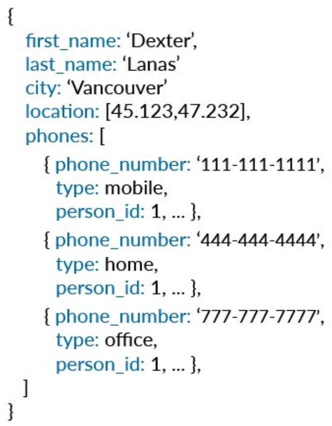
Non-relational



```
{
  first_name: ‘Dexter’,
  last_name: ‘Lanas’
  city: ‘Vancouver’
  location: [45.123,47.232],
  phones: [
    { phone_number: ‘111-111-1111’,
      type: mobile,
      person_id: 1, ... },
    { phone_number: ‘444-444-4444’,
      type: home,
      person_id: 1, ... },
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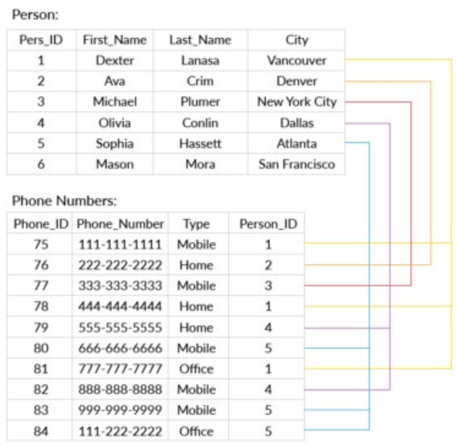
      type: office,
      person_id: 1, ... },
  ]
}
```

Which database structure will be best for retrieving all first names?

- A The relational database
- B The non-relational database
- C They will be about the same
- D I’m not sure
- E [space intentionally left blank]

Relational



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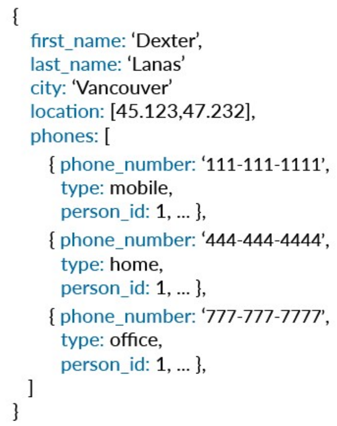
Non-relational



```
{
   first_name: ‘Dexter’,
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   city: ‘Vancouver’
   location: [45.123,47.232],
   phones: [
      { phone_number: ‘111-111-1111’,
        type: mobile,
        person_id: 1, ... },
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        type: office,
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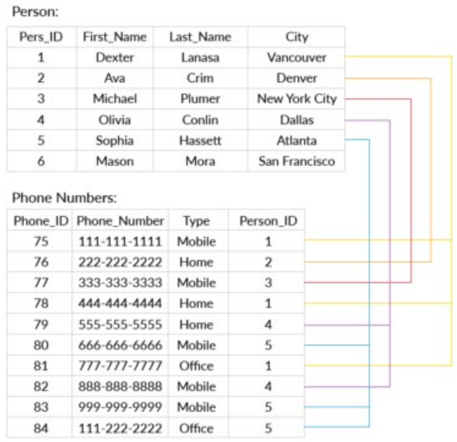
   ]
}
```

Which database structure will be best for retrieving all phone numbers?

- A The relational database
- B The non-relational database
- C They will be about the same
- D I'm not sure
- E [space intentionally left blank]

Relational



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Non-relational

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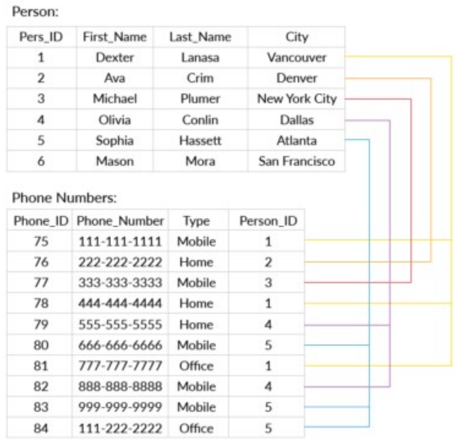

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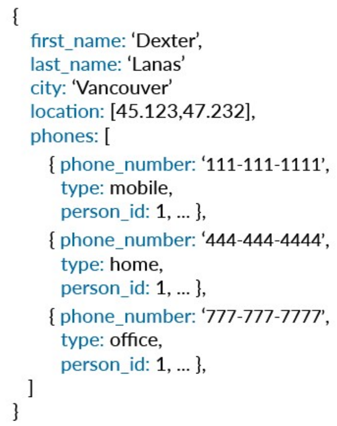

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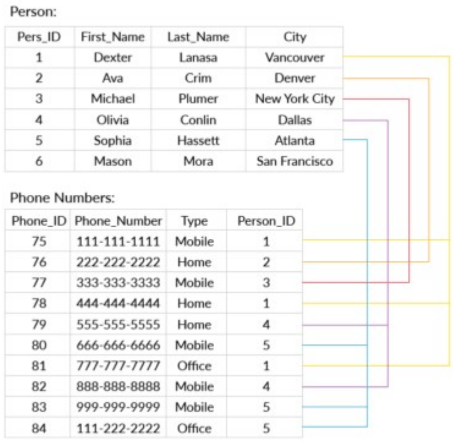
Relational



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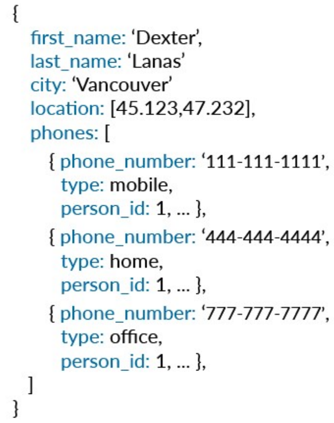

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A The relational database

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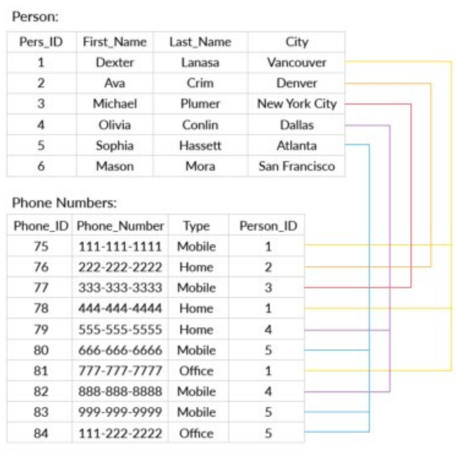

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Non-relational

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  ]
}
```

Databases

Advantages of relational databases

- Relational databases support better querying
  - Provide *languages* for querying, such as Structured Query Language (SQL)
  - Those languages can be used to ask for specific tables or even join data across tables
  - “Give me the first name of every user whose phone number starts with 949”

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https://www.mongodb.com/scale/relational-vs-non-relational-database

Databases

Advantages of relational databases

- Relational databases are more organized
  - Because field types are defined, data reliably follows that structure
- Relational databases are more reliable
  - Structure is enforced when new data is added
  - Transactions are atomic, so it’s easy to “get” the current state of the database

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Databases

Advantages of non-relational databases

- Non-relational databases support more flexibility
  - Structure imposes restrictions
  - Adding a new field (column) can mess up a relational database
- Non-relational databases are faster for simple operations
  - It’s much easier to “watch all the files” than to query and index many rows across multiple tables

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https://www.mongodb.com/scale/relational-vs-non-relational-database

Databases

Relational vs. Non-relational

- Relational databases tend to be used in Enterprise, large-scale applications
    - It’s important that data conforms to standards
    - It’s important to robustly query large amounts of data
- Non-relational databases tend to be used in smaller applications
    - Data flexibility is valuable
    - Data is small enough to reliably retrieve and parse
- That said, plenty of large apps use non-relational databases and vice versa

Databases vs. Local Storage

- Who needs access to the data?
    - Just the user, or others?
    - As a developer, do you need access?
- Is the data sensitive?
- Is the data valuable enough that it should not be lost?

Databases vs. Local Storage

- Databases are crucial if more than the local device needs access
  - Cross-device app: facebook.com and the mobile app need your profile information
  - Developer: to understand habits across users or provide a data-driven service
- Some privacy can be preserved if data is only stored locally
- Which to use depends on the type of data and context

One non-relational database: Firebase

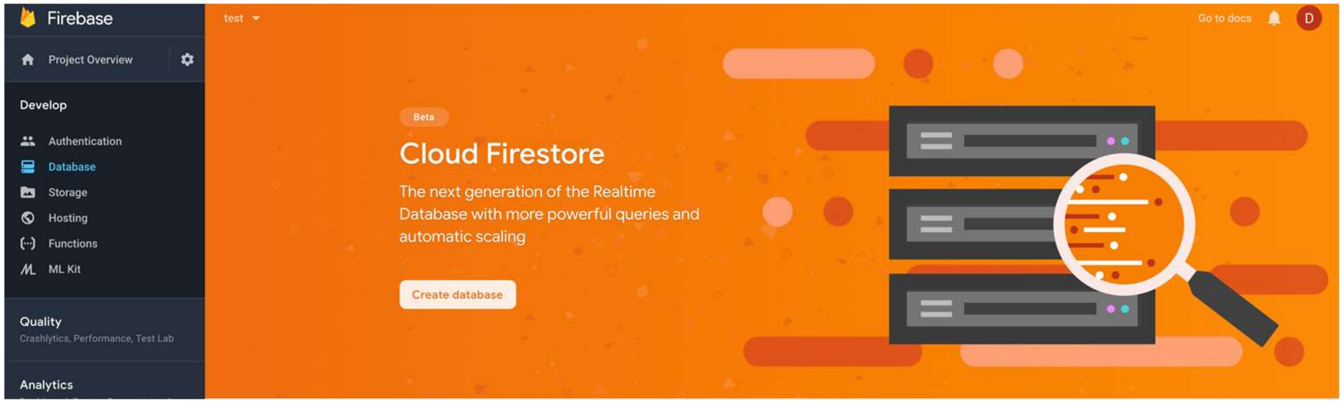
Firebase

- First released in 2011
- Acquired by Google in 2014
- Has features besides databases
  - Media storage
  - Authentication
  - Analytics

Firebase

Setting up the database

- Create a new project: https://firebase.google.com/
- Create a database



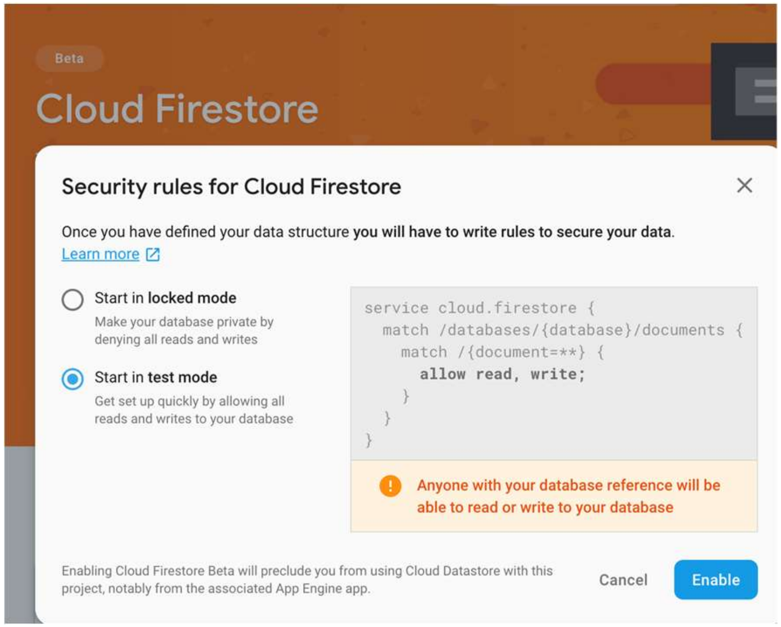
Cloud Firestore

The next generation of the Realtime Database with more powerful queries and automatic scaling

Firebase

Setting up the database

- Start your database in “test mode”
  - Anyone can read or write to your database
  - This means *anyone*, even localhost
  - Gets around browser’s origin restriction
  - This is bad practice, of course. It’s better to allow specific users
  - Take a databases class to learn about permissions



Security rules for Cloud Firestore

Once you have defined your data structure **you will have to write rules to secure your data**.
Learn more

○ Start in **locked mode**
Make your database private by denying all reads and writes

● Start in **test mode**
Get set up quickly by allowing all reads and writes to your database

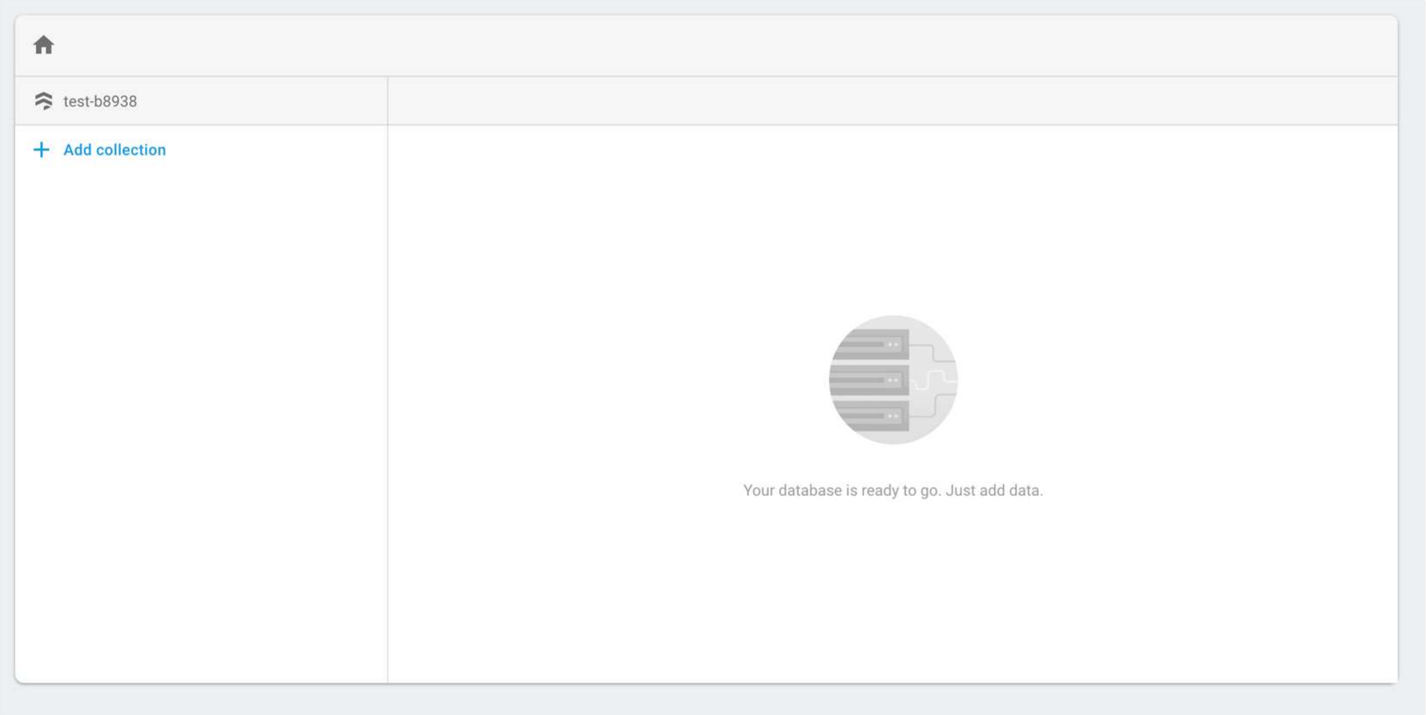
```
service cloud.firestore {
  match /databases/{database}/documents {
    match /{document=**} {
      allow read, write;
    }
  }
}
```

Anyone with your database reference will be able to read or write to your database

Enabling Cloud Firestore Beta will preclude you from using Cloud Datastore with this project, notably from the associated App Engine app.

Firebase

Setting up the database



Your database is ready to go. Just add data.

Firebase

Setting up the database

- Firebase documents (objects) are organized into *collections*
- Collections are somewhat like tables in relational databases
- But Firebase is non-relational and has no structure requirement
- Multiple documents in the same collection may have different structure
- Example collections: users, sleepdata

https://firebase.google.com/docs/firestore/data-model

Firebase

Setting up the mobile app

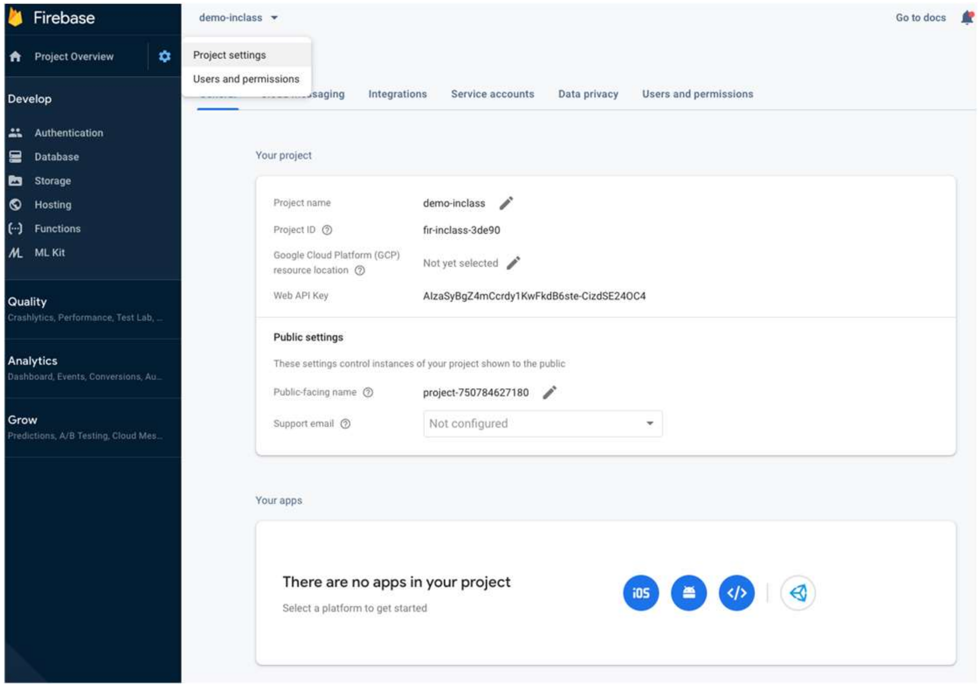
- Angular officially supports a Firebase library
  - It works with Ionic since Ionic builds on Angular
- `npm install firebase`
- `npm install @angular/fire`

https://github.com/angular/angularfire

Firebase

Setting up the mobile app

- Add configuration information for your Firebase app to `environments.ts` file in Ionic
- Edit Ionic's `module.ts` to point to this environment information
- Also add AngularFirestoreModule to the `module.ts`



Your project

Project name	demo-inclass
Project ID	fir-inclass-3de90
Google Cloud Platform (GCP) resource location	Not yet selected
Web API Key	AIzaSyBgZ4mCcrdy1KwFkdB6ste-CizdSE24OC4

Public settings

These settings control instances of your project shown to the public

Public-facing name	project-750784627180
Support email	Not configured

Your apps

There are no apps in your project

Select a platform to get started

https://github.com/angular/angularfire/blob/master/docs/install-and-setup.md

Firebase

Accessing the database from the mobile app

- `AngularFirestore` is a service and is injected like any other service
  - Can retrieve a collection by its name

```
import { AngularFirestore, AngularFirestoreCollection, DocumentData } from '@angular/fire/firestore';
import { Observable } from 'rxjs';

export class FirebaseService {
  collection:AngularFirestoreCollection;

  constructor(db:AngularFirestore) {
    this.collection = db.collection('test-collection');
  }
}
```

Firebase

Getting some data

Firebase

Accessing the database from the mobile app

- We probably don’t want to “get” data once
  - What if someone logged their sleep from their desktop?
  - Documents can be large, it takes some time for a transaction to complete
  - Instead of “getting”, we use an `Observable` to listen for any time the data changes
  - Same as listening for new accelerometer data every second with Ionic Native

Firebase

Listing for changes

```
/* .component.ts */
export class MyApp {
  testItems: Observable<any[]>;
  constructor(db: AngularFirestore) {
    this.testItems = db.collection(‘test-collection').valueChanges();
  }
}


<!--.component.html -->
<ul>
  <li *ngFor="let item of testItems | async">
    {{ item.name }}
  </li>
</ul>
```

Firebase

Add

- New objects can be added asynchronously

```
export class FirebaseService {
  collection:AngularFirestoreCollection;

  constructor(db:AngularFirestore) {
    this.collection = db.collection('test-collection');
  }

  addData(data:{}) {
    this.collection.add(data).then((reference) => {
      console.log("Reference to added data, kind of like a URL");
      console.log(reference);
    });
  }
}
```

Firebase

Delete and Update

- The string reference can be used to delete or update documents

```
deleteDocument(reference:string) {
  this.collection.doc(reference).delete().then(() => {
      console.log('The document at ' + reference + 'no longer exists');
    });
}

updateDocument(reference:string, newData:{}) {
  this.collection.doc(reference).update(newData).then(() => {
      console.log('The document at ' + reference + 'is now ' + newData);
    });
}
```

Firebase

Querying data

```
var citiesRef = db.collection("cities");

citiesRef.doc("SF").set({
    name: "San Francisco", state: "CA", country: "USA",
    capital: false, population: 860000,
    regions: ["west_coast", "norcal"] });
citiesRef.doc("LA").set({
    name: "Los Angeles", state: "CA", country: "USA",
    capital: false, population: 3900000,
    regions: ["west_coast", "socal"] });
citiesRef.doc("DC").set({
    name: "Washington, D.C.", state: null, country: "USA",
    capital: true, population: 680000,
    regions: ["east_coast"] });
citiesRef.doc("TOK").set({
    name: "Tokyo", state: null, country: "Japan",
    capital: true, population: 9000000,
    regions: ["kanto", "honshu"] });
citiesRef.doc("BJ").set({
    name: "Beijing", state: null, country: "China",
    capital: true, population: 21500000,
    regions: ["jingjinji", "hebei"] });
```

```
var citiesRef = db.collection("cities");

citiesRef.where("state", "==", “CA");
//SF, LA

citiesRef.where("capital", "==", true);
//D.C., Tokyo, Beijing

citiesRef.where("population", "<", 1000000);
//LA, Tokyo, Beijing

citiesRef.where("name", ">=", "San Francisco");
//SF, Tokyo, D.C.
```

https://firebase.google.com/docs/firestore/query-data/queries

Firebase

Converting TypeScript objects to and from JSON

- Firebase expects JSON rather than a TypeScript object
- TypeScript classes need to be converted to and from JSON

```
export class DataLog {
  id:string;
  values:number[];

  toObject():{} {
    return {'id':this.id,
    'value':this.values};
  }

  fromObject(object:{}) {
    this.id = object['id'];
    this.values = object['value'];
  }
}
```

Firebase

Converting TypeScript objects to and from JSON

- Non-primitive fields, like Date, may need extra conversion

```
export class DataLog {
  date:Date;

  toObject():{} {
    return {'date':this.date};
  }

  fromObject(object:{}) {
    //Stored as number of milliseconds
    this.date = new Date(object['date'].seconds*1000);
  }
}
```

Goals for today’s lecture

By the end of this lecture, you should be able to…

- Differentiate relational from non-relational databases
- Explain the advantages of each style of database
- Use Firebase to implement a non-relational database