CS 4530: Fundamentals of Software Engineering
Module 2.2: Test-Driven Development

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Learning Goals for this Lesson

- At the end of this lesson, you should be prepared to
  - Explain the basics of Test-Driven Development
  - Explain the connection between conditions of satisfaction and testable behaviors
  - Begin developing simple applications using TypeScript and Vitest

Non-Goals for this Lesson

- This is *not* a tutorial for Typescript or for Vitest
- We will show you simple examples, but you will need to go through the tutorials to learn the details.

Part 3: Test-Driven Development

PEOPLE

PROCESSES

PROGRAMS

PLANNING

ORGANIZING

IMPLEMENTING

Requirements Analysis

User Stories

Testing Conditions of Satisfaction

Review: User Stories

- As a College Administrator, I want to keep track of students, the courses they have taken, and the grades they received in those courses, so that I can advise them on their studies.

As a <role>
I want <capability>
so that I can <get some benefit>

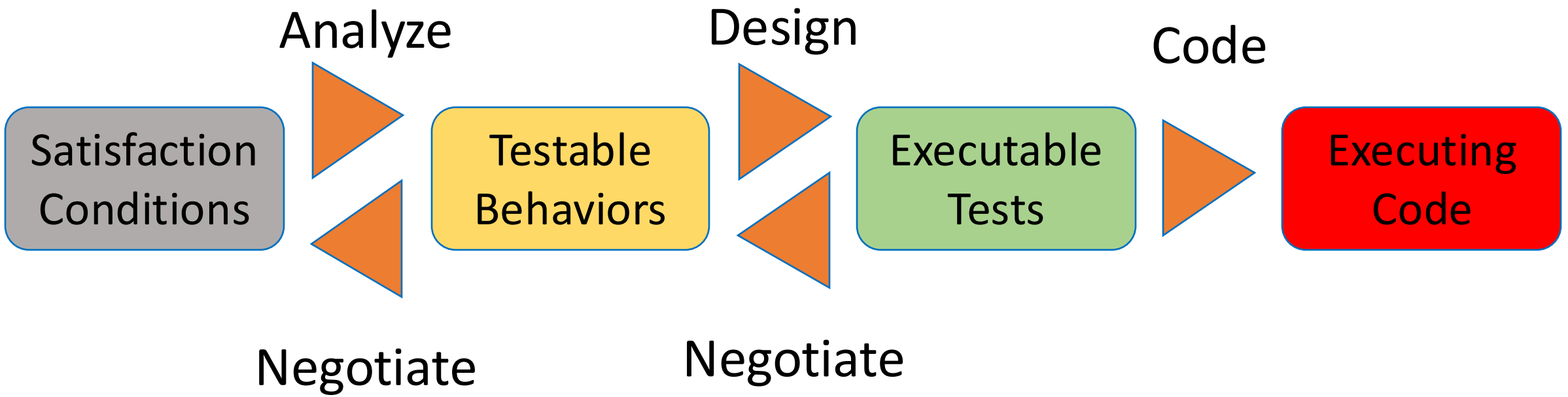
Review: Conditions of Satisfaction

- We will build a secure web application backed by a persistent database that allows an authenticated administrator to:
  - Add a new student to the database
  - Add a new student with the same name as an existing student.
  - Retrieve the transcript for a student
  - Delete a student from the database
  - Add a new grade for an existing student
  - Find out the grade that a student got in a course that they took

Test Driven Development (TDD)

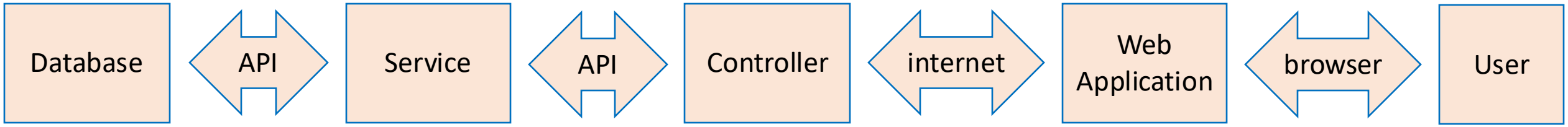
- Puts test specification as the critical design activity
  - Understands that deployment comes when the system passes testing
- The act of defining tests requires a deep understanding of the problem
- Clearly defines what success means
  - No more guesswork as to what “complete” means

The TDD Cycle



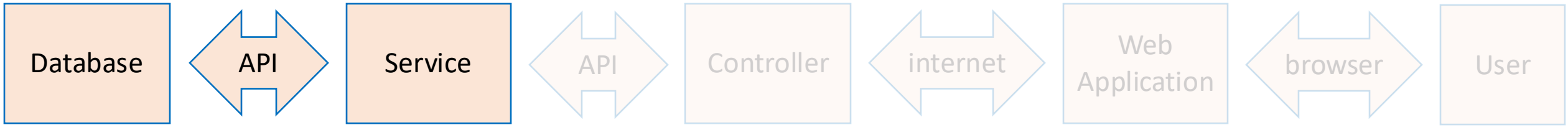
CoS are ultimately about the user

We will build a secure web application backed by a persistent database that allows an authenticated administrator to add a new student to the database



CoS are ultimately about the user

We will build a secure web application backed by a persistent database that allows an authenticated administrator to add a new student to the database



The addStudent service function should add a student to the database

Analyzing CoS to get testable behaviors

```
import {
  StudentID,
  Student,
  Course,
  CourseGrade,
  Transcript,
} from './types.ts';
export interface TranscriptService {
  addStudent(studentName: string): StudentID;
  getTranscript(id: StudentID): Transcript;
  deleteStudent(id: StudentID): void; // hmm, what to do about errors??
  addGrade(id: StudentID, course: Course, courseGrade: CourseGrade): void;
  getGrade(id: StudentID, course: Course): CourseGrade;
  nameToIDs(studentName: string): StudentID[];
}
```

Analyzing CoS to get testable behaviors

CoS: The user can…

- …add a new student to the database
- …add a new student with the same name as an existing student
- …retrieve the transcript for a student

Testable behaviors:

- addStudent should add a student to the database and return their ID
- addStudent should return an ID distinct from any ID in the database
- addStudent should permit adding a student with the same name as an existing student
- getTranscript, given the ID of a student, should return the student's transcript.
- getTranscript, given an ID that is not the ID of any student, should …*????*…

The tiniest introduction to Vitest

```
import {
  StudentID,
  Student,
  Course,
  CourseGrade,
  Transcript,
} from './types.ts';
export interface TranscriptService {
  addStudent(studentName: string): StudentID;
  getTranscript(id: StudentID): Transcript; // throws error if ID invalid
  deleteStudent(id: StudentID): void; // throws error if ID invalid
  addGrade(id: StudentID, course: Course, courseGrade: CourseGrade): void;
  getGrade(id: StudentID, course: Course): CourseGrade;
  nameToIDs(studentName: string): StudentID[];
}
```

The tiniest introduction to Vitest

```
// types.ts - types for the transcript service
export type StudentID = number;
export type Student = { studentID: number; studentName: StudentName };
export type Course = string;
export type CourseGrade = { course: Course; grade: number };
export type Transcript = { student: Student; grades: CourseGrade[] };
export type StudentName = string;
```

The tiniest introduction to Vitest

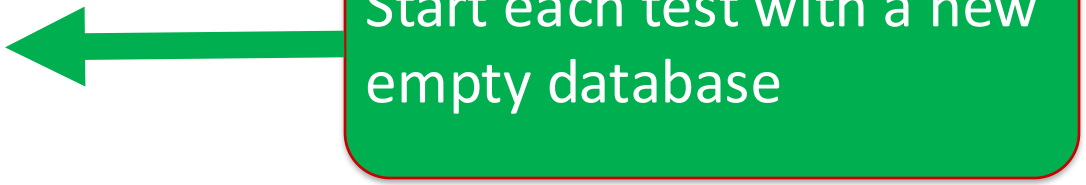
```
// types.spec.ts
import { describe, expect, it } from 'vitest';
import { type Student } from './types.ts';

const alvin: Student = { studentID: 37, studentName: 'Alvin' };
const bryn: Student = { studentID: 38, studentName: 'Bronwyn' };

describe('the Student type', () => {
  it('should allow extraction of id', () => {
    expect(alvin.studentID).toEqual(37);
    expect(bryn.studentID).toEqual(38);
  });
  it('should allow extraction of name', () => {
    expect(alvin.studentName).toEqual('Alvin');
    expect(bryn.studentName).toEqual('Jazzhands'); // will fail
  });
});
```

The tiniest introduction to Vitest

```
% npx vitest --run src/types.spec.ts

 RUN  v4.0.16 /Users/rjsimmon/r/transcript-server

 ❯ src/types.spec.ts (2 tests | 1 failed) 4ms
   ❯ the Student type (2)
     ✓ should allow extraction of id 1ms
     × should allow extraction of name 3ms

⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯ Failed Tests 1 ⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯⎯

 FAIL  src/types.spec.ts > the Student type > should allow extraction of name
AssertionError: expected 'Bronwyn' to deeply equal 'Jazzhands'

Expected: "Jazzhands"
Received: "Bronwyn"

 ❯ src/types.spec.ts:13:30
    11|   it('should allow extraction of name', () => {
    12|     expect(alvin.studentName).toEqual('Alvin');
    13|     expect(bryn.studentName).toEqual('Jazzhands'); // will fail
      |                              ^
    14|   });
    15| });


 Test Files  1 failed (1)
      Tests  1 failed | 1 passed (2)
```

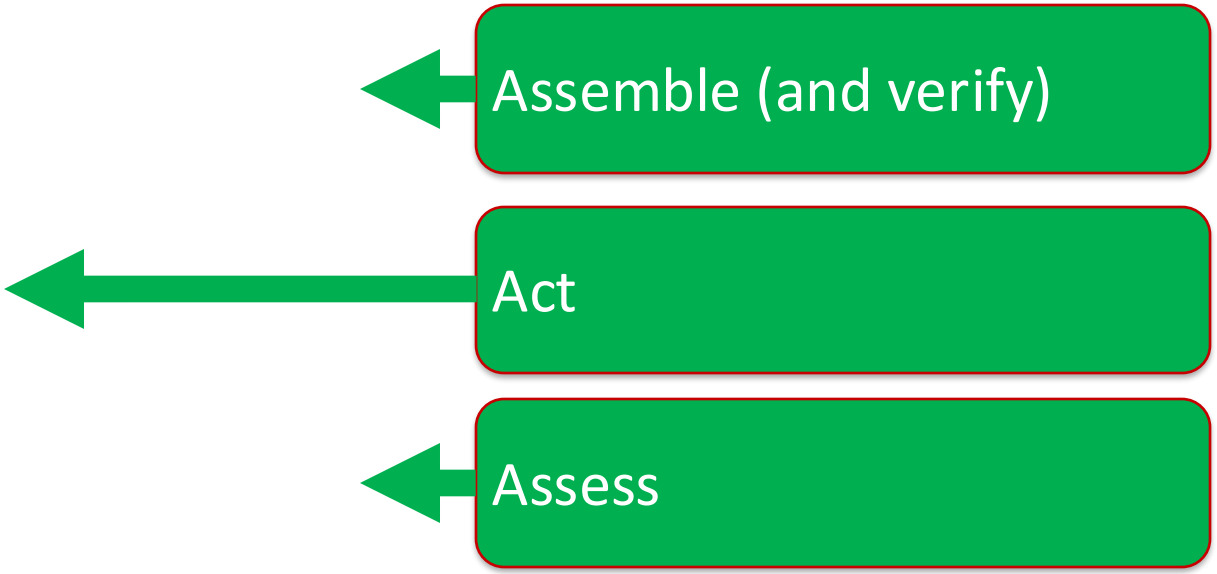
Turning testable behaviors into Vitest tests

```
// transcript.service.spec.ts
import { beforeEach, describe, expect, it } from 'vitest';
import { TranscriptDB, type TranscriptService } from ‘./transcript.service.ts';

let db: TranscriptService;
beforeEach(() => {
  db = new TranscriptDB();
});

describe('addStudent', () => {
  it('should add a student to the database and return their id', () => {
    expect(db.nameToIDs('blair')).toStrictEqual([]);
    const id1 = db.addStudent('blair’);
    expect(db.nameToIDs('blair')).toStrictEqual([id1]);
  });
});
```



Turning testable behaviors into Vitest tests

```
describe('addStudent', () => {
  it('should add a student to the database and return their id', () => {

    expect(db.nameToIDs('blair')).toStrictEqual([]);


    const id1 = db.addStudent('blair’);


    expect(db.nameToIDs('blair')).toStrictEqual([id1]);

  });
});
```



Turning testable behaviors into Vitest tests

```
describe('addStudent', () => {
  it('should return an ID distinct from any ID in the database', () => {
    // we'll add 3 students and check to see that their IDs are all different.
    const id1 = db.addStudent('blair');
    const id2 = db.addStudent('corey');
    const id3 = db.addStudent('del');
    expect(id1).not.toEqual(id2);
    expect(id1).not.toEqual(id3);
    expect(id2).not.toEqual(id3);
  });
});
```

Turning testable behaviors into Vitest tests

```
describe('addStudent', () => {
  it('should permit adding a student w/ same name as an existing student', () => {
    const id1 = db.addStudent('blair');
    const id2 = db.addStudent('blair');
    expect(id1).not.toEqual(id2);
  });
});
```

Turning testable behaviors into Vitest tests

```
describe('addStudent', () => {
  it('should permit adding a student w/ same name as an existing student', () => {
    const id1 = db.addStudent('blair');
    const id2 = db.addStudent('blair');
    expect(id1).not.toEqual(id2);
  });
});
```

Turning testable behaviors into Vitest tests

```
describe('getTranscript', () => {
  it('should permit adding a student w/ same name as an existing student’, () => {
    const id1 = db.addStudent('blair’);
    expect(db.getTranscript(id1)).not.toBeNull();
  });


  it('should permit adding a student w/ same name as an existing student’, () => {
    // in an empty database, all IDs are bad :)
    // Note: the expression you expect to throw
    // must be wrapped in a (() => ...)
    expect(() => db.getTranscript(1)).toThrowError();
  });
});
```

A quick word about cleanup

Start each test with a new empty database

```
let db: TranscriptService;
beforeEach(() => {
  db = new TranscriptDB();
});
```

OR

```
let db: TranscriptService;
beforeAll(() => {
  db = new TranscriptDB();
});
```

Create one database at the very start

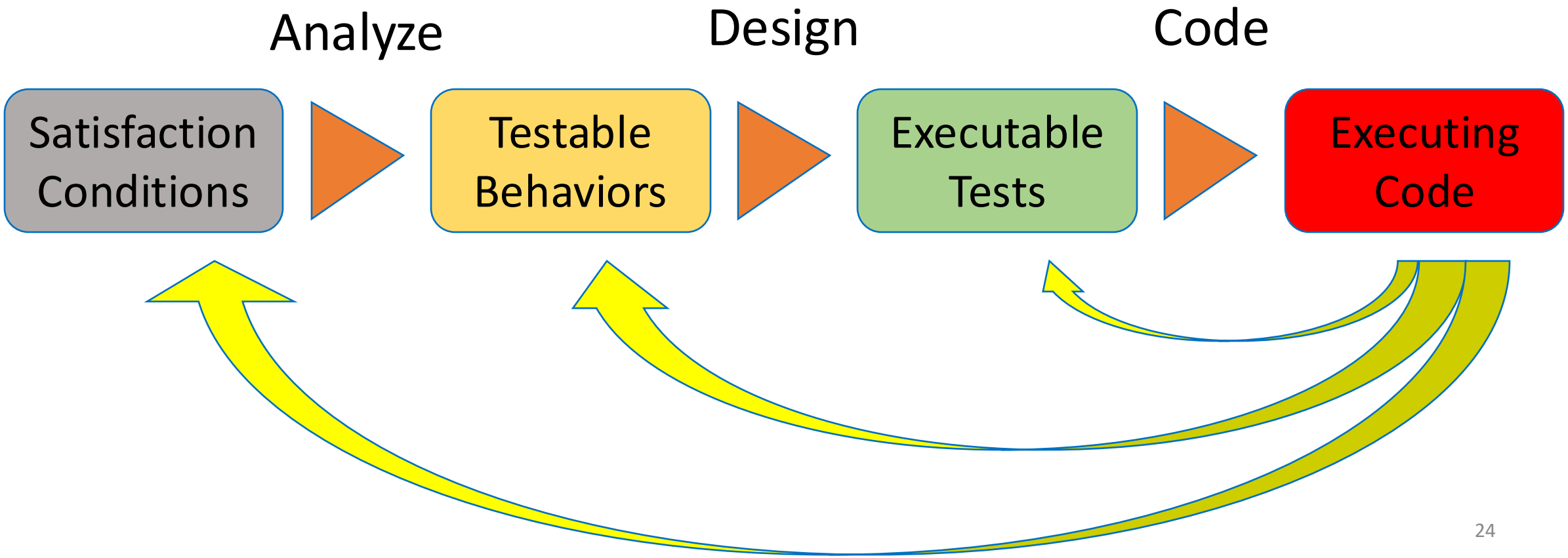
```
beforeEach(() => {
 db.clear([]);
});
```

Start every test with the database cleared out

- Use `afterEach()` if needed.

…now TDD lets us implement addStudent!

Implementing the TranscriptDB according to the TranscriptService spec will let us turn our testable behaviors into fully executable tests.



Review

It’s the end of the lesson, so you should be prepared to:

- Explain the basics of Test-Driven Development
- Explain the connection between conditions of satisfaction and testable behaviors
- Begin developing simple applications using TypeScript and Vitest