

# Dynamic Analysis: Testing

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# Introduction

- Dynamic Analysis verifies properties of a system during execution/runtime.
- Testing Analysis is one example of Dynamic Analysis
  - Unit tests, integration tests, system tests, and acceptance tests use dynamic testing

# Testing in the Book

- Tests are your life insurance!
- Tests are essential to assuring the quality of code activities.
- Write Tests to Enable Evolution
  - Good tests can find bugs in your artifact
  - Tests can also detect unwanted behavior
- You can also write tests to understand a part of a system
- Test the Interface, Not the implementation. This is essentially Black-box testing.

# Unit Testing

- In this session, we focus on Unit Testing.
  - Unit testing focuses on the smallest testable parts of an application called units (e.g., a class method or function)
- There are other types of testing (Integration, Performance, Security, etc.)
- It does not mean that Unit Testing is more important, but those are the tests we can more easily automatize and benefit from tool support.

# Quality of a Test Suite

- How do you know if your unit test cases are good enough?
- Are they really testing the application?
- When do we stop testing?

**Solution:** Test Coverage!

# Test Coverage

$$\text{Coverage} = \frac{\text{Number of Covered Items}}{\text{Total number of items}} \times 100\%$$

- Examples:
  - Statement (Line, or Code) Coverage.
  - Branch (Condition) Coverage
  - Path Coverage
  - Mutation Coverage

# Example: a function to test

```
int foo(int input, bool b1, bool b2, bool b3){  
    int x = input;  
    int y = 0;  
    if(b1)  
        x++;  
    if(b2)  
        x--;  
    if(b3)  
        y=x;  
    return y;  
}
```

# Statement/Line/Code Coverage

Test Case(s)

```
ASSERT foo(0, true, true, true) == 0;
```

```
int foo(int input, bool b1, bool b2, bool b3){  
    int x = input;  
    int y = 0;  
    if(b1)  
        x++;  
    if(b2)  
        x--;  
    if(b3)  
        y=x;  
    return y;  
}
```



# Statement/Line/Code Coverage

Test Case(s)

```
ASSERT foo(0, true, true, true) == 0;
```

```
int foo(int input, bool b1, bool b2, bool b3){  
    int x = input;  
    int y = 0;  
    if(b1)  
        x++;  
    if(b2)  
        x--;  
    if(b3)  
        y=x;  
    return y;  
}
```

**100% Statement Coverage**

# Statement/Line/Code Coverage

Test Case(s)

```
ASSERT foo(0, false, true, true) == -1;
```

```
int foo(int input, bool b1, bool b2, bool b3){  
    int x = input;  
    int y = 0;  
    if(b1)  
        x++;  
    if(b2)  
        x--;  
    if(b3)  
        y=x;  
    return y;  
}
```

$$\frac{8}{9} \times 100\% = 88.9\%$$

~~100% Statement Coverage~~

# Branch/Condition Coverage

Test Case(s)

```
ASSERT foo(0, true, true, true) == 0;
```

```
int foo(int input, bool b1, bool b2, bool b3){  
    int x = input;  
    int y = 0;  
    if(b1)  
        x++;  
    if(b2)  
        x--;  
    if(b3)  
        y=x;  
    return y;  
}
```

**50% Branch Coverage**

# Branch/Condition Coverage

Test Case(s)

```
ASSERT foo(0, true, true, true) == 0;  
Assert foo(0, false, false, false) == 0;
```

New Test

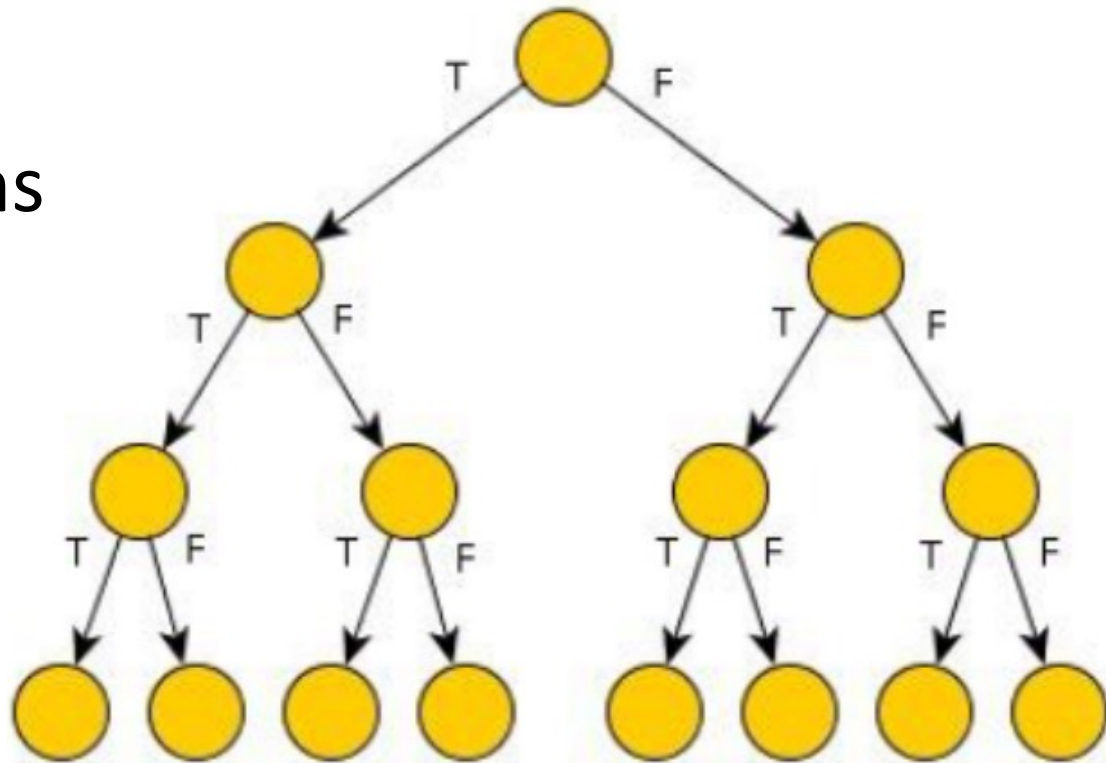
```
int foo(int input, bool b1, bool b2, bool b3){  
    int x = input;  
    int y = 0;  
    if(b1)  
        x++;  
    if(b2)  
        x--;  
    if(b3)  
        y=x;  
    return y;  
}
```

100% Branch Coverage

# Path Coverage

Paths for three “if” each can be either true (T) or false (F)

# 8-Paths

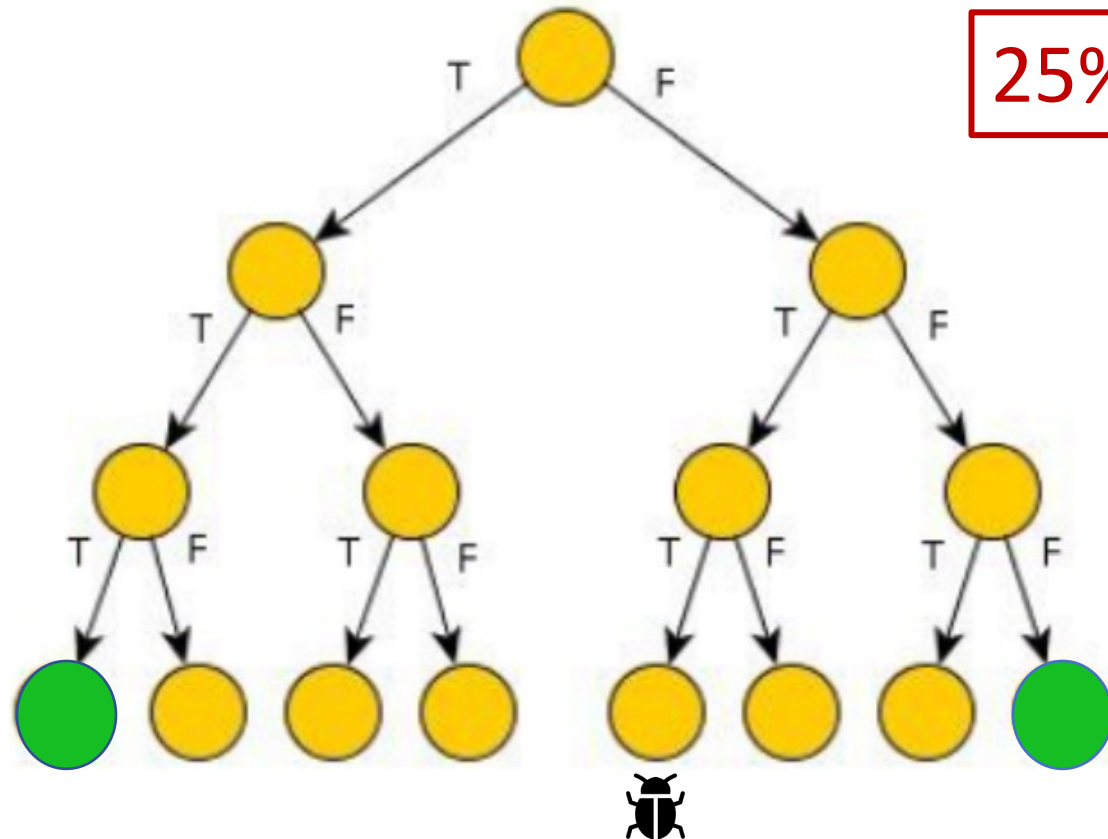


# Path Coverage

## Test Case(s)

```
ASSERT foo(0, true, true, true) == 0;
```

```
ASSERT foo(0, false, false, false) == 0;
```



# Testing Coverage for the Project

- It is required to show coverage for your Project (in both the Intermediate and the Final Report)
  - At least Statement Coverage, but Branch Coverage is better.
- There is no set coverage limit to reach for the project.
- But if your project has very low coverage, you better have a good explanation for that.
- Focus on increasing the coverage for the system parts that will be affected by your change.