IN4MATX 133: User Interface Software

Lecture 16:
Databases and Local Storage

Professor Daniel A. Epstein
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Today’s goals

By the end of today, 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
  - Capacitor 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://capacitorjs.com/docs/apis/storage

Local Storage

- Capacitor provides a cross-platform storage API

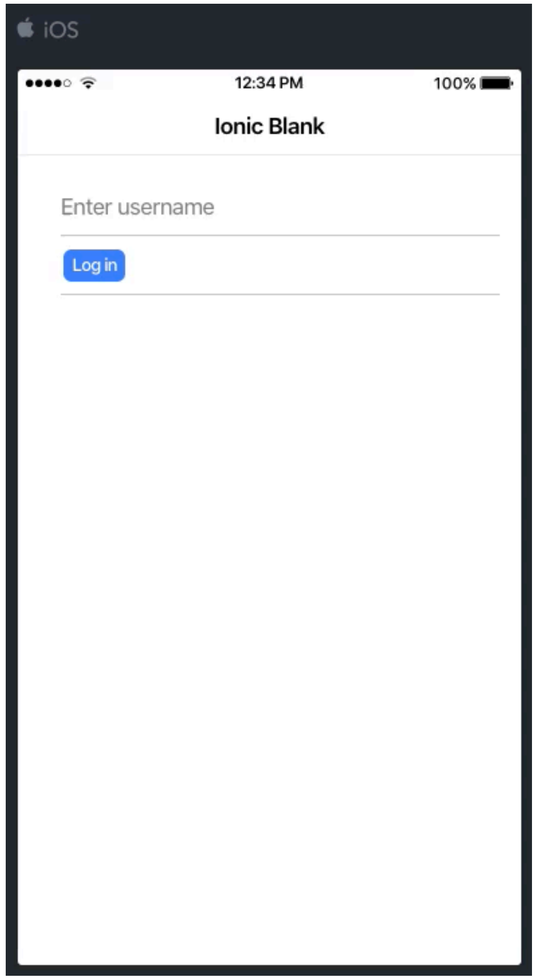
```
import { Storage } from '@capacitor/storage';

Storage.get({key:'keyName'}).then((data) => {
  console.log(data.value);
});

Storage.set({key:'keyName', value:'value'}).then(() => {
  console.log("set value");
});
```

https://capacitorjs.com/docs/apis/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

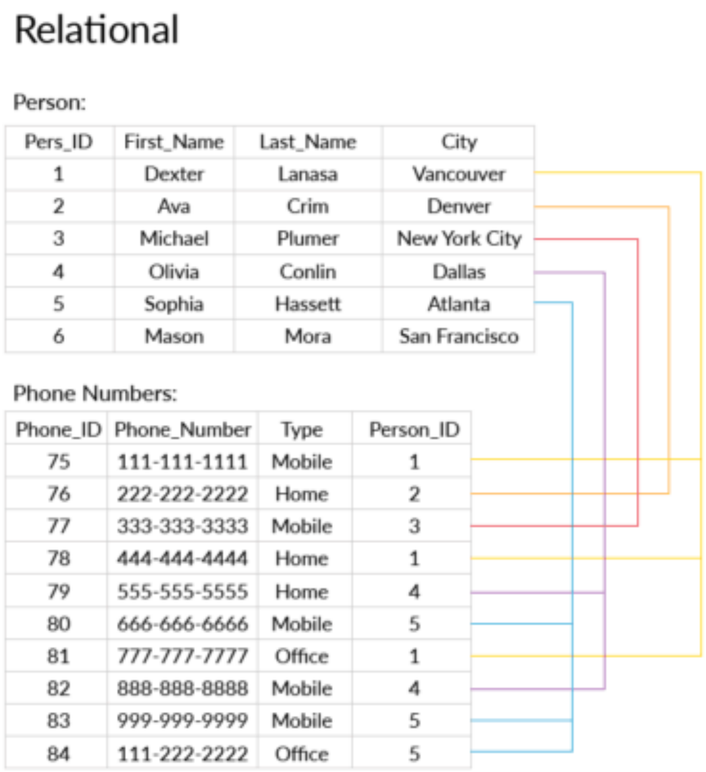
Relational databases

- 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



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

Databases

Relational databases

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

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, ... },
   ]
}
```

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

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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

Question

dbfirst

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

Person:

Pers_ID	First_Name	Last_Name	City
1	Dexter	Lanasa	Vancouver
2	Ava	Crim	Denver
3	Michael	Plumer	New York City
4	Olivia	Conlin	Dallas
5	Sophia	Hassett	Atlanta
6	Mason	Mora	San Francisco

Phone Numbers:

Phone_ID	Phone_Number	Type	Person_ID
75	111-111-1111	Mobile	1
76	222-222-2222	Home	2
77	333-333-3333	Mobile	3
78	444-444-4444	Home	1
79	555-555-5555	Home	4
80	666-666-6666	Mobile	5
81	777-777-7777	Office	1
82	888-888-8888	Mobile	4
83	999-999-9999	Mobile	5
84	111-222-2222	Office	5

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, ... },
    { phone_number: '777-777-7777',
      type: office,
      person_id: 1, ... },
  ]
}
```

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Non-relational

```
{
  first_name: 'Dexter',
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  ]
}
```

Question

dbphone

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

Person:

Pers_ID	First_Name	Last_Name	City
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Non-relational

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  first_name: 'Dexter',
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dbphone

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- **C** They will be about the same
- **D** I'm not sure
- **E** [space intentionally left blank]

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```

Question

dball

Which database structure will be best for retrieving all data?

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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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}
```

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      type: office,
      person_id: 1, ... },
  ]
}
```

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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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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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

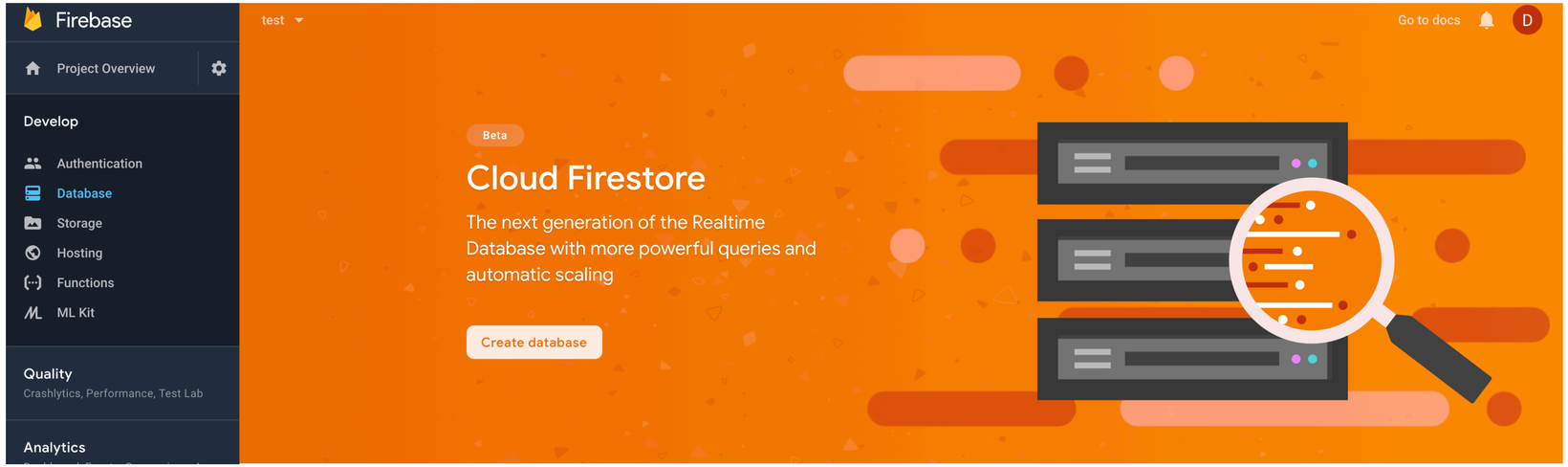
Firebase

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

Firebase

Setting up the database

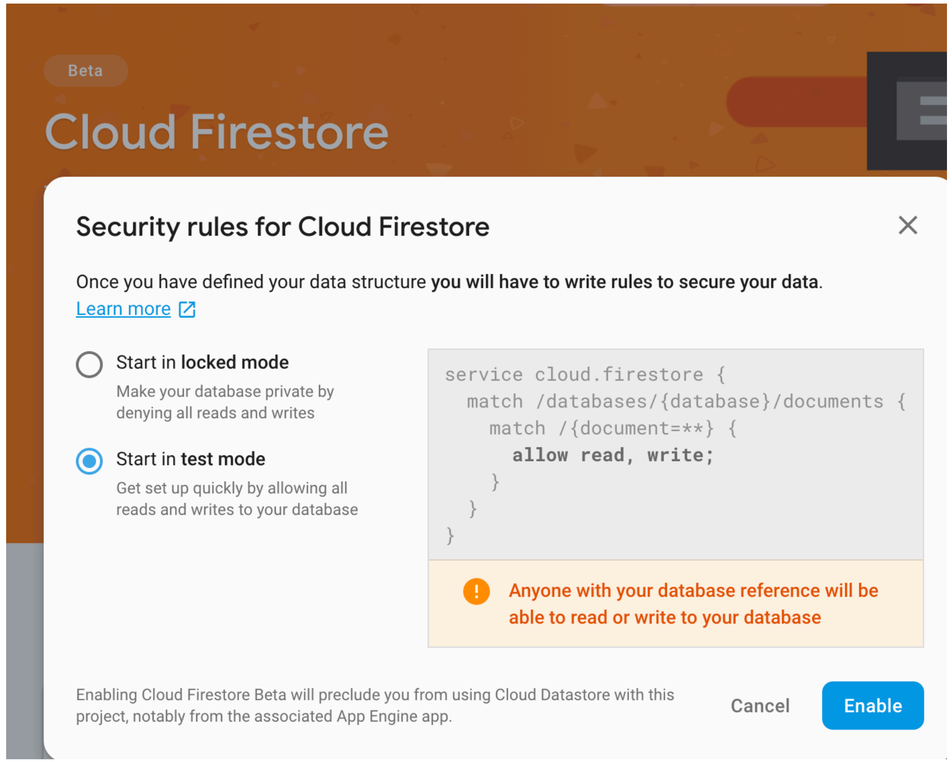
- Create a new project: https://firebase.google.com/
- Create a database



Firebase

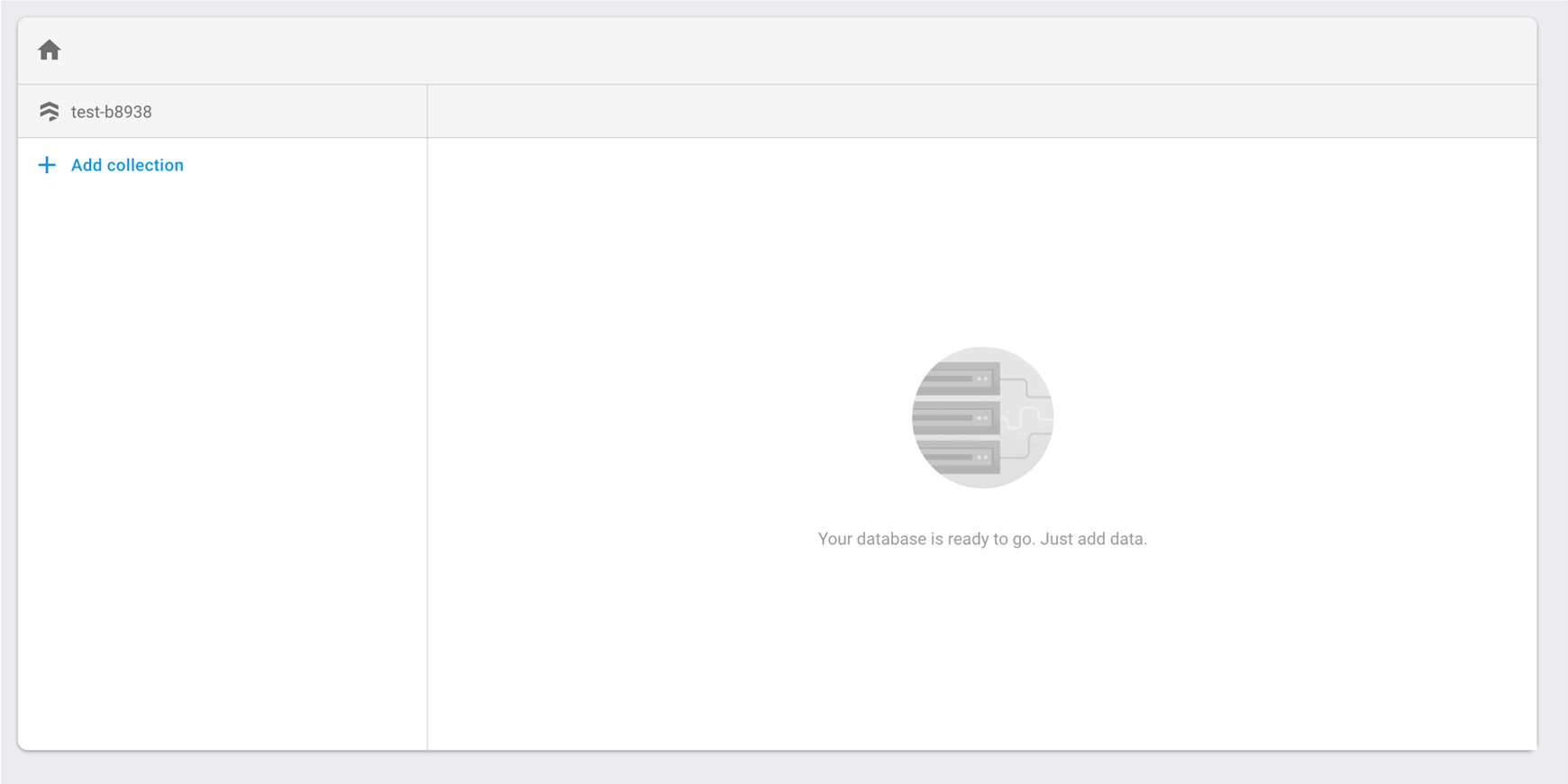
Setting up the database

- 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



Firebase

Setting up the database



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

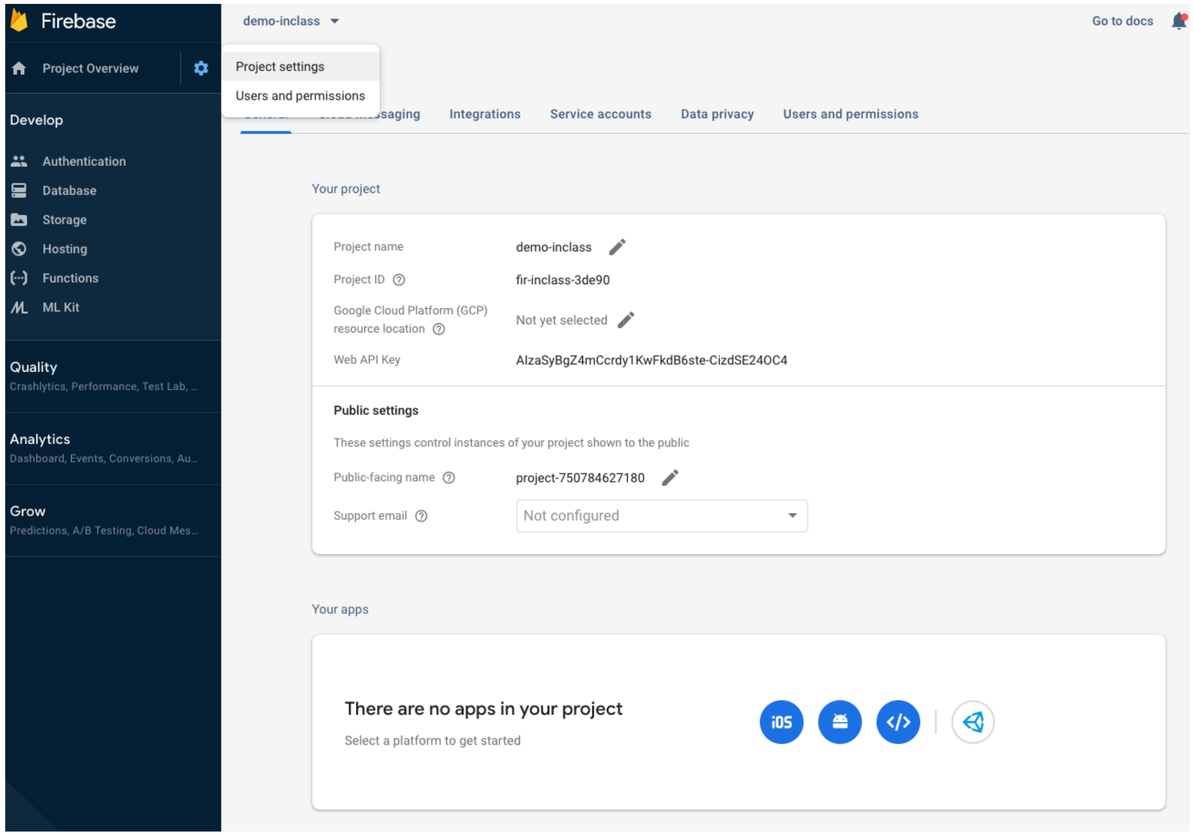
- Angular officially supports a Firebase library
  - It works with Ionic since Ionic builds on Angular
- `ng add @angular/fire`
- Install `firestore`

https://github.com/angular/angularfire

Firebase

Setting up the mobile app

- Command line should walk through
- 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`



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

Firebase

Accessing the database from the mobile app

- `Firestore` is a service and is injected like any other service

```
import { Component } from '@angular/core';
import { Firestore, doc, deleteDoc, setDoc, getDoc } from '@angular/fire/firestore';
import { Observable } from 'rxjs';

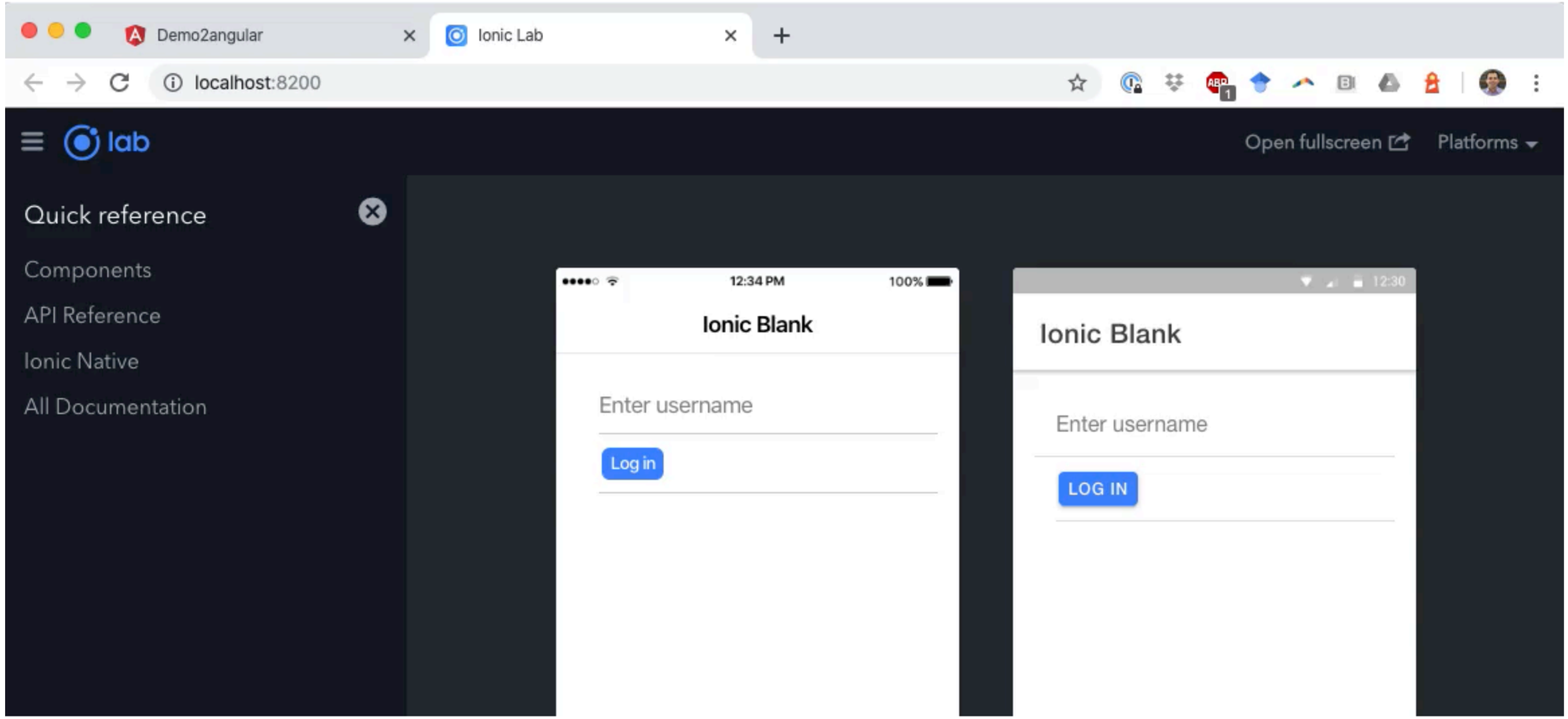
export class HomePage {

  constructor(private db:Firestore) {}

}
```

Firebase

Getting some data



Firebase

Get values

```
getDoc(doc(this.db, 'path')).then((response:any) => {
   var data = response.data();
});
```

Firebase

Add

- New objects can be added asynchronously

```
setDoc(doc(this.db, 'path'), {'key': value}).then(() => {
     console.log('object added');
});
```

Firebase

Delete and Update

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

```
deleteDoc(doc(this.db, 'path')).then(() => {
   console.log('document deleted');
});
```

```
updateDoc(doc(this.db, ‘path'), {'key': value}).then(() => {
   console.log('document updated');
});
```

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);
  }
}
```

Documentation

- AngularFire documentation is unfortunately out of date and inaccurate
- Google’s direct Firestore documentation is more useful
- https://firebase.google.com/docs/firestore

Today’s goals

By the end of today, 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

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