CSE 403
Lecture 16

Continuous Integration; Integration Testing

Reading:

Continuous Integration (Fowler)
The Art of Unit Testing, Ch. 1, 3, 4-5 (Osherove)
Code Complete, Ch. 29 (McConnell)

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http://www.cs.washington.edu/403/

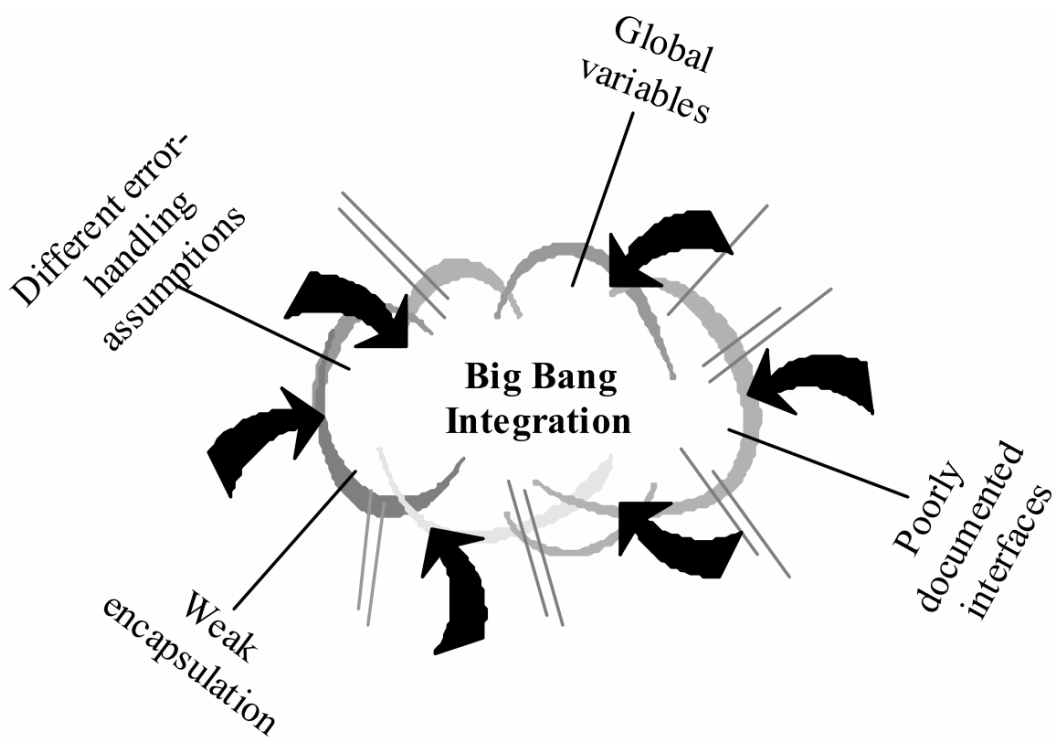
Integration

- **integration**: Combining 2 or more software units
  - often a subset of the overall project (!= system testing)

- Why do software engineers care about integration?
  - new problems will inevitably surface
    - many systems now together that have never been before
  - if done poorly, all problems present themselves at once
    - hard to diagnose, debug, fix
  - cascade of interdependencies
    - cannot find and solve problems one-at-a-time

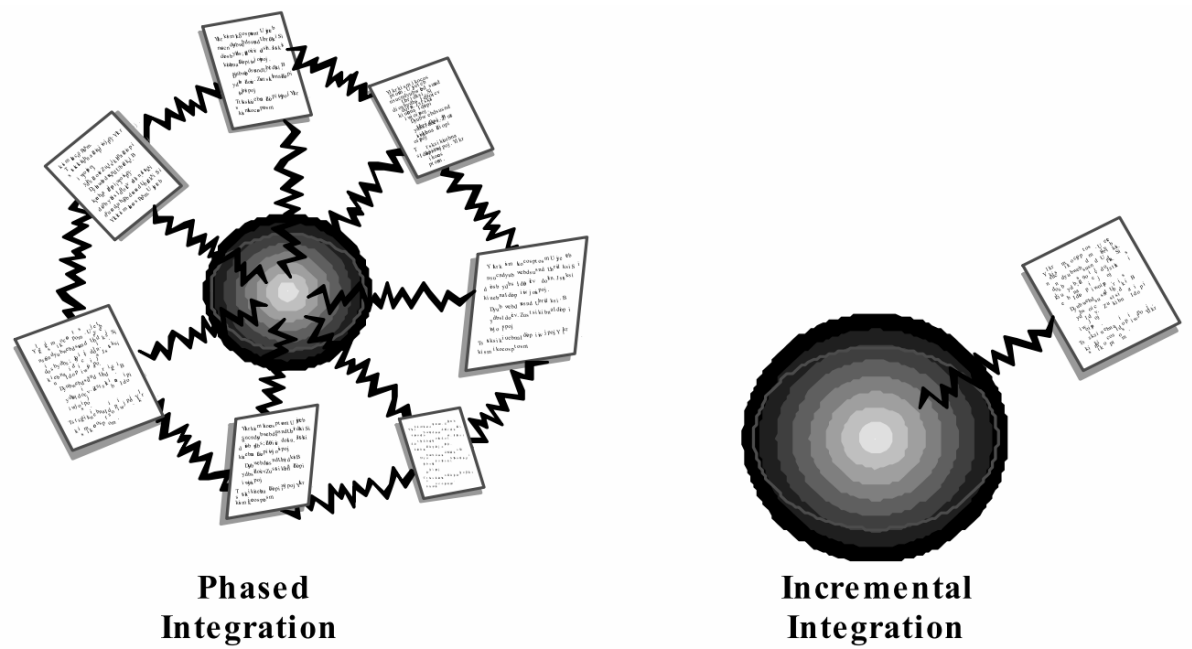
Phased integration

- **phased ("big-bang") integration**:
  - design, code, test, debug each class/unit/subsystem separately
  - combine them all
  - pray



Incremental integration

- **incremental integration**:
  - develop a functional "skeleton" system (i.e. ZFR)
  - design, code, test, debug a small new piece
  - integrate this piece with the skeleton
    - test/debug it before adding any other pieces

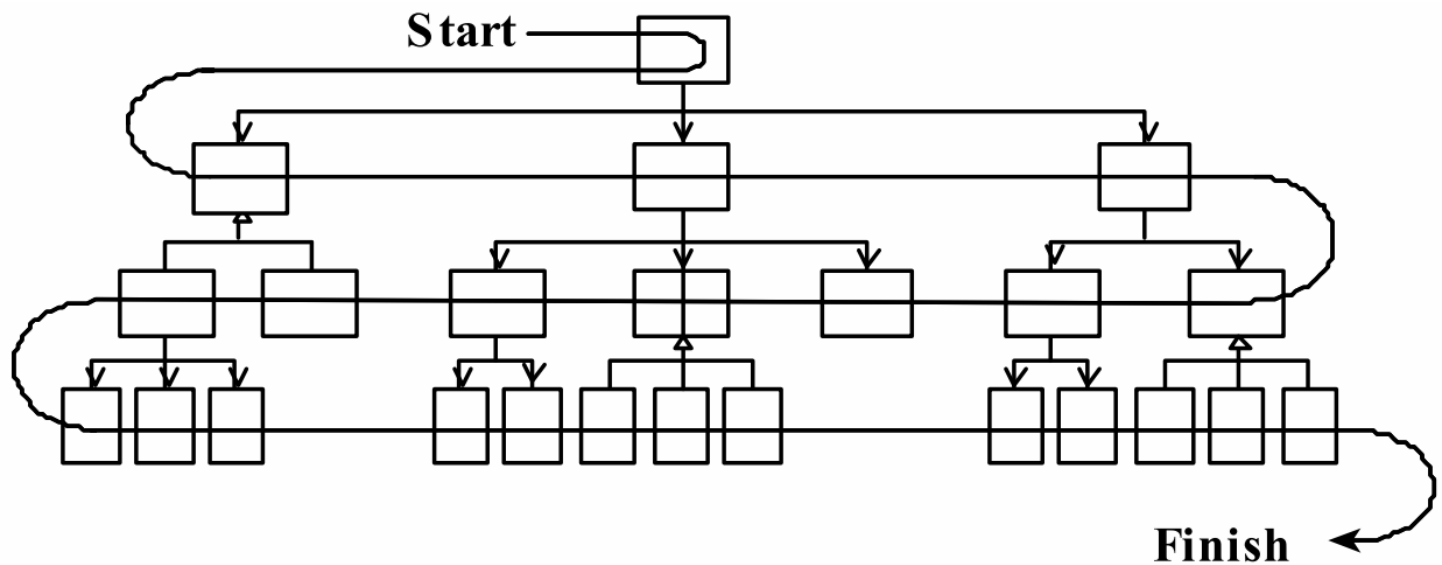


Benefits of incremental

- Benefits:
  - Errors easier to isolate, find, fix
    - reduces developer bug-fixing load
  - System is always in a (relatively) working state
    - good for customer relations, developer morale
- Drawbacks:
  - May need to create "stub" versions of some features that have not yet been integrated

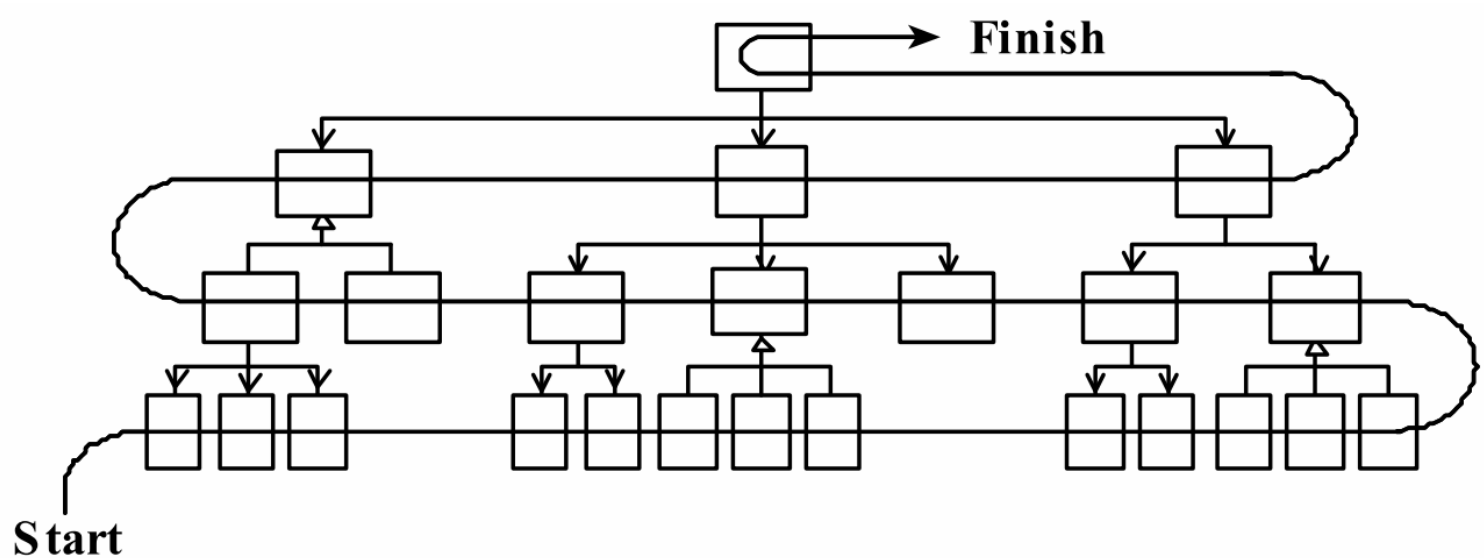
Top-down integration

- **top-down integration**:
  Start with outer UI layers and work inward
  - must write (lots of) stub lower layers for UI to interact with
  - allows postponing tough design/debugging decisions (bad?)



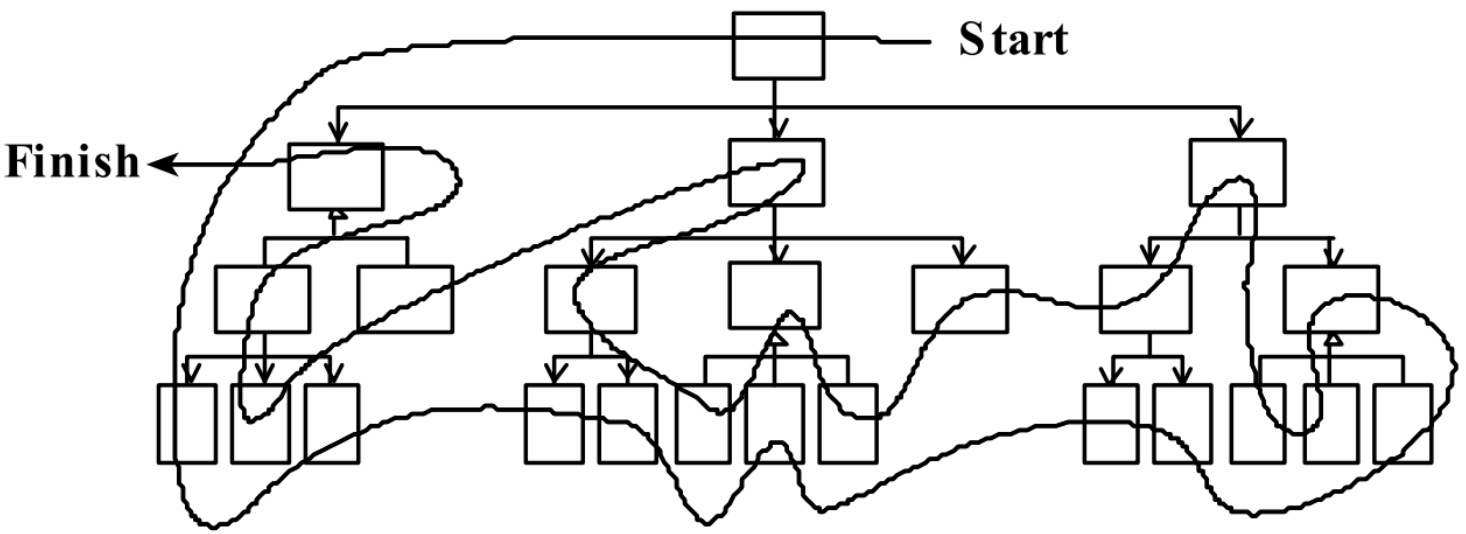
Bottom-up integration

- **bottom-up integration**:
  Start with low-level data/logic layers and work outward
  - must write test drivers to run these layers
  - won't discover high-level / UI design flaws until late



"Sandwich" integration

- **"sandwich" integration**:
  Connect top-level UI with crucial bottom-level classes
  - add middle layers later as needed
  - more practical than top-down or bottom-up?



Continuous Integration

- Pioneered by Martin Fowler; part of Extreme Programming
- Ten principles:
  - maintain a single source repository
  - automate the build
  - make your build self-testing
  - everyone commits to mainline every day
  - every commit should build mainline on an integration machine
  - keep the build fast
  - test in a clone of the production environment
  - make it easy for anyone to get the latest executable
  - everyone can see what's happening
  - automate deployment

Daily builds

"Automate the build."

- **daily build**: Compile working executable on a daily basis
  - allows you to test the quality of your integration so far
  - helps morale; product "works every day"; visible progress
  - best done *automated* or through an easy script
  - quickly catches/exposes any bug that breaks the build

- **Continuous Integration (CI) server**: An external machine that automatically pulls down your latest repo code and fully builds all resources.
  - If anything fails, contacts your team (e.g. by email).
  - Ensures that the build is never broken for long.

Build from command line

- An Android project needs a `build.xml` to be used by Ant.
  - This file allows your project to be compiled from the command line, making automated builds possible.

```
<?xml version="1.0" encoding="UTF-8"?>
<project name="MainActivity" default="help">
    <property file="ant.properties" />
    <import file="${sdk.dir}/tools/ant/build.xml" />
    <taskdef name="findbugs" classname="edu.umd.cs.findbugs.anttask.FindBugsTask"/>
    <target name="findbugs">
        <findbugs home="${findbugs.home}" output="xml" outputFile="findbugs.xml" excludeFilter="findbugs-exclude.xml">
            <auxClasspath path="${android.jar}" />
            <auxClasspath path="${rt.jar}" />
            <auxClasspath path="libs\android-support-v4.jar" />
            <class location="${out.dir}" />
        </findbugs>
    </target>

    <taskdef resource="checkstyletask.properties" classpath="${basedir}/libs/checkstyle-5.6-all.jar"/>
    <checkstyle config="sun_checks.xml" failonviolation="false">
        <fileset dir="src" includes="**/*.java"/>
        <formatter type="plain"/>
        <formatter type="xml" toFile="checkstyle-result.xml"/>
    </checkstyle>
</project>
```

Automated tests

"Make your build self-testing."

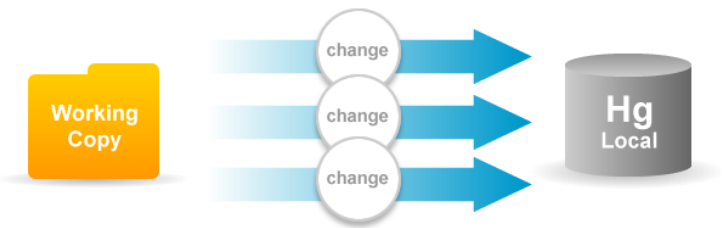
- **automated tests**: e.g. Tests that can be run from the command line on your project code at any time.
  - can be unit tests, coverage, static analysis / style checking, ...

- **smoke test**: A quick set of tests run on the daily build.
  - NOT exhaustive; just sees whether code "smokes" (breaks)
  - used (along with compilation) to make sure daily build runs

Daily commits

"Everyone commits to the mainline every day."

- **daily commit**: Submit work to main repo at end of each day.
  - Idea: Reduce merge conflicts; avoid later integration issues.
  - This is the key to "continuous integration" of new code.

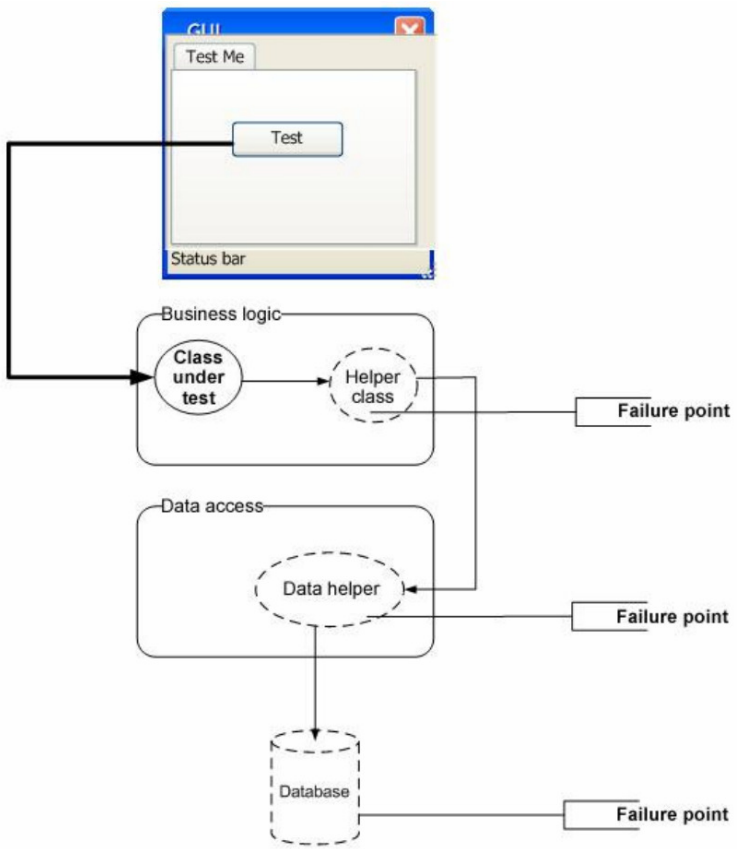


  - *Caution:* Don't check in faulty code (does not compile, does not pass tests) just to maintain the daily commit practice.
  - If your code is not ready to submit at end of day, either submit a coherent subset or be flexible about commit schedule.

Integration testing

- **integration testing**: Verifying software quality by testing two or more dependent software modules as a group.

- challenges:
  - Combined units can fail in more places and in more complicated ways.
  - How to test a partial system where not all parts exist?
  - How to "rig" the behavior of unit A so as to produce a given behavior from unit B?

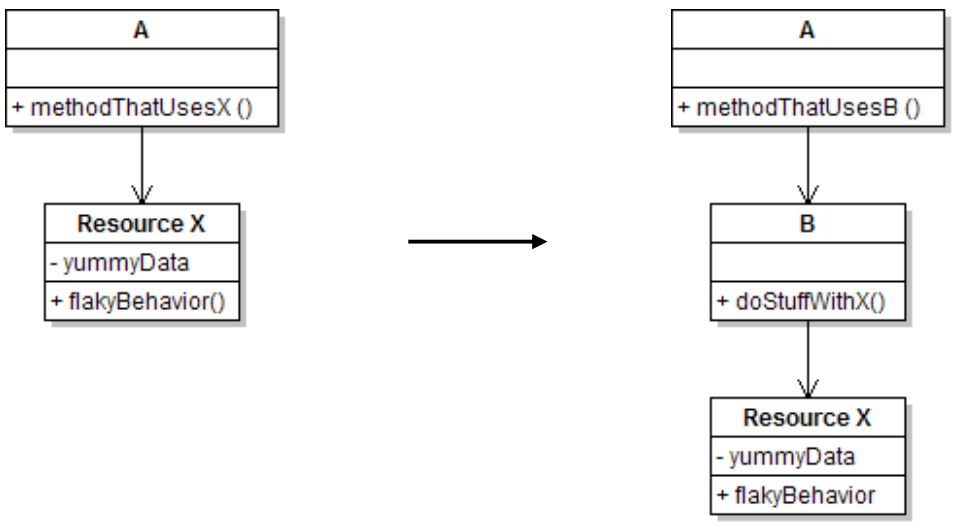


Stubs

- **stub**: A controllable replacement for an existing software unit to which your code under test has a dependency.
  - useful for simulating difficult-to-control elements:
    - network / internet
    - database
    - time/date-sensitive code
    - files
    - threads
    - memory
  - also useful when dealing with brittle legacy code/systems

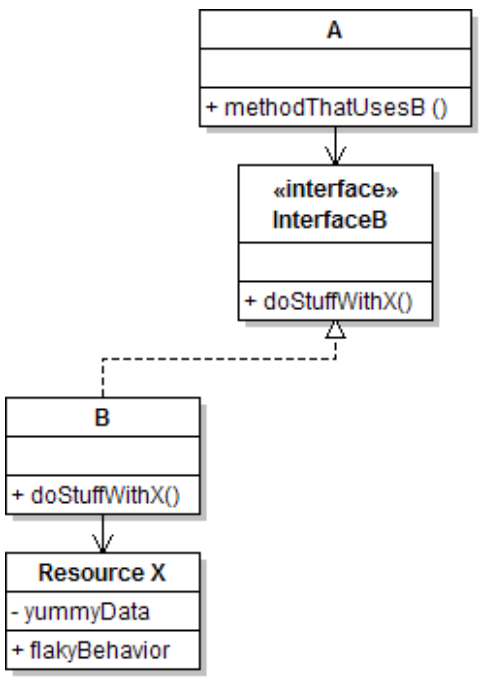
Create a stub, step 1

- Identify the external dependency.
  - This is either a resource or a class/object.
  - If it isn't an object, wrap it up into one.
    - (Suppose that Class A depends on troublesome Class B.)



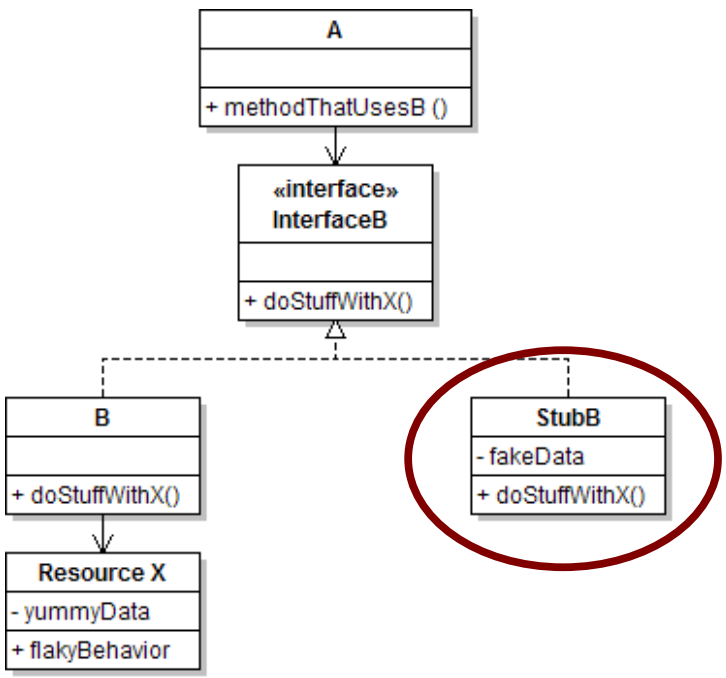
Create a stub, step 2

- Extract the core functionality of the object into an interface.
  - Create an InterfaceB based on B
  - Change all of A's code to work with type InterfaceB, not B



Create a stub, step 3

- Write a second "stub" class that also implements the interface, but returns pre-determined fake data.
  - Now A's dependency on B is dodged and can be tested easily.
  - Can focus on how well A *integrates* with B's external behavior.



Injecting a stub

- **seams**: Places to inject the stub so Class A will talk to it.
  - at construction (not ideal)

```
A aardvark = new A(new StubB());
```

  - through a getter/setter method (better)

```
A apple = new A(...);
aardvark.setResource(new StubB());
```

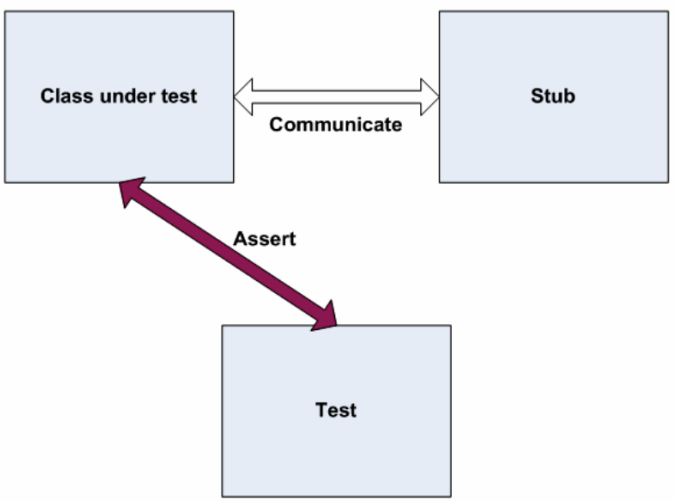
  - just before usage, as a parameter (also better)

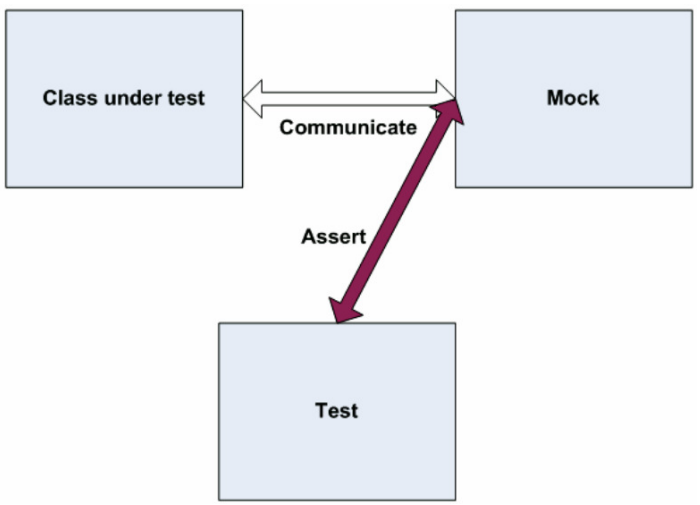
```
aardvark.methodThatUsesB(new StubB());
```

- You should not have to change A's code everywhere (beyond using your interface) in order to use your Stub B. (a "testable design")

"Mock" objects

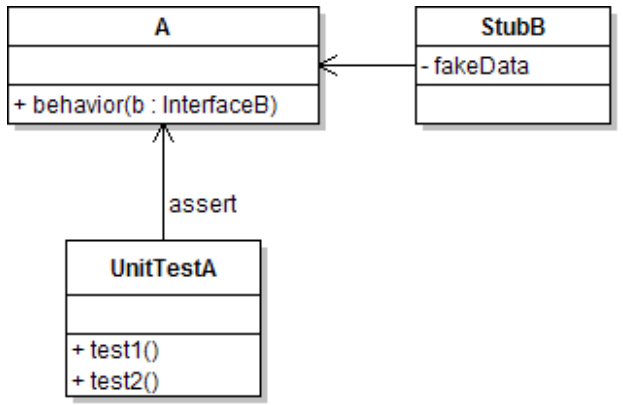
- **mock object**: A fake object that decides whether a unit test has passed or failed by watching interactions between objects.
  - useful for **interaction testing** (as opposed to **state testing**)



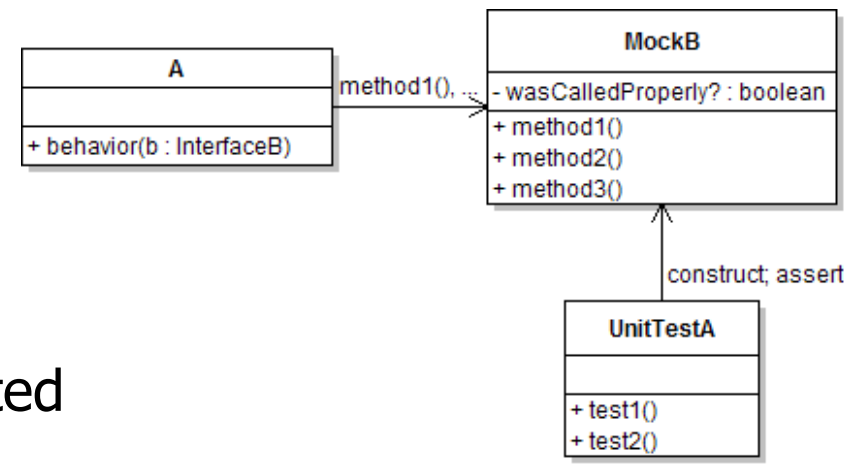


Stubs vs. mocks

- A **stub** gives out data that goes to the object/class under test.
- The unit test directly asserts against class under test, to make sure it gives the right result when fed this data.



- A **mock** waits to be called by the class under test (A).
  - Maybe it has several methods it expects that A should call.
- It makes sure that it was contacted in exactly the right way.
  - If A interacts with B the way it should, the test passes.



Mock object frameworks

- Stubs are often best created by hand/IDE.
  Mocks are tedious to create manually.

- Mock object frameworks help with the process.
  - android-mock, EasyMock, jMock (Java)
  - FlexMock / Mocha (Ruby)
  - SimpleTest / PHPUnit (PHP)
  - ...

- Frameworks provide the following:
  - auto-generation of mock objects that implement a given interface
  - logging of what calls are performed on the mock objects
  - methods/primitives for declaring and asserting your expectations

A jMock mock object

```
import org.jmock.integration.junit4.*;  // Assumes that we are testing
import org.jmock.*;                     // class A's calls on B.

@RunWith(JMock.class)
public class ClassATest {
    private Mockery mockery = new JUnit4Mockery();  // initialize jMock

    @Test  public void testACallsBProperly1() {
        // create mock object to mock InterfaceB
        final InterfaceB mockB = mockery.mock(InterfaceB.class);

        // construct object from class under test;  attach to mock
        A aardvark = new A(...);
        aardvark.setResource(mockB);

        // declare expectations for how mock should be used
        mockery.checking(new Expectations() {{
            oneOf(mockB).method1("an expected parameter");
            will(returnValue(0.0));
            oneOf(mockB).method2();
        }});

        // execute code A under test; should lead to calls on mockB
        aardvark.methodThatUsesB();

        // assert that A behaved as expected
        mockery.assertIsSatisfied();
    }
}
```

jMock API

- jMock has a strange API based on "Hamcrest" testing syntax.
- Specifying objects and calls:
  - `oneOf(`**`mock`**`), exactly(`**`count`**`).of(`**`mock`**`),`
  - `atLeast(`**`count`**`).of(`**`mock`**`), atMost(`**`count`**`).of(`**`mock`**`),`
  - `between(`**`min`**`, `**`max`**`).of(`**`mock`**`)`
  - `allowing(`**`mock`**`), never(`**`mock`**`)`

    - The above accept a mock object and return a descriptor that you can call methods on, as a way of saying that you demand that those methods be called by the class under test.

  - `atLeast(3).of(mockB).method1();`
    - "I expect that `method1` will be called on `mockB` 3 times here."

Expected actions

- `.will(action)`
  - actions: `returnValue(`**v**`), throwException(`**e**`)`

- values:
  - `equal(`**value**`), same(`**value**`), any(`**type**`), aNull(`**type**`), aNonNull(`**type**`), not(`**value**`), anyOf(`**value1, ..,valueN**`)`

  - ```
    oneOf(mockB).method1();
    will(returnValue(anyOf(1, 4, -3)));
    ```

    - "I expect that `method1` will be called on `mockB` once here, and that it will return either 1, 4, or -3."
    ```

Using stubs/mocks together

- Suppose a log analyzer reads from a web service.
  If the web fails to log an error, the analyzer must send email.
  - How to test to ensure that this behavior is occurring?

- Set up a *stub* for the web service that intentionally fails.
- Set up a *mock* for the email service that checks to see whether the analyzer contacts it to send an email message.