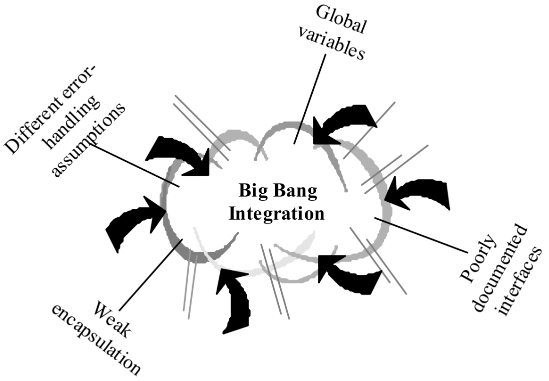
Integration Testing

slides created by Marty Stepp
http://www.cs.washington.edu/403/

Edited by J-P Corriveau

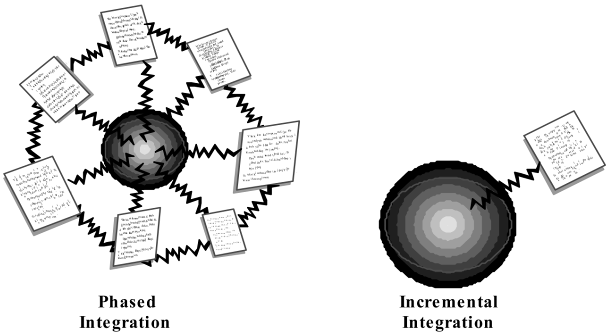
Phased integration

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


Global variables
Different error-handling assumptions
Big Bang Integration
Poorly documented interfaces
Weak encapsulation

Incremental integration

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

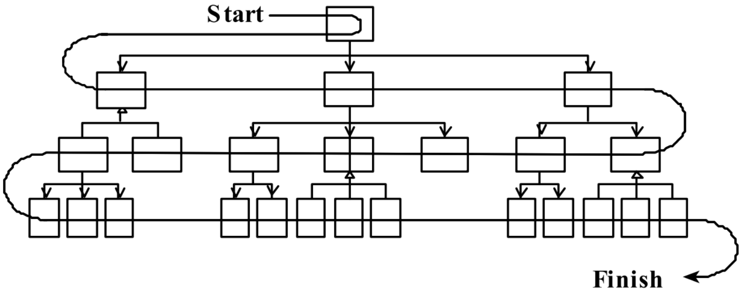


Benefits of incremental

- 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

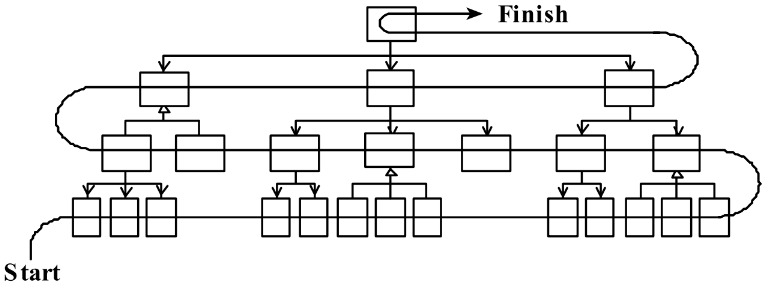
Top-down integration

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



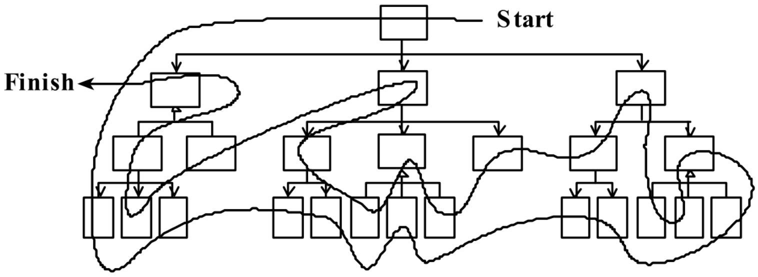
Bottom-up integration

- **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 it’s (too?) 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?



Daily builds

- **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 if *automated* or through an easy script
  - quickly catches/exposes any bug that breaks the build

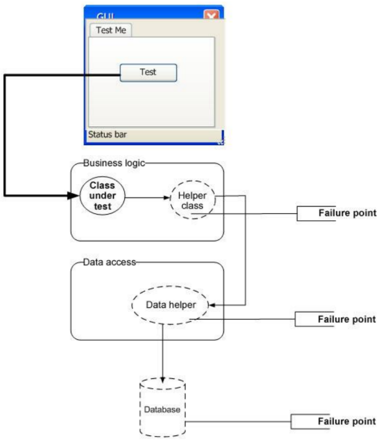
- **smoke test**: A quick set of tests run on the daily build.
  - NOT exhaustive; just sees whether code "smokes" (breaks)
  - used (along with compilation) to make sure daily build runs

- **continuous integration**:
  Adding new units immediately as they are written.

Integration testing

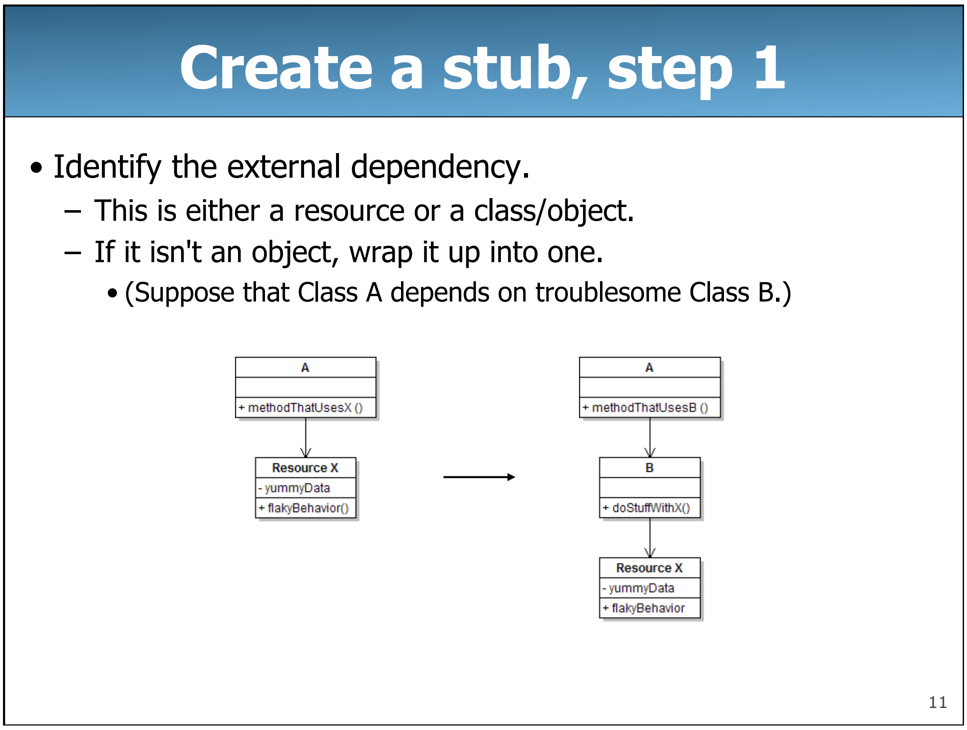
- **integration testing**: Verifying software quality by testing two or more dependent software modules as a group.

- 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

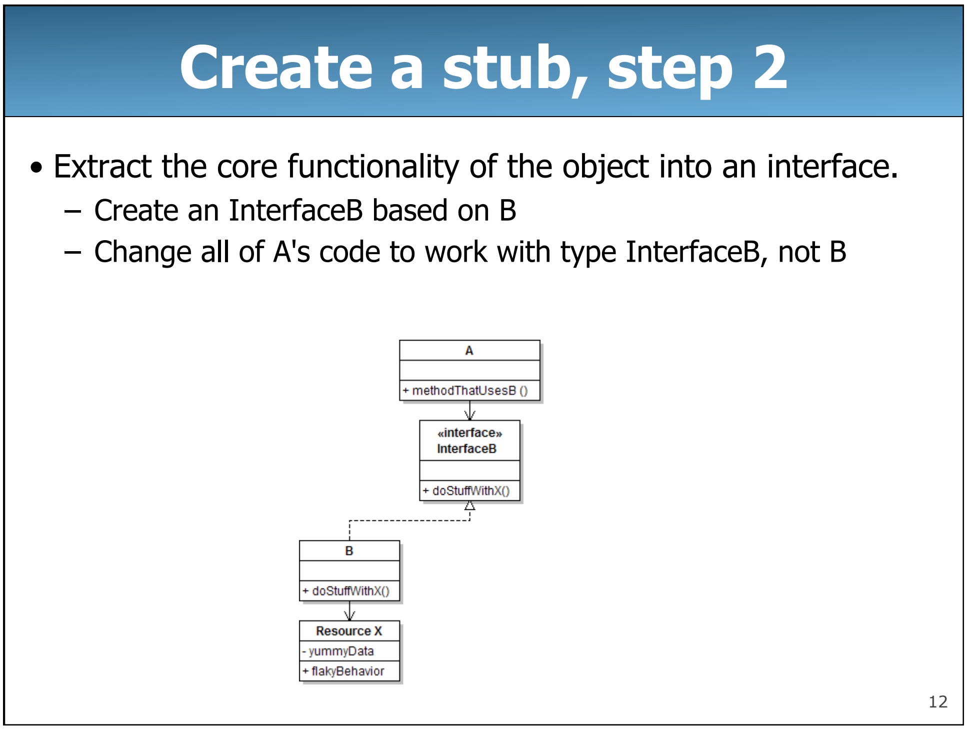
- **stub**: A controllable replacement for an existing software unit to which your code under test has a dependency.
  - useful for simulating difficult-to-control elements:
    - network / internet
    - database
    - time/date-sensitive code
    - files
    - threads
    - memory
  - also useful when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

A
+ methodThatUsesX ()
Resource X
- yummyData
+ flakyBehavior()
A
+ methodThatUsesB ()
B
+ doStuffWithX()
Resource X
- yummyData
+ flakyBehavior



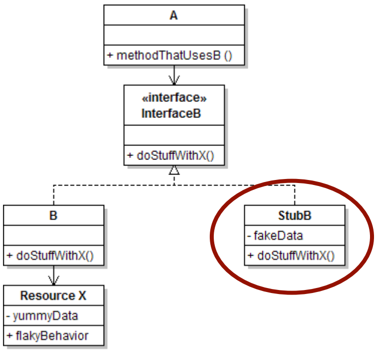
Create a stub, step 2

- 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

A
+ methodThatUsesB ()
«interface»
InterfaceB
+ doStuffWithX()
B
+ doStuffWithX()
Resource X
- yummyData
+ flakyBehavior

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());
```

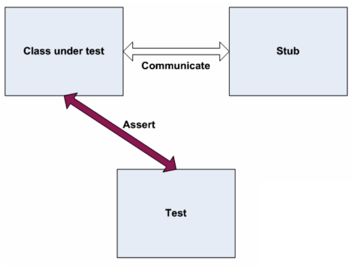
  - just before usage, as a parameter (also better)

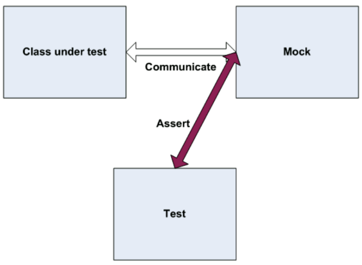
```
aardvark.methodThatUsesB(new StubB());
```

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

"Mock" objects

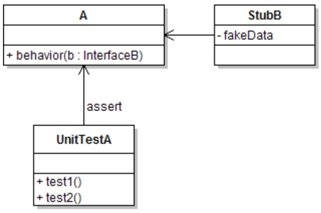
- **mock object**: A fake object that decides whether a unit test has passed or failed by watching interactions between objects.
  - useful for **interaction testing** (as opposed to **state testing**)



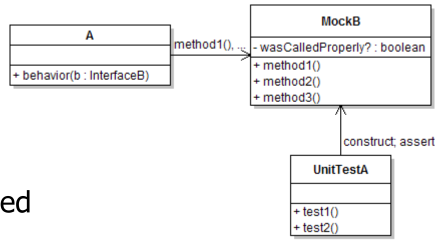


Stubs vs. mocks

- 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.



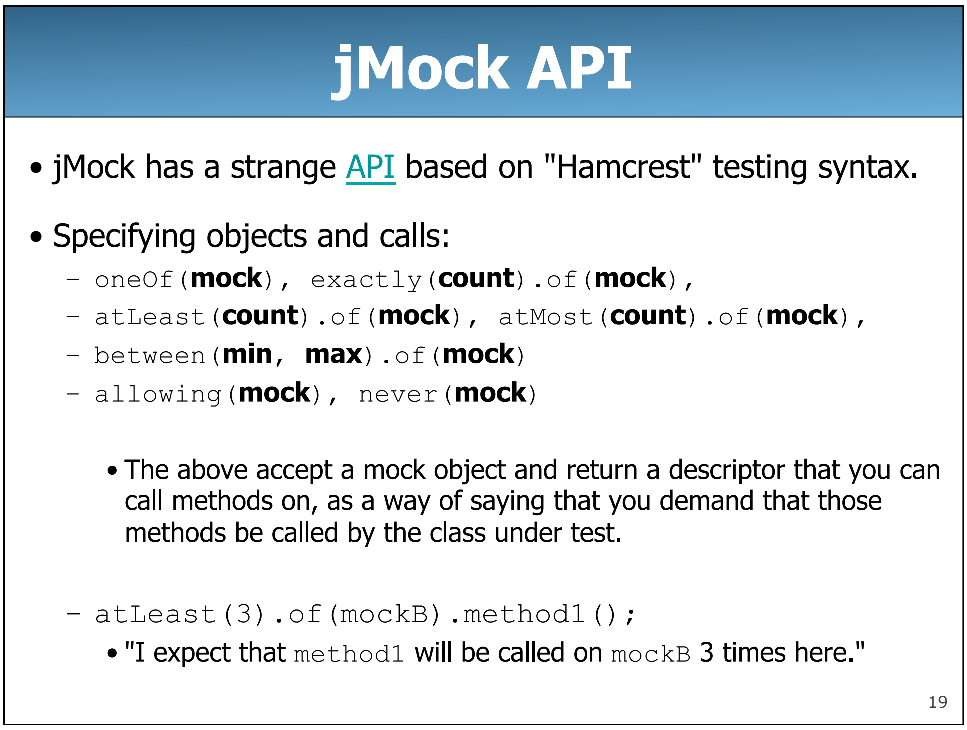
- It makes sure that it was contacted in exactly the right way.
  - If A interacts with mockB the way it should, the test passes.

Mock object frameworks

- Stubs are often best created by hand.
  Mocks are tedious to create manually.
- Mock object frameworks help:
  - 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

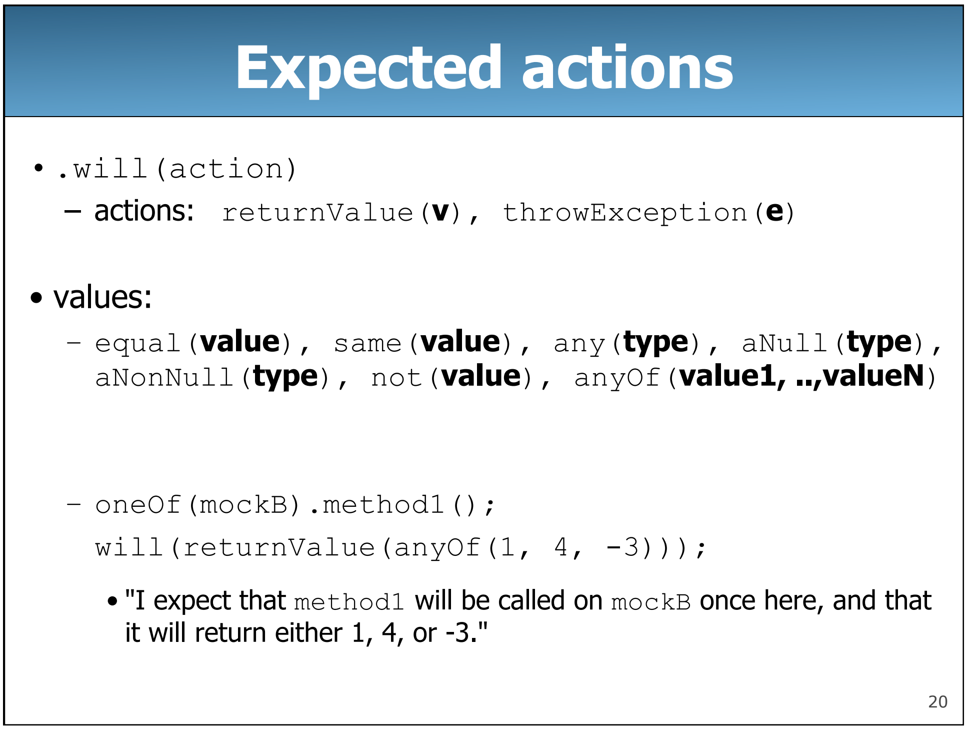
A jMock mock object

```
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

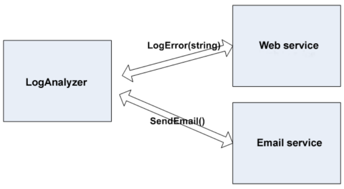
- `.will(action)`
  - actions: returnValue(**v**), throwException(**e**)
- values:
  - equal(**value**), same(**value**), any(**type**), aNull(**type**), aNonNull(**type**), not(**value**), anyOf(**value1, ..,valueN**)

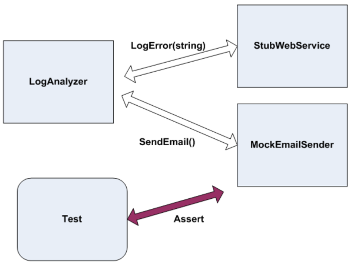
  -
    ```
    oneOf(mockB).method1();
    will(returnValue(anyOf(1, 4, -3)));
    ```
    - "I expect that `method1` will be called on `mockB` once here, and that it will return either 1, 4, or -3."

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.


LogAnalyzer
LogError(string)
Web service
SendEmail()
Email service


LogAnalyzer
LogError(string)
StubWebService
SendEmail()
MockEmailSender
Test
Assert