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>

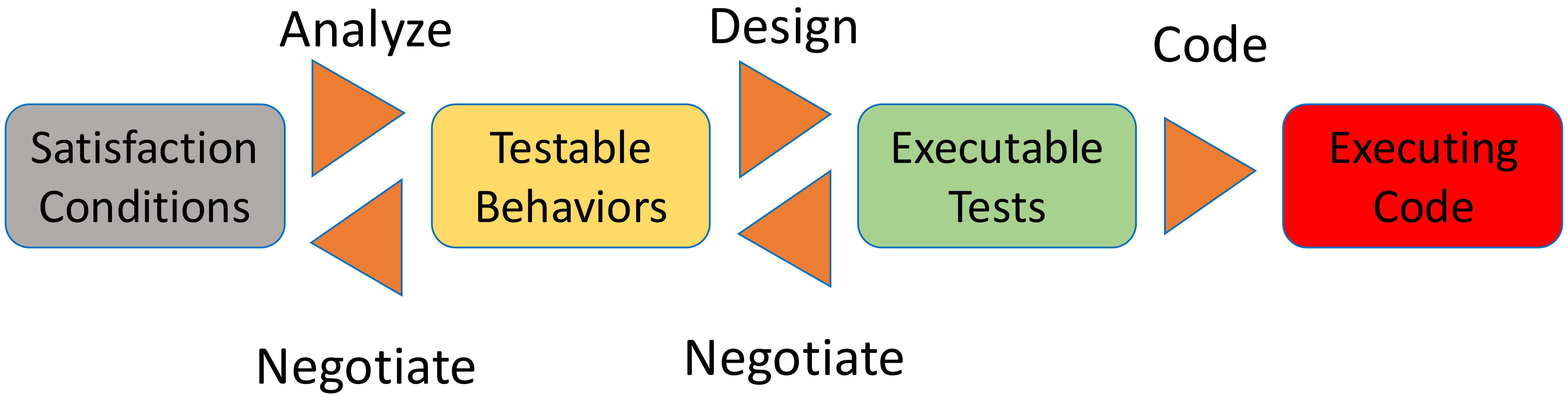
Review: Conditions of Satisfaction

- The college administrator can…
  - Access a persistent database of student records
  - Prevent unauthorized people from accessing or modifying the database
  - 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)

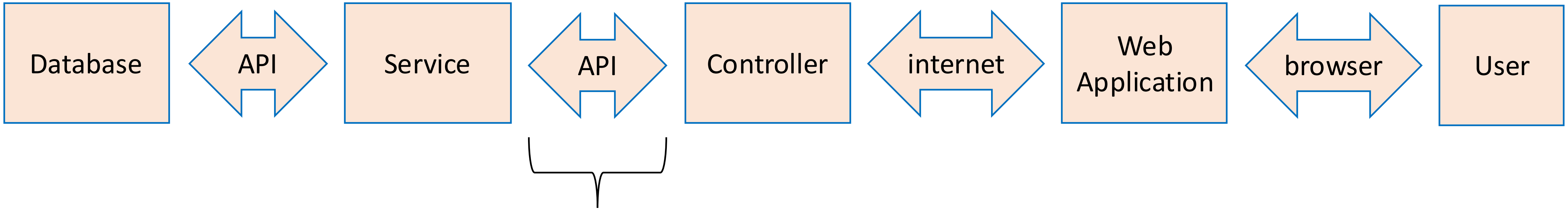
- Puts test specification as the critical design activity
  - Understands that deployment comes when the system passes testing
- The act of defining tests requires a deep understanding of the problem
- Clearly defines what success means
  - No more guesswork as to what “complete” means

The TDD Cycle



Analyzing CoS to get testable behaviors

A user story is about a person in a specific role, who will need to access a complex application



We test specific parts of the application, still thinking about the user story and conditions of satisfaction

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 college administrator can…	Testable behaviors:
• …add a new student to the database	• addStudent should add a student to the database and return their ID
	• addStudent should return an ID distinct from any ID in the database
• …add a new student with the same name as an existing student	• addStudent should permit adding a student with the same name as an existing student
• …retrieve the transcript for a 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[];
}
```

types.ts used to explain interface

```typescript
// 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;
```

Now we can start writing tests

```
// 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
  });
});
```

Running tests on the command line

```
% 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)
```

Tests from testable behaviors

```
// 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]);
  });
});
```

Start each test with a new empty database

Assemble/Act/Assess

```
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]);

  });
});
```

Assemble (and verify)

Act

Assess

Tests from testable behaviors

```
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);
  });
});
```

Tests from testable behaviors

```
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);
  });
});
```

Tests from testable behaviors

```
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

Create one database at the very start

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

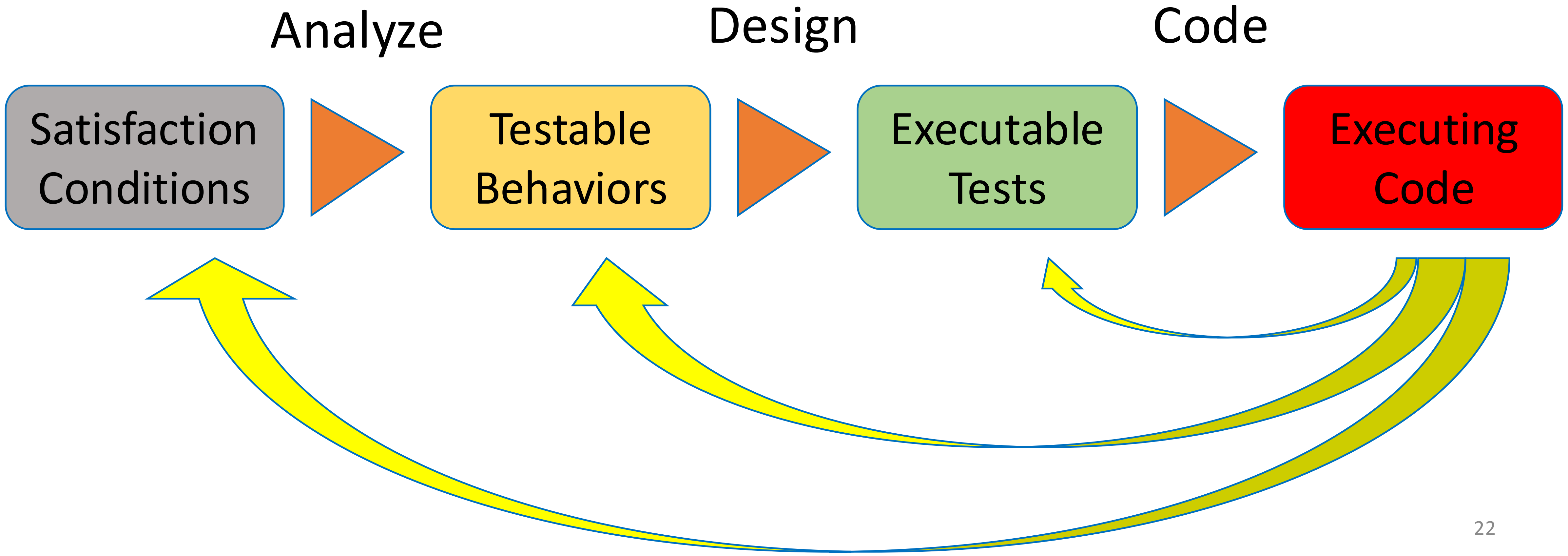
Start every test with the database cleared out

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

- 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: CoS to testable behaviors to TDD

CoS: The college administrator can…

- …add a new student to the database

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

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