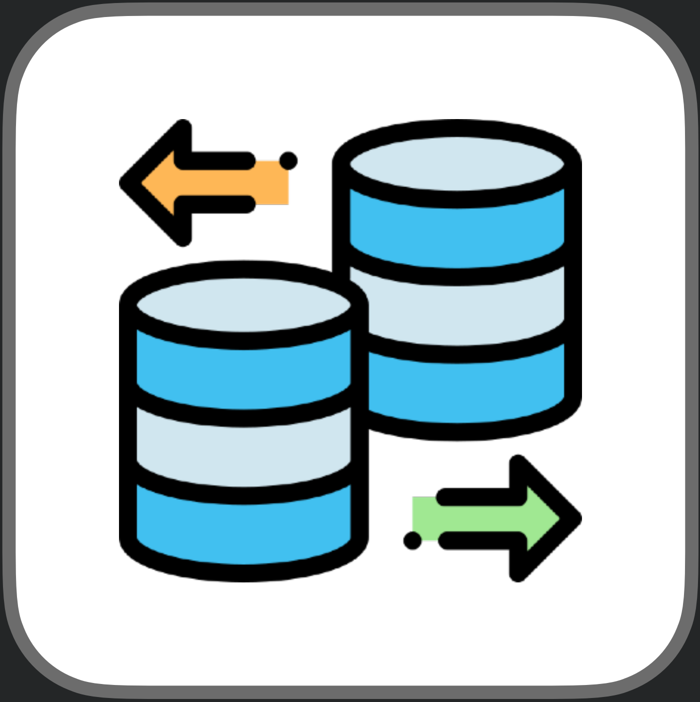
SWE 432 -Web Application Development

Fall 2021

George Mason University

Dr. Kevin Moran

Week 5: Persistence & Microservices



Administrivia

- *Quiz #3* - Grades Available on Blackboard, will discuss in class today

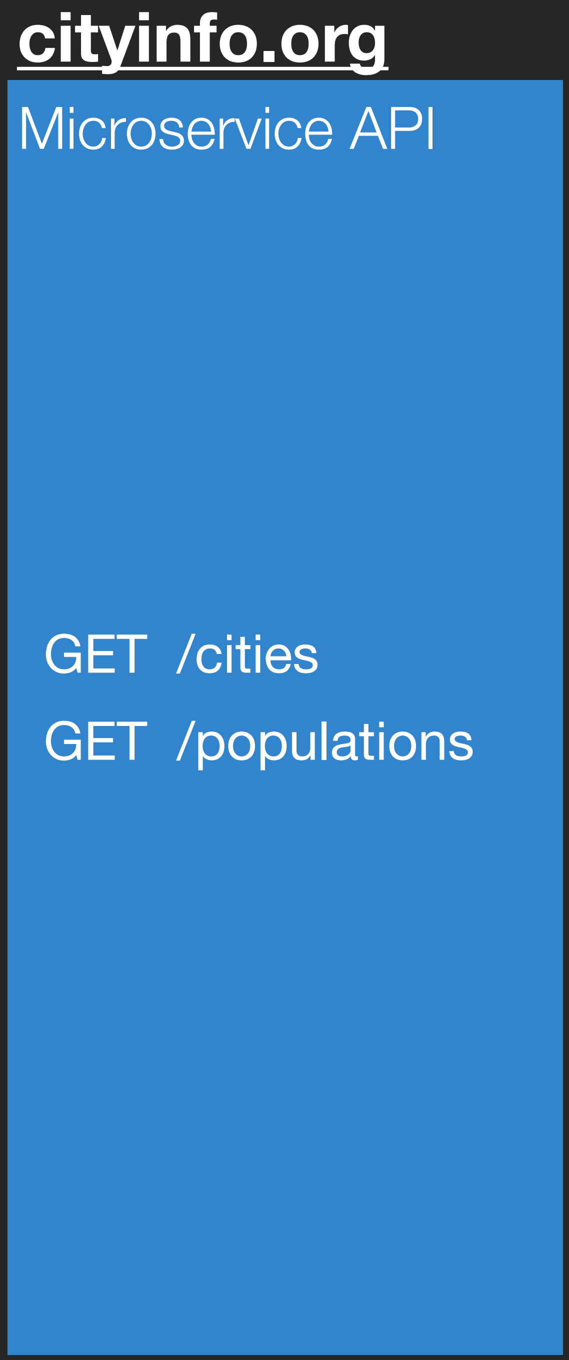
- *HW Assignment 2* - Due September 28th Before Class
  - Sign Up on GitHub Classroom today!!

Class Overview

- *Part 1 - Microservices & Persistence:* Storing and Manipulating Data in Web Applications.
- ***10 minute Break***
- *Part 2 - Even More Microservices:* A Few More Concepts and a Demo

More Microservices

Demo: Building a Microservice w/ Express



cityinfo.org

Microservice API

GET /cities

GET /populations

API: Application Programming Interface

cityinfo.org

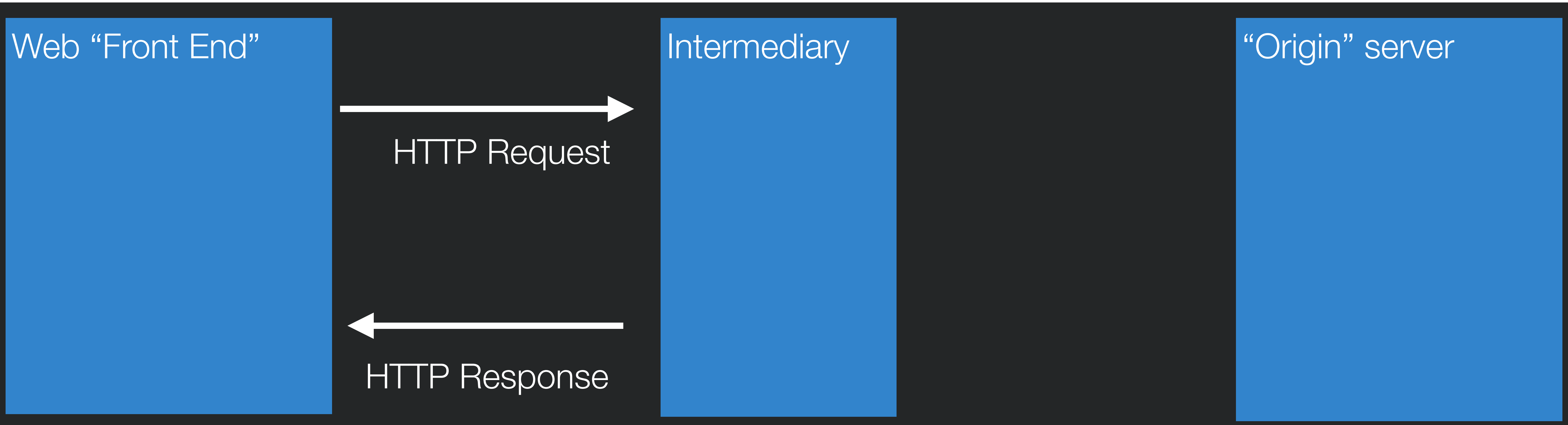
Microservice API

GET /cities

GET /populations

- Microservice offers public **interface** for interacting with backend
  - Offers abstraction that hides implementation details
  - Set of endpoints exposed on micro service
- Users of API might include
  - Frontend of your app
  - Frontend of other apps using your backend
  - Other servers using your service

Intermediaries



Web “Front End”

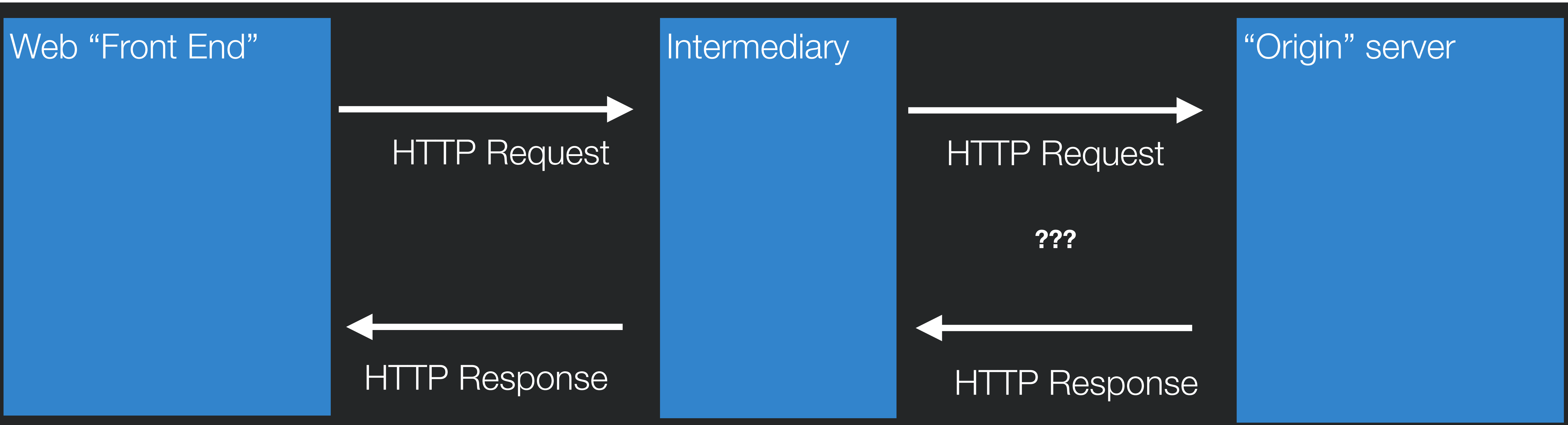
HTTP Request

HTTP Response

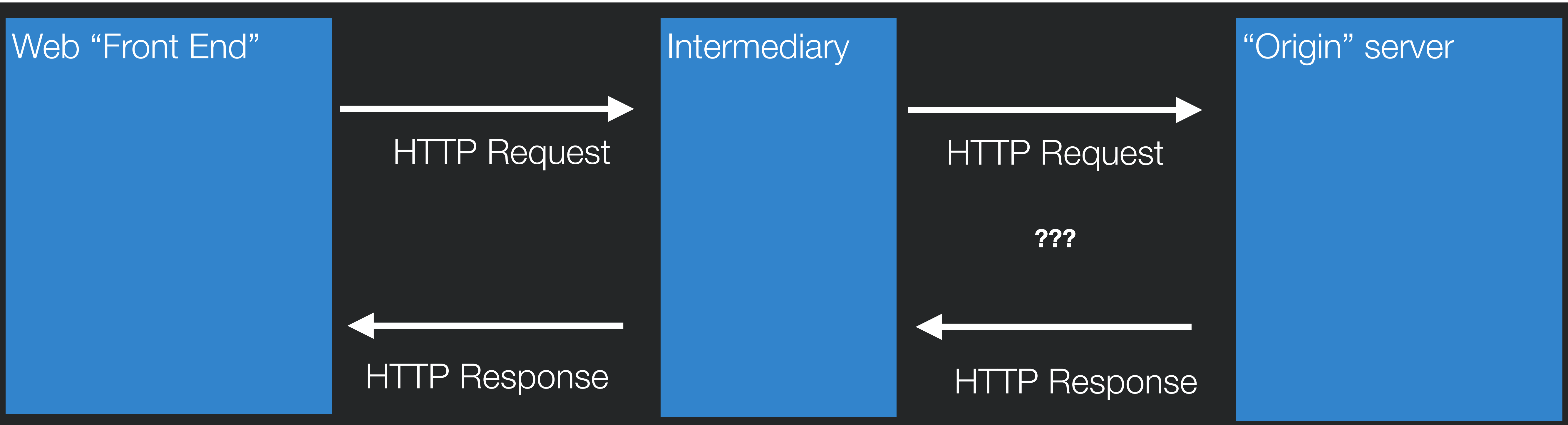
Intermediary

“Origin” server

Intermediaries



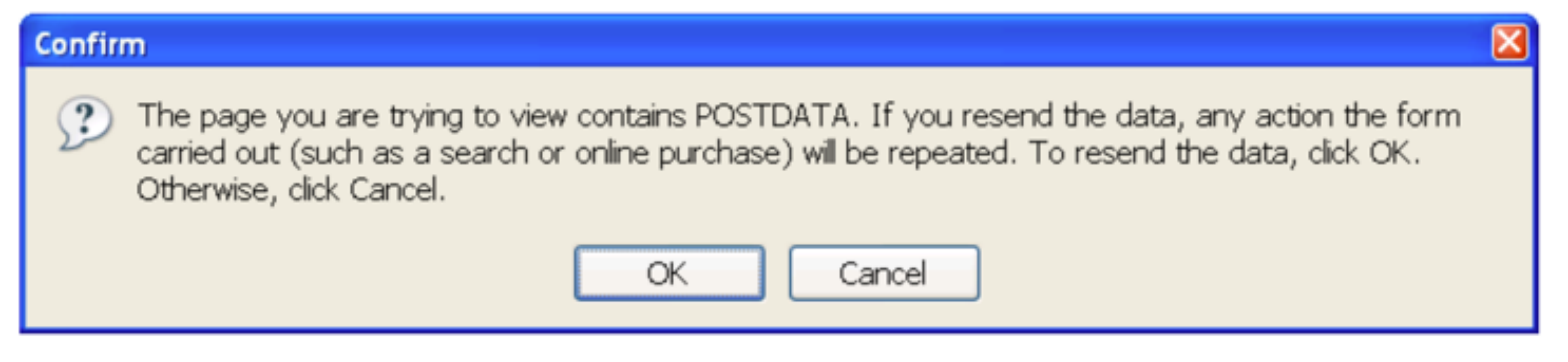
Intermediaries



- Client interacts with a resource identified by a URI
- But it never knows (or cares) whether it interacts with origin server or an unknown intermediary server
  - Might be randomly load balanced to one of many servers
  - Might be cache, so that large file can be stored locally
    - (e.g., GMU caching an OSX update)
  - Might be server checking security and rejecting requests

HTTP Actions

- GET: safe method with no side effects
    - Requests can be intercepted and replaced with cache response
- PUT, DELETE: idempotent method that can be repeated with same result
    - Requests that fail can be retried indefinitely till they succeed
- POST: creates new element
    - Retrying a failed request might create duplicate copies of new resource



Confirm

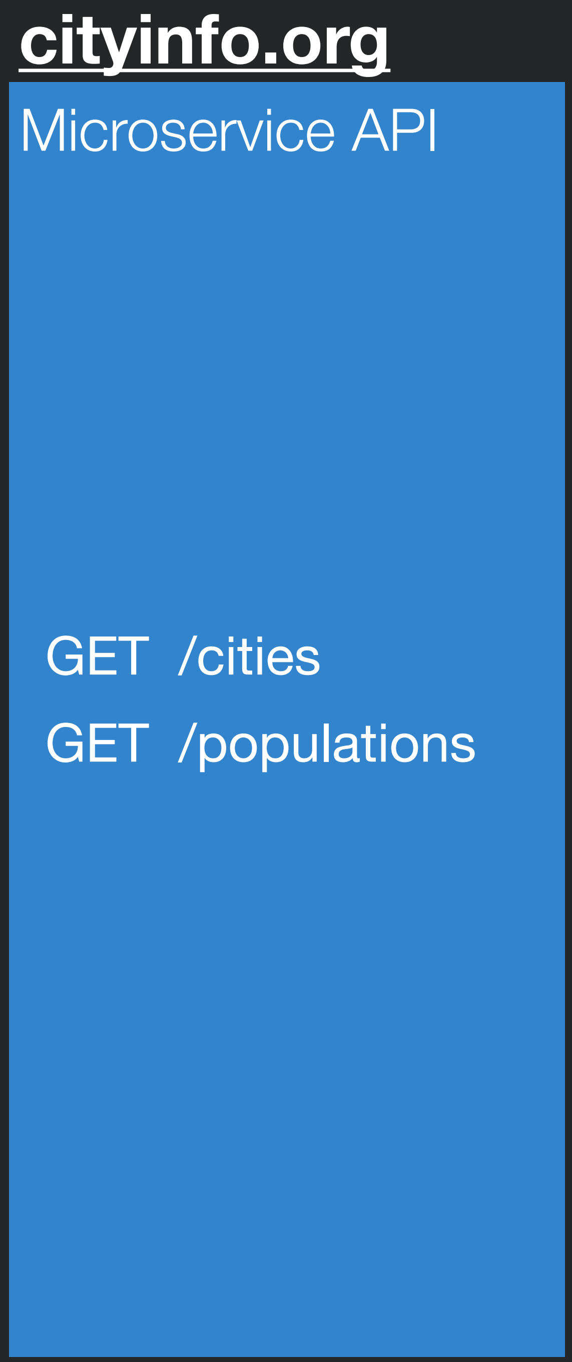
The page you are trying to view contains POSTDATA. If you resend the data, any action the form carried out (such as a search or online purchase) will be repeated. To resend the data, click OK. Otherwise, click Cancel.

Support Scaling

- Yesterday, cityinfo.org had 10 daily active users. Today, it was featured on several news sites and has 10,000 daily active users.

- Yesterday, you were running on a single server. Today, you need more than a single server.

- Can you just add more servers?
  - What should you have done yesterday to make sure you can scale quickly today?



Versioning

- Your web service just added a great new feature!
  - You'd like to expose it in your API.
  - But… there might be old clients (e.g., websites) built using the old API.
    - These websites might be owned by someone else and might not know about the change.
  - Don't want these clients to throw an error whenever they access an updated API.

Cool URIs don’t change

- In theory, URI could last forever, being reused as server is rearchitected, new features are added, or even whole technology stack is replaced.

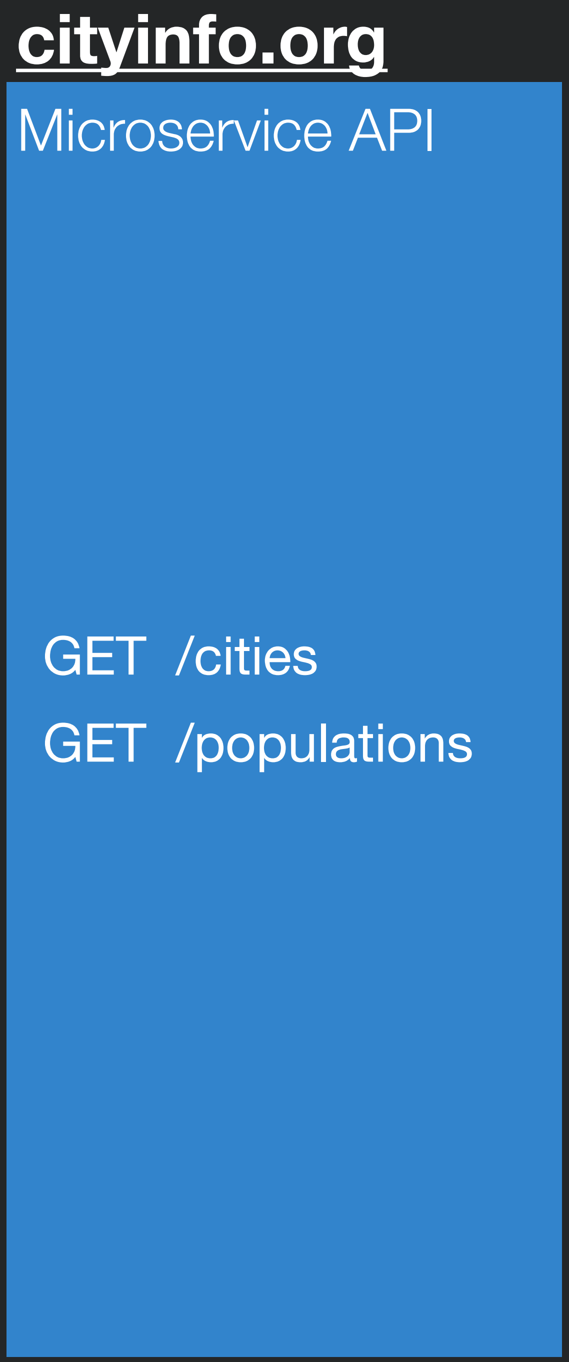
- “What makes a cool URI?
  A cool URI is one which does not change.
  What sorts of URIs change?
  URIs don't change: people change them.”
  - https://www.w3.org/Provider/Style/URI.html
  - Bad:
    - https://www.w3.org/Content/id/50/URI.html (What does this path mean? What if we wanted to change it to mean something else?)
- Why might URIs change?
  - We reorganized our website to make it better.
  - We used to use a cgi script and now we use node.JS.

URI Design

- URIs represent a contract about what resources your server exposes and what can be done with them
- Leave out **anything that might change**
  - Content author names, status of content, other keys that might change
  - File name extensions: response describes content type through MIME header not extension (e.g., .jpg, .mp3, .pdf)
  - Server technology: should not reference technology (e.g., .cfm, .jsp)
- Endeavor to make all changes backwards compatible
  - Add new resources and actions rather than remove old
- If you must change URI structure, support old URI structure **and** new URI structure

Support Change

- Due to your popularity, your backend data provider just backed out of their contract and are now your competitor.
- The data you have is now in a different format.
- Also, you've decided to migrate your backend from PHP to node.js to enable better scaling.
- How do you update your backend without breaking all of your clients?



Support Change

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cityinfo.org

Microservice API

GET /cities.jsp

GET /populations.jsp

Nouns vs. Verbs

- URIs should hierarchically identify **nouns** describing **resources** that exist
- Verbs describing actions that can be taken with resources should be described with an HTTP **action**

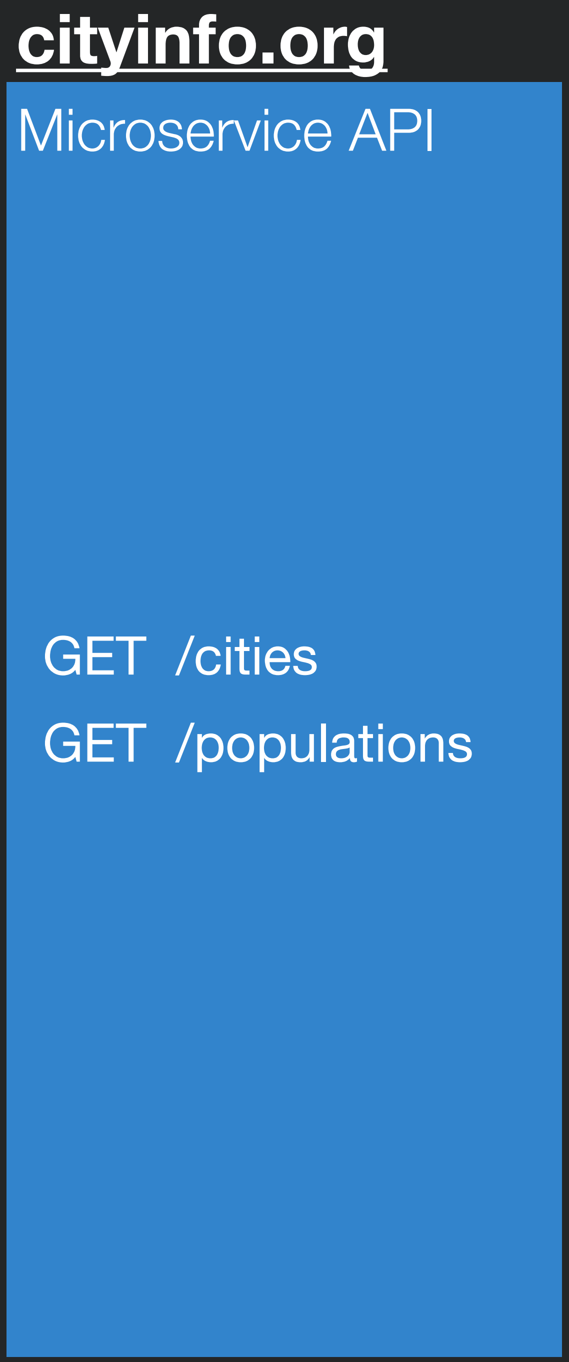
- PUT /cities/:cityID (nouns: cities, :cityID)(verb: PUT)
- GET /cities/:cityID (nouns: cities, :cityID)(verb: GET)

- Want to offer **expressive** abstraction that can be reused for many scenarios

Support Reuse

- You have your own frontend for cityinfo.org. But everyone now wants to build their own sites on top of your city analytics.

- Can they do that?



cityinfo.org

Microservice API

GET /cities

GET /populations

Support Reuse

cityinfo.org

Microservice API

/topCities	GET
/topCities/:cityID/descrip	PUT, GET

/city/:cityID	GET, PUT, POST, DELETE
/city/:cityID/averages	GET
/city/:cityID/weather	GET
/city/:cityID/transitProvders	GET, POST
/city/:cityID/transitProvders/:providerID	GET, PUT, DELETE

What happens when a request has many parameters?

- `/topCities/:cityID/descrip` PUT

- Shouldn't this really be something more like
  - `/topCities/:cityID/descrip/:descriptionText/:submitter/:time/`

Solution 1: Query strings

-
  ```
  var express = require('express');
  var app = express();

  app.put('/topCities/:cityID', function(req, res){
      res.send(`descrip: ${req.query.descrip} submitter: ${req.query.submitter}`);
  });

  app.listen(3000);
  ```

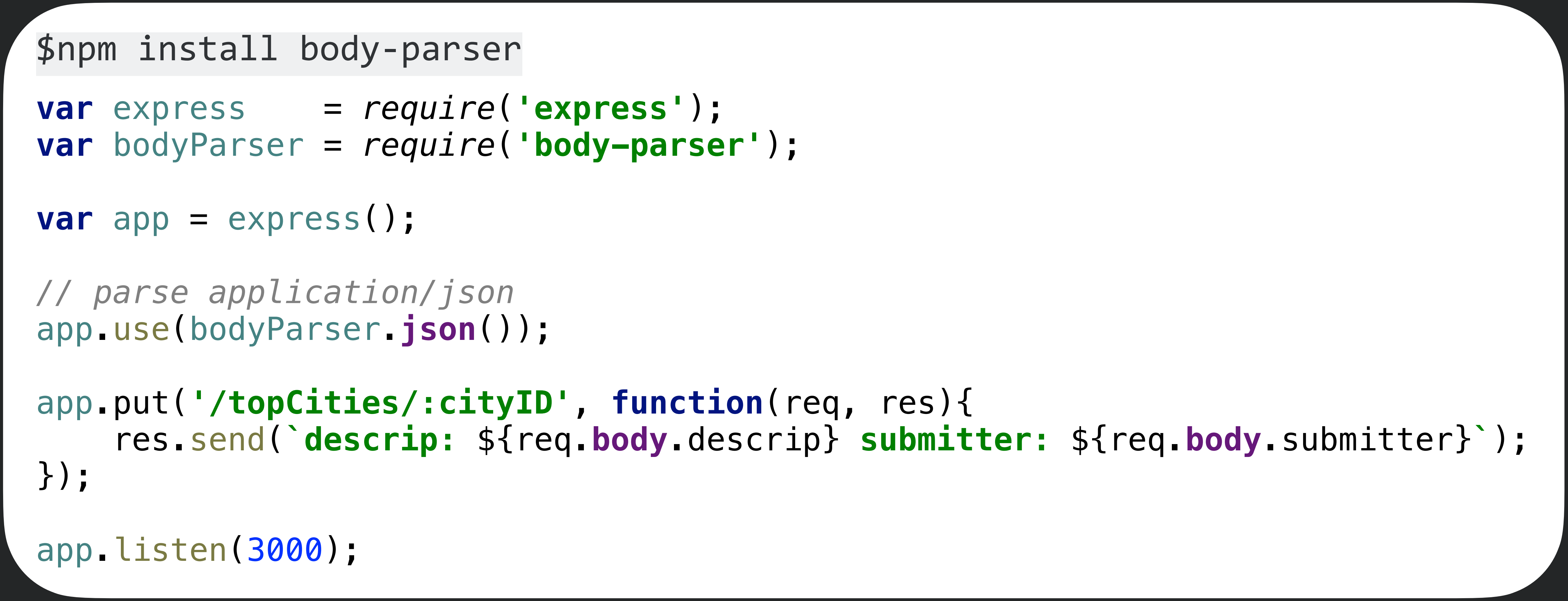
- Use req.query to retrieve
- Shows up in URL string, making it possible to store full URL
  - e.g., user adds a bookmark to URL
- Sometimes works well for short params

Solution 2: JSON Request Body

- PUT /topCities/Memphis
  { "descrip": "Memphis is a city of ...",
    "submitter": "Dan", "time": 1025313 }

- Best solution for all but the simplest parameters (and often times everything)

- Use body-parser package and req.body to retrieve



```
$npm install body-parser

var express    = require('express');
var bodyParser = require('body-parser');

var app = express();

// parse application/json
app.use(bodyParser.json());

app.put('/topCities/:cityID', function(req, res){
    res.send(`descrip: ${req.body.descrip} submitter: ${req.body.submitter}`);
});

app.listen(3000);
```

https://www.npmjs.com/package/body-parser

Data Persistence

Persistence

- The user sent you some data.
- You retrieved some data from a 3rd party servcie.
- You generated some data, which you want to keep reusing.

- Where and how could you store this?

What forms of data might you have

- Key / value pairs
- JSON objects
- Tabular arrays of data
- Files

Options for backend persistence

- Where it is stored
  - On your server or another server you own
    - SQL databases, NoSQL databases
    - File system
  - Storage provider (not on a server you own)
    - NoSQL databases
    - BLOB store

Storing state in a global variable

- **Global variables**

```
var express = require('express');
var app = express();
var port = process.env.port || 3000;

[redacted]
app.get('/', function (req, res) {
    [redacted]Hello World has been said ' + counter + ' times!');
    counter++;
});

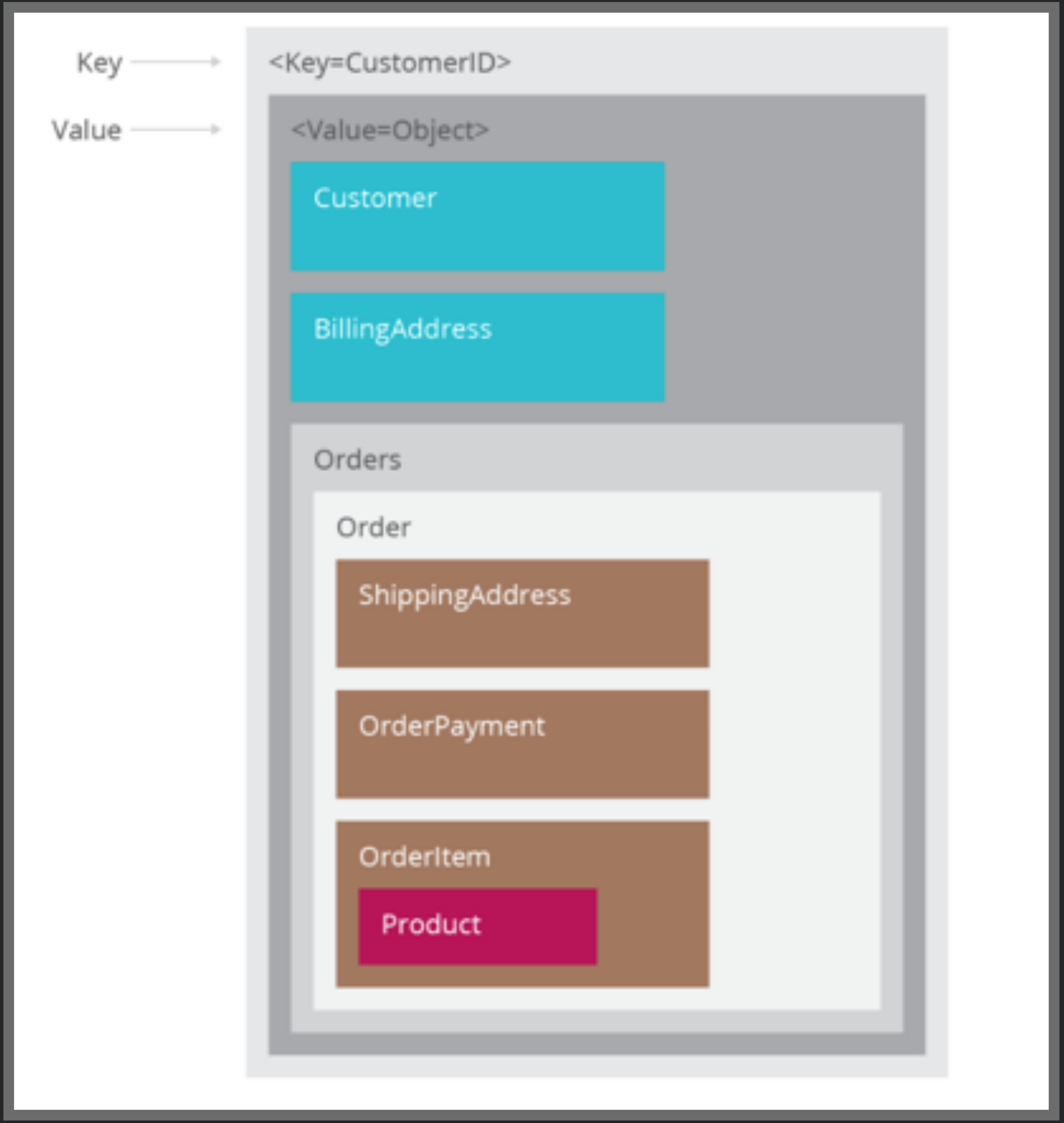
app.listen(port, function () {
    console.log('Example app listening on port' + port);
});
```

- Pros/cons?
  - Keep data between requests
  - **Goes away** when your server stops
    - Should use for transient state or as cache

NoSQL

- ***non SQL***, non-relational, "not only" SQL databases
- Emphasizes ***simplicity*** & scalability over support for relational queries
- Important characteristics
  - Schema-less: each row in dataset can have different fields (just like JSON!)
  - Non-relational: no structure linking tables together or queries to "join" tables
  - (Often) weaker consistency: after a field is updated, all clients *eventually* see the update but may see older data in the meantime
- Advantages: greater scalability, faster, simplicity, easier integration with code
- Several types. We'll look only at key-value.

Key-Value NoSQL



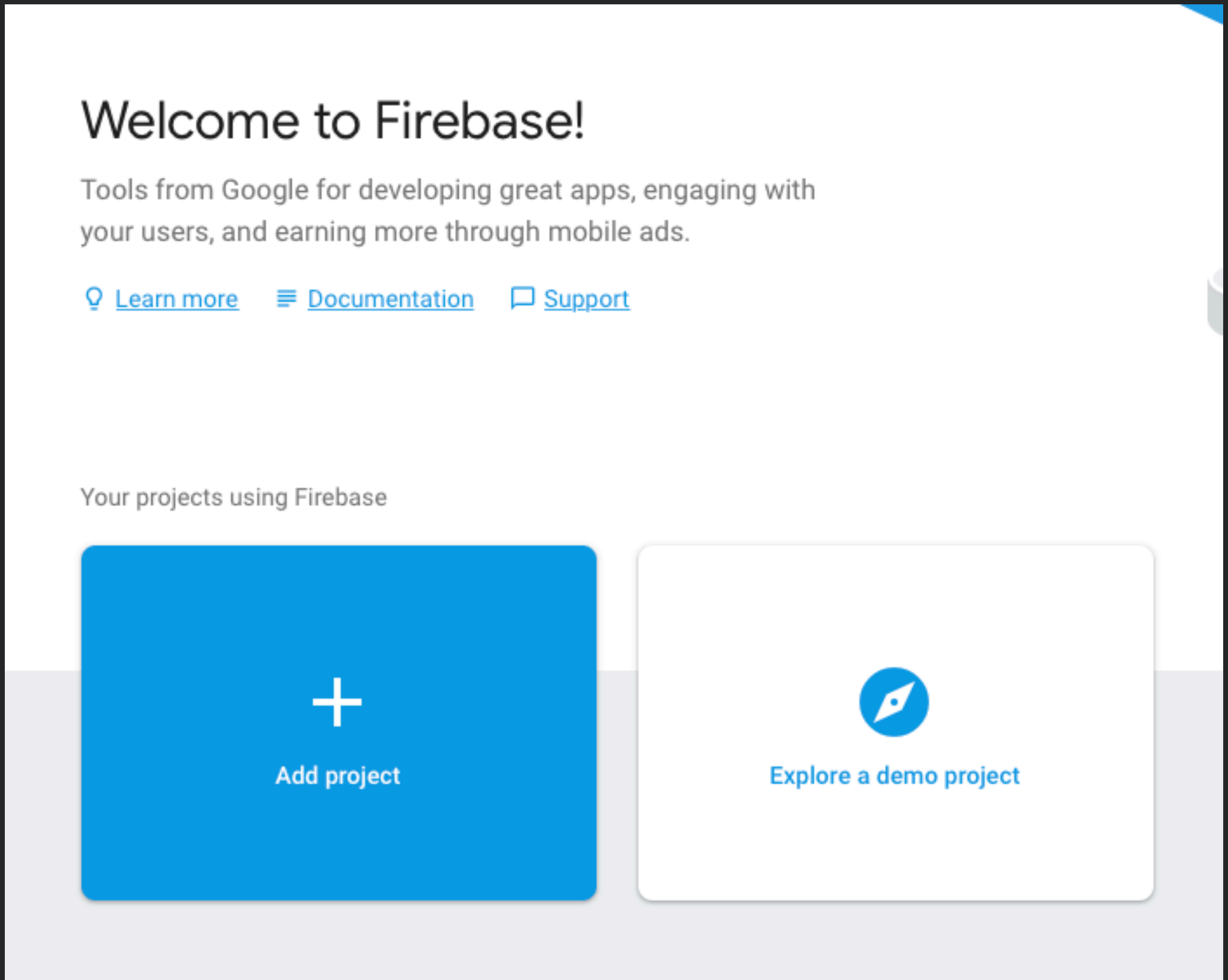
https://www.thoughtworks.com/insights/blog/nosql-databases-overview

Firebase Cloud Firestore

- Example of a NoSQL datastore
- Google web service
    - https://firebase.google.com/docs/firestore/
- “Realtime” database
    - Data stored to remote web service
    - Data synchronized to clients in real time
- Simple API
    - Offers library wrapping HTTP requests & responses
    - Handles synchronization of data
- Can also be used on frontend to build web apps with persistence without backend

Setting up Firebase Cloud Firestore

- Detailed instructions to create project, get API key
  - https://firebase.google.com/docs/firestore/quickstart



Welcome to Firebase!

Tools from Google for developing great apps, engaging with your users, and earning more through mobile ads.

Your projects using Firebase

Setting up Firebase Realtime Database

- Go to https://console.firebase.google.com/, create a new project
- Install firebase module `npm install firebase-admin --save`
  - Go to IAM & admin > Service accounts, create a new private key, save the file.
  - Include Firebase in your web app

```
const admin = require('firebase-admin');

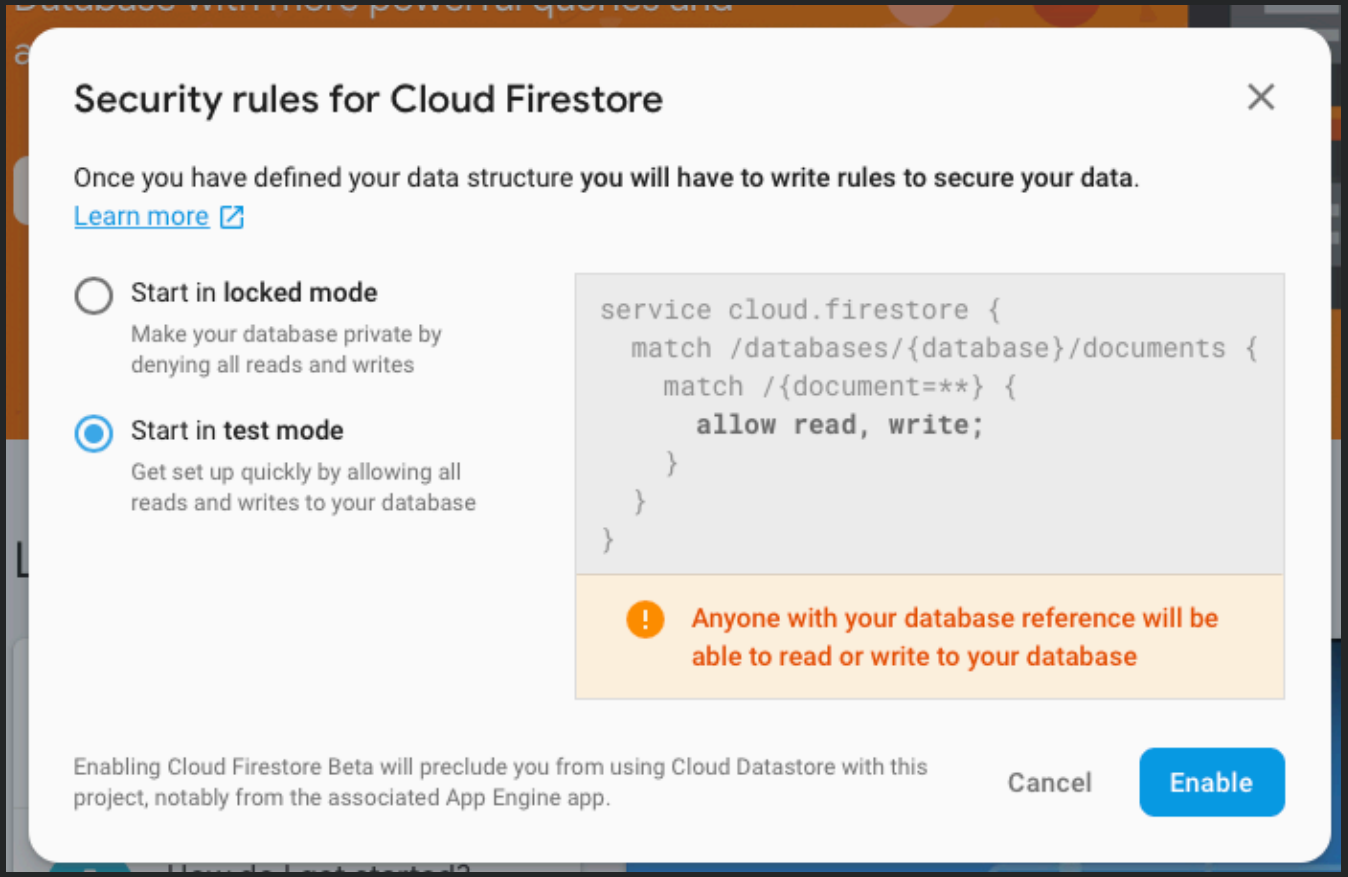
let serviceAccount = require('path/to/serviceAccountKey.json');

admin.initializeApp({
  credential: admin.credential.cert(serviceAccount)
});

let db = admin.firestore();
```

Permissions

- “Test mode” - anyone who has your app can read/write all data in your database
    - Good for development, bad for real world
- “Locked mode” - do not allow everyone to read/write data
    - Best solution, but requires learning how to configure security



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;
    }
  }
}
```

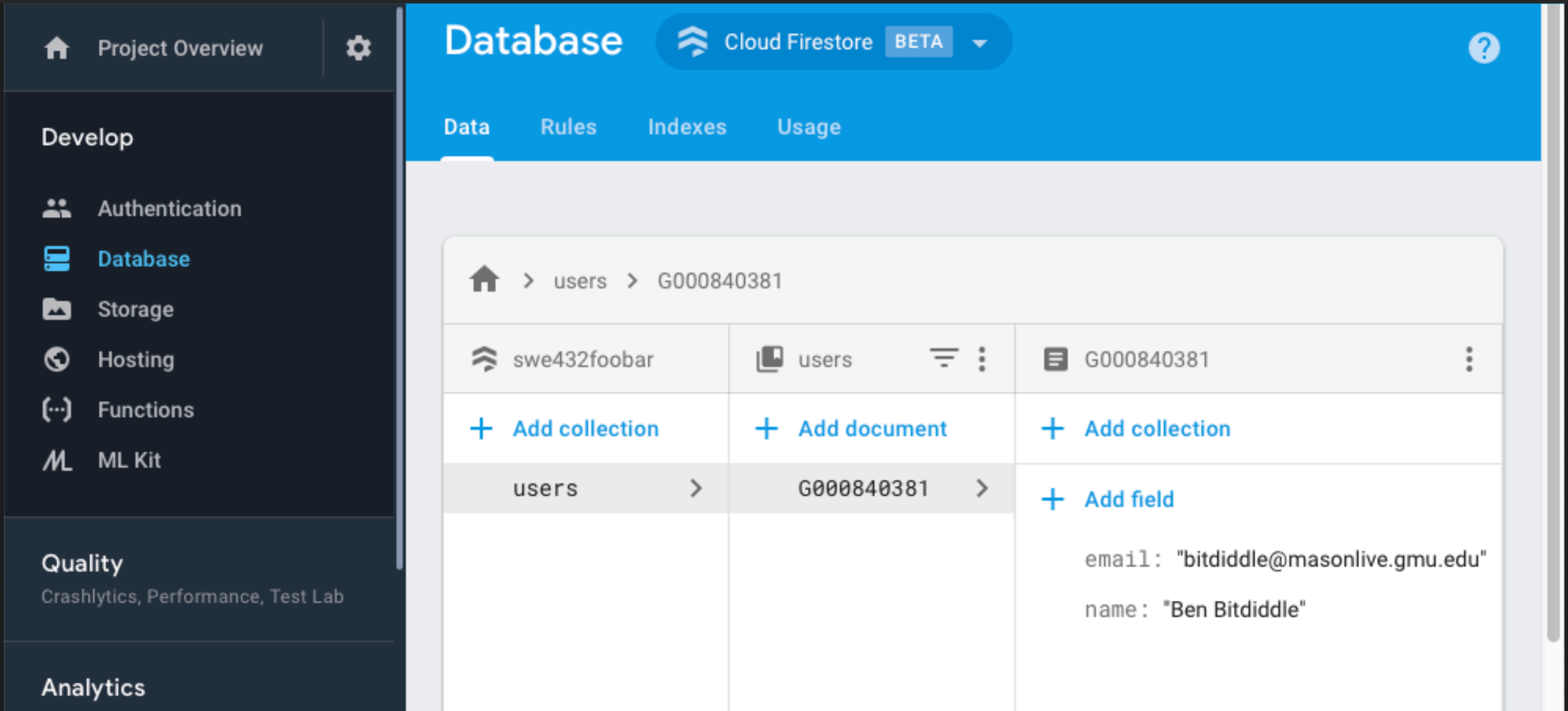
Anyone with your database reference will be able to read or write to your database

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

Firebase Console

- See data values, updated in realtime
- Can edit data values

https://console.firebase.google.com



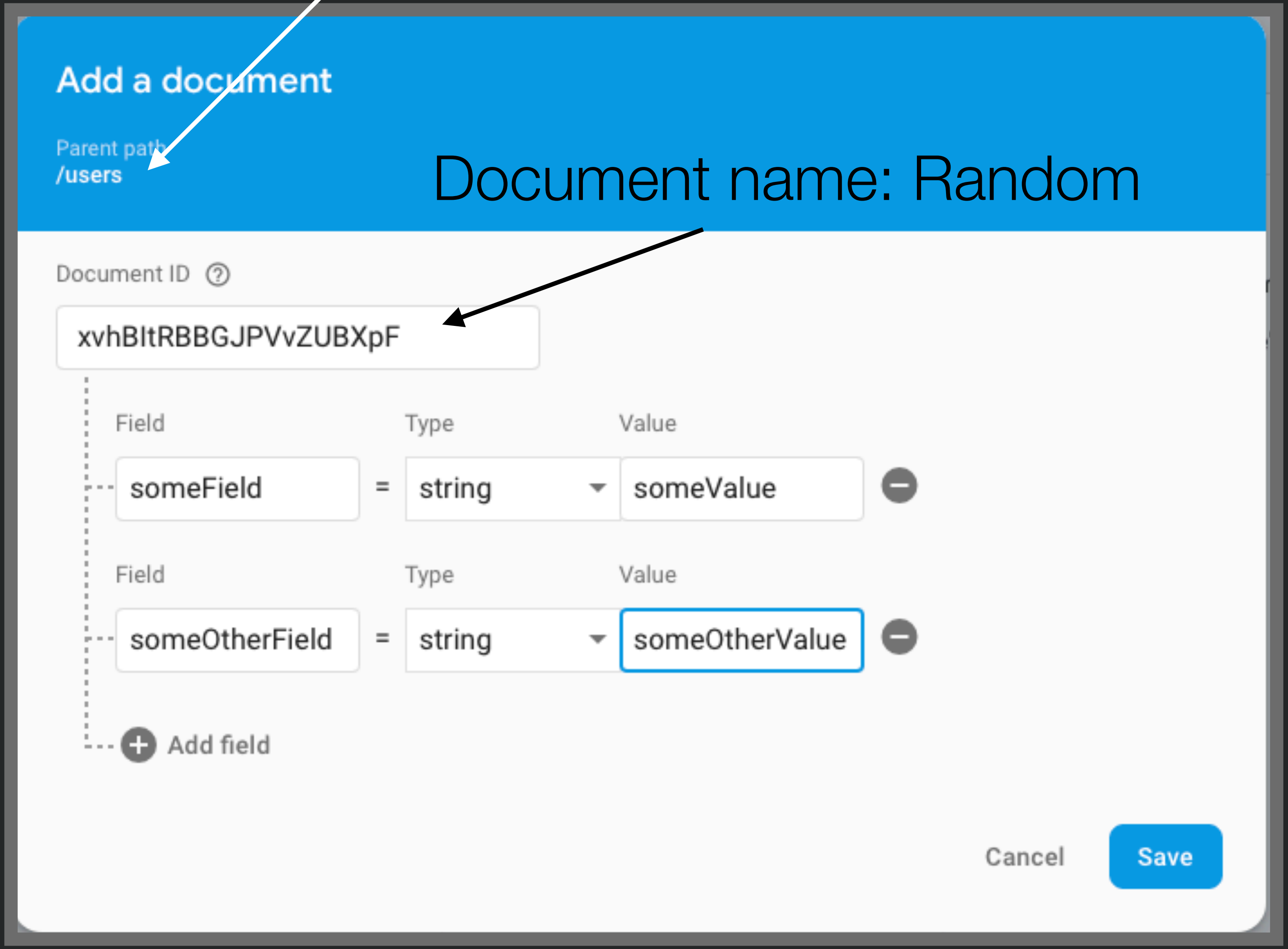
email: "bitdiddle@masonlive.gmu.edu"

name: "Ben Bitdiddle"

Firebase Data Model: JSON

- **Collections** of JSON documents
  - Hierarchic tree of key/value pairs
  - Can view as one big object
  - Or describe path to descendent and view descendent as object

Collection: users



Document name: Random

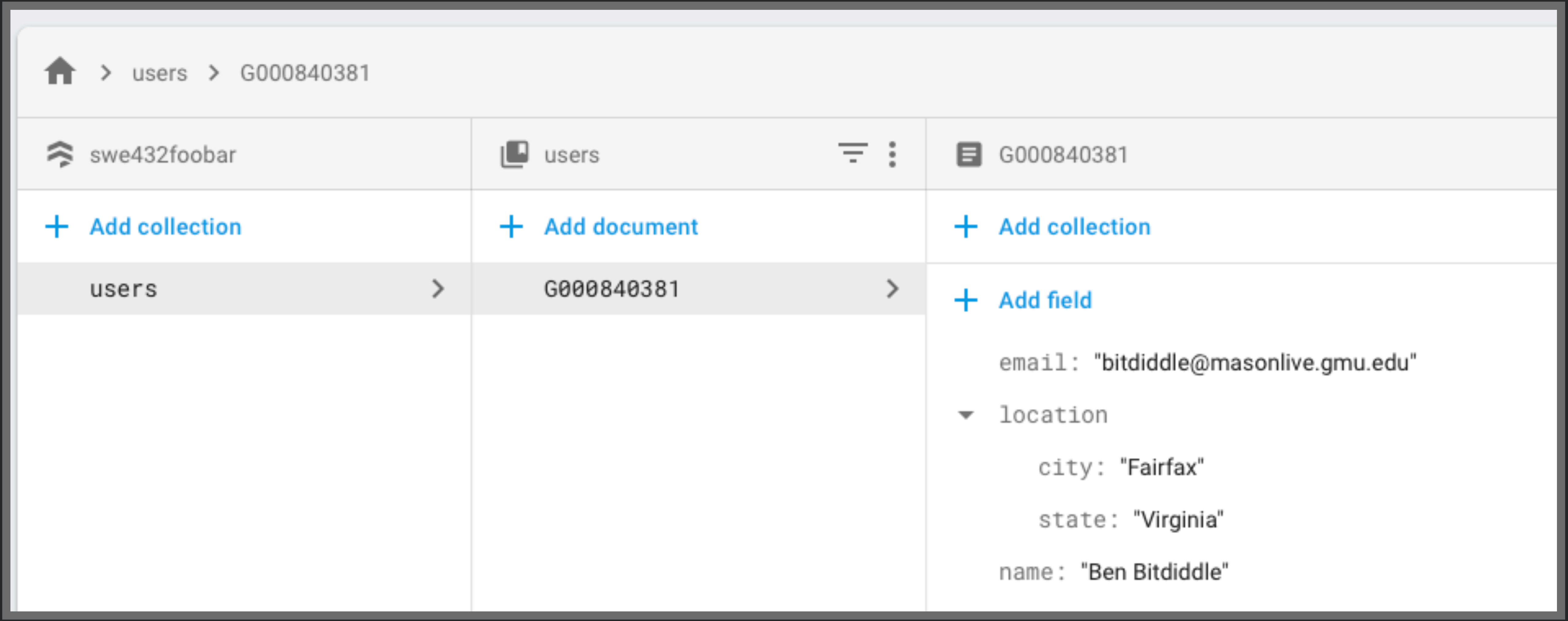
Add a document

Parent path
/users

Document ID
xvhBItRBBGJPVvZUBXpF

Field		Type	Value
someField	=	string	someValue
someOtherField	=	string	someOtherValue

JSON is JSON…



email: "bitdiddle@masonlive.gmu.edu"

location

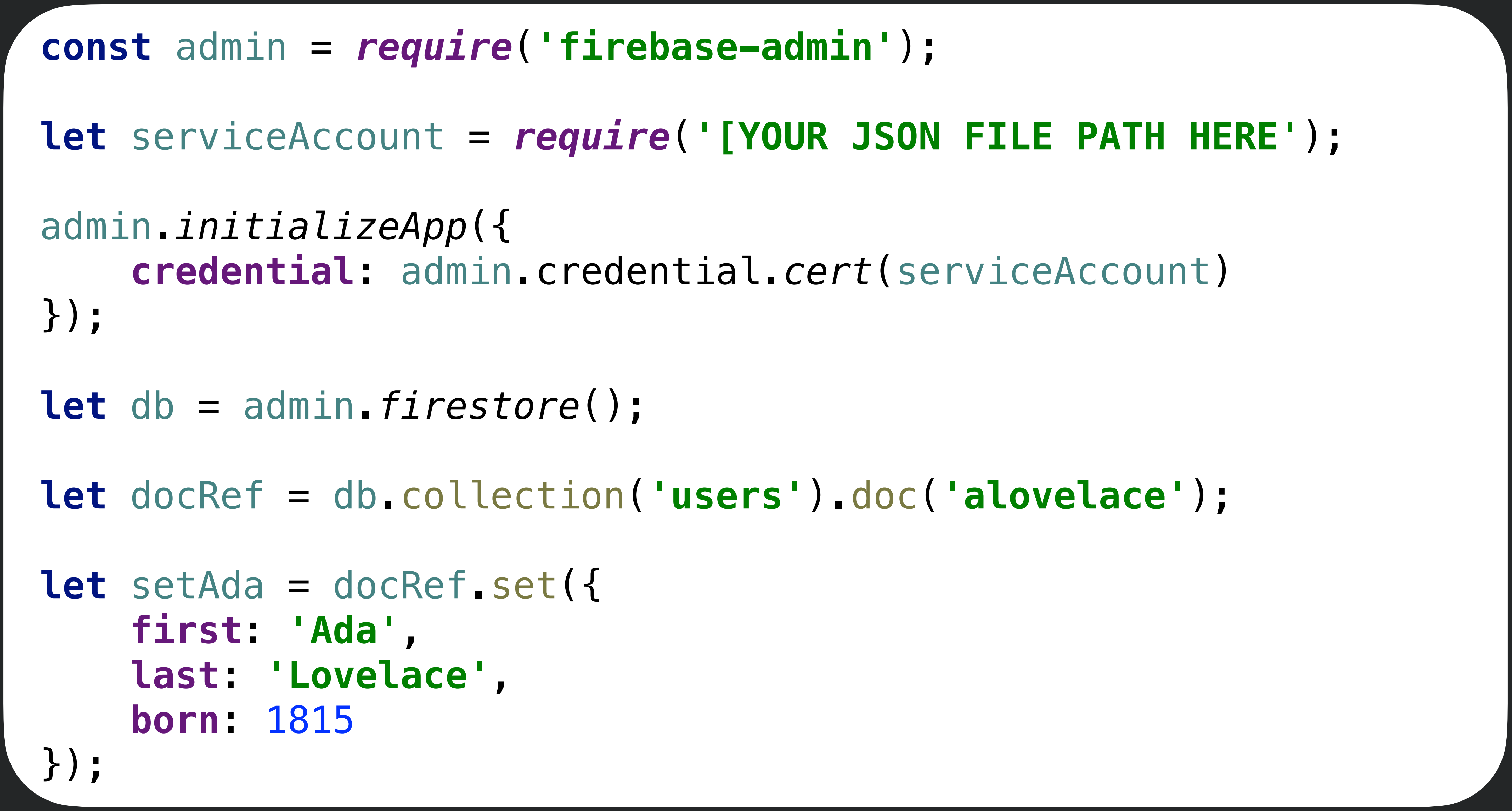
city: "Fairfax"

state: "Virginia"

name: "Ben Bitdiddle"

Demo: Simple Test Program

- After successfully completing previous steps, should be able to replace config and run this script. Can test by viewing data on console.



```
const admin = require('firebase-admin');

let serviceAccount = require('[YOUR JSON FILE PATH HERE']);

admin.initializeApp({
    credential: admin.credential.cert(serviceAccount)
});

let db = admin.firestore();

let docRef = db.collection('users').doc('alovelace');

let setAda = docRef.set({
    first: 'Ada',
    last: 'Lovelace',
    born: 1815
});
```

Structuring Data

- I want to build a chat app with a database
- App has chat rooms: each room has some users in it, and messages
- How should I store this data in Firebase? What are the collections and documents?

Structuring Data

- Should be considering what types of records clients will be requesting.
  - Do not want to force client to download data that do not need.
- Better to think of structure as **lists** of data that clients will retrieve

Storing Data: Set

```
async function writeUserData(userID, newName, newEmail) {
    return database.collection("users").doc(userID).set({
        name: newName,
        email: newEmail
    });
}
```

Storing Data: Set

(because firebase is asynchronous)

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async function writeUserData(userID, newName, newEmail) {
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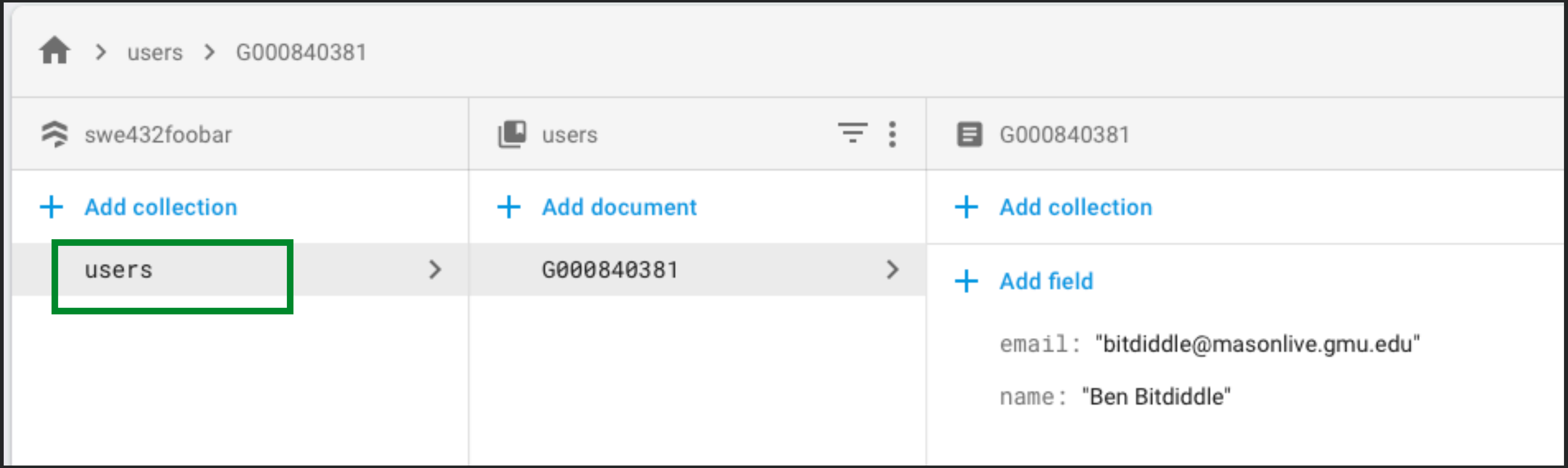
```

Get the users collection



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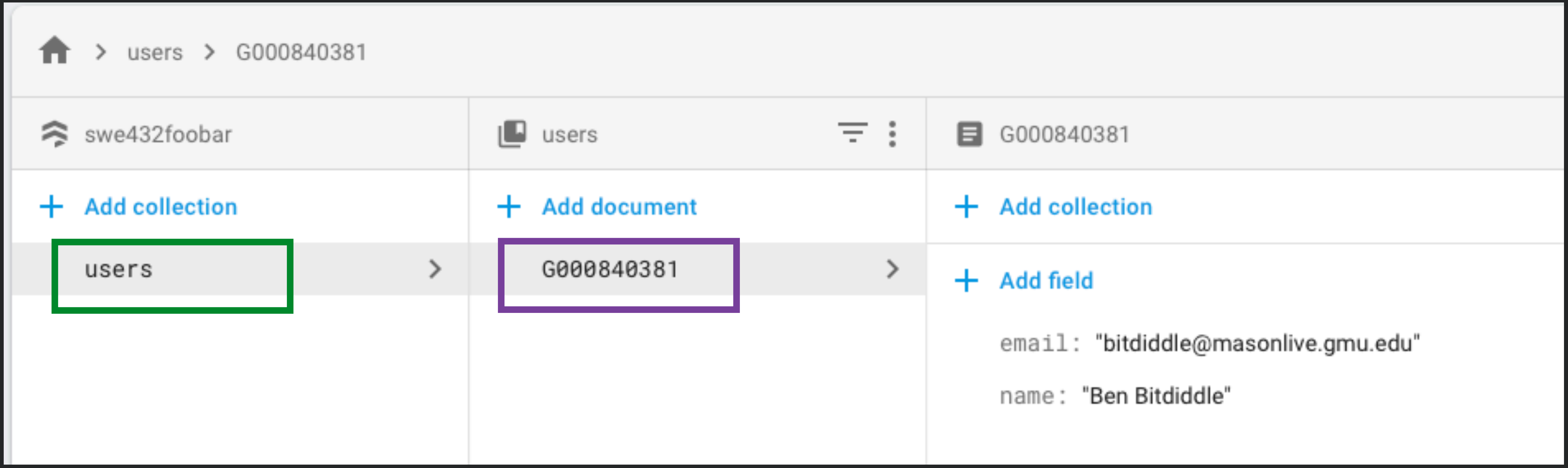
```

Create this one user by ID

Get the users collection



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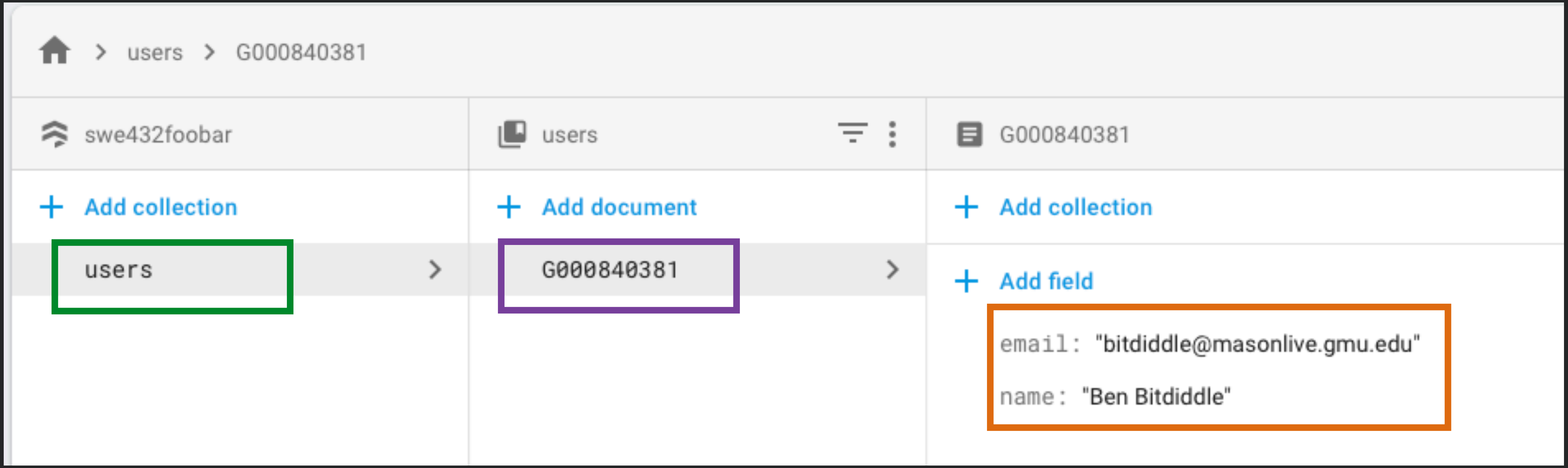
Get the users collection

Create this one user by ID

Set the val



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Storing Data: Add

- Where does this ID come from?
    - It MUST be unique to the document
- Sometimes easier to let Firebase manage the IDs for you - it will create a new one uniquely automatically

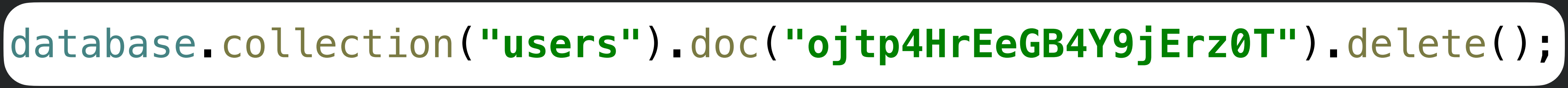
```
async function addNewUser(newName, newEmail) {
    return database.collection("users").add({
        name: newName,
        email: newEmail
    });
}
async function demo(){
   let ref = await addNewUser("Foo Bar","fbar@gmu.edu")
    console.log("Added user ID " + ref.id)
}
```

Storing Data: Update

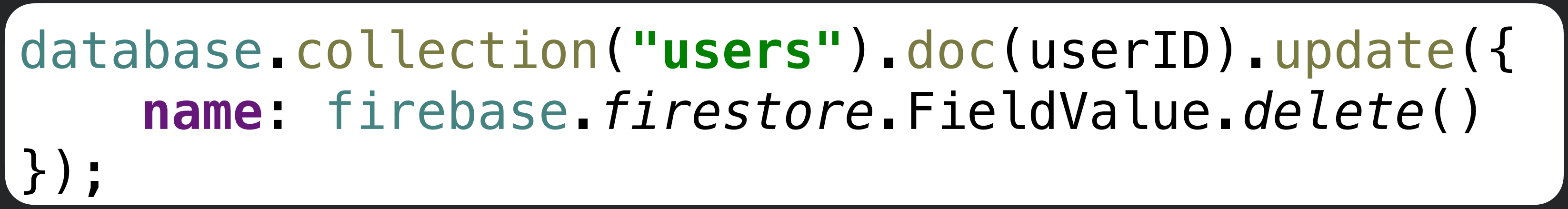
- Can either use “set” (with {merge:true}) or “update” to update an existing document (set will possibly create the document if it doesn’t exist)

```
database.collection("users").doc(userID).update({
    name: newName
});
```

Storing Data: Delete



```
database.collection("users").doc("ojtp4HrEeGB4Y9jErz0T").delete();
```



```
database.collection("users").doc(userID).update({
    name: firebase.firestore.FieldValue.delete()
});
```

- Can delete a key by setting value to null
    - If you want to store null, first need to convert value to something else (e.g., 0, '')

Storing Data: Delete

```
database.collection("users").doc("ojtp4HrEeGB4Y9jErz0T").delete();
```

Removes a document

```
database.collection("users").doc(userID).update({
    name: firebase.firestore.FieldValue.delete()
});
```

Removes a field

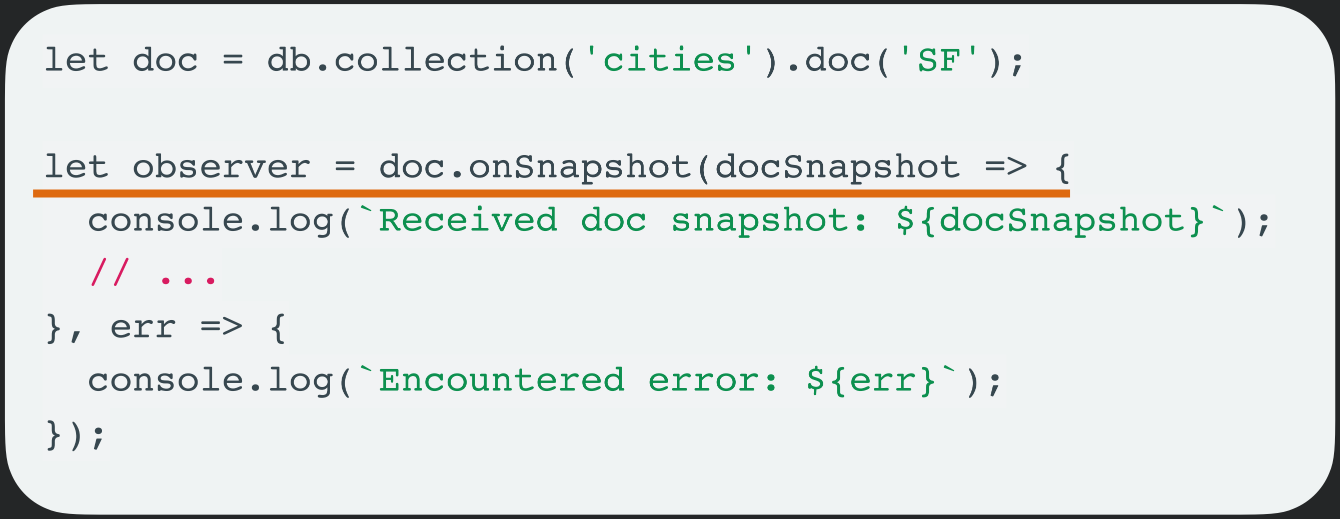
- Can delete a key by setting value to null
  - If you want to store null, first need to convert value to something else (e.g., 0, '')

Fetching Data (One Time)

```
async function getUser(userId){
    return database.collection("users").doc(userId).get();
}
async function demo(){
   let user = await getUser("G000840381");
    console.log(user.data());
}
```

Can also call get directly on the collection

Listening to Data Changes

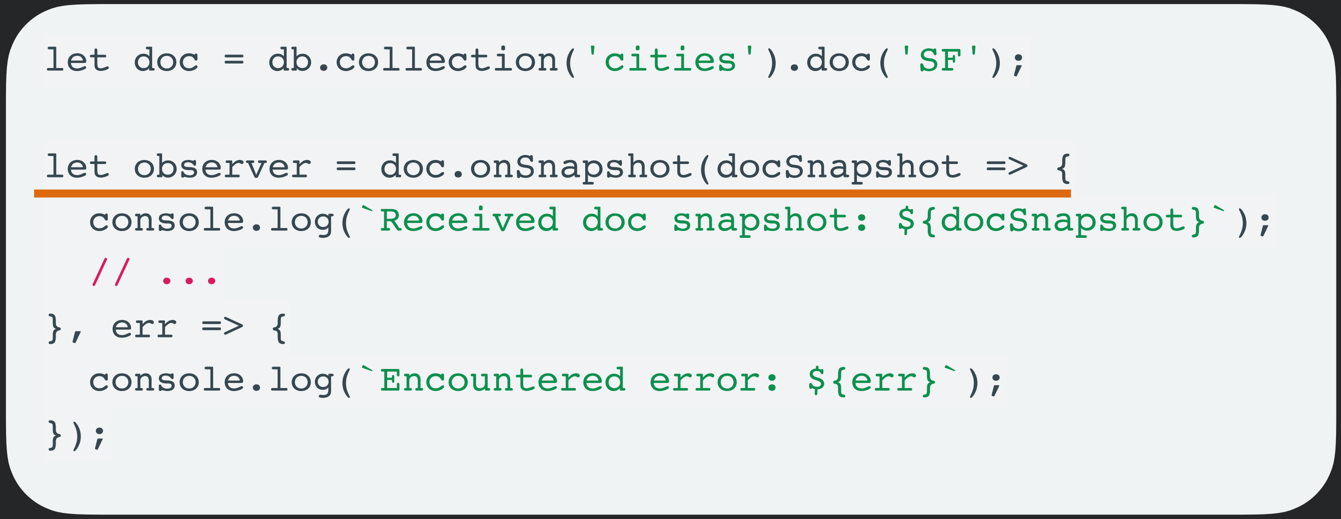


```
let doc = db.collection('cities').doc('SF');

let observer = doc.onSnapshot(docSnapshot => {
  console.log(`Received doc snapshot: ${docSnapshot}`);
  // ...
}, err => {
  console.log(`Encountered error: ${err}`);
});
```

- Read data by *listening* to changes to specific subtrees
- Events will be generated for initial values and then for each subsequent update

Listening to Data Changes



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let observer = doc.onSnapshot(docSnapshot => {
  console.log(`Received doc snapshot: ${docSnapshot}`);
  // ...
}, err => {
  console.log(`Encountered error: ${err}`);
});
```

“When values changes, invoke function”

Specify a subtree by creating a reference to a path. This listener will be called until you cancel it

- Read data by *listening* to changes to specific subtrees
- Events will be generated for initial values and then for each subsequent update

Ordering data

- Data is by, default, ordered by document ID in ascending order
  - e.g., numeric index IDs are ordered from 0…n
  - e.g., alphanumeric IDs are ordered in alphanumeric order
- Can get only first (or last) n elements

```
let firstThree = citiesRef.orderBy('name').limit(3);
```

- Can use where statements to query

```
citiesRef.where('population', '>', 2500000).orderBy('population');
```

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Instructor:
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Teaching Assistant:
David Gonzalez Samudio

Class will start in:

10:00

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Even More Microservices!

Blobs: Storing uploaded files

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- Example: User uploads picture

Blobs: Storing uploaded files

- Example: User uploads picture
  - … and then?

Blobs: Storing uploaded files

- Example: User uploads picture
  - … and then?
  - … somehow process the file?

How do we store our files?

- Dealing with text is easy - we already figured out firebase
  - Could use other databases too… but that's another class!
- But
  - What about pictures?
  - What about movies?
  - What about big huge text files?
- Aka…Binary Large OBject (BLOB)
  - Collection of binary data stored as a single entity
  - Generic terms for an entity that is array of bytes

Working with Blobs

- Module: multer

- Simplest case: take a file, save it on the server

```
app.post('/upload',upload.single("upload"), function(req, res) {
        var sampleFile = req.file.filename;
      //sampleFile is the name of the file that now is living on our server
        res.send('File uploaded!');
    });
});
```

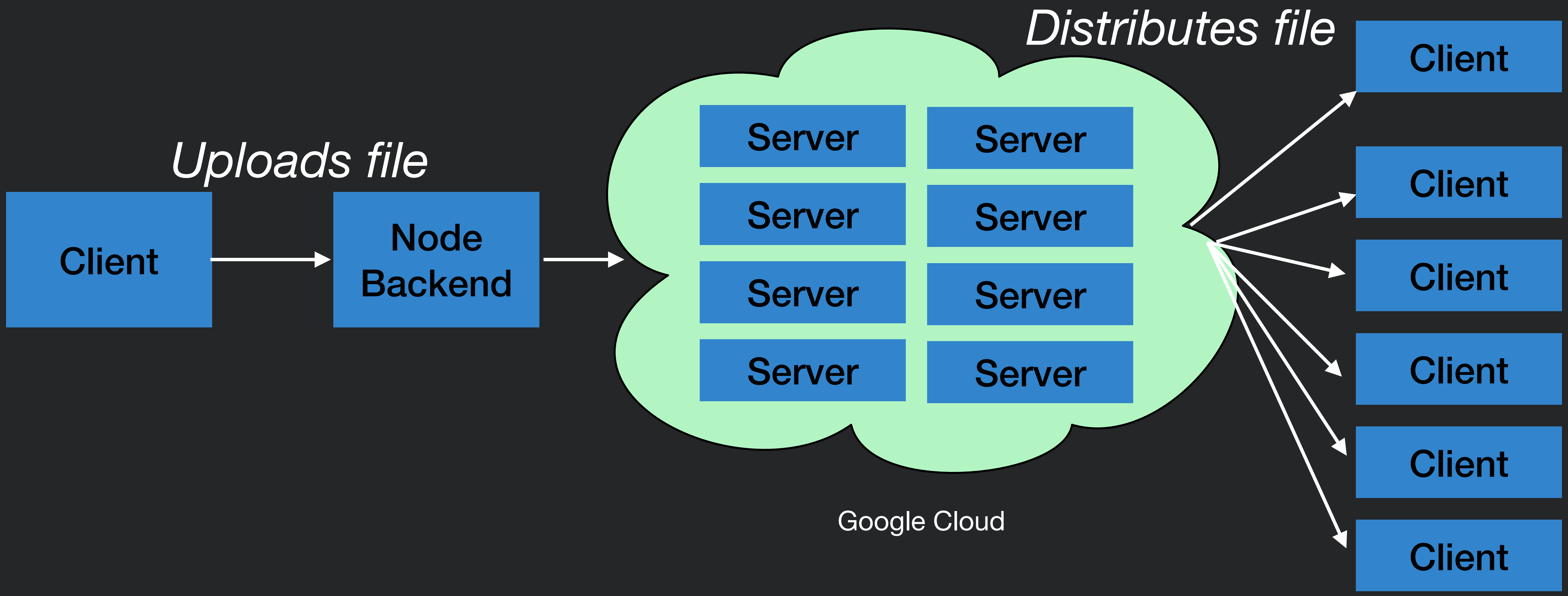
- Long story... can’t easily have file uploads and JSON requests at the same time

Where to store blobs

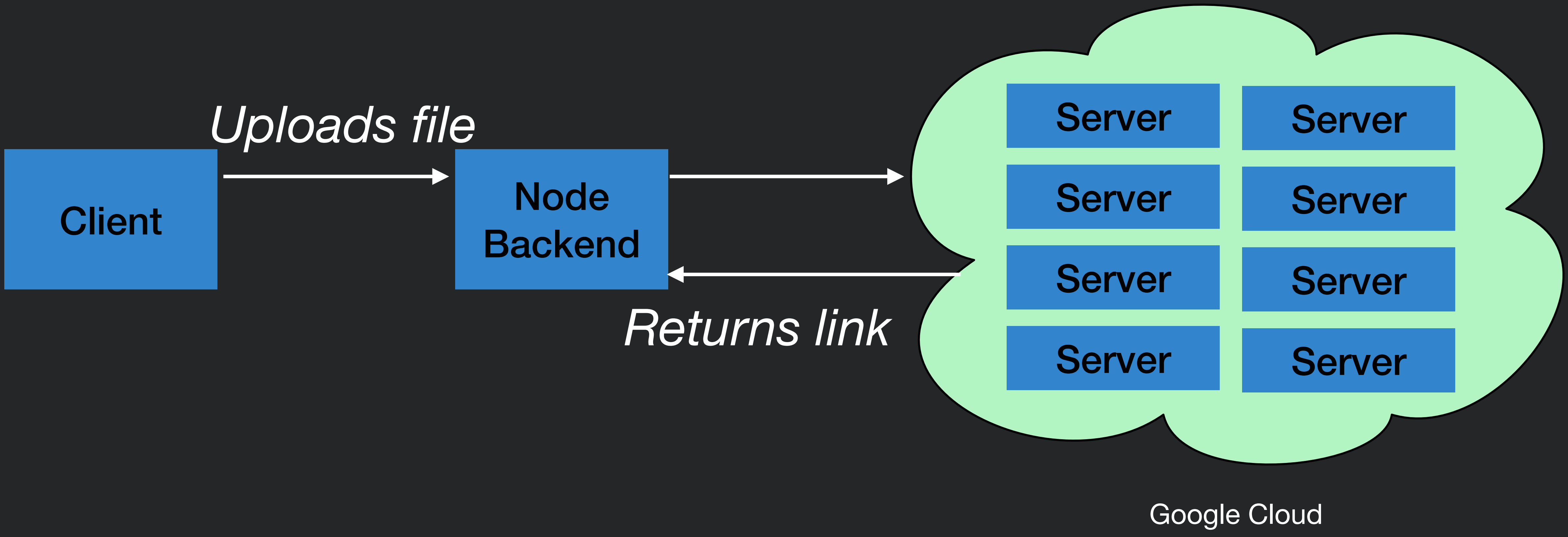
- Saving them on our server is fine, but…
  - What if we don't want to deal with making sure we have enough storage
  - What if we don't want to deal with backing up those files
  - What if our app has too many requests for one server and state needs to be shared between load-balanced servers
  - What if we want someone else to deal with administering a server

Blob stores

- Amazon, Google, and others want to let you use their platform to solve this!



Blob Stores

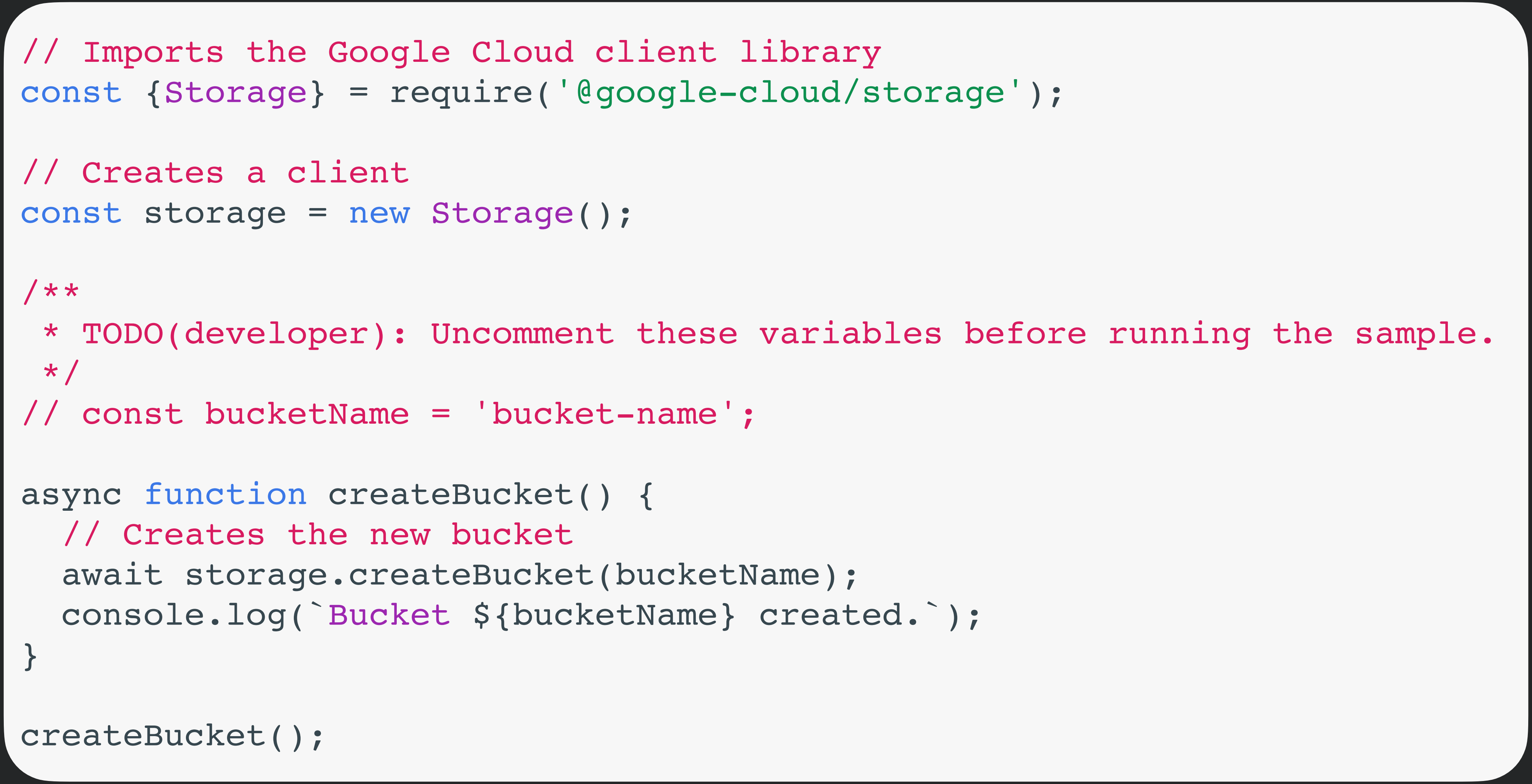


Typical workflow:
Client uploads file to your backend
Backend persists file to blob store
Backend saves link to file, e.g. in Firebase

Google Cloud Storage

- You get to store 5GB for free (but not used in this class)
- Setup

```
npm install --save @google-cloud/storage
```



```
// Imports the Google Cloud client library
const {Storage} = require('@google-cloud/storage');

// Creates a client
const storage = new Storage();

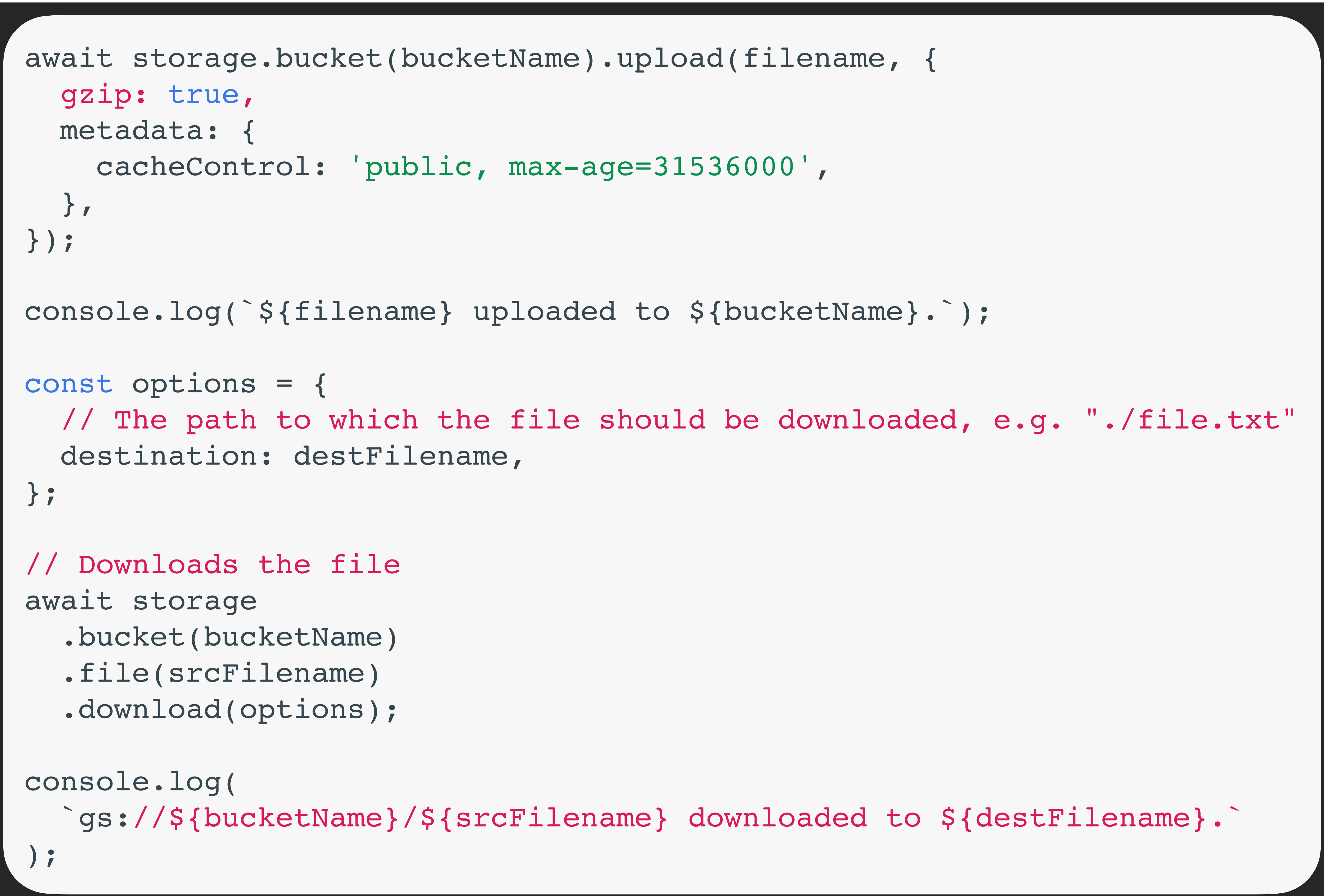
/**
 * TODO(developer): Uncomment these variables before running the sample.
 */
// const bucketName = 'bucket-name';

async function createBucket() {
  // Creates the new bucket
  await storage.createBucket(bucketName);
  console.log(`Bucket ${bucketName} created.`);
}

createBucket();
```

https://cloud.google.com/storage/docs/reference/libraries

Google Cloud Storage



```
await storage.bucket(bucketName).upload(filename, {
  gzip: true,
  metadata: {
    cacheControl: 'public, max-age=31536000',
  },
});

console.log(`${filename} uploaded to ${bucketName}.`);

const options = {
  // The path to which the file should be downloaded, e.g. "./file.txt"
  destination: destFilename,
};

// Downloads the file
await storage
  .bucket(bucketName)
  .file(srcFilename)
  .download(options);

console.log(
  `gs://${bucketName}/${srcFilename} downloaded to ${destFilename}.`
);
```

https://cloud.google.com/storage/docs/reference/libraries

Demo: Let's build a Microservice!

- We've now seen most of the key concepts in building a microservice.
- Let's build a microservice!
  - - Firebase for persistence
  - - Handle post requests
  - Microservice for madlibs