CIS 371 Web Application Programming

Cloud DataBase

Firebase Cloud Firestore II

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Based on the original version by Professor Hans Dulimarta.

Recall

- Why Cloud Data Stores?
- SQL vs. noSQL(Schemaless)
- Firebase: Cloud Firestore
  - Creating a new WebApp & Local Project Setup
  - Data Model: Hierarchy of Collections-Documents
  - CRUD Operations: Create Doc (own Doc ID)
  - CRUD Operations: Create Doc (automatic Doc ID)
  - CRUD Operations: Create Docs from Array

CRUD: Firestore Read Functions

CRUD Operations: Read All Documents

```
SELECT * FROM states
```
SQL

states (SQL table)

Abbrev (PK)	Name	Capital
AK	Alaska	Juneau
AL	Alabama	Montgomery
FL	Florida	Tallahassee

```
// Assume saved data has the
// following structure
type StateType = {
  abbrev: string;
  name: string;
  capital: string;
};
```

```
import {
  CollectionReference,
  collection,
  QuerySnapshot,
  QueryDocumentSnapshot,
  getDocs,
} from "firebase/firestore";

const myStateColl: CollectionReference = collection(db, "states");

getDocs(myStateColl).then((qs: QuerySnapshot) => {
  qs.forEach((qd: QueryDocumentSnapshot) => {
    const stateData = qd.data() as StateType;
    const docId = qd.id; // Fixed 'cost' to 'const'
    // More code here to manipulate stateData
  });
});
```

Firestore in TS

CRUD Operations: Read A Specific Document

SQL

```
// Select a tuple with a known primary key
SELECT * FROM states WHERE abbrev = “FL”
```

states (SQL table)

Abbrev (PK)	Name	Capital
AK	Alaska	Juneau
AL	Alabama	Montgomery
FL	Florida	Tallahassee

```ts
// Assume saved data has the
// following structure
type StateType = {
  abbrev: string;
  name: string;
  capital: string;
};
```

```ts
import {
  DocumentReference,
  doc,
  DocumentSnapshot,
  getDoc,
} from "firebase/firestore";
// FL is a document ID
const myDoc: DocumentReference = doc(db, "states/FL");
getDoc(myDoc).then((qd: DocumentSnapshot) => {
  if (qd.exists()) {
    const stateData = qd.data() as StateType;
    // More code here to manipulate stateData
  }
});
```

Firestore in TS

CRUD Operations: Fetch Document(s) Where...

SQL

```
// Select tuples satisfying some conditions
SELECT * FROM states WHERE name = “Florida”
```

states (SQL table)

Abbrev (PK)	Name	Capital
AK	Alaska	Juneau
AL	Alabama	Montgomery
FL	Florida	Tallahassee

```ts
// Assume saved data has the
// following structure
type StateType = {
  abbrev: string;
  name: string;
  capital: string;
};
```

```ts
import {
  Query,
  getDocs,
  collection,
  where,
  query,
  QuerySnapshot,
  QueryDocumentSnapshot,
} from "firebase/firestore";
const getFL: Query = query(
  collection(db, "states"),
  where("name", "==", "Florida")
);
getDocs(getFL).then((qs: QuerySnapshot) => {
  qs.forEach((qd: QueryDocumentSnapshot) => {
    const stateData = qd.data() as StateType;
    // More code here to manipulate stateData
  });
});
```

Firestore in TS

CRUD Operations: Fetch Document(s) Where...

SQL

```
// Select tuples satisfying some conditions
SELECT * FROM states WHERE population > 10_000_000
```

states (SQL table)

Name	Capital	Population
California	Sacramento	39_123_612
Michigan	Lansing	8_432_911
Florida	Tallahassee	26_222_943

```ts
// Assume saved data has the
// following structure
type StateType = {
  name: string;
  capital: string;
  population: number;
};
```

```ts
import {
  Query,
  getDocs,
  collection,
  query,
  where,
  QuerySnapshot,
  QueryDocumentSnapshot,
} from "firebase/firestore";
const aboveTenMil: Query = query(
  collection(db, "states"),
  where("population", ">", 10_000_000)
);
getDocs(aboveTenMil).then((qs: QuerySnapshot) => {
  qs.forEach((qd: QueryDocumentSnapshot) => {
    const stateData = qd.data() as StateType;
    // More code here to manipulate stateData
  });
});
```

Firestore in TS

CRUD Operations: Fetch Document(s) Where...

SQL

```
// Select tuples satisfying some conditions
SELECT * FROM states WHERE population > 10_000_000
AND population < 15_000_000
```

states (SQL table)

Name	Capital	Population
California	Sacramento	39_123_612
Michigan	Lansing	8_432_911
Florida	Tallahassee	26_222_943

```ts
// Assume saved data has the
// following structure
type StateType = {
  name: string;
  capital: string;
  population: number;
};
```

```ts
import {
  Query,
  getDocs,
  collection,
  query,
  where,
  QuerySnapshot,
  QueryDocumentSnapshot,
} from "firebase/firestore";
const aboveTenMil: Query = query(
  collection(db, "states"),
  where("population", ">", 10_000_000),
  where("population", "<", 15_000_000)
);
getDocs(aboveTenMil).then((qs: QuerySnapshot) => {
  qs.forEach((qd: QueryDocumentSnapshot) => {
    const stateData = qd.data() as StateType;
    // More code here to manipulate stateData
  });
});
```

Firestore in TS

Available Query Where Operators

Operator	Example	SQL Equivalent
<, <=, ==, >=, >	where("population", ">", 20_000_000)	WHERE population > 20000000
!=	where("name", "!=", "Andy")	WHERE name != "Andy"
in	where("city", "in", ["Ada", "Flint"])	WHERE city == "Ada" OR city == "Flint"
not-in	where("city", "not-in", ["Ada", "Flint"])	WHERE city != "Ada" AND city != "Flint"

Operator	Example (courses must be an ARRAY)
array-contains	// Has this student taken MTH200? where("courses", "array-contains", "MTH200")
array-contains-any	// Has this student taken either MTH200 or STA215? where("courses", "array-contains-any", ["MTH200", "STA215"])

Query Limitations

```
// Multiple .where() on the same field
const q = query(
  collection(__, "states"),
  where("population", ">=", 5_000_000),
  where("population", "<=", 10_000_000)
);
getDocs(q).then(() => {
  /* code */
});
```

OK

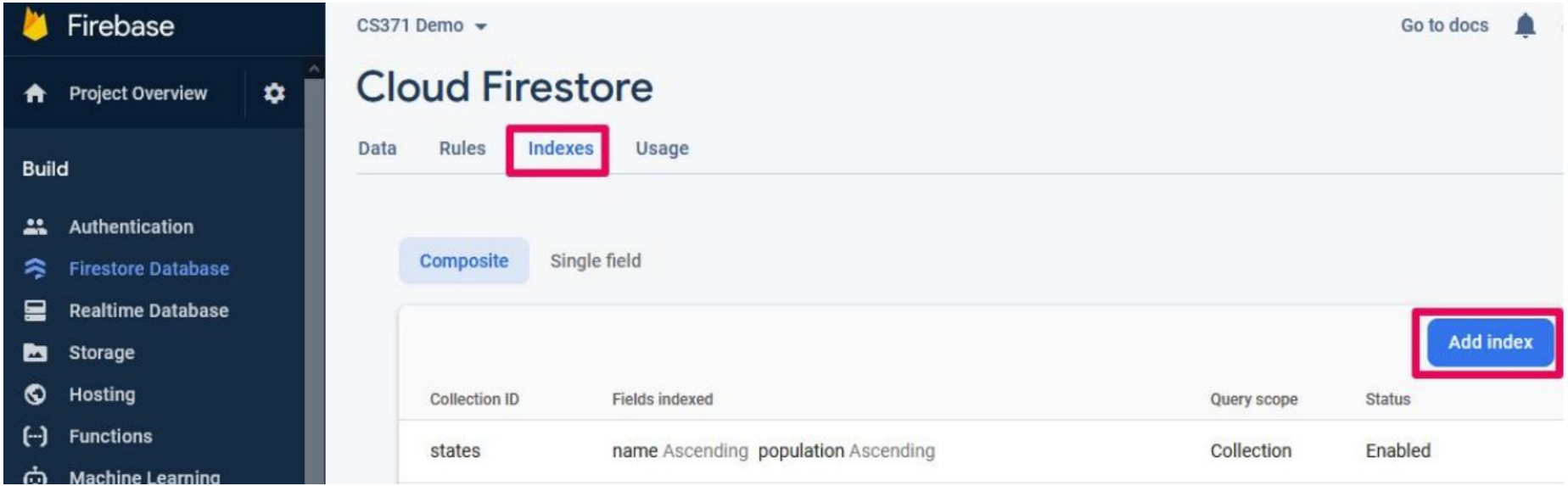
```
// Can"t use inequalities on two different fields
query(
  collection(__, "states"),
  where("population", ">=", 5_000_000),
  where("area", "<=", 200_000)
);
```

Not OK

```
// Multiple .where on different fields
// require a composite index on both fields
// At most one inequality comparison!!
const q = query(
  collection(__, "students"),
  where("major", "==", "MATH"),
  where("gpa", ">=", 3.0)
);
getDocs(q).then(/* more code */);
```

OK

Building Composite Index



Order of index build does matter!!!

CRUD: Firestore Update Functions

CRUD: Update Doc (change a simple field)

```
// Update a record with a known primary key
UPDATE students SET phone = "616-616-6161" WHERE gnumber = "G71884"
```

SQL

SQL table

Gnumber	Name	Phone
G81291	Abby	517-123-4567
G71884	Ally	269-333-4444 → 616-616-6161
G53181	Annie	616-777-3332

```
// Assume saved data has the
// following structure
type StudentType = {
  gnumber: string; // PrimaryKey
  name: string;
  phone: string;
};
```

```
import { doc, updateDoc, DocumentReference } from "firebase/firestore";
// After initialization
const docRef: DocumentReference = doc(db, "students/G71884");
// add a new simple data
updateDoc(docRef, { phone: "616-616-6161" }).then(() => {
  console.debug("Update successful");
});
```

Firestore in TS

CRUD: Update Doc (change a simple field)

// Update a record when **primary key is UNKNOWN**
UPDATE students SET phone = "616-616-6161" WHERE name = "Abby"

SQL

SQL table

Gnumber	Name	Phone
G81291	Abby	517-123-4567
G71884	Ally	269-333-4444
G53181	Annie	616-777-3332

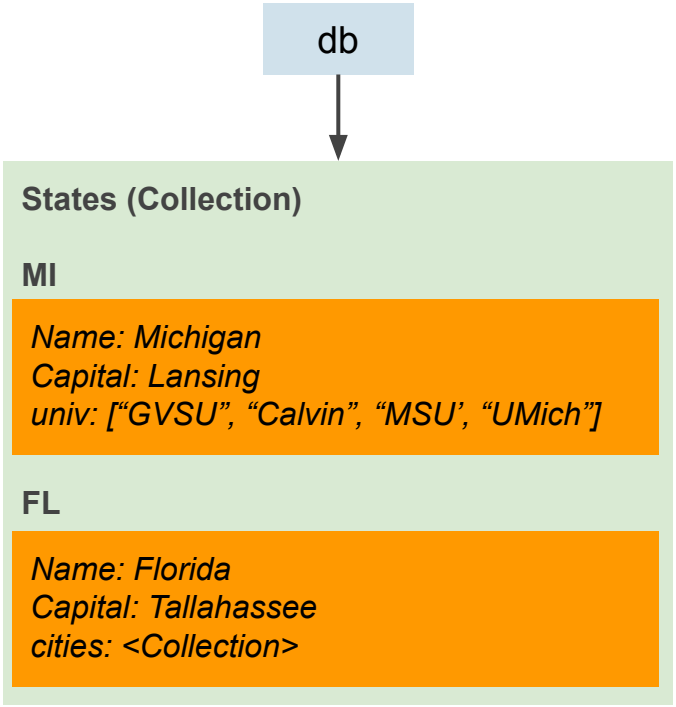
616-616-6161

```ts
// Assume saved data has the
// following structure
type StudentType = {
  gnumber: string; // PrimaryKey
  name: string;
  phone: string;
};
```

```ts
import {
  collection, CollectionReference, doc, getDocs, QueryDocumentSnapshot,
  QuerySnapshot, query, updateDoc, where,
} from "firebase/firestore";
const myCol: CollectionReference = collection(db, "students");
const qr = query(myCol, where("name", "==", "Abby"));
getDocs(qr).then((qs: QuerySnapshot) => {
  qs.forEach(async (qd: QueryDocumentSnapshot) => {
    const myDoc = doc(db, qd.id);
    await updateDoc(myDoc, { phone: "616-616-6161" });
  });
});
```

Firestore in TS

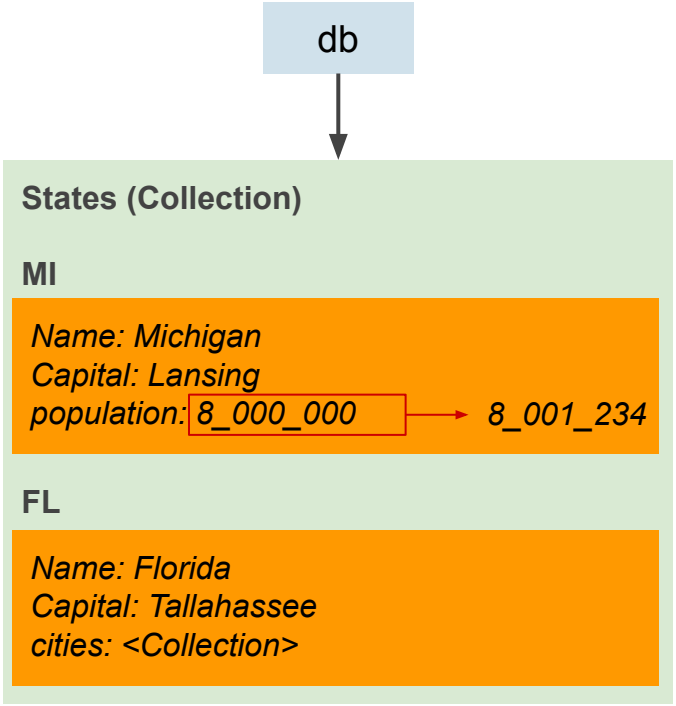
CRUD: Update array field in a Document




```
// After initialization
import {
  updateDoc,
  arrayRemove,
  arrayUnion,
  DocumentReference,
  doc,
} from "firebase/firestore";
const mich: DocumentReference = doc(db, "states/MI");
// add a new JS/TS array
updateDoc(mich, { universities: ["GVSU", "Calvin", "XYZ"] }).then(() => {
  console.debug("Update successful");
});
// updated erroneous entry in the array
updateDoc(mich, {
  universities: arrayRemove("XYZ"),
}).then(() => {
  console.debug("Update successful");
});
// Add more entries in the array
updateDoc(mich, {
  universities: arrayUnion("MSU", "UMich"),
}).then(() => {
  console.debug("Update successful");
});
```

Firestore in TS

CRUD: Update array field in a Document




```
import {
  updateDoc,
  increment,
  DocumentReference,
  doc,
} from "firebase/firestore";
const mich: DocumentReference = doc(db, "states/MI");
updateDoc(mich, {
  // Add 1234 to the current population
  population: increment(1234),
}).then(() => {
  console.debug("Update successful");
});
```

Firestore in TS

CRUD: Firestore Delete Functions

CRUD: Delete one Document

```sql
// Delete a record with a known primary key
DELETE FROM students WHERE gnumber = "G71884"
```

SQL

SQL table

Gnumber	Name	Phone
G81291	Abby	517-123-4567
G71884	Ally	269-333-4444
G53181	Annie	616-777-3332

```ts
// Assume saved data has the
// following structure
type StudentType = {
  gnumber: string; // PrimaryKey
  name: string;
  phone: string;
};
```

```ts
import { deleteDoc, doc } from "firebase/firestore";
// Delete the entire document
const toRemove = doc(db, "students/G71884");
deleteDoc(toRemove).then(() => {
  console.debug("Student G71884 removed");
});
```

Firestore in TS

CRUD: Delete one Document (unknown Doc ID)

```
// Update a record when primary key is UNKNOWN
DELETE FROM students WHERE name = "Abby"
```

SQL

SQL table

Gnumber	Name	Phone
G81291	Abby	517-123-4567
G71884	Ally	269-333-4444
G53181	Annie	616-777-3332

```ts
// Assume saved data has the
// following structure
type StudentType = {
  gnumber: string; // PrimaryKey
  name: string;
  phone: string;
};
```

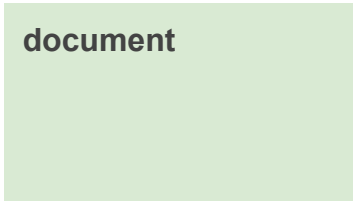
```ts
import {  deleteDoc,  doc,  collection,  CollectionReference,
  QueryDocumentSnapshot,  QuerySnapshot,  query,  where,  getDocs,
} from "firebase/firestore";
const myCol: CollectionReference = collection(db, "students");
const qr = query(myCol, where("name", "==", "Abby"));
getDocs(qr).then((qs: QuerySnapshot) => {
  qs.forEach(async (qd: QueryDocumentSnapshot) => {
    const myDoc = doc(db, qd.id);
    await deleteDoc(myDoc);
  });
});
```

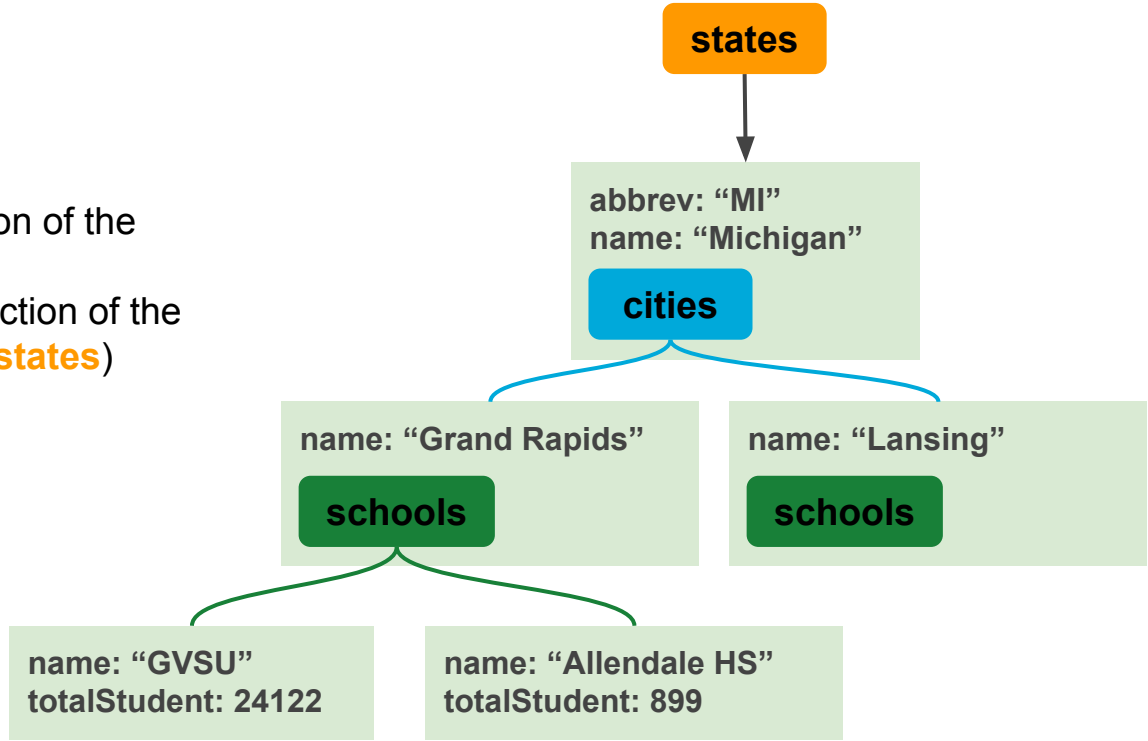
Firestore in TS

SubCollections: One-to-Many Relationship

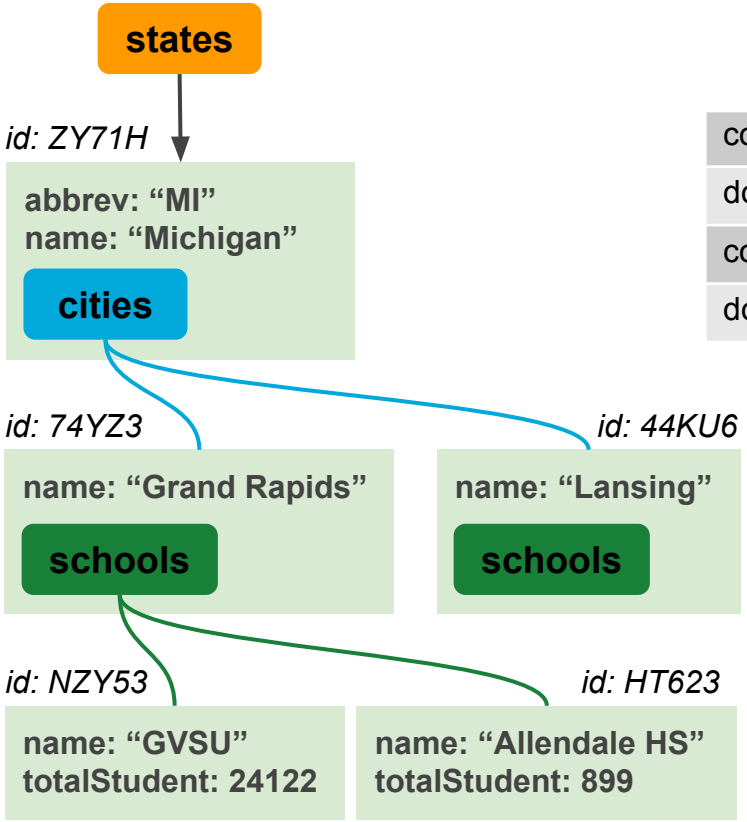
One-to-Many Relationships

- One **state** has many **cities**
- One **city** has many **schools**
- In Firebase Firestore
  - **cities** becomes a subcollection of the **states** collection
  - **schools** becomes a subcollection of the **cities** (sub)collection (under **states**)





Sub-Collections



collection(db, “states/ZY71H/cities”)	Cities in Michigan
doc(db, “states/Z71H/cities/74Y23”)	City of Grand Rapids
collection(db, “states/ZY71H/cities/74Y23/schools”)	Schools in GR
doc(db, “states/ZY71H/cities/74Y23/schools/NZY53”	GVSU

Operations on SubCollections

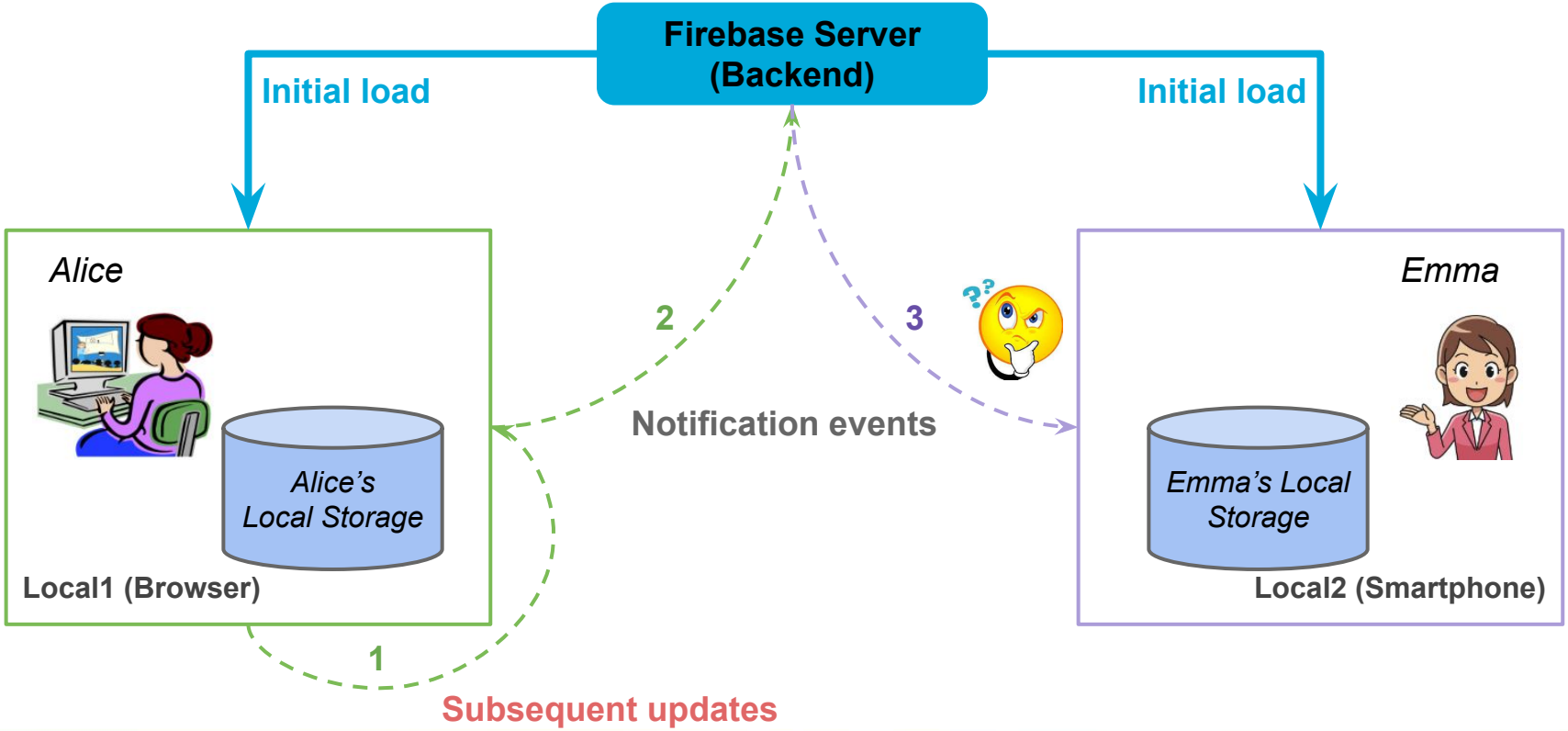
collection(db, “states/ZY71H/cities”)	Cities in Michigan
doc(db, “states/Z71H/cities/74Y23”)	City of Grand Rapids
collection(db, “states/ZY71H/cities/74Y23/schools”)	Schools in GR
doc(db, “states/ZY71H/cities/74Y23/schools/NZY53”	GVSU

```
// Add a new city in Michigan
const miCities = collection(db, "states/ZY71H/cities");
await addDoc(miCities, {
  name: "Holland",
  /* more details on Holland */
});
```

```
// Update Grand Rapids details
const grDoc = doc(db, "states/Z71H/cities/74Y23");
await updateDoc(grDoc, { subwayAvailable: false });
```

```
// Get all schools in Grand Rapids
const grSchools = collection(db, "states/ZY71H/cities/74Y23/schools");
getDocs(grSchools).then((qs: QuerySnapshot) => {
  qs.forEach((qd: QueryDocumentSnapshot) => {
    const skool = qd.data() as SchoolType;
  });
});
```

Local Storage, Local Events, & Global Events



Collection/Doc Update Listener(s) Benefit:
Interactive Web App

Listening to Field Updates on a SINGLE doc

db

buildings

MAK

name: Mackinac Hall
location: Allendale
depts: [“CIS”, “Math”]
numStaffs: 134
rooms: <SubCollection>

PAD

name: Padnos Hall
location: Allendale

DEV

name: DeVos Hall
location: Pew

```
import { doc, onSnapshot, DocumentSnapshot } from "firebase/firestore";
const mac = doc(db, "buildings/MAK");
// Listen to updates on a single document
const unsubscribe = onSnapshot(mac, (snapshot: DocumentSnapshot) => {
  const newData = snapshot.data();
  console.log("Document has been updated to", newData);
});

// Later ...

// Stop listening to changes
unsubscribe();
```

Firestore in TS

Will NOT receive notifications on updates of the doc subcollections (rooms in the example)

Listening to Updates on a Collection of Docs

db

buildings

MAK

name: Mackinac Hall
location: Allendale
depts: [“CIS”, “Math”]
numStaffs: 134
rooms: <SubCollection>

PAD

name: Padnos Hall
location: Allendale

DEV

name: DeVos Hall
location: Pew

```
import { collection, onSnapshot, QuerySnapshot } from "firebase/firestore";
const bldColl = collection(db, "buildings");
const unsubscribe = onSnapshot(bldColl, (s: QuerySnapshot) => {
  for (let chg of s.docChanges()) {
    const newData = chg.doc.data();
    const updateAction = chg.type; // "added", "modified", "removed"
    console.log(chg.doc.id, "has been", updateAction, newData);
  }
});

// Later ...

// Stop listening to changes
unsubscribe();
```

Firestore in TS

Handle listen errors

db

buildings

MAK

name: Mackinac Hall
location: Allendale
depts: [“CIS”, “Math”]
numStaffs: 134
rooms: <SubCollection>

PAD

name: Padnos Hall
location: Allendale

DEV

name: DeVos Hall
location: Pew

Detach listeners when leaving a page or unmounting a component.

```
import { doc, onSnapshot, DocumentSnapshot } from "firebase/firestore";
const mac = doc(db, "buildings/MAK");
// Listen to updates on a single document
const unsubscribe = onSnapshot(
  mac,
  (snapshot: DocumentSnapshot) => {
    const newData = snapshot.data();
    console.log("Document has been updated to", newData);
  },
  (error) => {
    // ...
  }
);
// Later ...

// Stop listening to changes
unsubscribe();
```

Firestore in TS

Firebase Firestore & Vue.js: Listening Functionality

- How to bind a textbox input's value with a Firestore document value?
- When modifying the value in the textbox, how do you update the corresponding document value in Firestore?
- How to detach this listener?

```
<template>
  <input v-model="data" @input="updateFirestore" />
</template>

<script setup lang="ts">
// Import necessary functions...
const updateFirestore = async () => {
  await updateDoc(docRef, { fieldName: data.value });
};
</script>
```

```
<template>
  <input v-model="data" />
</template>

<script setup lang="ts">
// Import necessary functions...
const data = ref("");
const docRef = doc(db, "collectionName", "docId");
onSnapshot(docRef, (docSnapshot) => {
  data.value = docSnapshot.data()?.fieldName;
});
</script>
```

```
<script setup lang="ts">
// Import necessary functions...
const unsubscribe = onSnapshot(docRef, docSnapshot => { ... });
onUnmounted(() => {
  unsubscribe();
});
</script>
```

Summary

- Firebase: Cloud Firestore
  - CRUD Operations: Read
    - All Documents, A Specific Document
  - CRUD Operations: Fetch Document(s) Where...
    - Where Operators: <, <=, ==, >=, >, !=, in, not-in, array-contains, array-contains-any
    - Query Limitations
    - Composite Index
  - CRUD Operations: Update
    - Update Doc (change a simple field): known Doc ID, unknown Doc ID
    - Update array field in a Document
  - CRUD Operations: Delete one Document: known Doc ID, unknown Doc ID
  - SubCollections: One-to-Many Relationship
  - Listening to Field Updates on a SINGLE doc
  - Listening to Updates on a Collection of Docs

Exercises

- What is the difference between a collection and a document?
- What is the difference between the functions addDoc() and setDoc()?
- What is the difference between the functions getDocs() and getDoc()?