CS 4530: Fundamentals of Software Engineering
Module 2: From Requirements to Tests

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Learning Goals for this Lesson

- At the end of this lesson, you should be prepared to
  - Explain the overall purposes of requirements analysis
  - Recall the three major dimensions of risk in requirements analysis
  - Explain the connection between requirements analysis and user stories
  - 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.

The big picture

PEOPLE

PROCESSES

PROGRAMS

PLANNING

ORGANIZING

IMPLEMENTING

user stories
and
conditions of satisfaction

Part 1: Requirements analysis

PEOPLE

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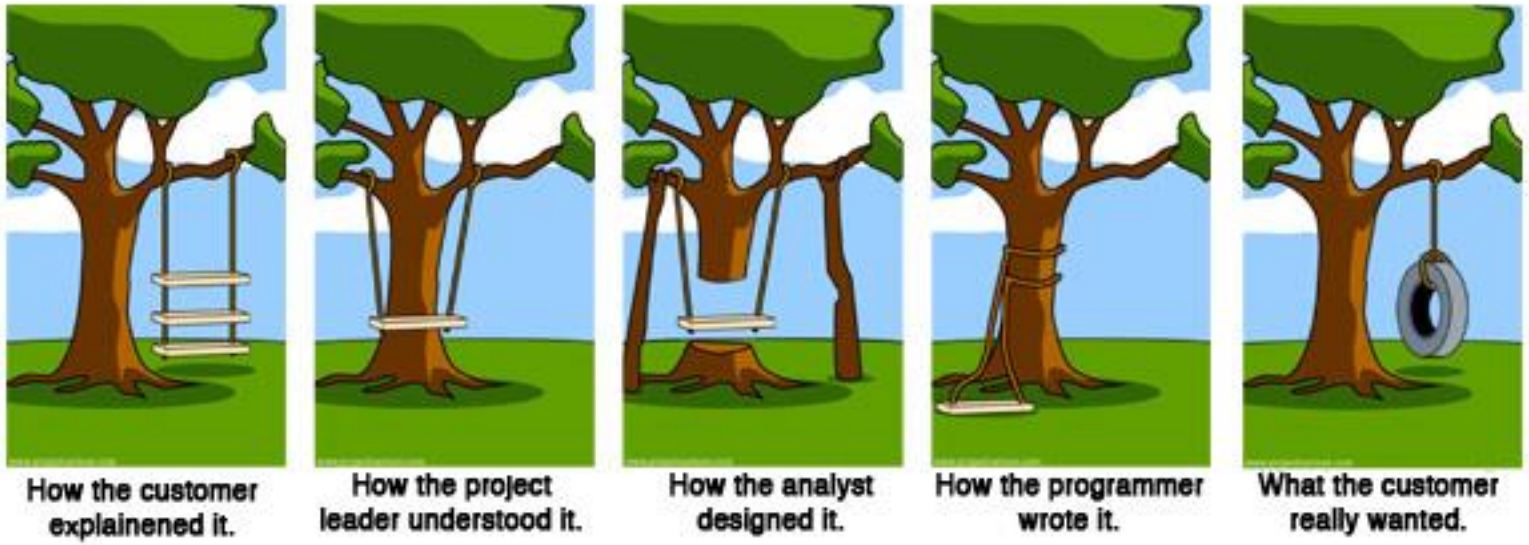
Requirements Analysis

User Stories

Testing Conditions of Satisfaction

Overall question:
How to make sure we are building the right thing



https://en.wikipedia.org/wiki/Tree_swing_cartoon

Why is requirements analysis hard?

Problems of understanding

Do users know what they want?

Do users know what we don't know?

Do we know who are users even are?

Problems of scope

What are we building?

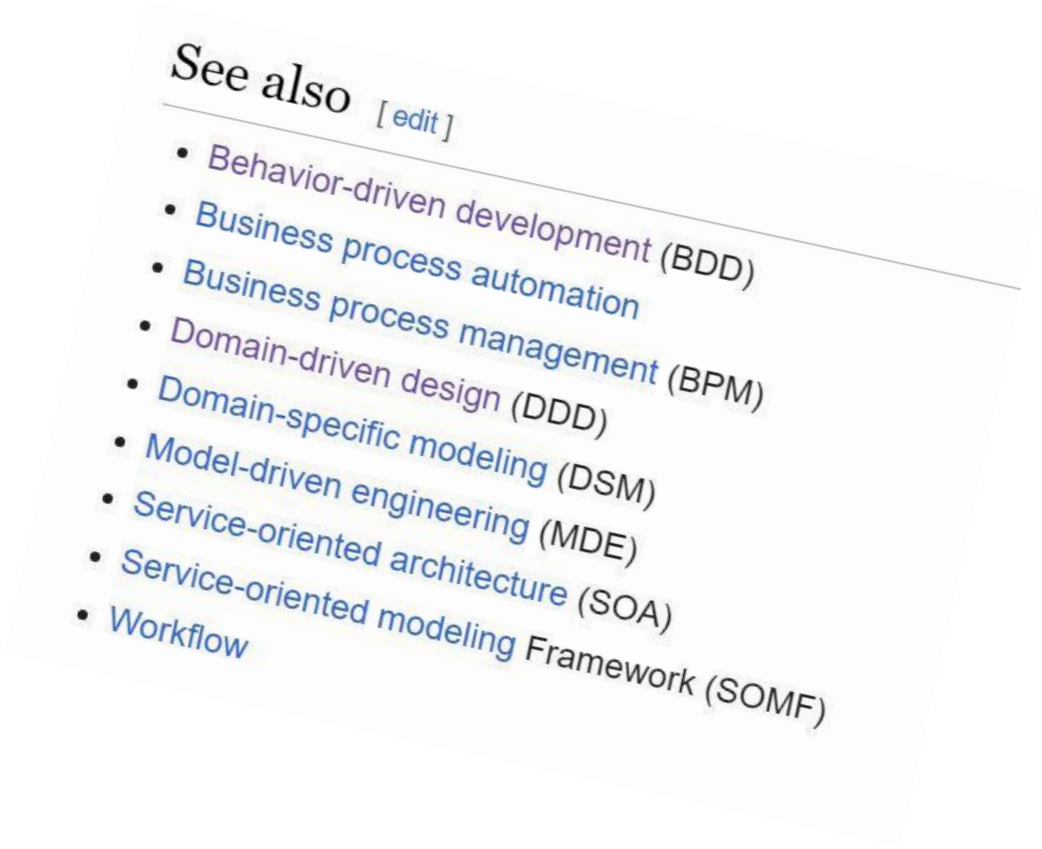
What non-functional quality attributes are included?

Problems of volatility

Changing requirements over time

How do we capture the requirements?

- There are many methodologies for this.
- Often described as x-Driven Design (for some x)
- They differ in scope & details, but they have many features in common.


See also [edit]

- Behavior-driven development (BDD)
- Business process automation
- Business process management (BPM)
- Domain-driven design (DDD)
- Domain-specific modeling (DSM)
- Model-driven engineering (MDE)
- Service-oriented architecture (SOA)
- Service-oriented modeling Framework (SOMF)
- Workflow

Common Elements

- Meet with stakeholders
- Develop a common language
- Collect desired system behaviors that offer value
- Document the desired behaviors
- Iterate and refine!!

User stories are the least common denominator of most approaches

Requirements gathering frameworks inform the structure and priority of user stories

- “Building the right thing” is necessarily a value judgment
  - (right for whom? who benefits?)

- You need some way to think about what capabilities you *shouldn’t* implement!

Your scientists were so preoccupied with whether or not they could, they didn't stop to think if they should."

- Ian Malcom (in *Jurassic Park*, 1993)

Requirements gathering frameworks inform the structure and priority of user stories

- Value Sensitive Design (VSD) is one framework (of many!)
- VSD guides designers and engineers to pay special attention to **stakeholders** and **human values** when writing and prioritizing user stories
- Combines **empirical**, **value**, and **technical**

VSD Example – Informed Consent

Empirical Investigation:

- Understand what we mean by informed consent, encompasses:
  - Disclosure. Do we know the pros and cons of taking an action?
  - Comprehension. Do we understand the disclosures?
  - Voluntariness. Is there coercion or manipulation?
  - Agreement. Is there a clear opportunity to consent or not?
  - Competence. Are we capable to give consent?

Values Investigation:

- Who are the direct and indirect stakeholders?
- Do the stakeholders have conflicting values?
- How can we resolve them?

Technical Investigation:

- What are the technical mechanisms for implementing informed consent.
  - One way => cookie consent management system.
  - Websites use them to obtain and manage user permission for using cookies.

Read the tutorial!

Review: Requirements analysis

- How do we make sure we are building the right thing?
- How do we learn from potential users before we start?
- Values: what even makes something the “right thing”
- Most forms of x-Driven Design could be a whole course on their own

Part 3: Test-Driven Development

PEOPLE

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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>

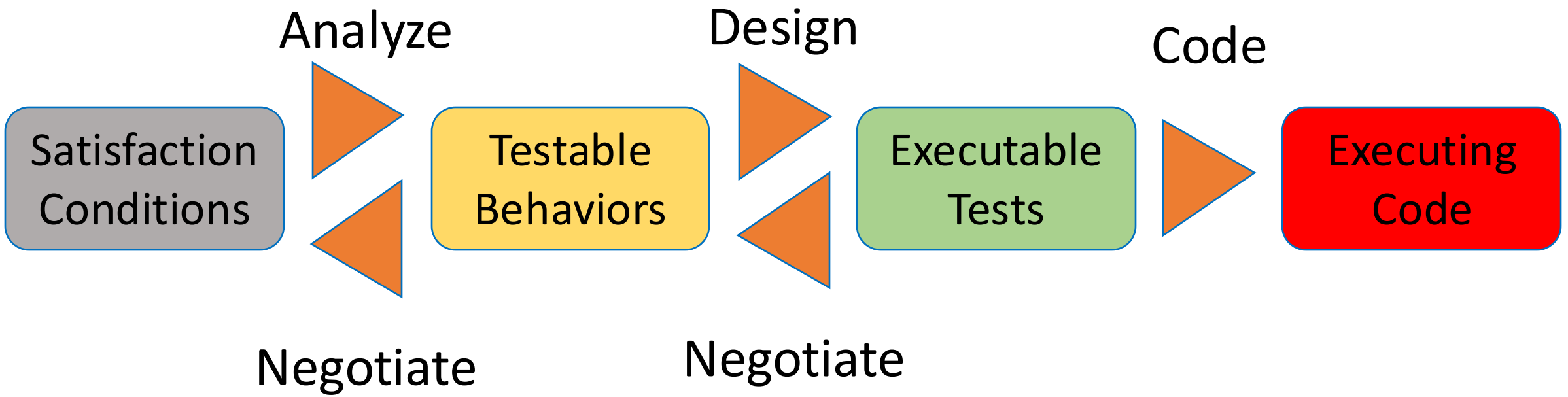
Review: Conditions of Satisfaction

- 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)

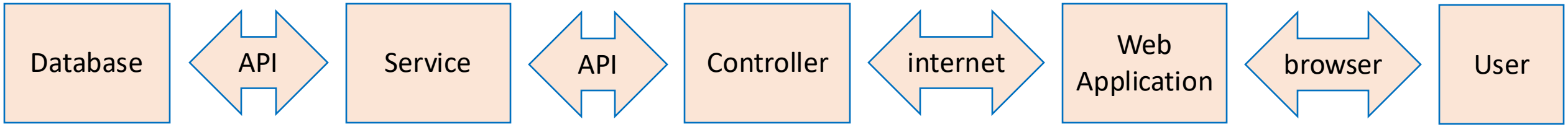
- Puts test specification as the critical design activity
  - Understands that deployment comes when the system passes testing
- The act of defining tests requires a deep understanding of the problem
- Clearly defines what success means
  - No more guesswork as to what “complete” means

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



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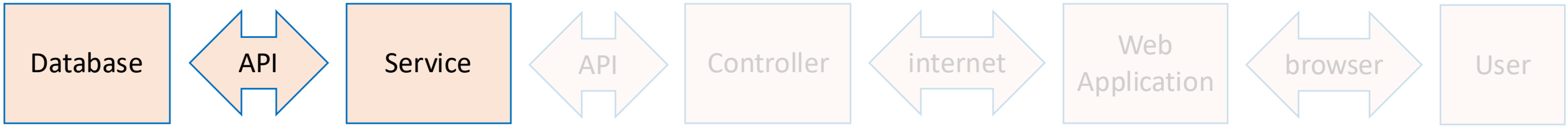
We will build a secure web application backed by a persistent database that allows an authenticated administrator to add a new student to the database



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

```ts
// 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| });

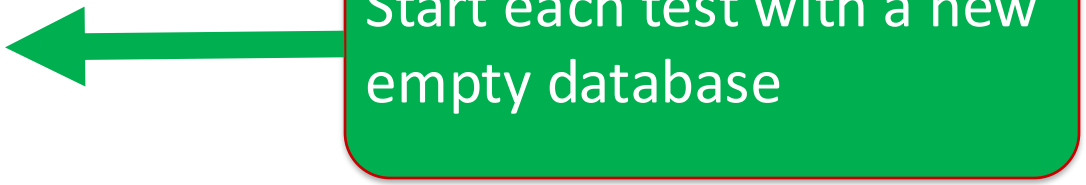

 Test Files  1 failed (1)
      Tests  1 failed | 1 passed (2)
```

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

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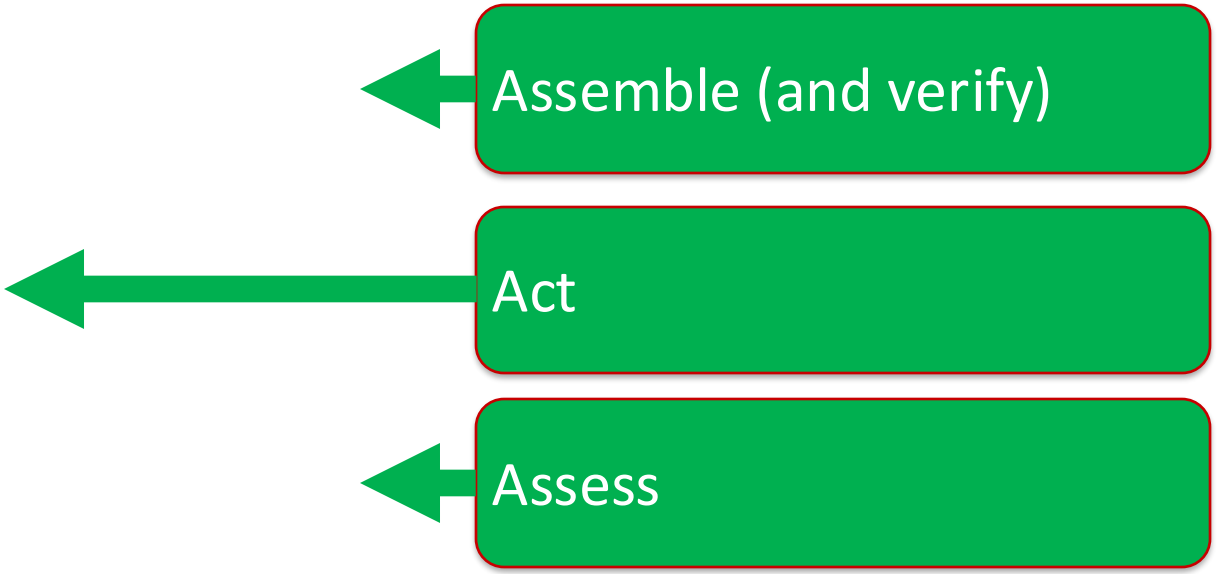
describe('addStudent', () => {
  it('should add a student to the database and return their id', () => {

    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', () => {
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    const id1 = db.addStudent('blair');
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    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

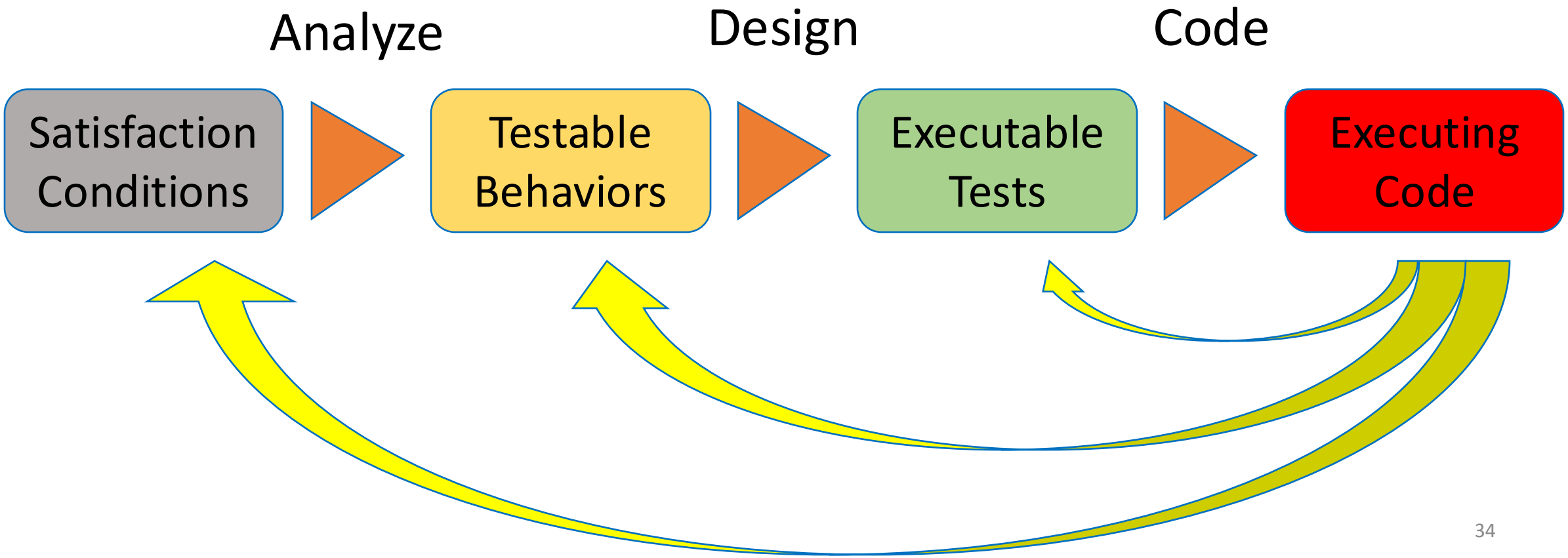
```
beforeEach(() => {
 db.clear([]);
});
```

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 overall purposes of requirements analysis
- Recall the three major dimensions of risk in requirements analysis
- Explain the connection between requirements analysis and user stories
- 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