CSE 403: Software Engineering, Fall 2016

courses.cs.washington.edu/courses/cse403/16au/

System Testing

Emina Torlak
emina@cs.washington.edu

Outline

- Recap: system testing
- Integration testing
- Performance testing

system testing

System testing

- **System testing**: tests the behavior of a system as a whole, with respect to scenarios and requirements
  - Functional testing, integration testing
  - Load, stress, performance testing
  - Acceptance, usability, installation, beta testing

System testing

- **System testing**: tests the behavior of a system as a whole, with respect to scenarios and requirements
  - Functional testing, integration testing
  - Load, stress, performance testing
  - Acceptance, usability, installation, beta testing

integration testing

Integration testing

- **Integration testing:** checking software quality by testing two or more dependent software modules as a group or a (sub)system.
- Challenges same as in unit testing, plus:
  - 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?

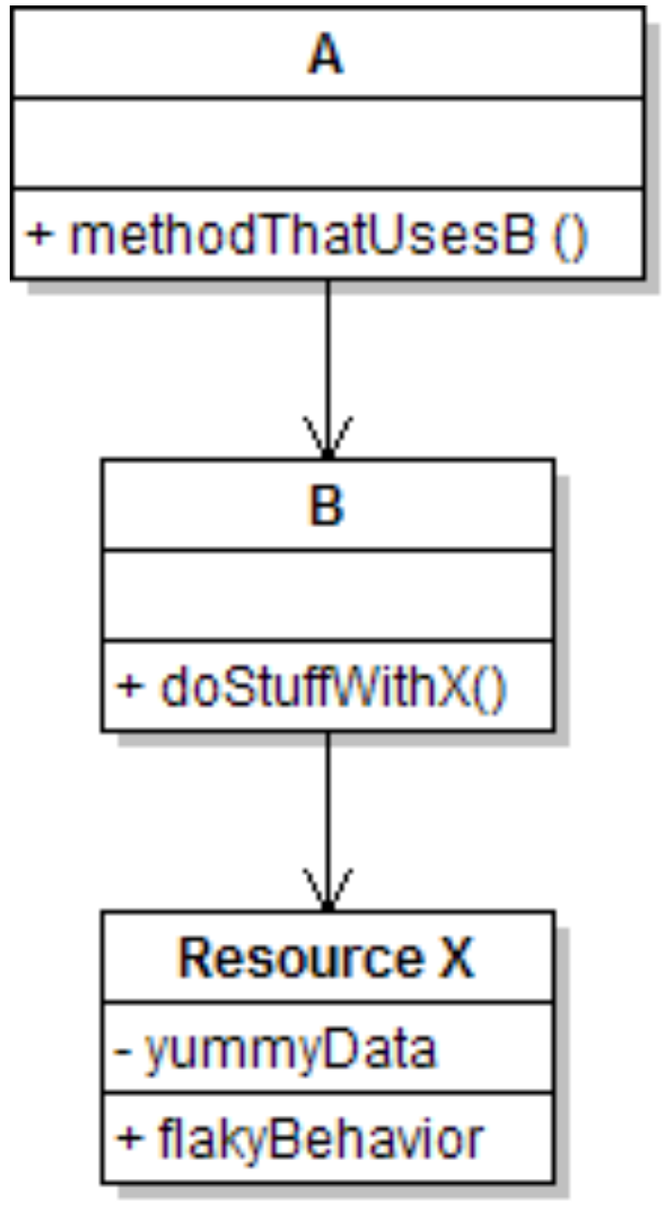
Stubs: a way to test a partial system

- **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
    - time/date-sensitive code
    - database, files, io, threads, memory
    - brittle legacy code /systems

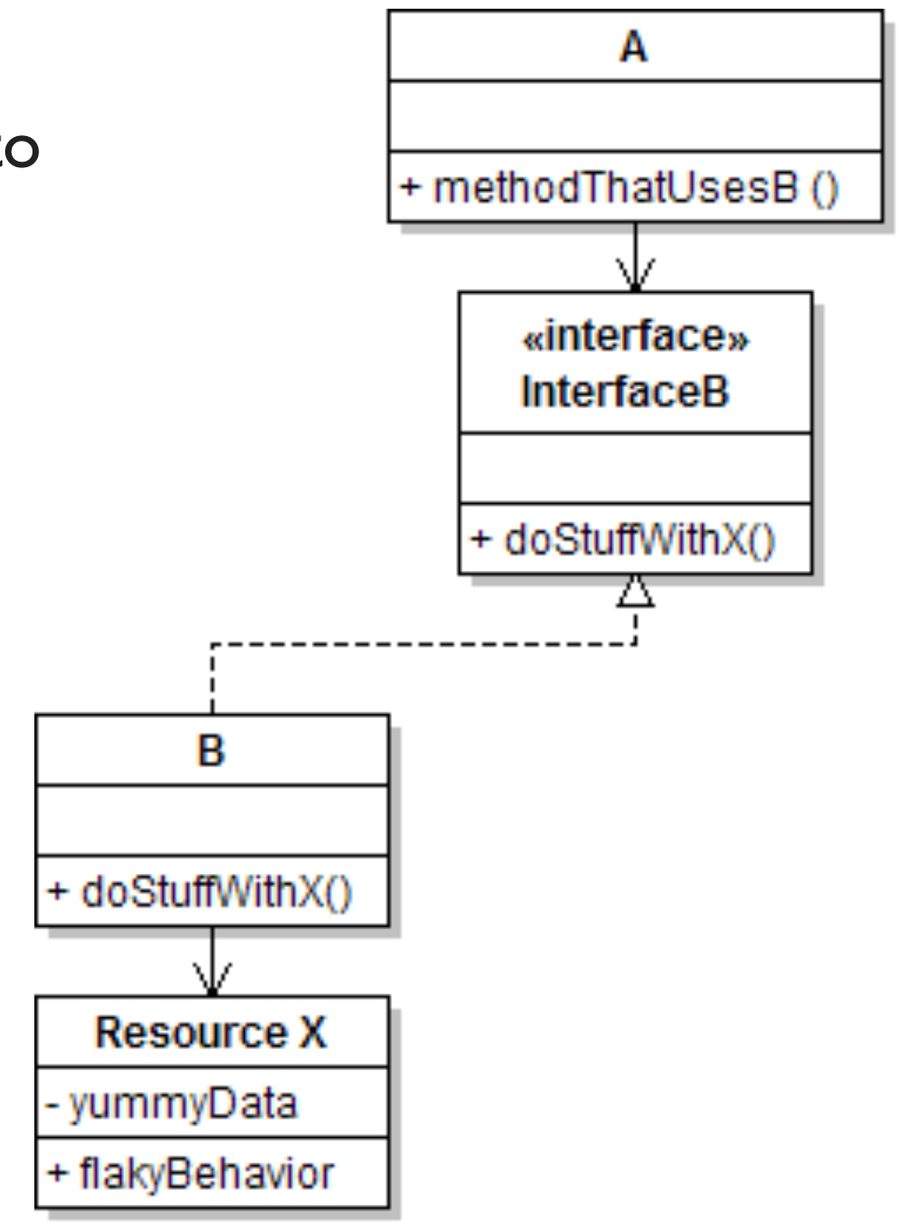
Testing with stubs (1/3)

- 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 Class B.)



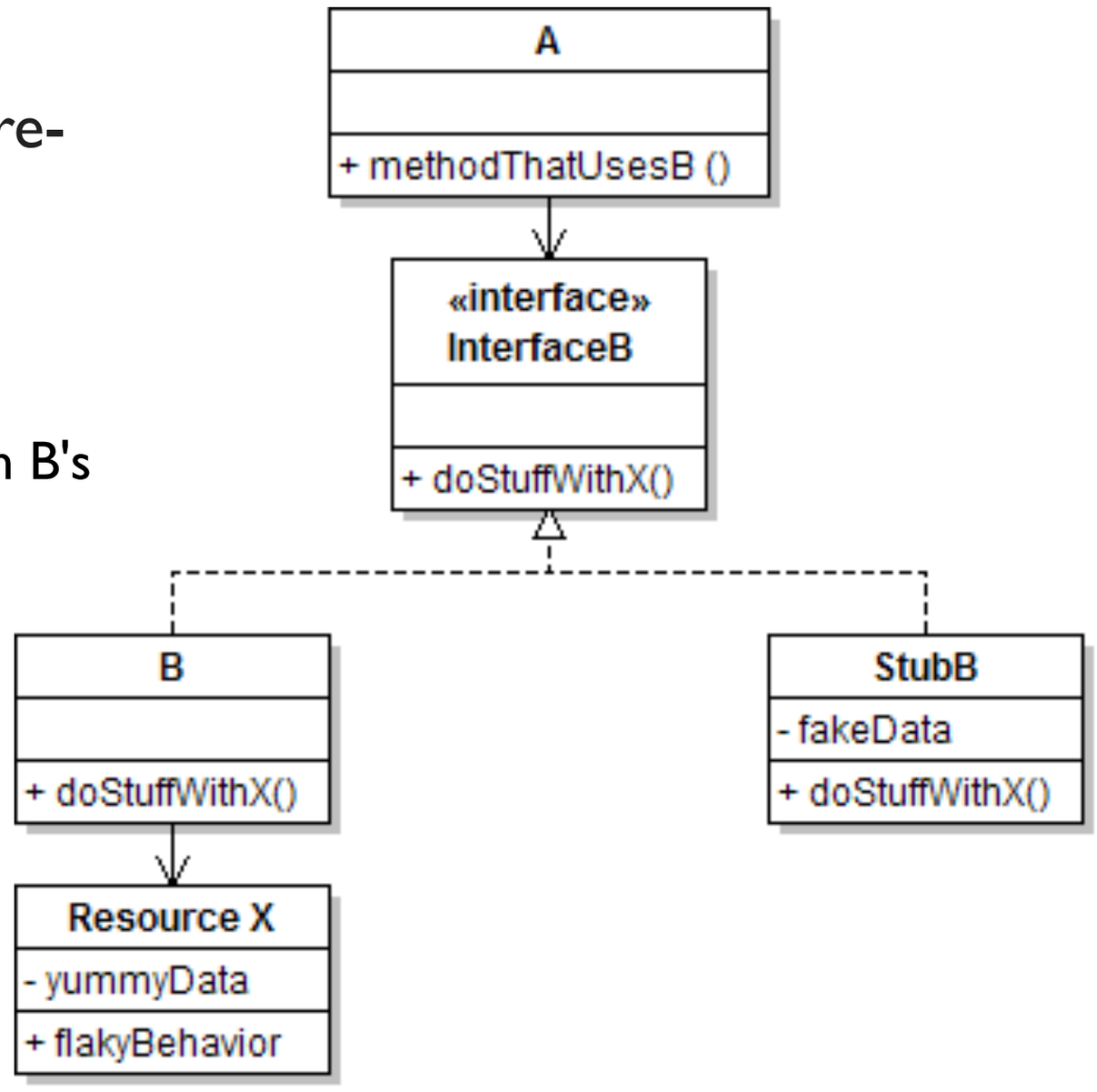
Testing with stubs (2/3)

- 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



Testing with stubs (3/3)

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



Where to inject stubs?

- 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());
```

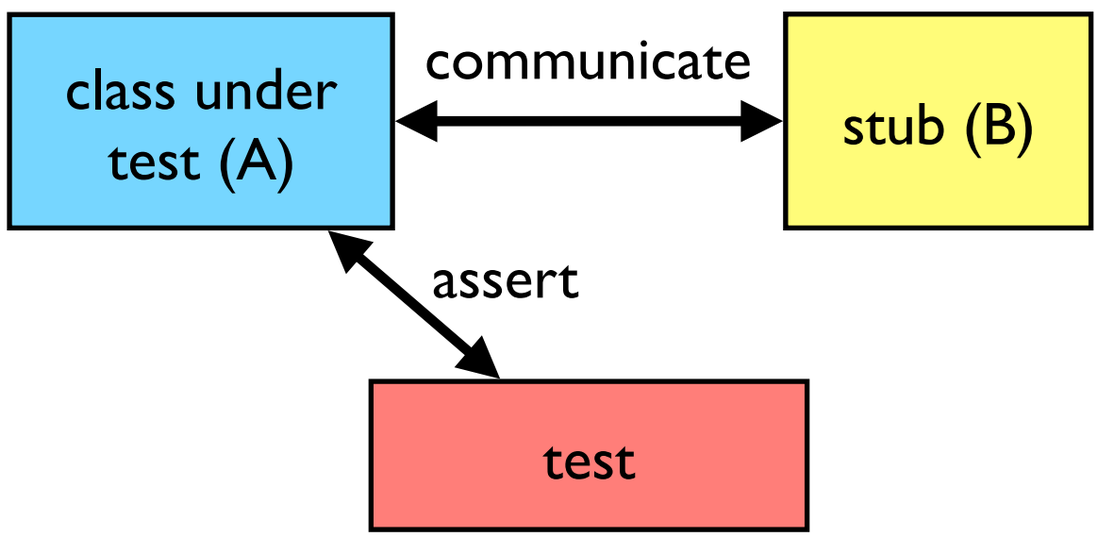
- You should not have to change A's code everywhere (beyond using your interface) in order to use your Stub B. (a "testable design")

Mock objects: a way to test interactions

- **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

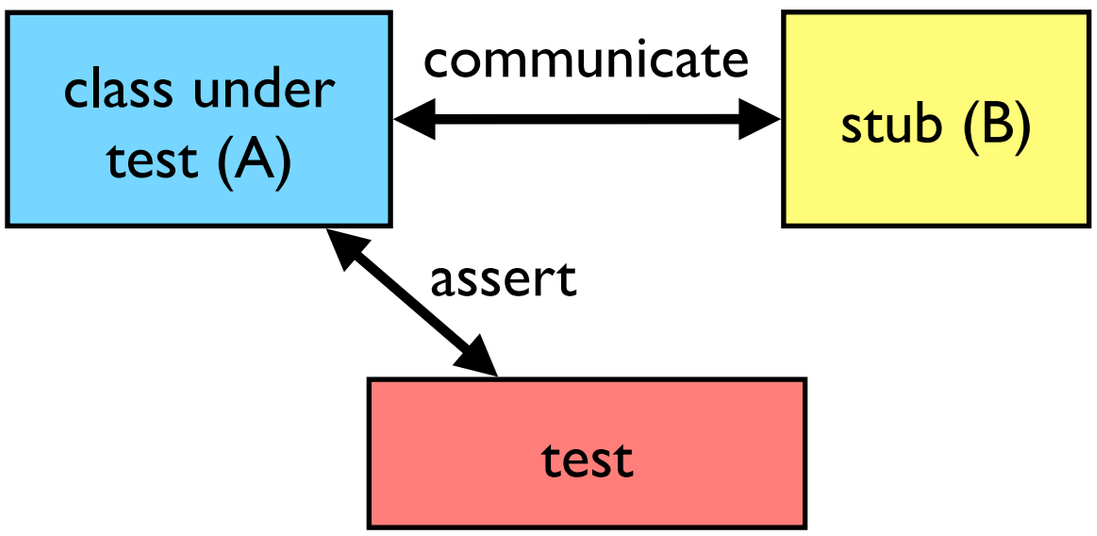
Stubs vs mocks

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

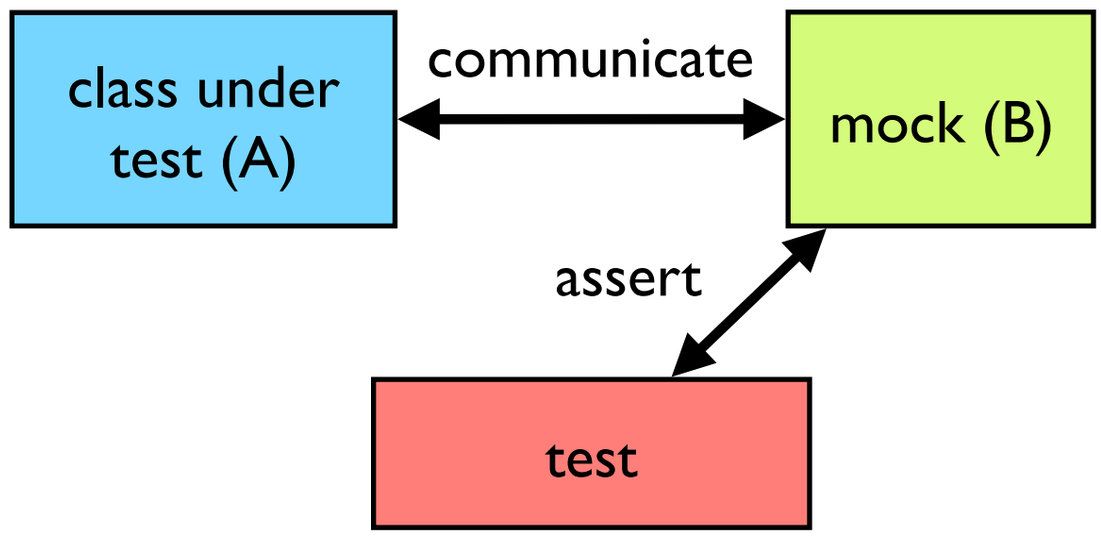


Stubs vs mocks

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



- A **mock** (B) waits to be called by the class under test (A).
    - It may have several methods it expects that A should call.
    - It makes sure that it was called 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)
    - ...
- 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 example

```
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();
    }
}
```

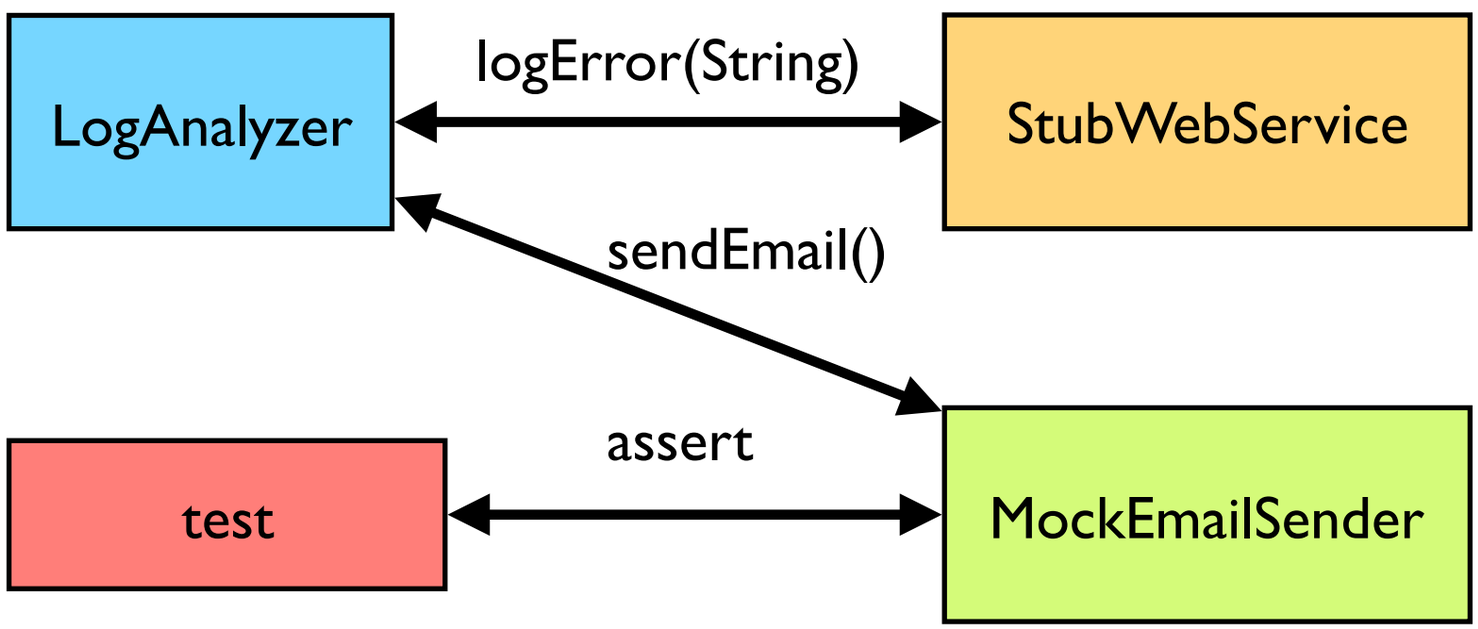
Using stubs and mocks together

Using stubs and mocks together

- Suppose a log analyzer reads from a web service. If the web fails to log an error, the analyzer must send email.

Using stubs and 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.



performance testing

Acceptance, performance

- **Acceptance testing**: System is shown to the user / client / customer to make sure that it meets their needs.
    - A form of black-box system testing.
- Performance is important.
    - Performance is a major aspect of program acceptance by users.
    - Your intuition about what's slow is often wrong.

> Premature optimization is the root of all evil.
>
> *Donald Knuth*

Thinking about performance

Thinking about performance

- The app is only too slow if it doesn't meet your project's stated performance requirements.
    - If it meets them, DON'T optimize it!

Thinking about performance

- The app is only too slow if it doesn't meet your project's stated performance requirements.
    - If it meets them, DON'T optimize it!
- Which is more important, fast code or correct code?

Thinking about performance

- The app is only too slow if it doesn't meet your project's stated performance requirements.
    - If it meets them, DON'T optimize it!
- Which is more important, fast code or correct code?
- What are reasonable performance requirements?
    - What are the user's expectations? How slow is "acceptable" for this portion of the application?
    - How long do users wait for a web page to load?
    - Some tasks (admin updates database) can take longer

Profile and measure before optimizing

- **Runtime / CPU usage**
  - what lines of code the program is spending the most time in
  - what call/invocation paths were used to get to these lines
- **Memory usage**
  - what kinds of objects are on the heap
  - where were they allocated
  - who is pointing to them now
  - "memory leaks" (does Java have these?)
- **Web page load times, requests/minute, …**

Profile and measure before optimizing

- **Runtime / CPU usage**
  - what lines of code the program is spending the most time in
  - what call/invocation paths were used to get to these lines
- **Memory usage**
  - what kinds of objects are on the heap
  - where were they allocated
  - who is pointing to them now
  - "memory leaks" (does Java have these?)
- **Web page load times, requests/minute, …**

CPU profiling slows down your code (a lot). Design your profiling tests to be very short.

Optimization hints: think high-level

Optimization hints: think high-level

- Focus on high-level optimizations (algorithms, data structures)
    - Leave the low-level ones to the compiler

Optimization hints: think high-level

- Focus on high-level optimizations (algorithms, data structures)
    - Leave the low-level ones to the compiler
- Some common high-level optimizations
    - **Lazy evaluation** saves you from computing/loading
        - don't read / compute things until you need them
    - **Hashing, caching** save you from reloading resources
        - combine multiple database queries into one query
        - save I/O / query results in memory for later Web page load times, requests/minute, etc.
    - **Precomputing** values and storing them in a lookup table
        - the first 1000 primes

Summary

- System testing checks the behavior of a system as a whole.
- Integration testing checks software quality by testing two or more dependent software modules as a group.
- Performance testing checks that a system meets performance requirements (e.g., responsiveness).