CS 4350: Fundamentals of Software Engineering

Lesson 5.3 Testing Systems

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Learning Objectives for this Lesson

- By the end of this lesson, you should be able to:
  - Explain why you might need a "test double“ in your testing
  - Explain the differences between different kinds of test “doubles” such as “stubs, mocks, spies, fakes”

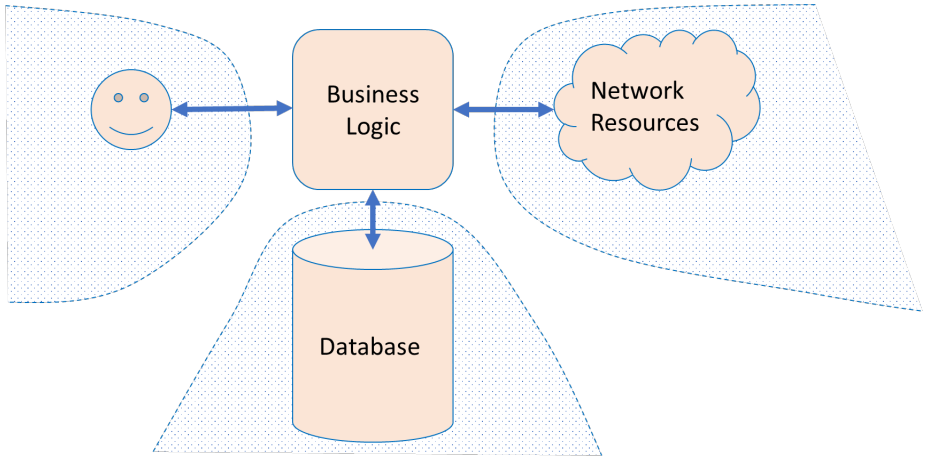
Review: What is the purpose of Test Suite?

- Test Driven Development
  - Does the SUT satisfy its specification? (“functional testing”)
- Regression Test
  - Did something change since some previous version?
  - Prevent bugs from (re-)entering during maintenance.
- Acceptance Test
  - Does the SUT satisfy the customer (requirement testing)
  - Validation: Are we building the right system ?

These purposes are copied from Lesson 5.2

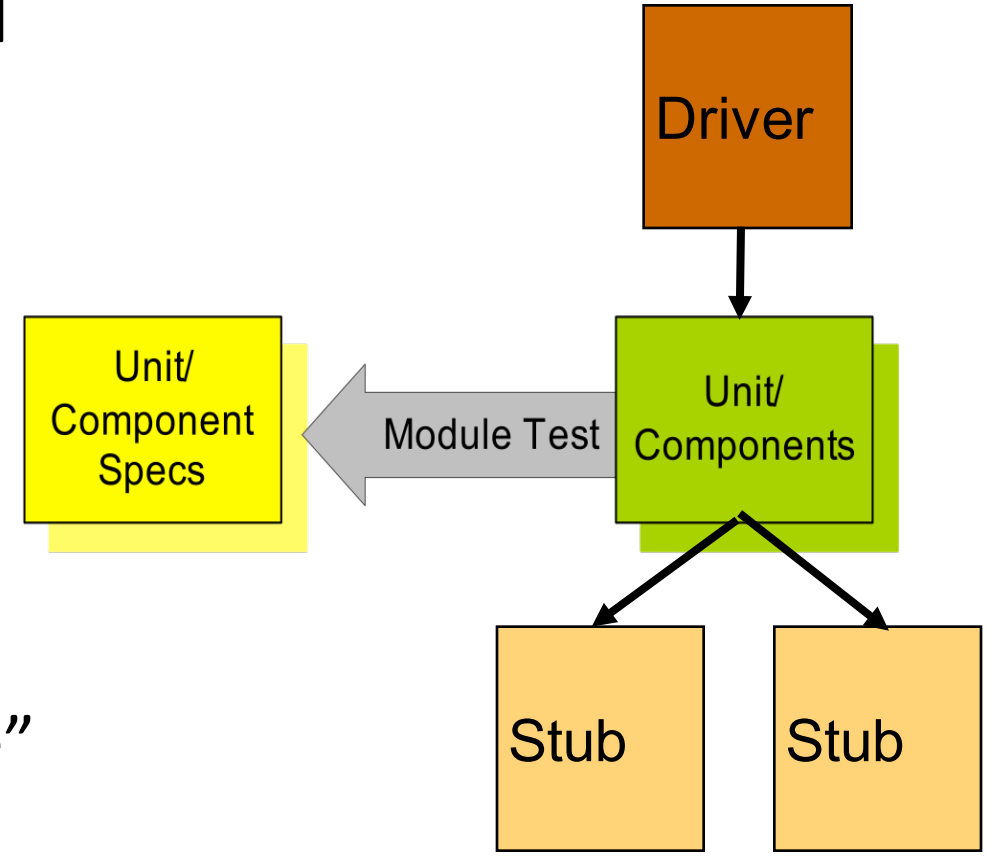
Large Systems are Hard to Test

- Database component
  - Contents may need to reflect/simulate real-world;
  - Data may be expensive/proprietary/confidential.
- Network connections
  - ”Real” connections may be slow/flaky/disrupted;
  - Resources may have changed since test was written.
- Environment
  - Interactions with OS, locale or other software.
- Human actors
  - Ultimately unpredictable.



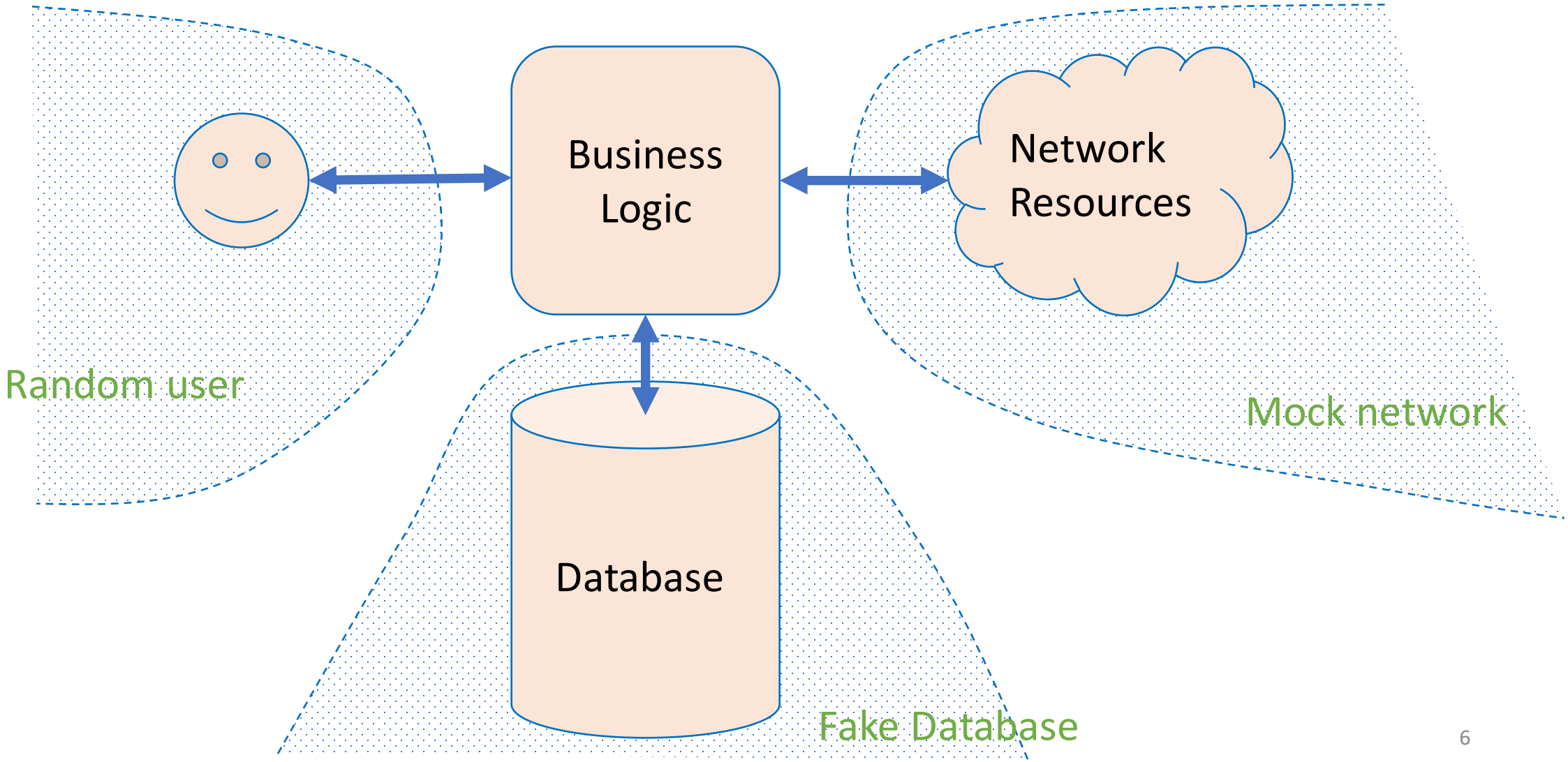
Unit Testing is not sufficient

- You are used to using Drivers and Stubs in your tests

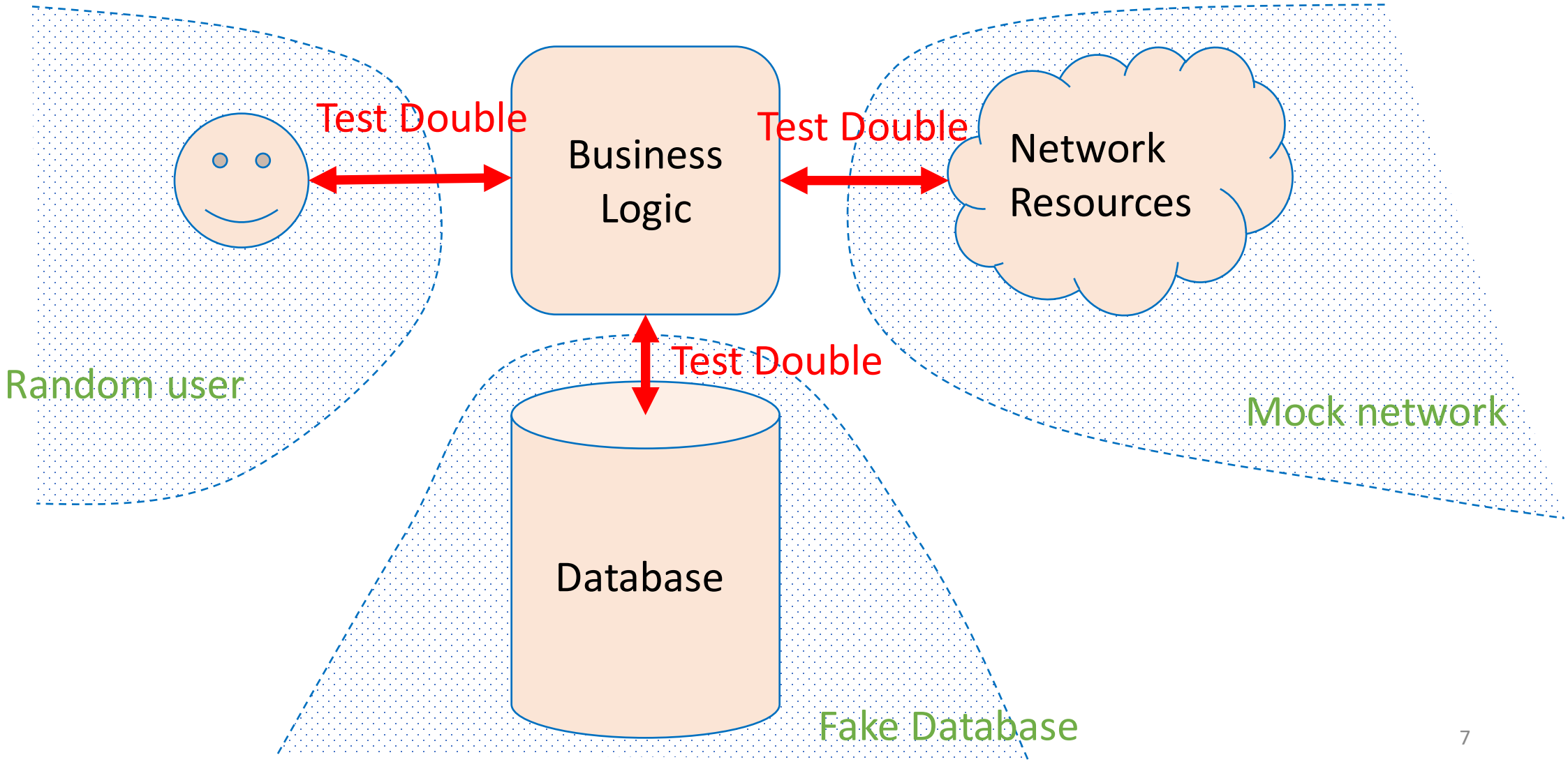


- Overall systems are “a little more” complicated

Test Doubles replace uncontrollable pieces of the environment



What are Test Doubles?



Test Stub is a Double that just supplies the same interface

- Supply an object with the same interface:
  - Same methods;
  - Default result values (i.e., canned answers).
- The stub gets the test to run:
  - If the client blindly uses the stub, it can proceed;
  - If the client expects something specific from the object, the test will likely fail.

Test Stub Example

```
final class Service {
    public function doSomething(UserModelInterface user): Int {
        /* Do things */
        return user.uuid;
    }
}
final class ServiceTest extends TestCase {
    public function testDoSomething(): void {
        // The service needs a implementation `UserModelInterface`.
        String uuid = (new Service()).doSomething(new UserStub());
        self.assertStringContainsString('0000-000-000-00001', uuid);
    }
}
interface UserModelInterface {
    public function getUuid(): String;
}
final class UserStub implements UserModelInterface {
    public function getUuid(): String {
        return '0000-000-000-00001';
    }
}
```

getUuid() is a stub

Sometimes Test Stub is not enough

- You might want your stub to do atleast two more things:
  1. Remember how the stub was used; (“memory”)
  2. Program the responses of the stub for different situations.

Test Spy is a stub that remembers how the object was called

- Test can check what happened earlier;
  - For example: a particular method should be called
    1. First with parameters “foo” and 42;
    2. Then with parameters “quux” and -88.
- A spy can be useful in conjunction with the “real” environment:
  - What was sent on the network?
  - How many times a problem was logged?
  - What was inserted in the database?
- But most often used with a “mock.” (we will discuss this later)

Spy “remembers”

Test Spy Example

```
interface Logger {
    public function log(String message): void;
}
final class LoggerSpy implements Logger {
    public Array messages = [];
    public function log(string message): void {
        this.messages[] = message;
    }
}
final class UserNotifier {
    public function __construct(private Logger logger) {}
    public function registerUser(UserModelInterface user): void {
        this.logger.log("Notifying the user: {user.name()}");
        // ...
    }
}
```

```
final class UserNotifierTest extends TestCase {
    public function testLogMessage(): void {
        LoggerSpy logger = new LoggerSpy();
        UserNotifier notifier = new UserNotifier(logger);
        User user = new User(name = 'Jesus');
        notifier.registerUser(user);
        self.assertStringContainsString(
            "Notifying the user: {user.name()}",
            first(logger.messages)     );    }}
```

Logger "remembers" messages

Test Mock is a Double that has Scripted results

- A test mock has scripted results:
  - If such-and-such a method is called
    - return some particular value.
- A complex mock can have many scripts:
  - Multiple methods;
  - Different results for subsequent calls.
- Useful mocking assumes we know how mocked object will be used.
- If a “mock” has real logic, it becomes a “fake” (we will discuss this later).

Mock has “scripted answers” and is used for “behavior verification”

Jest supports Mocks

Jest's Mock API: https://jestjs.io/docs/mock-function-api

- Replacing TwilioVideo with Mock

```
const mockTwilioVideo = mockDeep<TwilioVideo>();
jest.spyOn(TwilioVideo, 'getInstance').mockReturnValue(mockTwilioVideo);
```

You will see more of these in HW3

- Jest Tests can be written

```
it('should use the coveyTownID and player ID properties when requesting a video token',
      async () => {
        const townName = `FriendlyNameTest-${nanoid()}`;
        const townController = new CoveyTownController(townName, false);
        const newPlayerSession = await townController.addPlayer(new Player(nanoid()));
        expect(mockTwilioVideo.getTokenForTown).toBeCalledTimes(1);
        expect(mockTwilioVideo.getTokenForTown).toBeCalledWith(townController.coveyTownID, newPlayerSession.pla
      });
```

Here is another Example of Mock /1

```
describe('conversationAreaCreateHandler', () => {

    const mockCoveyTownStore = mock<CoveyTownsStore>();
    const mockCoveyTownController = mock<CoveyTownController>();
    beforeAll(() => {
      // Set up a spy for CoveyTownsStore that will always return our mockCoveyTownsStore as the
singleton instance
      jest.spyOn(CoveyTownsStore, 'getInstance').mockReturnValue(mockCoveyTownStore);
    });
    beforeEach(() => {
      // Reset all mock calls, and ensure that getControllerForTown will always return the same
mock controller
      mockReset(mockCoveyTownController);
      mockReset(mockCoveyTownStore);
      mockCoveyTownStore.getControllerForTown.mockReturnValue(mockCoveyTownController);
    });
. . . .
```

spying on getInstance() method

Here is another Example of Mock /2

```
. . . .
    it('Checks for a valid session token before creating a conversation area', ()=>{
      const coveyTownID = nanoid();
      const conversationArea :ServerConversationArea = { boundingBox: { height: 1, width: 1, x:1, y:1 }, label:
nanoid(), occupantsByID: [], topic: nanoid() };
      const invalidSessionToken = nanoid();
      // Make sure to return 'undefined' regardless of what session token is passed
      mockCoveyTownController.getSessionByToken.mockReturnValueOnce(undefined);
      requestHandlers.conversationAreaCreateHandler({
        conversationArea,
        coveyTownID,
        sessionToken: invalidSessionToken,
      });
      expect(mockCoveyTownController.getSessionByToken).toBeCalledWith(invalidSessionToken);
      expect(mockCoveyTownController.addConversationArea).not.toHaveBeenCalled();
   });
});
```

If SessionToken is invalid, don't call addConversationArea()

Test Fake is a Mock with semi-real implementation

- A *fake* has an implementation of the object being replaced
  - A *low-fidelity* fake implements things partially
    - Enough to work for the test.
  - A *high-fidelity* fake implements most aspects:
    - Usually all functional aspects;
    - Usually not as efficiently or as scalable.
- The purpose of the fake is to avoid processes/network/cost:
  - So the test can be cheap and deterministic.

Fake has "semi-real implementation"

- Transcript Server you used in Activity 4.1 was a Fake

How do you provide a Test Double for a User?

- To replace a user, we can program a “Bot”
  - Randomly use mouse, press buttons;
  - Arbitrary text;
  - Fast or slow.
- Smarter (“Fuzzing”)
  - Capture real actions;
  - Then make targeted mutations.
  - (This applies also to programs taking text input.)
- Expected result can only be imprecise:
  - e.g., “not crash” or “not leak secrets”.

Weaknesses of Test Doubles

- The Mock/Fake may not behave correctly
  - The test may assume wrong behavior;
  - Particularly an issue if original object changes
    - Mocks have to be maintained as well!
  - Solution: Test the mock/fake against a higher fidelity fake, or against the real thing.
- The SUT may use a different algorithm:
  - The Spies expect a particular usage of double;
  - The test is “brittle” because it depends on internal behavior of SUT;

Review: Learning Objectives for this Lesson

- You should now be able to:
  - Explain why you might need a "test double“ in your testing
  - Explain the differences between different kinds of test “doubles” such as “stubs, mocks, spies, fakes”

- For Further Reading
  - Check out Martin Fowler’s article, “Mocks Aren’t Stubs” https://martinfowler.com/articles/mocksArentStubs.html
  - “xUnit Test Patterns: Refactoring Test Code” by Gerard Meszaros