

CS 4530: Fundamentals of Software Engineering

Module 2.2: Test-Driven Development

Adeel Bhutta, Rob Simmons, and Mitch Wand

Khoury College of Computer Sciences

© 2026 Released under the [CC BY-SA](#) license

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.

Test-Driven Development



PEOPLE



PROCESSES

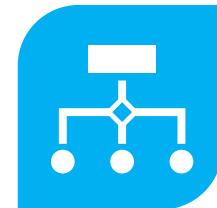


PROGRAMS

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>*



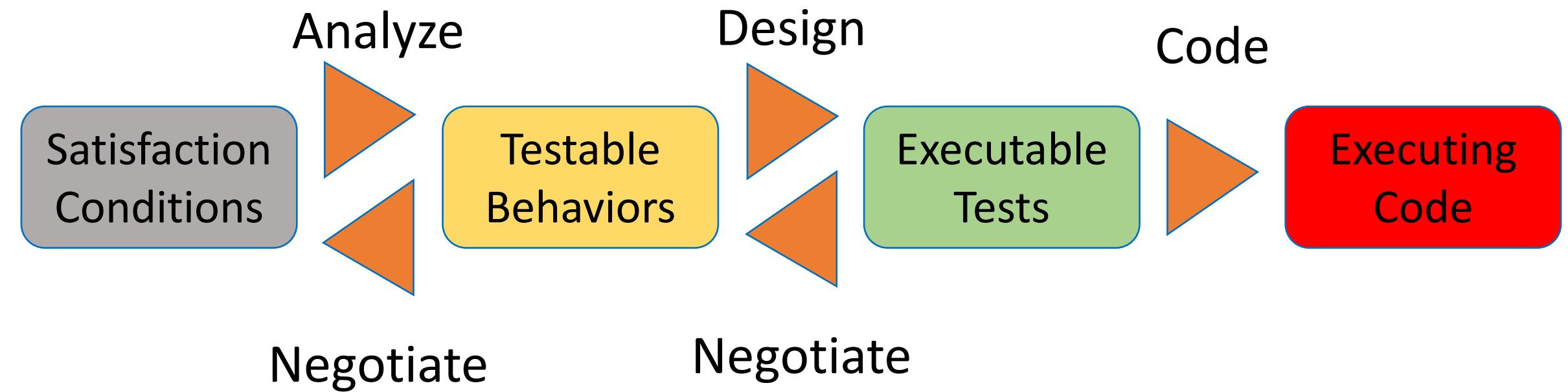
Review: Conditions of Satisfaction

- 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)

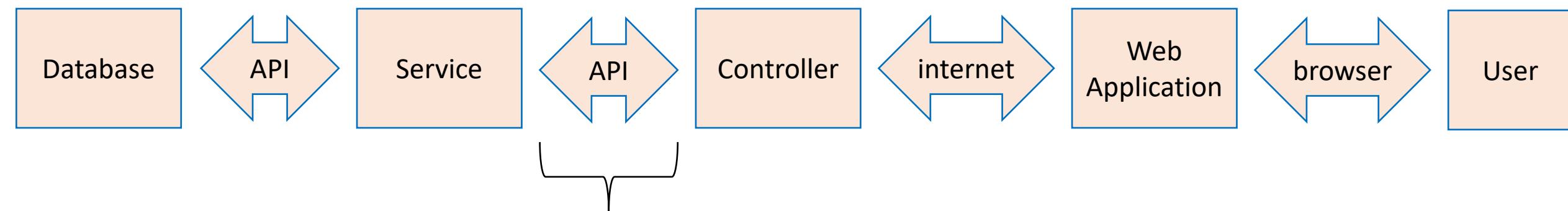
- Puts test specification as the critical design activity
 - Understands that deployment comes when the system passes testing
- The act of defining tests requires a deep understanding of the problem
- Clearly defines what success means
 - No more guesswork as to what “complete” means

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...

- ...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[];  
}
```

types.ts used to explain interface

```
// 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(brynn.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();  
});
```

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

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

OR

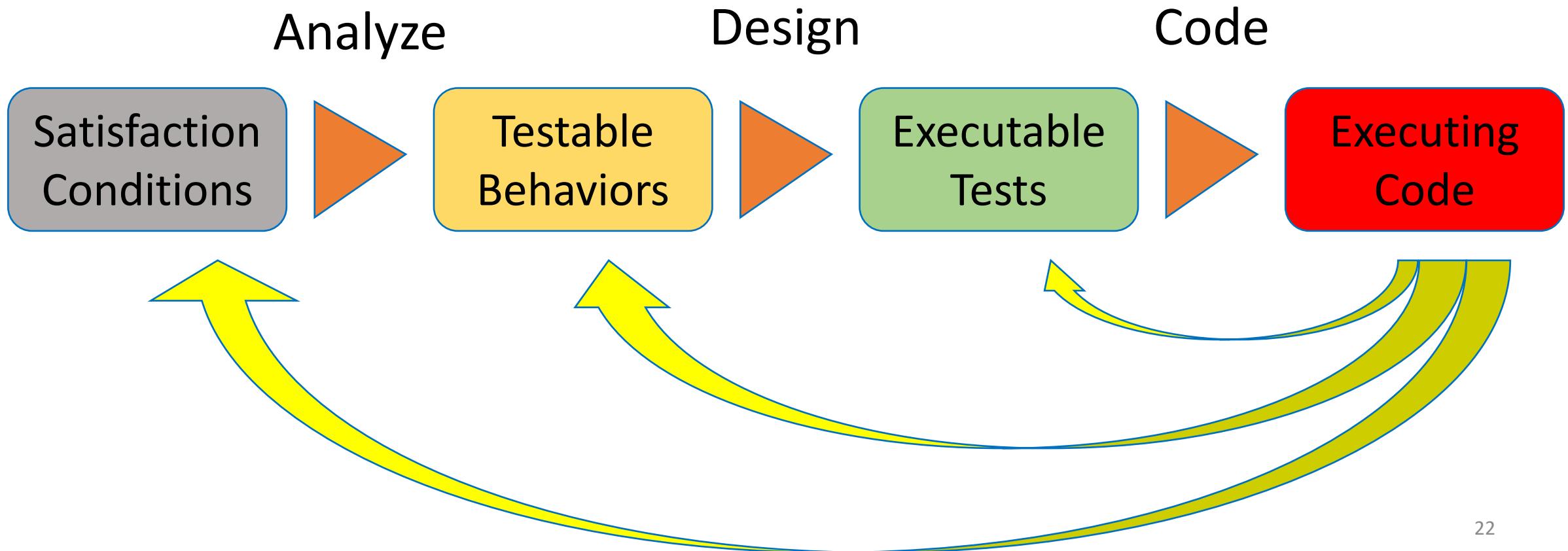
Create one database at the very start

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: 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