CS 146: Intro to Web Programming and Project Development

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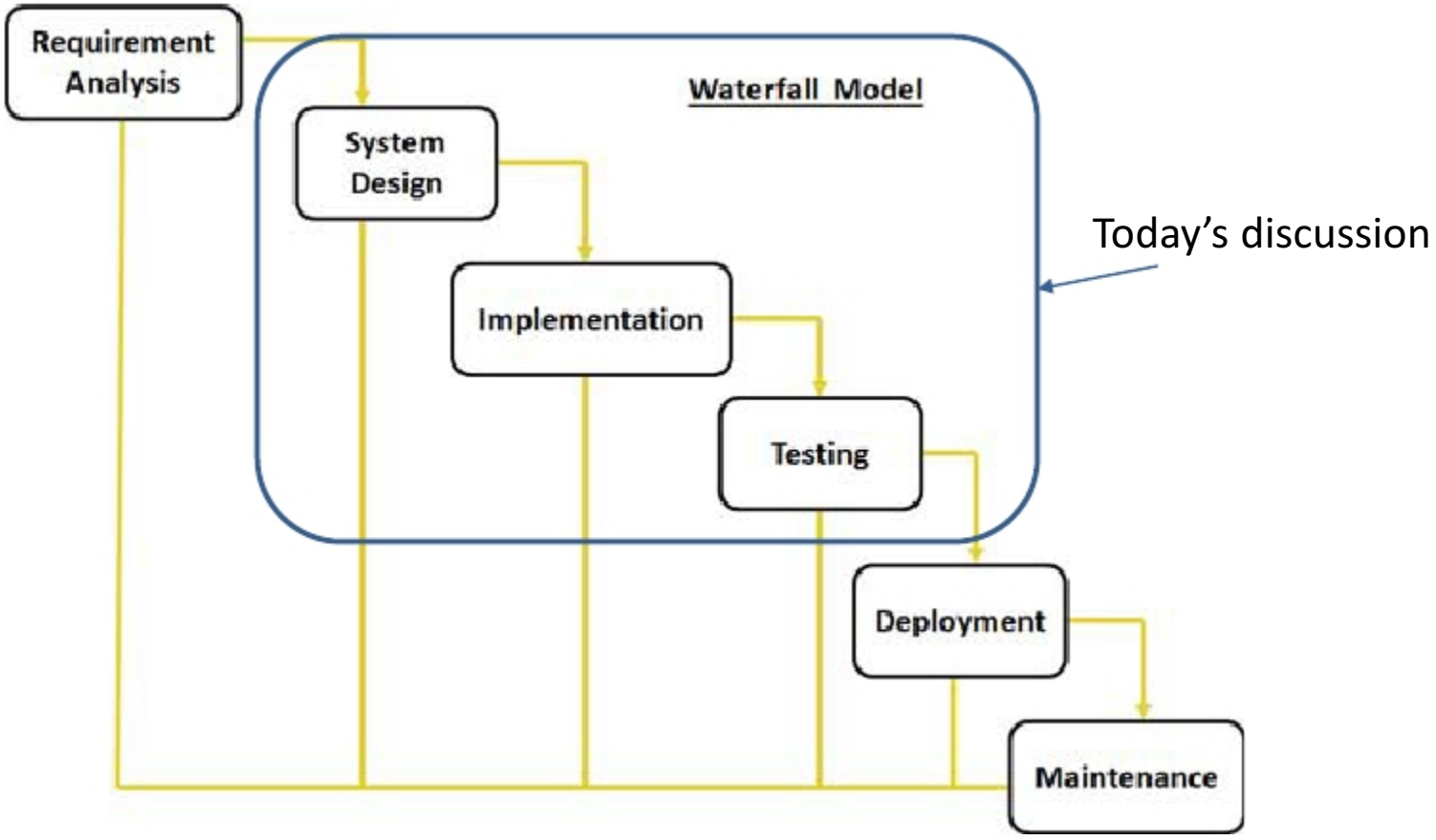
Introduction to Software Engineering

Waterfall Model Visualized



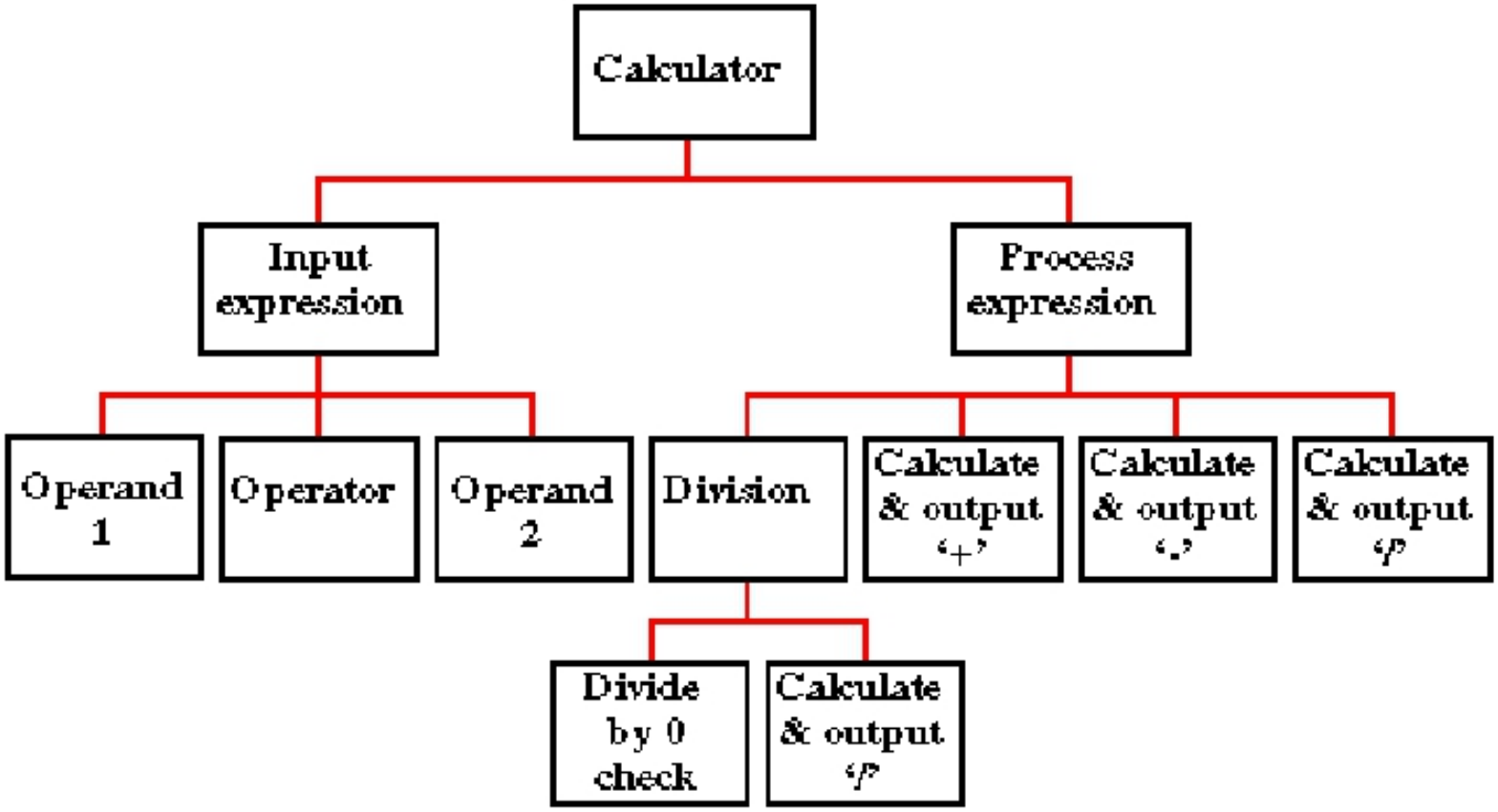
System Design

- The system design phase is, as it sounds, where you create the design for your solution; the end product is one step away from becoming code
- We concentrate on how things will work, but algorithms are language-independent
- Different approaches:
  - Top-down
  - Bottom-up
  - Object-oriented (can be applied to either top-down or bottom-up)

Top-Down Design

- The top-down approach starts with the big picture; it breaks down from there into smaller segments
- Start with an overall solution
- Then "zoom in" on your solution and figure out the major steps that will be needed
  - Then "zoom in" on those steps and figure out what they need
  - Repeat the process as needed
  - Stop when you are no longer answering *"How do we do these steps?*" and start answering *"How do we write this in code?*"
- Works well for large projects

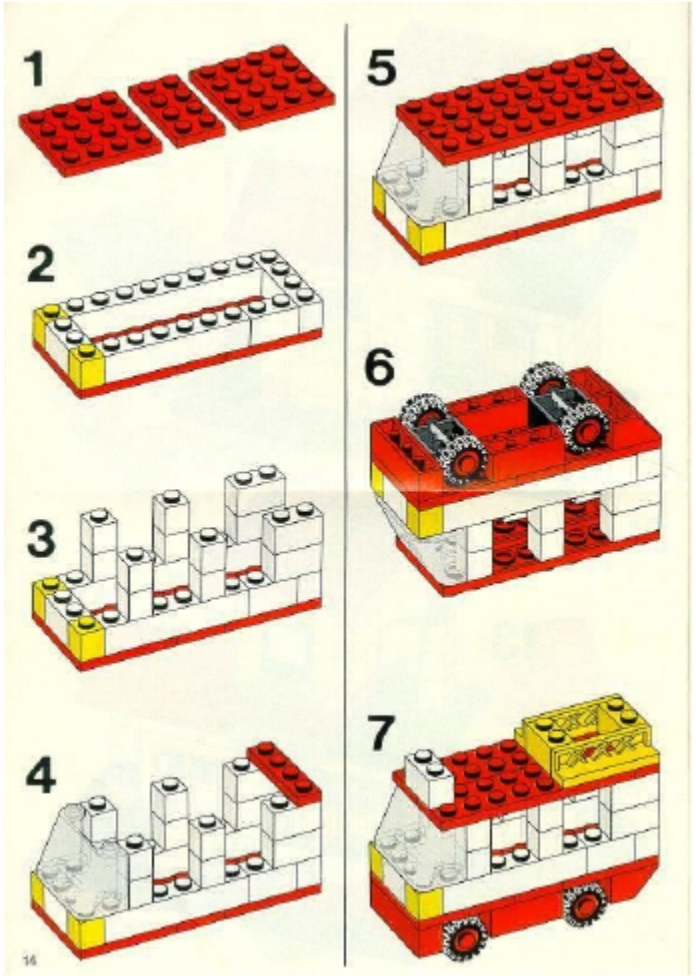
Example of Top-Down Design



Bottom-Up Design

- Start with your goal and figure out what can help you get there
- Then figure how to get to that previous step, and work your way up, building upon the lower-level components that are now available for use
- This strategy often resembles a "seed" model, whereby the beginnings are small but eventually grow in complexity and completeness
- However, "organic strategies" may result in a tangle of elements and subsystems, developed in isolation and subject to local optimization as opposed to meeting a global purpose

Example of Bottom-Up Design



Discussion

What are some of the projects that you've worked that you used one of the two above-mentioned designs?

Object-Oriented Design

- Based on 3 principles:
  - Encapsulation
  - Inheritance
  - Polymorphism

Encapsulation

- Encapsulation is the grouping of related ideas into one unit, which can thereafter be referred to by a single name
- It is sometimes, though incorrectly, referred to as information hiding, if the definition is very specific, as seen below:
  - Encapsulation: the technique of making the fields in a class private and providing access to the fields via public methods
  - With this definition, encapsulation allows abstracting things away from the user when they don't need to know how things work

Examples

- Is this encapsulation? If so, which definition applies?

```
public class Point
{
    public double x;
    public double y;
}
```

Examples

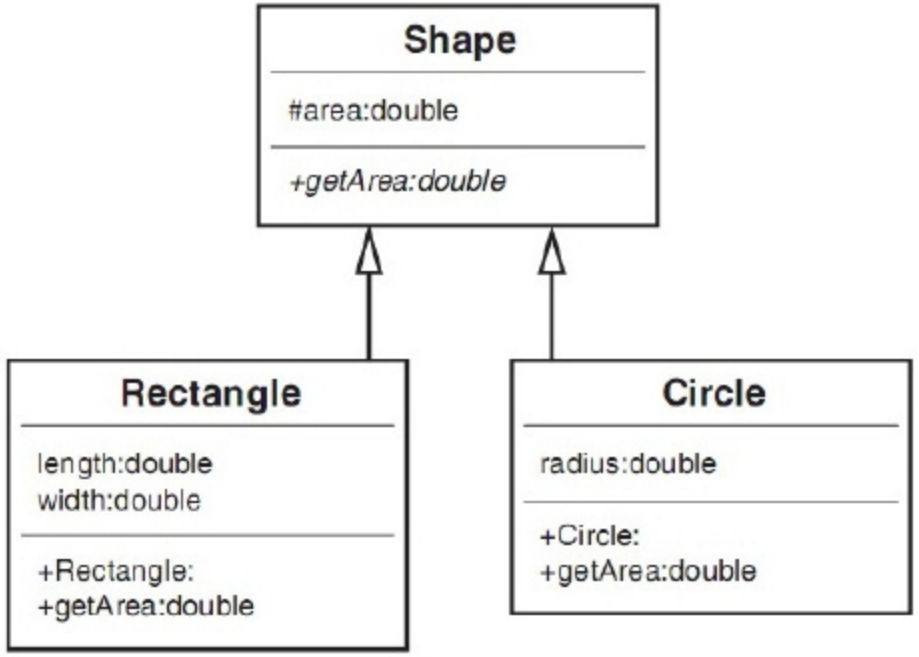
- Is this encapsulation? If so, which definition applies?

```
public interface Point
{
    double GetX();
    double GetY();
    void SetCartesian(double x, double y);
    double GetR();
    double GetTheta();
    void SetPolar(double r, double theta);
}
```

For more information, read **Clean Code: A Handbook of Agile Software Craftsmanship**.

Inheritance

- Inheritance: make subclasses that derive from other classes as a refinement of the parent class so you don't have to re-do something that was already done.



Shape UML diagram.

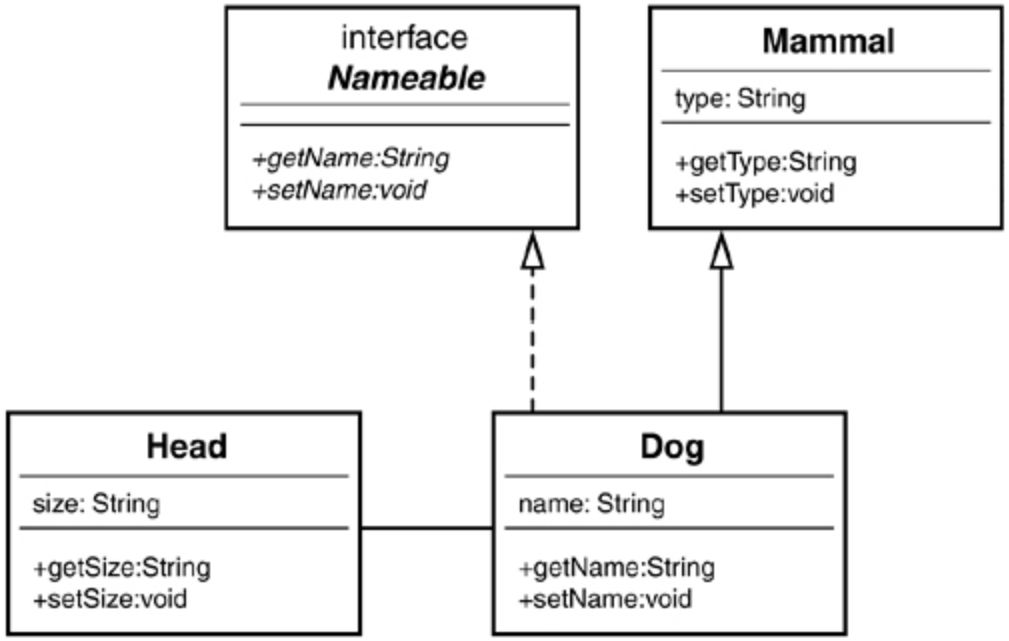
UML is short for *Unified Modeling Language*.

Polymorphism

- Polymorphism is the ability of an object to take on many forms
- The most common use of polymorphism in OOP occurs when a parent class reference is used to refer to a child class object
- In Java, polymorphism also means the ability to refer to a concrete class object through an interface reference

Examples of Polymorphism

- Nameable creature1 =
  new Dog();
- Mammal creature2
  new Dog();



Testing

- Testing: A means of determining if software contains bugs
- Debugging: Finding the bug in the code so it can be fixed
- Testing should start during the analysis/design phase, where you come up with a test plan
  - Ask yourself, "How are you going to test your code?"
  - Test cases should be written for all methods before you even write the method; this is sometimes referred to as "test driven programming", which is very common in industry

Three main categories of Errors

- Syntax Errors
- Run-time errors
- Logic errors

Syntax Errors

- You have a typo somewhere or wrote something the compiler didn't understand
- Easy to find because you just need to try to compile your code
- Syntax errors are UNACCEPTABLE, as it shows you never even had the chance to run your code
- The compiler actually tells you what's wrong with your code
- If you are overwhelmed by a multitude of errors, just look at them one at a time (top-most first), fix it, and compile again

Run-time Errors

- Run-time errors: Your program crashes during execution
- Reasonably easy to find with thorough testing, though **much** harder if code is multithreaded and the error is the result of a race condition
- Trace back where it happens to figure out what's wrong with the code; debuggers can be very helpful with this type of error

Logic Errors

- Hardest ones to fix
- Program doesn't crash but produces wrong output; it doesn’t do what you intended
- May result in code that leads to a race condition and manifests itself as a run-time error somewhere else
- Hardest part is that the bug usually comes from your thought processes, making you think a wrong line of code is producing good output when it isn't

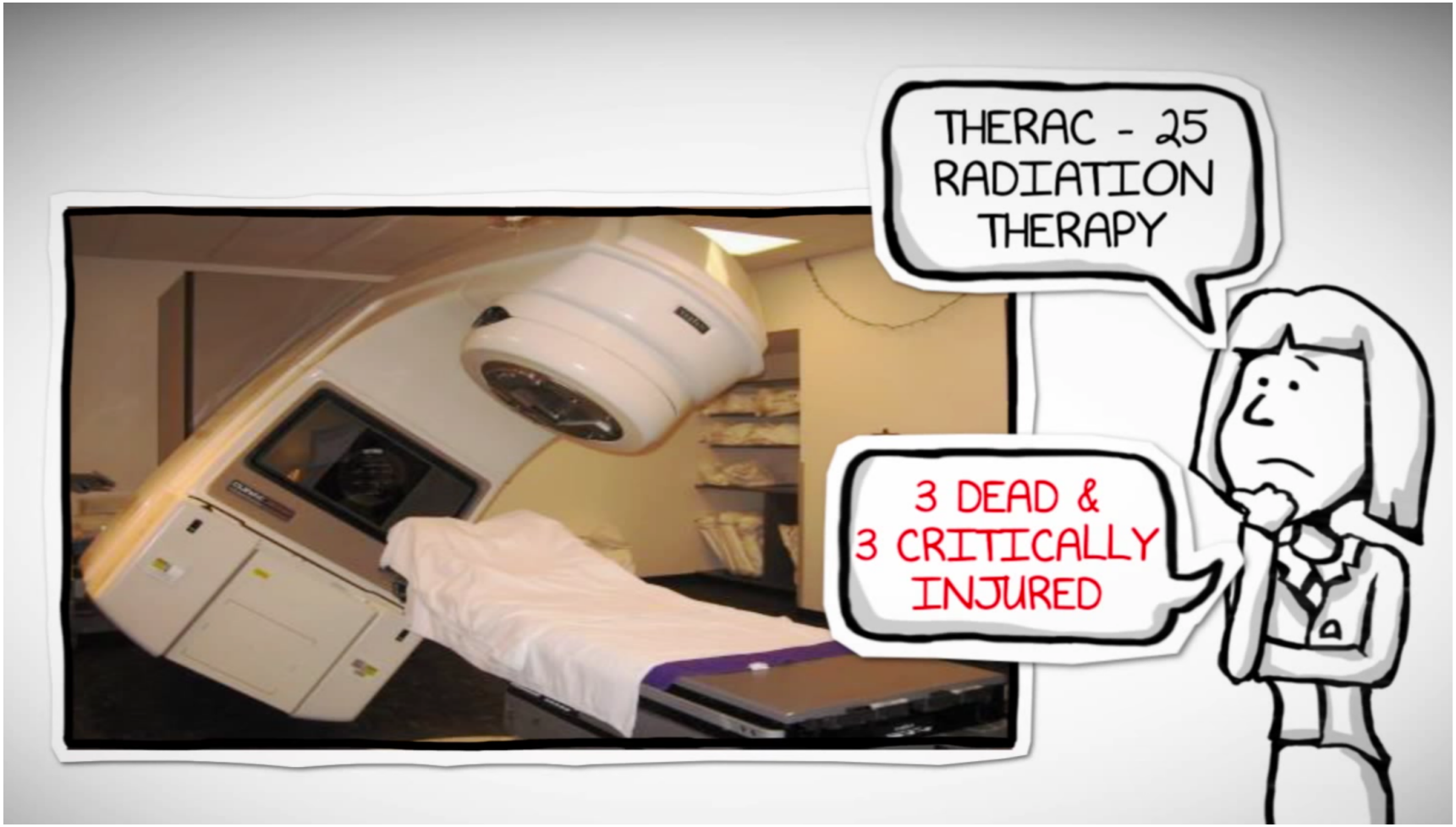
Purposes of Testing

- To make sure the software
  - meets the requirements that guided its design and development,
  - responds correctly to all kinds of inputs,
  - performs its functions within an acceptable time,
  - is sufficiently usable,
  - can be installed and run in its intended environments, and
  - achieves the general result its stakeholders desire

Why is Testing Important?

China Airlines Flight 140, April 26th, 1994

Why is Testing Important?



Why is Testing Important?

April, 1999

Why is Testing Important?

May, 1996

Paul Ehrlich:
"To err is human, but to really foul things up you need a computer."

Exercise

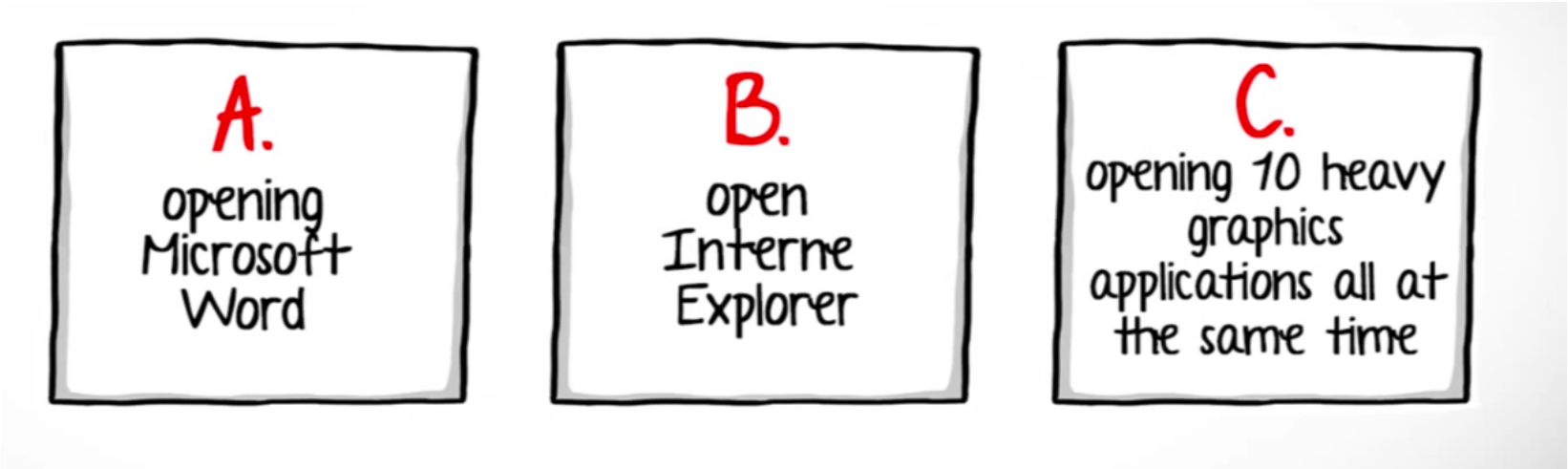
- Consider a scenario where you write the code to move a file from folder A to folder B
  - How can you test this?
  - What can go wrong?

Exhaustive Search

- Suppose you have 15 input fields with 5 possible values each
- In order to test all the combinations you'd need
  - 5^15 = 30,517,578,125 combinations to test
- If you were to test all the possible combinations, the project execution time and cost would rise exponentially
- Exhaustive Testing is not possible
- Instead we need optimal amount of testing based on the Risk Assessment of the application

Exercise

Which operations is most likely to cause your operating system to fail?



Defect Clustering

- A small number of modules contain most of the defects detected
- With experience, you can identify such risky modules
- However, this can lead to another problem..

Pesticide Paradox

- If the same tests are repeated over and over again, eventually the same test cases will no longer find new bugs
- This is called the Pesticide Paradox
- To overcome this, the test cases needed to be regularly reviewed and revised, adding new and different test cases to help find more defects
- You can never claim that your code is BUG-FREE
- Why?
- Absence of error is a fallacy

7 Testing Principles

- Testing shows presence of defects
- Exhaustive Testing is impossible
- Early Testing
- Defect Clustering
- Pesticide Paradox
- Testing is context dependent
- Absence of errors is a falacy

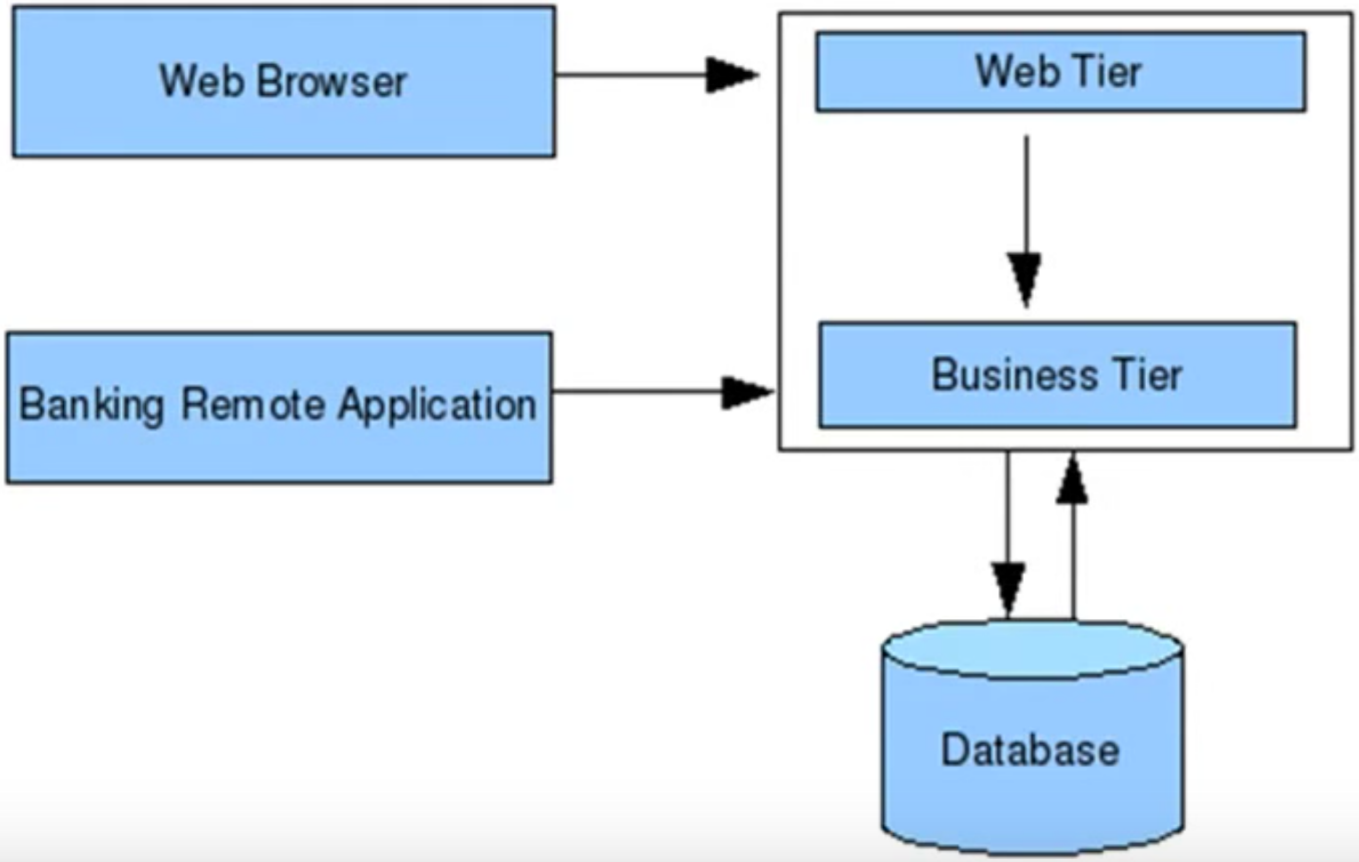
Testing Levels

- **Unit testing**, also known as component testing, refers to tests that verify the functionality of a specific section of code, usually at the function level. In an object-oriented environment, this is usually at the class level, and the minimal unit tests include the constructors and destructors.

Testing Scenario

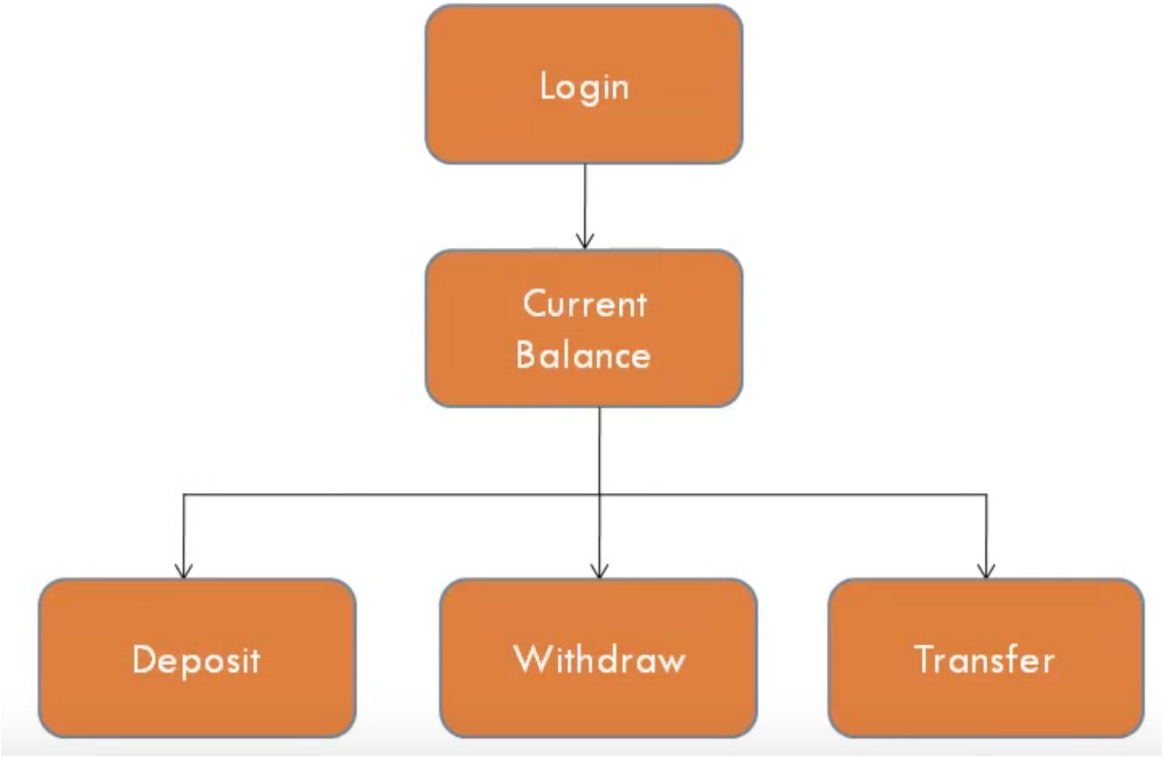
- Your company is hired by a bank to develop an online banking application
- Requirement Analysis
  - Log on
  - View Current Balance
  - Deposit
  - Withdraw
  - Transfer

Testing Scenario - Functional Design



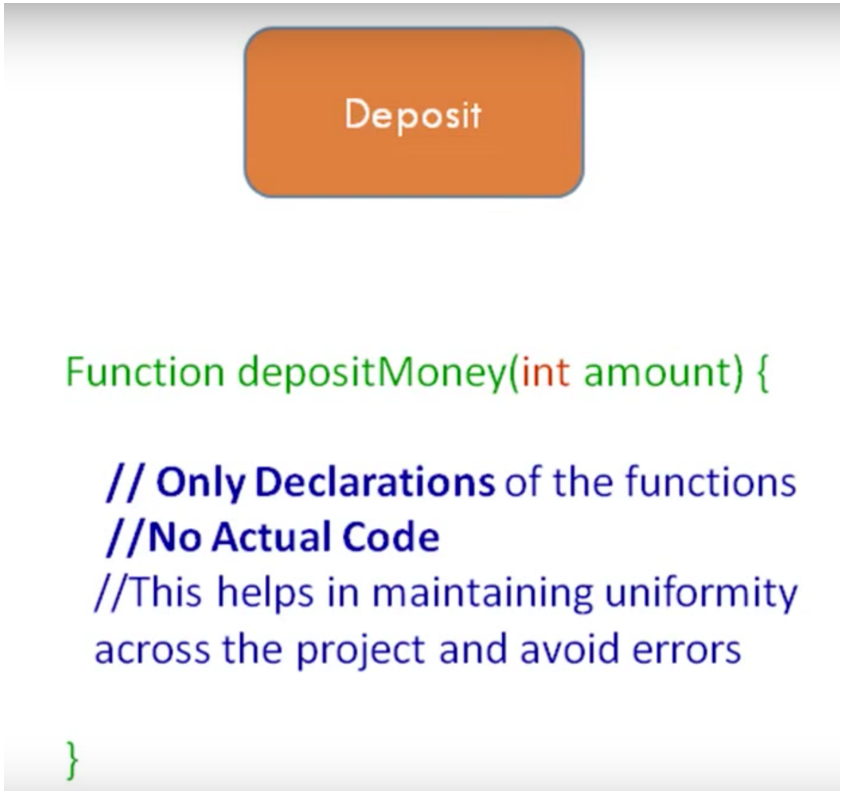
Testing Scenario – High Level Design

- Break down into modules



Testing Scenario – Detail Design

- Code Architecture/Skeleton and Documentation



Testing Scenario – Unit Testing

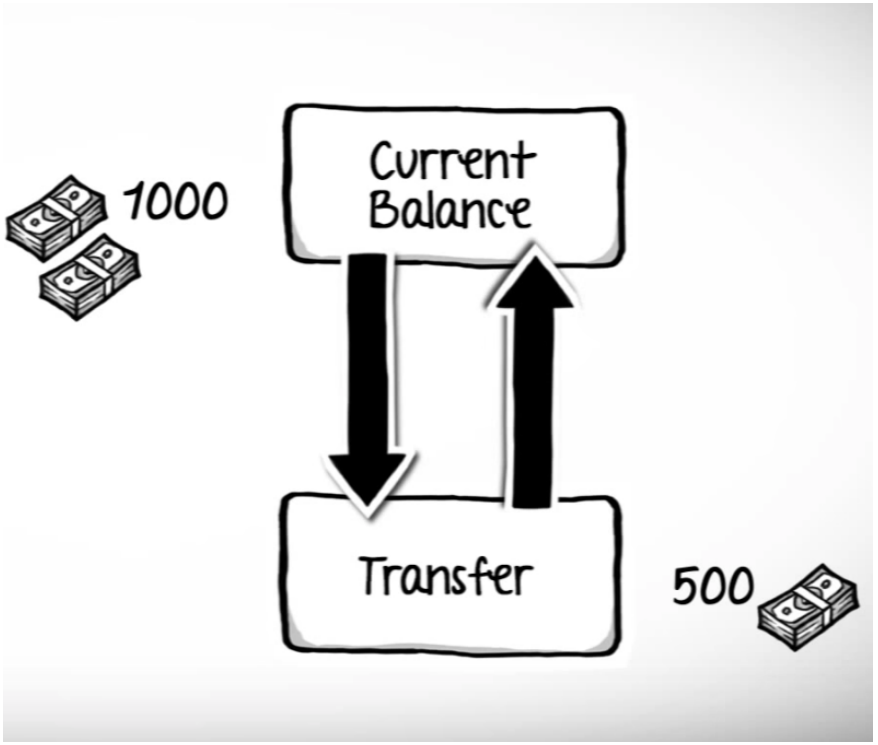
Testing Levels

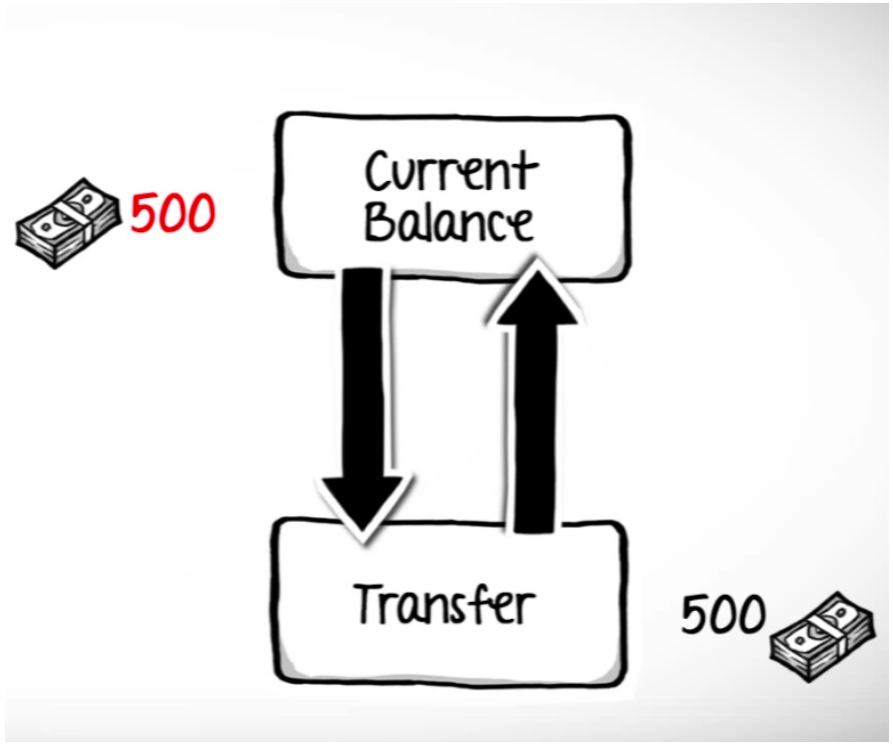
- **Integration testing** is any type of software testing that seeks to verify the interfaces between components against a software design.
- Integration testing works to expose defects in the interfaces and interaction between integrated components (modules).

Testing Levels

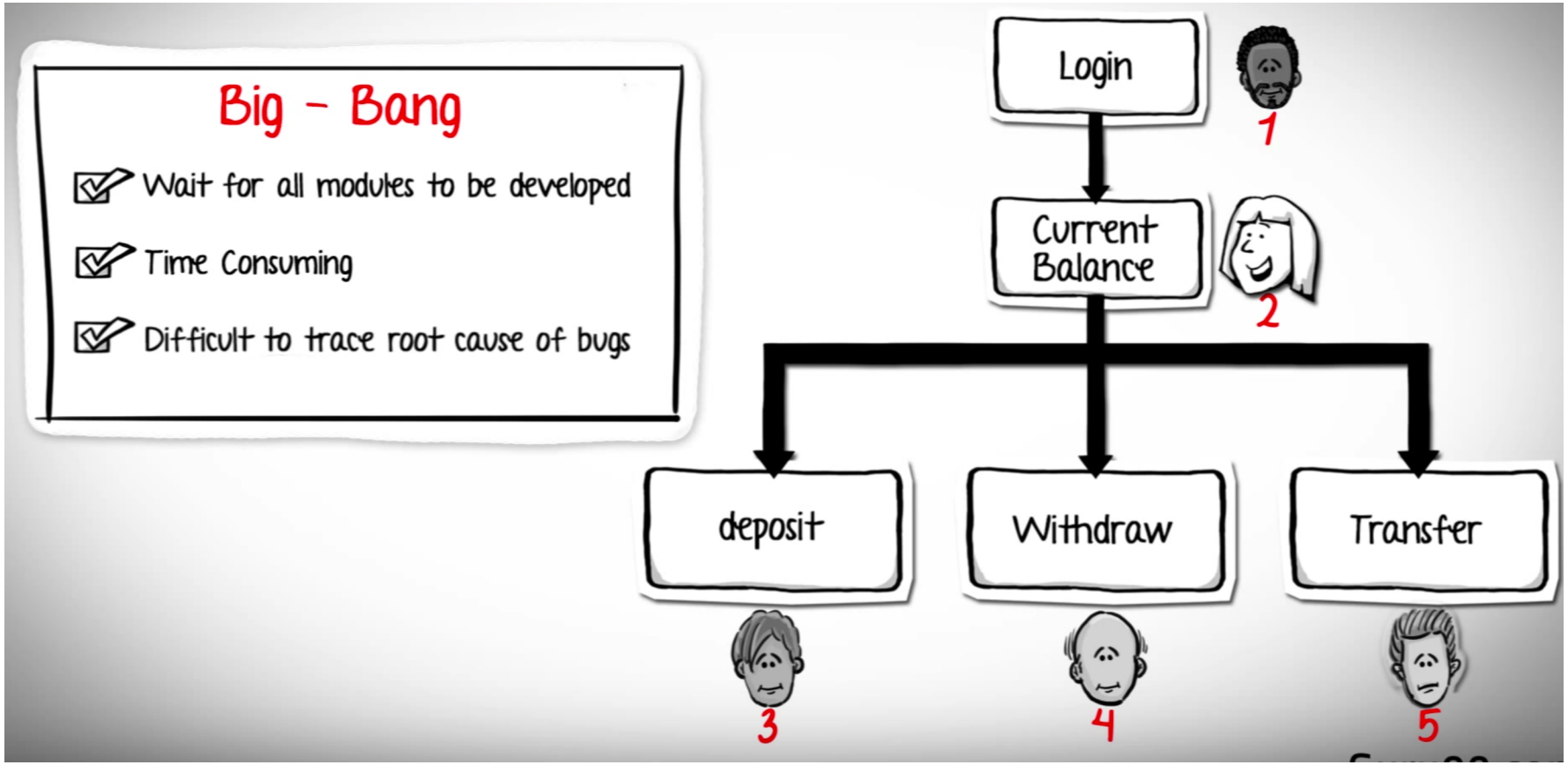
- The practice of **component interface testing** can be used to check the handling of data passed between various units, or subsystem components, beyond full integration testing between those units.
- The data being passed can be considered as "message packets" and the range or data types can be checked, for data generated from one unit, and tested for validity before being passed into another unit.

Testing Scenario – Integration Testing





Testing Scenario – Integration Testing



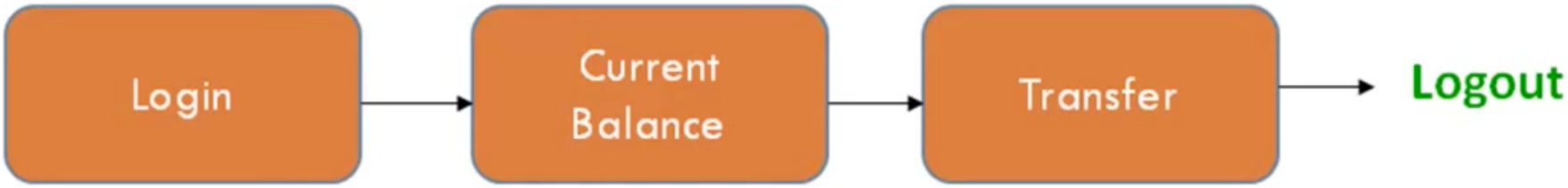
- We can also have incremental Integration Testing!

Testing Levels

- **System testing**, or end-to-end testing, tests a completely integrated system to verify that it meets its requirements
- At last the system is delivered to the user for **acceptance testing**
- Helps to avoid cases where the sponsor says, “This is not what I asked for!” after deployment

Testing Scenario – System Testing

- Whole System, instead of interaction of modules tested in integration testing
- Also, non-functional aspects such as the performance are tested here



- Acceptance Testing:
  - Alpha/beta testing

Testing Methods

- Within testing there are 2 main approaches:
  - Black-box testing: Testing without the knowledge on how the methods work. This means just testing input/outputs without caring about what goes on inside the method.
  - White-box testing: Testing every single line of code in your program. If you have obscure cases that normally never happen (like malloc returning null because memory is exhausted), fake them with a debugger.

White Box Vs Black Box Testing

BLACK-BOX TESTING

- based on a description of the software (specification)
- cover as much specified behavior as possible
- cannot reveal errors due to implementation details

WHITE-BOX TESTING

- based on the code
- cover as much coded behavior as possible
- cannot reveal errors due to missing paths

Black Box Testing

BLACK-BOX TESTING EXAMPLE

Specification: inputs an integer and prints it

```
1. void printNumBytes( param )
2.     if (param < 1024) printf("%d", param);
3.     else printf("%d KB", param/1024);
4. }
```

White Box Testing Example

WHITE-BOX TESTING EXAMPLE

Specification: inputs an integer param and returns half of its value if even, its value otherwise

```
1. int fun(int param){
2.     int result;
3.     result = param/2;
4.     return result;
5. }
```