

# CS 4530: Fundamentals of Software Engineering

## Lesson 5.3 Testing Systems

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# Learning Objectives for this Lesson

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- 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?

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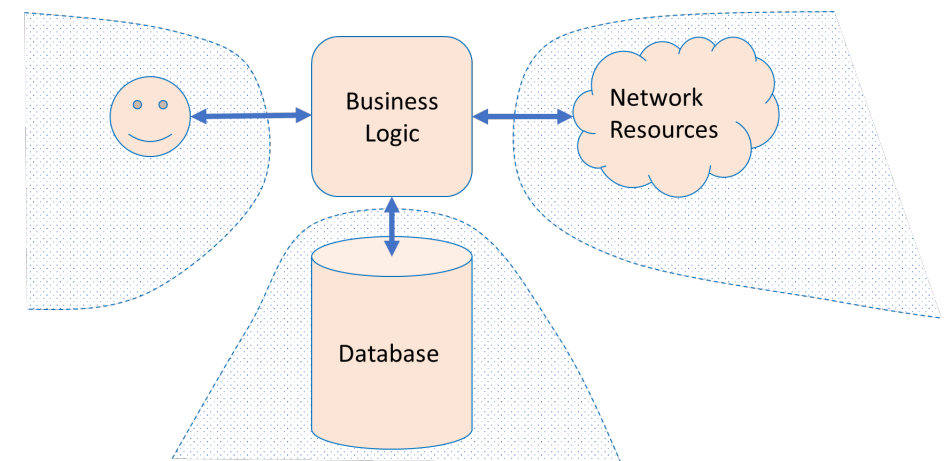
- Test Driven Development
  - Does the SUT satisfy its specification? (“functional testing”)
- Regression Test
  - Did something change since some previous version?
  - Prevent bugs from (re-)entering during maintenance.
- Acceptance Test
  - Does the SUT satisfy the customer (requirement testing)
 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

These purposes are copied from Lesson 5.2

# Large Systems are Hard to Test

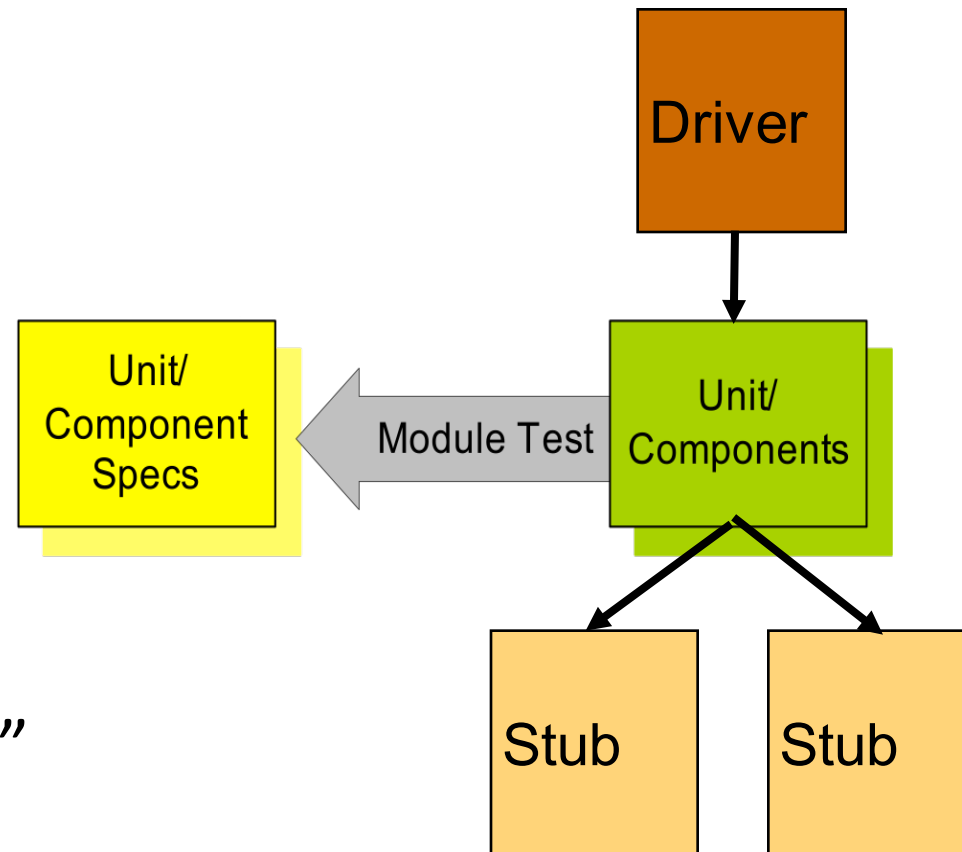
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- Database component
  - Contents may need to reflect/simulate real-world;
  - Data may be expensive/proprietary/confidential.
- Network connections
  - "Real" connections may be slow/flaky/disrupted;
  - Resources may have changed since test was written.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



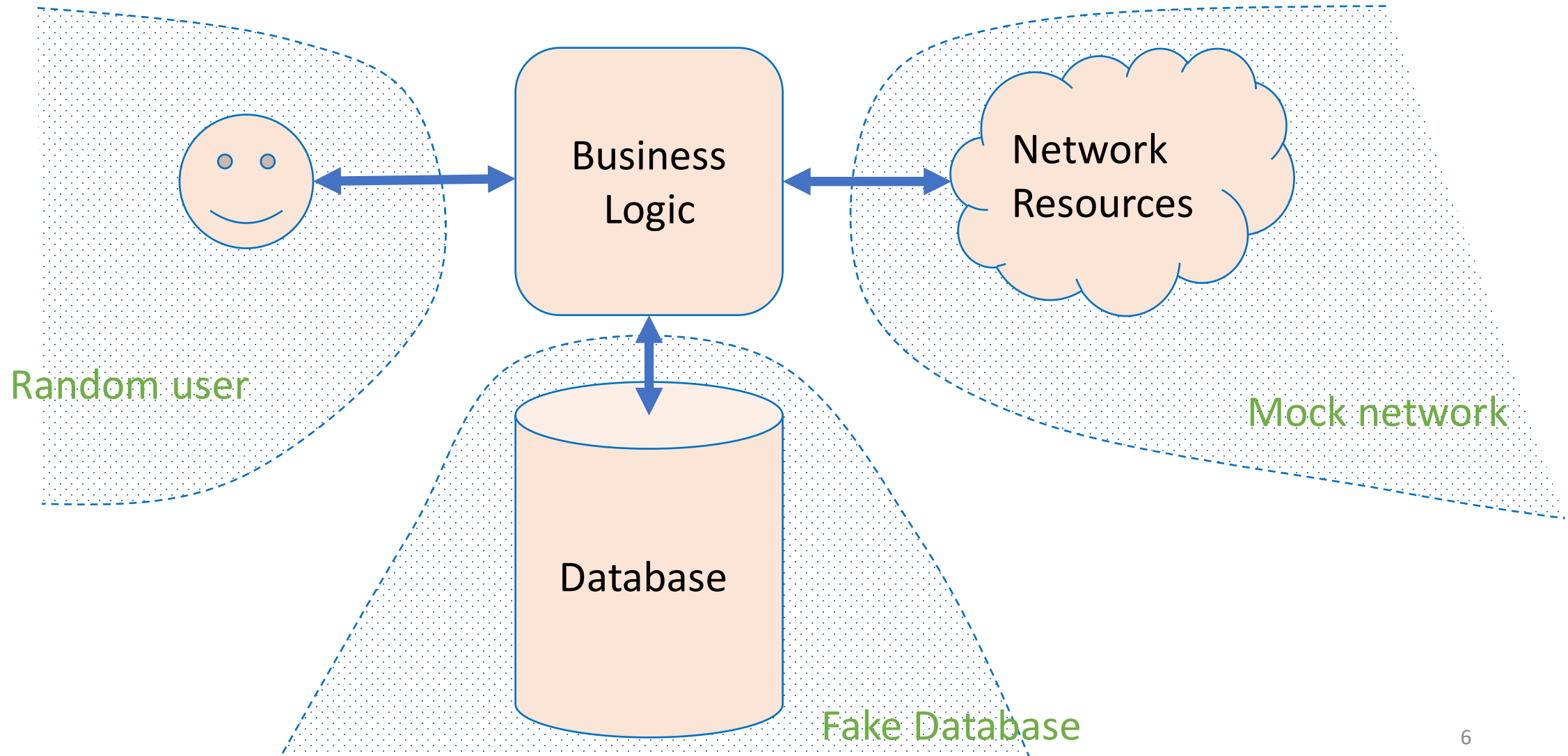
# Unit Testing is not sufficient

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

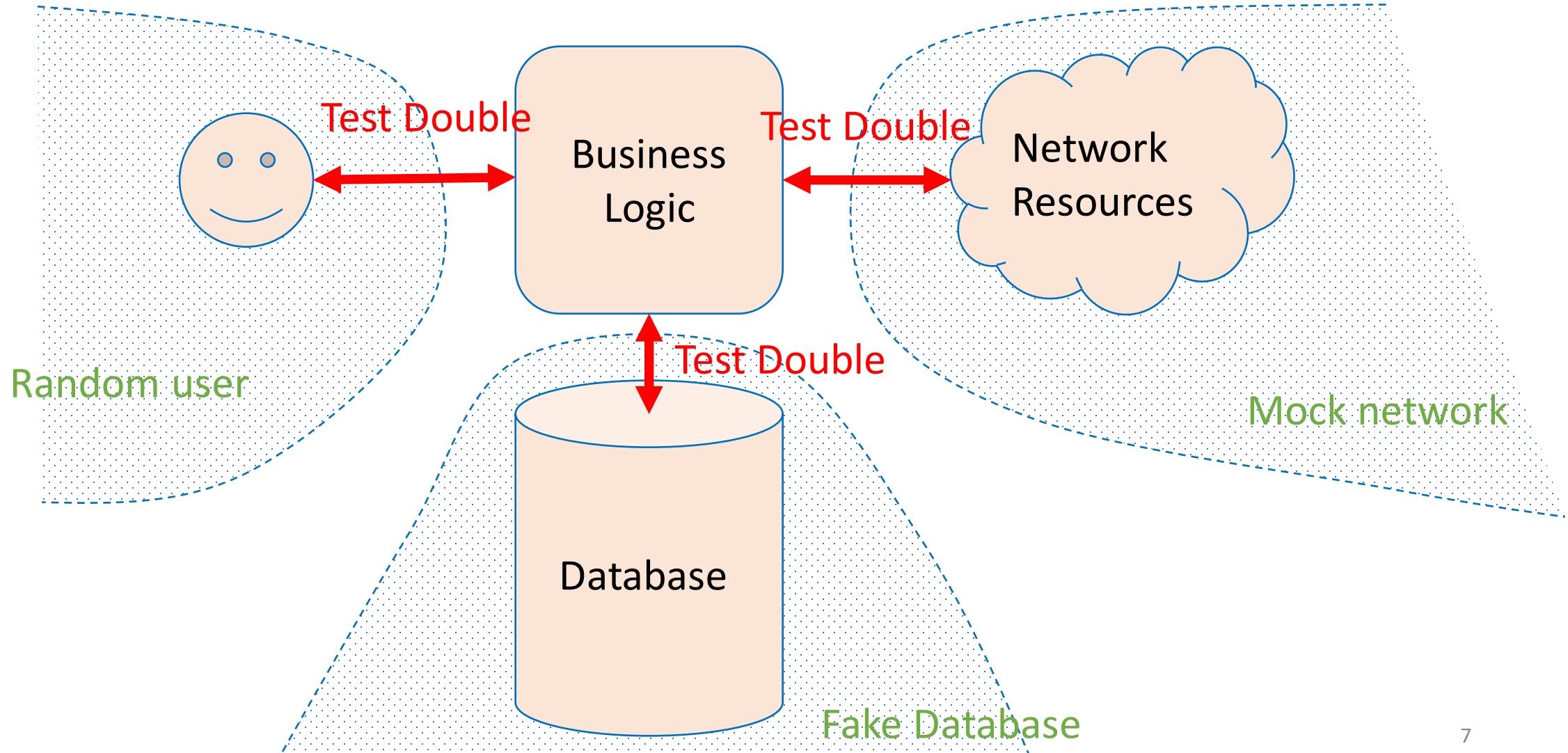


- Overall systems are “a little more” complicated

# Test Doubles replace uncontrollable pieces of the environment



# What are Test Doubles?



# Test Stub is a Double that just supplies the same interface

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- 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

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```
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

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- You might want your stub to do at least 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

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- 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

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```
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

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- 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<CoveyTownStore>();
```

```
    const mockCoveyTownController = mock<CoveyTownController>();
```

```
    beforeAll(() => {
```

```
        // Set up a spy for CoveyTownStore that will always return our mockCoveyTownStore as the  
        singleton instance
```

```
        jest.spyOn(CoveyTownStore, '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

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.....

```
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

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- 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.
- Transcript Server you used in **Activity 4.1** was a Fake

Fake has  
"semi-real  
implementation"

# How do you provide a Test Double for a User?

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- 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

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- 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

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- 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