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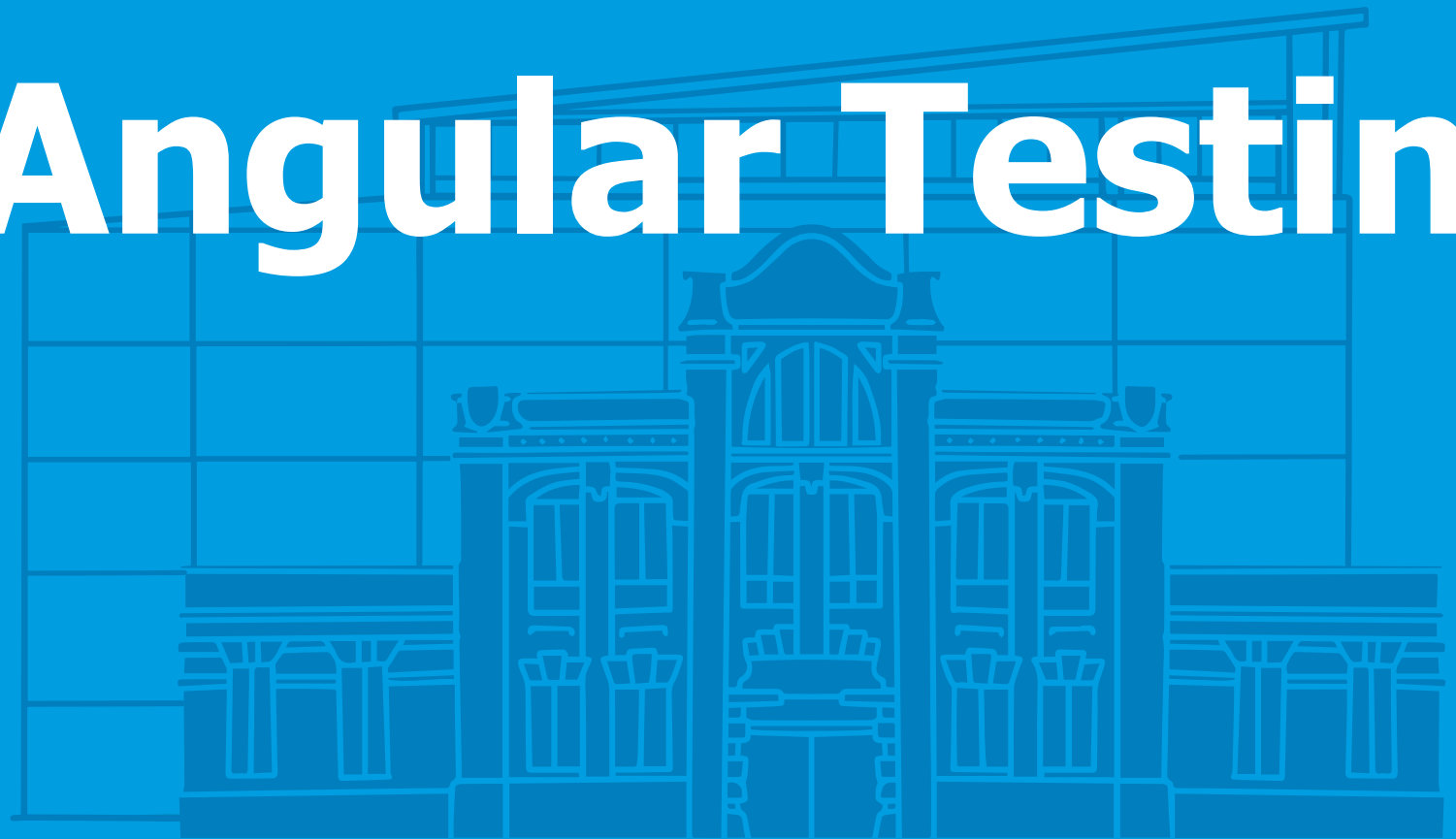
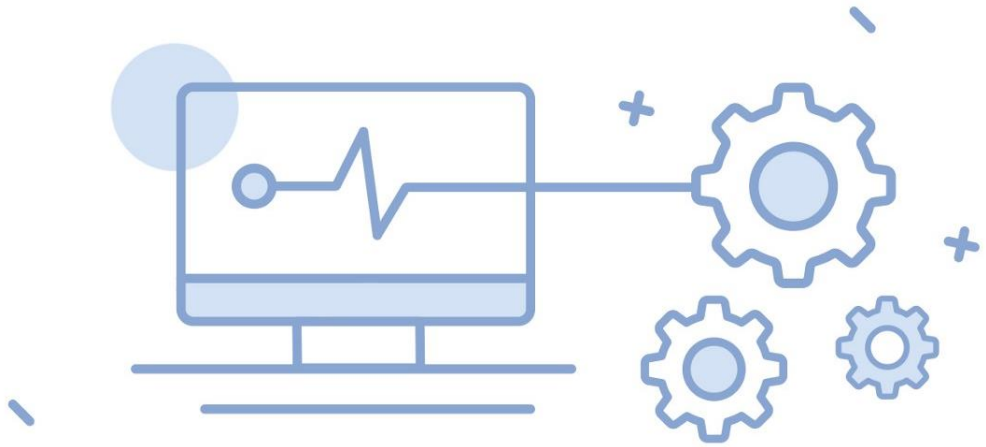
Angular 14 - 21

Angular Testing



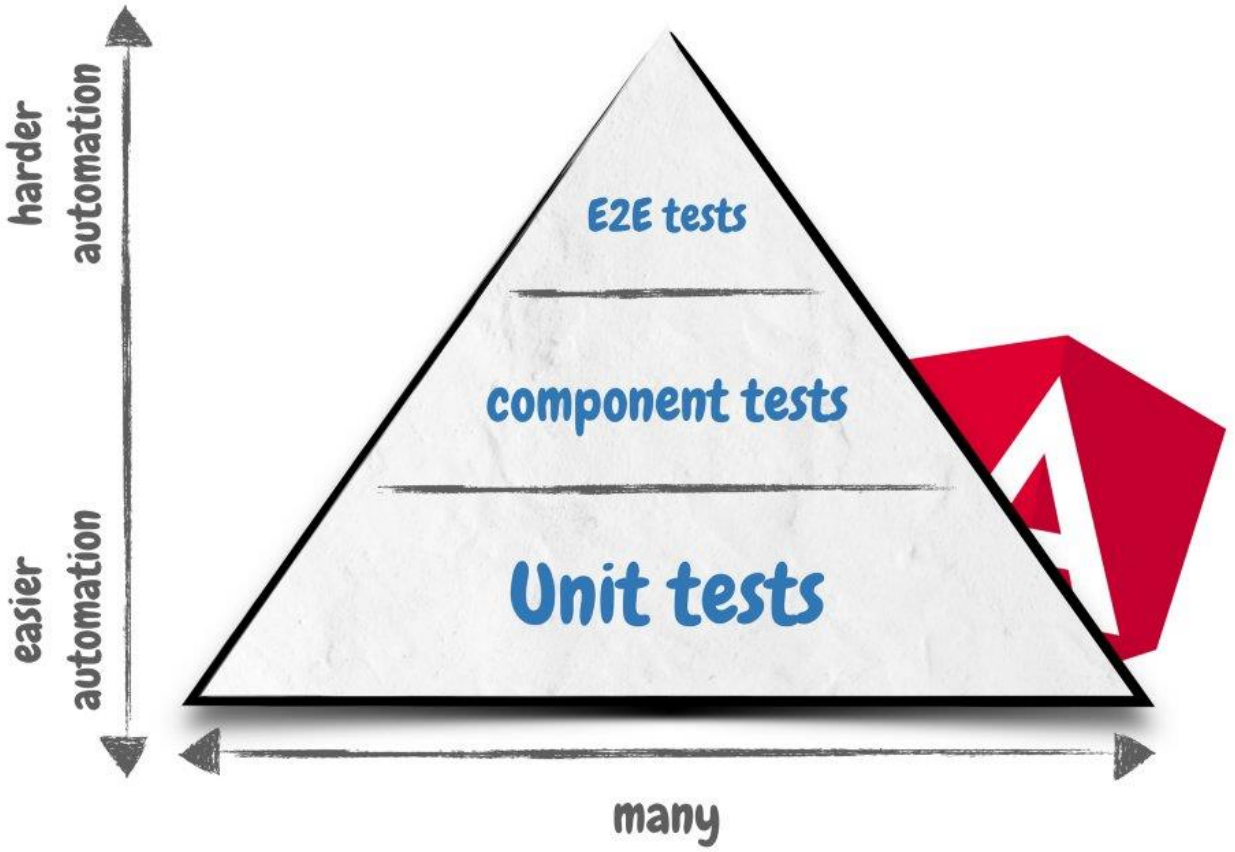
What makes a good test

- **COST-EFFECTIVE:** A valuable test is cost-effective. The test prevents bugs that could ultimately render the application unusable. The test is cheap to write compared to the potential damage it prevents.
- **DESCRIPTIVE:** A valuable test clearly describes how the implementation code should behave.
- **SUCCESS AND ERROR CASES:** A valuable test covers the important scenarios
- **PREVENT BREAKAGE:** A valuable test fails when essential code is changed or deleted.



The Angular testing pyramid

- **Unit tests** test functions
- **Component tests** are technical unit tests but actually they are integration tests - they test the interaction of multiple components
- **E2E Tests** test the most important scenarios



Angular testing principles

- **Testability**
  - **Testable architecture:** all application parts can be tested easily in a similar way..
  - **Well-structured code:** Angular breaks code into smaller chunks that "do one thing and do it well".
- **Dependency injection and faking**
  - **Loose coupling:** Dependency injection turns tight coupling into loose coupling.
  - **Original or fake:** In our test, we can decide how to deal with a dependency:
    - We can either provide an original, **fully-functional implementation**. In this case, we are writing an integration test that includes direct and indirect dependencies.
    - Or we provide a **fake implementation** that does not have side effects.
- **Testing tools**
  - The Angular team already made decisions for us:
  - **Jasmine** as testing framework and **Karma** as test runner.
  - Implementation and test code is bundled with **Webpack**.
  - Application parts are typically tested inside Angular's **TestBed**.
  - For e2e, we can choose between **Protractor** or **Cypress**.

Angular testing principles

- **Running the unit and integration tests**

For running all:

```
ng test
```

For running only one:

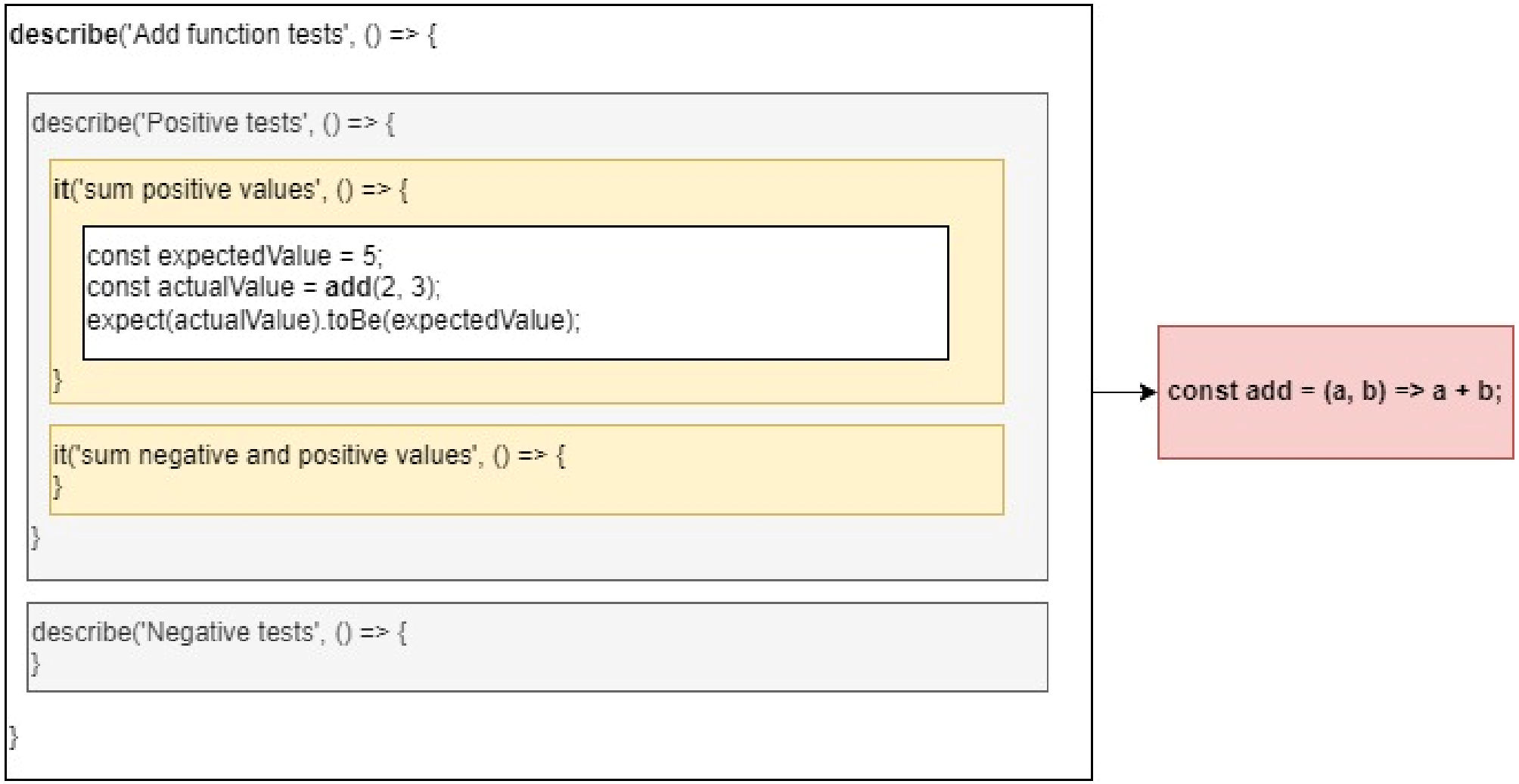
```
ng test --include [path_totest]
```

- ng test uses Webpack to compile the code into a JavaScript bundle. The entry point for the bundle is **src/test.ts**.
- Each **.spec.ts** file represents a test. Typically, it contains at least one Jasmine test suite. The files are co-located with the implementation code.
- ng test launches **Karma**, the test runner. Karma starts a development server at **http://localhost:9876/** that serves the JavaScript bundles compiled by Webpack.
- Test runner launches the browser and navigates to http://localhost:9876/, where the tests result are shown.
  - We enter in a "**red-green**" feedback cycle.
- https://angular.io/cli/test

Test suites with Jasmine

- Angular ships with Jasmine, a JavaScript framework that enables you to write and execute unit and integration tests.
  - https://jasmine.github.io/index.html
- Jasmine consists of three important parts:
  - A library with classes and functions for constructing tests.
  - A test execution engine.
  - A reporting engine that outputs test results in different formats.
- In Jasmine, a test consists of one or more **suites**. They can be nested.
- Each suit consists of one or more specifications, or **specs**. A spec is declared with an **it** block.
- Inside the it block lies the actual **testing code**, that typically consists of three phases:
  - **Arrange** is the preparation and setup phase. For example, the class under test is instantiated. Dependencies are set up. Spies and fakes are created.
  - **Act** is the phase where interaction with the code under test happens. For example, a method is called or an HTML element in the DOM is clicked.
  - **Assert** is the phase where the code behavior is checked and verified. For example, the actual output is compared to the expected output.
    - Jasmine allows us to create expectations in an easier manner using the **expect** function together with a **matcher** (https://jasmine.github.io/api/edge/matchers.html).

Test suites with Jasmine



- You can find most details in the official tutorial: https://jasmine.github.io/tutorials/your_first_suite
- And in this Jasmine cheatsheet: https://devhints.io/jasmine

Test suites with Jasmine

- When writing multiple specs in one suite, usually the Arrange phase is similar or even identical across these specs.
- For this purpose, Jasmine provides four functions: **beforeEach**, **afterEach**, **beforeAll** and **afterAll**. They are called inside of a describe block.

```
describe('Suite description', () => {
  beforeAll(() => {
    console.log('Called before all specs are run');
  });
  afterAll(() => {
    console.log('Called after all specs are run');
  });

  beforeEach(() => {
    console.log('Called before each spec is run');
  });
  afterEach(() => {
    console.log('Called after each spec is run');
  });

  it('Spec 1', () => {
    console.log('Spec 1');
  });
  it('Spec 2', () => {
    console.log('Spec 2');
  });
});
```

Faking dependencies

- When testing a piece of code, you need to decide between an **integration** test and a **unit** test.
  - To recap, the **integration** test **includes ("integrates") the dependencies**.
  - In contrast, the **unit** test **replaces the dependencies with fakes** (also called test doubles, stubs or mocks) in order to isolate the code under test.
- Jasmine provides the **Jasmine spy** for replacing a function dependency:

  `const spy = jasmine.createSpy('name');`

```
// Fake todos and response object
const todos = [
  'shop groceries',
  'mow the lawn',
  'take the cat to the vet'
];
const okResponse = new Response(JSON.stringify(todos), {
  status: 200,
  statusText: 'OK',
});
```

```
class TodoService {
  constructor(
    private fetch = window.fetch.bind(window)
  ) {}

  public async getTodos(): Promise<string[]> {
    const response = await this.fetch('/todos');
    if (!response.ok) {
      throw new Error(
        `HTTP error: ${response.status} ${response.statusText}`
      );
    }
    return await response.json();
  }
}
```

```
describe('TodoService', () => {
  it('gets the to-dos', async () => {
    // Arrange
    const fetchSpy = jasmine.createSpy('fetch')
      .and.returnValue(okResponse);
    const todoService = new TodoService(fetchSpy);

    // Act
    const actualTodos = await todoService.getTodos();

    // Assert
    expect(actualTodos).toEqual(todos);
    expect(fetchSpy).toHaveBeenCalledWith('/todos');
  });
});
```

Faking dependencies

- Sometimes, there is already an object whose method we need to spy on.
- This is especially helpful if the code uses global methods from the browser environment, like window.fetch in the example above.
- For this purpose, we can use the spyOn method:

```
spyOn(object, 'method');
```

```
describe('TodoService', () => {
  it('gets the to-dos', async () => {
    // Arrange
    spyOn(window, 'fetch')
      .and.returnValue(okResponse);
    const todoService = new TodoService();

    // Act
    const actualTodos = await todoService.getTodos();

    // Assert
    expect(actualTodos).toEqual(todos);
    expect(window.fetch).toHaveBeenCalledWith('/todos');
  });
});
```

Testing components

- Several chores are necessary to render a Component in Angular, even the simple counter Component.
- Angular team provides the **TestBed** to ease unit testing.
- The TestBed creates and configures an Angular environment so you can test particular application parts like Components and Services safely and easily.

```
TestBed.configureTestingModule({
  imports: [ /*… */ ],
  declarations: [ /*… */ ],
  providers: [ /*… */ ],
});
```

```
describe('CounterComponent', () => {
  let fixture: ComponentFixture<MyComponent>;

  beforeEach(async () => {
    await TestBed.configureTestingModule({
      declarations: [MyComponent],
    }).compileComponents();

    fixture = TestBed.createComponent(MyComponent);
    fixture.detectChanges();
  });

  it('…', () => {
    /* … */
  });
});
```

Testing components

- For accessing elements in the DOM, Angular has another abstraction: The **DebugElement** wraps the native DOM element.
- The fixture's debugElement property returns the Component's host element.

```
const { debugElement } = fixture;
```

- Often it is necessary to unwrap the DebugElement to access the native DOM element inside. Every DebugElement has a nativeElement property:

```
const { nativeElement } = debugElement;
```

```
/* Incomplete! */
describe('CounterComponent', () => {
  let fixture: ComponentFixture<CounterComponent>;
  let debugElement: DebugElement;

  // Arrange
  beforeEach(async () => {
    await TestBed.configureTestingModule({
      declarations: [CounterComponent],
    }).compileComponents();

    fixture = TestBed.createComponent(CounterComponent);
    fixture.detectChanges();
    debugElement = fixture.debugElement;
  });

  it('increments the count', () => {
    // Act
    const incrementButton = debugElement.query(
      By.css('[data-testid="increment-button"]')
    );
    incrementButton.triggerEventHandler('click', null);

    // Assert
    const countOutput = debugElement.query(
      By.css('[data-testid="count"]')
    );
    expect(countOutput.nativeElement.textContent).toBe('1');
  });
});
```

Testing helper

- A testing helper is a piece of code that makes writing tests easier. It makes test code more concise and more meaningful.
- Since a spec should describe the implementation, a readable spec is better than an obscure, convoluted one.

```
function findEl<T>(
  fixture: ComponentFixture<T>,
  testId: string
): DebugElement {
  return fixture.debugElement.query(
    By.css(`[data-testid="${testId}"]`)
  );
}
```

```
export function click<T>(
  fixture: ComponentFixture<T>,
  testId: string
): void {
  const element = findEl(fixture, testId);
  const event = makeClickEvent(element.nativeElement);
  element.triggerEventHandler('click', event);
}
```

```
export function makeClickEvent(
  target: EventTarget
): Partial<MouseEvent> {
  return {
    preventDefault(): void {},
    stopPropagation(): void {},
    stopImmediatePropagation(): void {},
    type: 'click',
    target,
    currentTarget: target,
    bubbles: true,
    cancelable: true,
    button: 0
  };
}
```

```
export function expectText<T>(
  fixture: ComponentFixture<T>,
  testId: string,
  text: string,
): void {
  const element = findEl(fixture, testId);
  const actualText = element.nativeElement.textContent;
  expect(actualText).toBe(text);
}
```

```
it('decrements the count', () => {
  // Act
  click(fixture, 'decrement-button');
  // Re-render the Component
  fixture.detectChanges();

  // Assert
  expectText(fixture, 'count', '-1');
});
```

Fake input event

- Angular forms cannot observe value changes directly. Instead, **Angular listens for an input event** that the browser fires when a field value changes.
- For compatibility with Template-driven and Reactive Forms, we need to dispatch a fake input event. Such events are also called synthetic events.
- We create a fake input event with new **Event('input')**. To dispatch the event, we use the **dispatchEvent** method of the target element.

```
const resetInputEl = findEl(fixture, 'reset-
input').nativeElement;
resetInputEl.value = '123';
resetInputEl.dispatchEvent(new Event('input'));
```

```
it('resets the count', () => {
  const newCount = '123';

  // Act
  const resetInputEl = findEl(fixture, 'reset-
input').nativeElement;
  // Set field value
  resetInputEl.value = newCount;
  // Dispatch input event
  const event = document.createEvent('Event');
  event.initEvent('input', true, false);
  resetInputEl.dispatchEvent(event);

  // Click on reset button
  click(fixture, 'reset-button');
  // Re-render the Component
  fixture.detectChanges();

  // Assert
  expectText(fixture, 'count', newCount);
});
```

Component state

- We can test the component state related to events in the view.
- For that we will lean on **ngOnChanges**, since it is called whenever a "data-bound property" changes, including Inputs.

```
describe('CounterComponent', () => {
  let component: CounterComponent;
  let fixture: ComponentFixture<CounterComponent>;

  const startCount = 123;

  beforeEach(async () => {
    await TestBed.configureTestingModule({
      declarations: [CounterComponent],
    }).compileComponents();

    fixture = TestBed.createComponent(CounterComponent);
    component = fixture.componentInstance;
    component.startCount = startCount;
    // Call ngOnChanges, then re-render
    component.ngOnChanges();
    fixture.detectChanges();
  });

  /* … */

  it('shows the start count', () => {
    expectText(fixture, 'count', String(startCount));
  });
});
```

Testing Outputs

- While Inputs pass data from parent to child, Outputs send data from child to parent. In combination, a Component can perform a specific operation just with the required data.
- The Component uses the **emit** method to publish new values. The parent Component uses the **subscribe** method to listen for emitted values.
- In the testing environment, we will do the same.

```
it('emits countChange events on decrement', () => {
  // Arrange
  let actualCount: number | undefined;
  component.countChange.subscribe((count: number) => {
    actualCount = count;
  });

  // Act
  click(fixture, 'decrement-button');

  // Assert
  expect(actualCount).toBe(-1);
});

it('emits countChange events on reset', () => {
  const newCount = '123';

  // Arrange
  let actualCount: number | undefined;
  component.countChange.subscribe((count: number) => {
    actualCount = count;
  });

  // Act
  setFieldValue(fixture, 'reset-input', newCount);
  click(fixture, 'reset-button');

  // Assert
  expect(actualCount).toBe(newCount);
});
```

Testing Components with children

- There are two fundamental ways to test Components with children:
  - A unit test using **shallow** rendering. The child Components are not rendered.
  - An integration test using **deep** rendering. The child Components are rendered.
- When configuring the testing Module, we can specify **schemas** to tell Angular how to deal with elements that are not handled by Directives or Components.

```
await TestBed.configureTestingModule({
  declarations: [HomeComponent],
  schemas: [NO_ERRORS_SCHEMA],
}).compileComponents();
```

- There is a middle ground between a naive unit test and an integration test. Instead of working with empty custom elements, we can render **fake child Components**.

```
@Component({
  selector: 'app-counter',
  template: '',
})
class FakeCounterComponent implements Partial<CounterComponent> {
  @Input()
  public startCount = 0;

  @Output()
  public countChange = new EventEmitter<number>();
}

describe('HomeComponent (faking a child Component)', () => {
  let fixture: ComponentFixture<HomeComponent>;
  let component: HomeComponent;
  let counter: FakeCounterComponent;

  beforeEach(async () => {
    await TestBed.configureTestingModule({
      declarations: [HomeComponent, FakeCounterComponent],
      schemas: [NO_ERRORS_SCHEMA],
    }).compileComponents();

    fixture = TestBed.createComponent(HomeComponent);
    component = fixture.componentInstance;
    fixture.detectChanges();

    const counterEl = fixture.debugElement.query(
      By.directive(FakeCounterComponent)
    );
    counter = counterEl.componentInstance;
  });

  it('renders an independent counter', () => {
    expect(counter).toBeTruthy();
  });

  it('passes a start count', () => {
    expect(counter.startCount).toBe(5);
  });

  it('listens for count changes', () => {
    spyOn(console, 'log');
    const count = 5;
    counter.countChange.emit(count);
    expect(console.log).toHaveBeenCalledWith(
      'countChange event from CounterComponent',
      count,
    );
  });
});
```

Testing Services

- Testing a service is similar to testing a generic class. TestBed is not needed, but instantiate the service object to be tested.

```
describe('CounterService', () => {
  let counterService: CounterService;

  function expectCount(count: number): void {
    let actualCount: number | undefined;
    counterService.getCount().pipe(first())
      .subscribe((actualCount2) => {
        actualCount = actualCount2;
      });
    expect(actualCount).toBe(count);
  }

  beforeEach(() => {
    counterService = new CounterService();
  });

  it('returns the count', () => {
    expectCount(0);
  });

  it('increments the count', () => {
    counterService.increment();
    expectCount(1);
  });

  it('decrements the count', () => {
    counterService.decrement();
    expectCount(-1);
  });

  it('resets the count', () => {
    const newCount = 123;
    counterService.reset(newCount);
    expectCount(newCount);
  });
});
```

Testing Services

- When a service depends on other services, specially on Angular's standard HTTP library, we will need to instantiate the dependencies and subscribe if there are asynchronous events.
- We can inject the depending services in the module using the TestBed.
- **HttpTestingController** will help to deal with requests.

```
const searchTerm = 'dragonfly';
const expectedUrl =
`https://www.flickr.com/services/rest/?tags=${searchTerm}&metho
d=flickr.photos.search&format=json&nojsoncallback=1&tag_mode=al
l&media=photos&per_page=15&extras=tags,date_taken,owner_name,ur
l_q,url_m&api_key=XYZ`;

describe('FlickrService', () => {
  let flickrService: FlickrService;
  let controller: HttpTestingController;

  beforeEach(() => {
    TestBed.configureTestingModule({
      imports: [HttpClientTestingModule],
      providers: [FlickrService],
    });
    flickrService = TestBed.inject(FlickrService);
    controller = TestBed.inject(HttpTestingController);
  });

  it('searches for public photos', () => {
    let actualPhotos: Photo[] | undefined;
    flickrService.searchPublicPhotos(searchTerm).subscribe(
      (otherPhotos) => {
        actualPhotos = otherPhotos;
      }
    );

    const request = controller.expectOne(expectedUrl);
    request.flush({ photos: { photo: photos } });
    controller.verify();

    expect(actualPhotos).toEqual(photos);
  });
});
```

Code coverage

- Code coverage, also called test coverage, tells which parts of the code are executed by running the unit and integration tests.
  - Code coverage is typically expressed as percent values, for example, 79% statements, 53% branches, 74% functions, 78% lines.
- In Angular's Karma and Jasmine setup, **Istanbul** is used for measuring test coverage.
  - https://istanbul.js.org/
- To activate Istanbul when running the tests, add the --code-coverage parameter:

```
ng test --code-coverage
```

  - After the tests have completed, Istanbul saves the report in the **coverage directory** located in the Angular project directory.
  - The report is a bunch of HTML files you can open with a browser.
  - Start by opening **coverage/index.html**.

Let's put it into practice: Tasks/Projects App

- Implement tests for the different elements of the application (at least a nested component and service)
    - Use the fake approach and the integration testing approach.
- Get the report of code coverage.

E2e testing Angular

- An end-to-end test mimics how a user interacts with the application. Typically, the test engine launches an ordinary browser and controls it remotely.
- There are two main frameworks to do e2e testing in the context of Angular:
  - **Protractor**, which is based on WebDriver.
  - **Cypress**, which does not use WebDriver.
- Up until Angular version 12, Protractor was the default end-to-end testing framework in projects created with Angular CLI.
  - Since Angular 12, Protractor is deprecated.
  - In new CLI projects, there is no default end-to-end testing solution configured.
  - The main reason for Protractor's deprecation is that it was not maintained for years.
- Instead, now is recommended using **Cypress** for e2e testing Angular applications.
  - https://docs.cypress.io/
  - Cypress is an end-to-end testing framework that is not based on WebDriver.
  - There are no Angular-specific features. Any web site can be tested with Cypress.
  - Cypress is well-maintained and well-documented.
- To add Cypress to the project we can use the next command:

```
ng add @cypress/schematic
```

E2e testing with Cypress

- In the project directory, you will find a sub-directory called cypress. It contains:
  - **tsconfig.json** configuration for all **TypeScript files** specifically in this directory,
  - **e2e** directory for the **end-to-end tests**,
  - **support** directory for **custom commands** and other testing helpers,
  - **fixtures** directory for **test data**.
- The test files reside in the e2e directory. Each test is TypeScript file with the **extension .cy.ts**.
- The tests itself are structured with the test framework **Mocha**. The assertions (also called expectations) are written using **Chai**.
- Mocha structure is similar to Jasmine.

```
describe('… Feature description …', () => {
  beforeEach(() => {
    // Navigate to the page
  });

  it('… User interaction description …', () => {
    // Interact with the page
    // Assert something about the page content
  });
});
```

E2e testing with Cypress

- Cypress commands are methods of the **cy** namespace object. Here, we are using two commands, visit and title.
- You can review the reference for commands, chainers and assertions here:
  - https://docs.cypress.io/api/table-of-contents
- Cheatsheet:
  - https://cheatography.com/aiqbal/cheat-sheets/cypress-io/

```
describe('Counter', () => {
  beforeEach(() => {
    cy.visit('/');
  });

  it('has the correct title', () => {
    cy.title().should('equal', 'Angular Workshop: Counters');
  });

  it('increments the count', () => {
    cy.get('[data-testid="count"]').should('have.text', '5');
    cy.get('[data-testid="increment-button"]').click();
    cy.get('[data-testid="count"]').should('have.text', '6');
  });

  it('decrements the count', () => {
    cy.get('[data-testid="decrement-button"]').click();
    cy.get('[data-testid="count"]').should('have.text', '4');
  });

  it('resets the count', () => {
    cy.get('[data-testid="reset-input"]').type('123');
    cy.get('[data-testid="reset-button"]').click();
    cy.get('[data-testid="count"]').should('have.text', '123');
  });
});
```

- Cypress has two shell commands to run the end-to-end tests:

🔗 **Non-interactive test runner:** Runs the tests in a “headless” browser. This means the browser window is not visible.

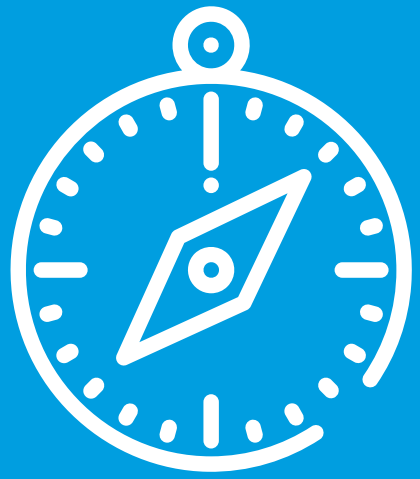
```
npx cypress run
```

🔗 **Interactive test runner:** Opens a window where you can select which browser to use and which tests to run.

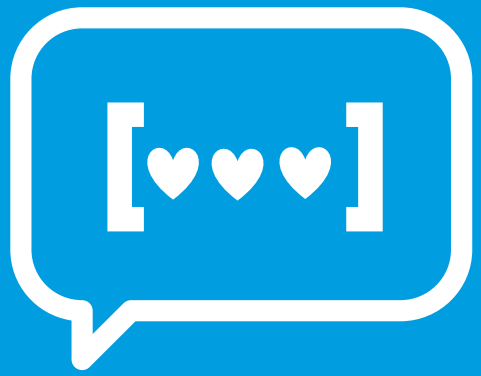
```
npx cypress open
```

Let's put it into practice: Tasks/Projects App

- Implement e2e tests for the project list, for deleting a task and for creating a new project.



Next steps



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