CSE 403
Lecture 13

Black/White-Box Testing

Reading:

Software Testing: Principles and Practices, Ch. 3-4 (Desikan, Ramesh)

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

Testing questions

- Should I test my own code, or should somebody else?
- Which code of my project should I test the most/least?
- Can I test all possible inputs to see whether something works?
- How do I know if I've tested well/enough?
- What constitutes a good or bad test case method?
- Is it good or bad if a test case fails?
- What if a test case itself has a bug in it?

JUnit exercise

Given a `Date` class with the following methods:

```
- public Date(int year, int month, int day)
- public Date()                          // today
- public int getDay(), getMonth(), getYear()
- public void addDays(int days)    // advances by days
- public int daysInMonth()
- public String dayOfWeek()        // e.g. "Sunday"
- public boolean equals(Object o)
- public boolean isLeapYear()
- public void nextDay()            // advances by 1 day
- public String toString()
```

- Come up with unit tests to check the following:
  - That no `Date` object can ever get into an invalid state.
  - That the `addDays` method works properly.
    - It should be efficient enough to add 1,000,000 days in a call.

Test-driven development

- Imagine that we'd like to add a method `subtractWeeks` to our Date class, that shifts this Date backward in time by the given number of weeks.

- Write code to test this method *before* it has been written.
  - This way, once we do implement the method, we'll know whether it works.

Black and white box testing

What is the difference between black- and white-box testing?

- **black-box** (procedural) **test**: Written without knowledge of how the class under test is implemented.
  - focuses on input/output of each component or call

- **white-box** (structural) **test**: Written with knowledge of the implementation of the code under test.
  - focuses on internal states of objects and code
  - focuses on trying to cover all code paths/statements
  - requires internal knowledge of the component to craft input
    - example: knowing that the internal data structure for a spreadsheet uses 256 rows/columns, test with 255 or 257

Black-box testing

- black-box is based on requirements and functionality, not code
- tester may have actually seen the code before ("gray box")
  - but doesn't look at it while constructing the tests
- often done from the end user or OO client's perspective
- emphasis on parameters, inputs/outputs (and their validity)

Types of black-box

- requirements based
- positive/negative - checks both good/bad results
- boundary value analysis
- decision tables
- equivalence partitioning - group related inputs/outputs
- state-based - based on object state diagrams
- compatibility testing
- user documentation testing
- domain testing

Boundary testing

- **boundary value analysis**: Testing conditions on bounds between classes of inputs.

- Why is it useful to test near boundaries?
  - likely source of programmer errors (< vs. <=, etc.)
  - language has many ways to implement boundary checking
  - requirement specs may be fuzzy about behavior on boundaries
  - often uncovers internal hidden limits in code
    - example: array list must resize its internal array when it fills capacity

Boundary example

- Imagine we are testing a `Date` class with a `daysInMonth(month, year)` method.
  - What are some conditions and boundary tests for this method?

- Possible answers:
  - check for leap years (every 4th yr, no 100s, yes 400s)
  - try years such as: even 100s, 101s, 4s, 5s
  - try months such as: June, July, Feb, invalid values

Decision tables

Status	Status of spouse	Age > 65? > 65?	Age of spouse	Blind? spouse	Spouse blind?	Standard deduction amount
Single	—	NO	—	NO	—	$4,750
Single	—	NO	—	YES	—	$5,750
Single	—	YES	—	NO	—	$5,750
Single	—	YES	—	YES	—	$6,750
Married, filing separate return	Claimed standard deduction	NO	—	NO	—	$7,000
Married, filing separate return	Claimed standard deduction	NO	—	YES	—	$8,000
Married, filing separate return	Claimed standard deduction	YES	—	NO	—	$8,000
Married, filing separate return	Claimed standard deduction	YES	—	YES	—	$9,000
Married, filing separate return	Did not claim standard deduction	—	—	—	—	$0
Married, filing joint return	—	NO	NO	NO	NO	$9,500
Married, filing joint return	—	YES	—	NO	NO	$10,500
Married, filing joint return	—	YES	—	YES	—	$11,500

Equivalence testing

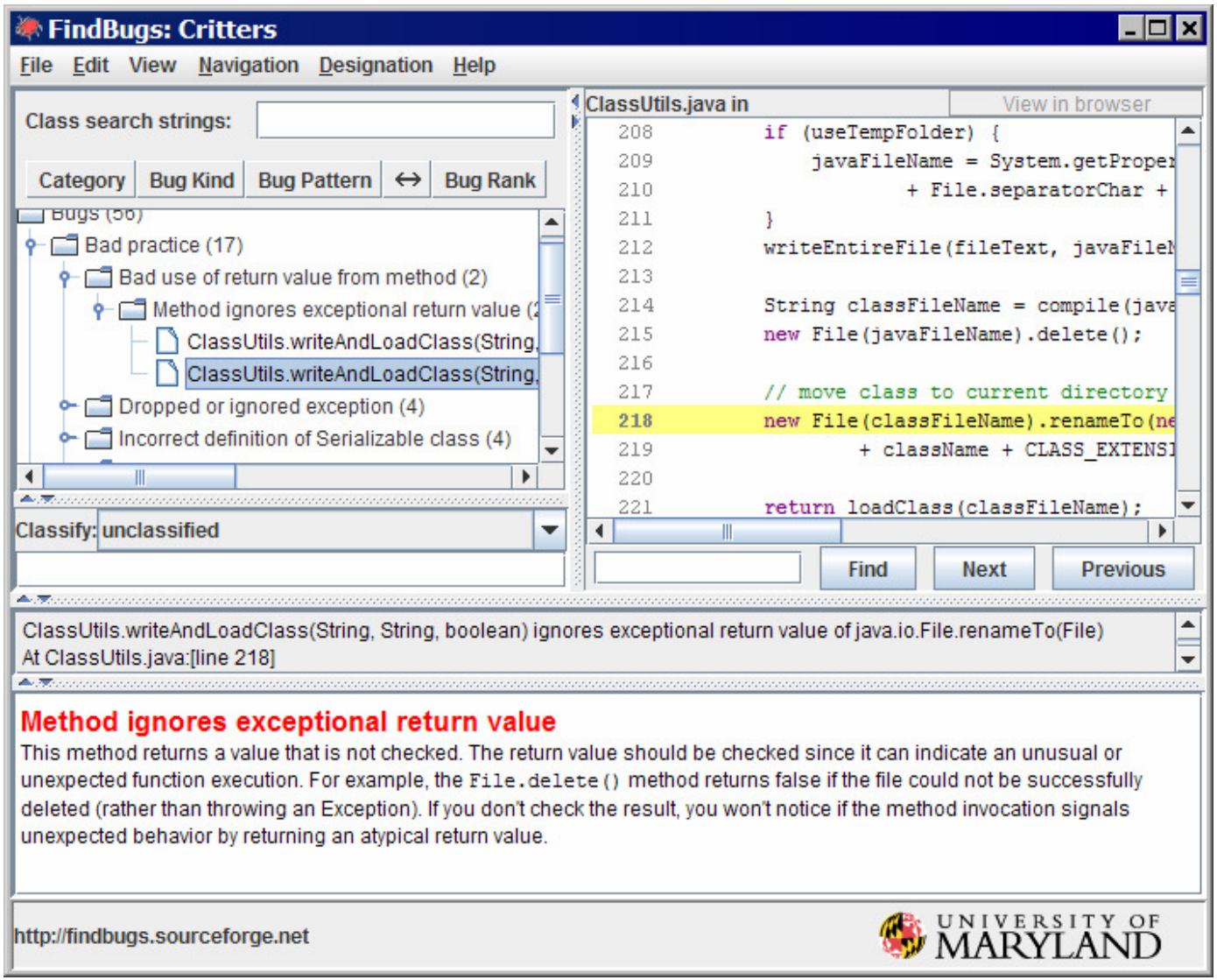
- **equivalence partitioning**:
  - A black-box test technique to reduce # of required test cases.
  - What is it?
  - steps in equivalence testing:
    - identify classes of inputs with same behavior
    - test on at least one member of each equivalence class
    - assume behavior will be same for all members of class
  - criteria for selecting equivalence classes:
    - *coverage* : every input is in one class
    - *disjointedness* : no input in more than one class
    - *representation* : if error with 1 member of class, will occur with all

White-box testing

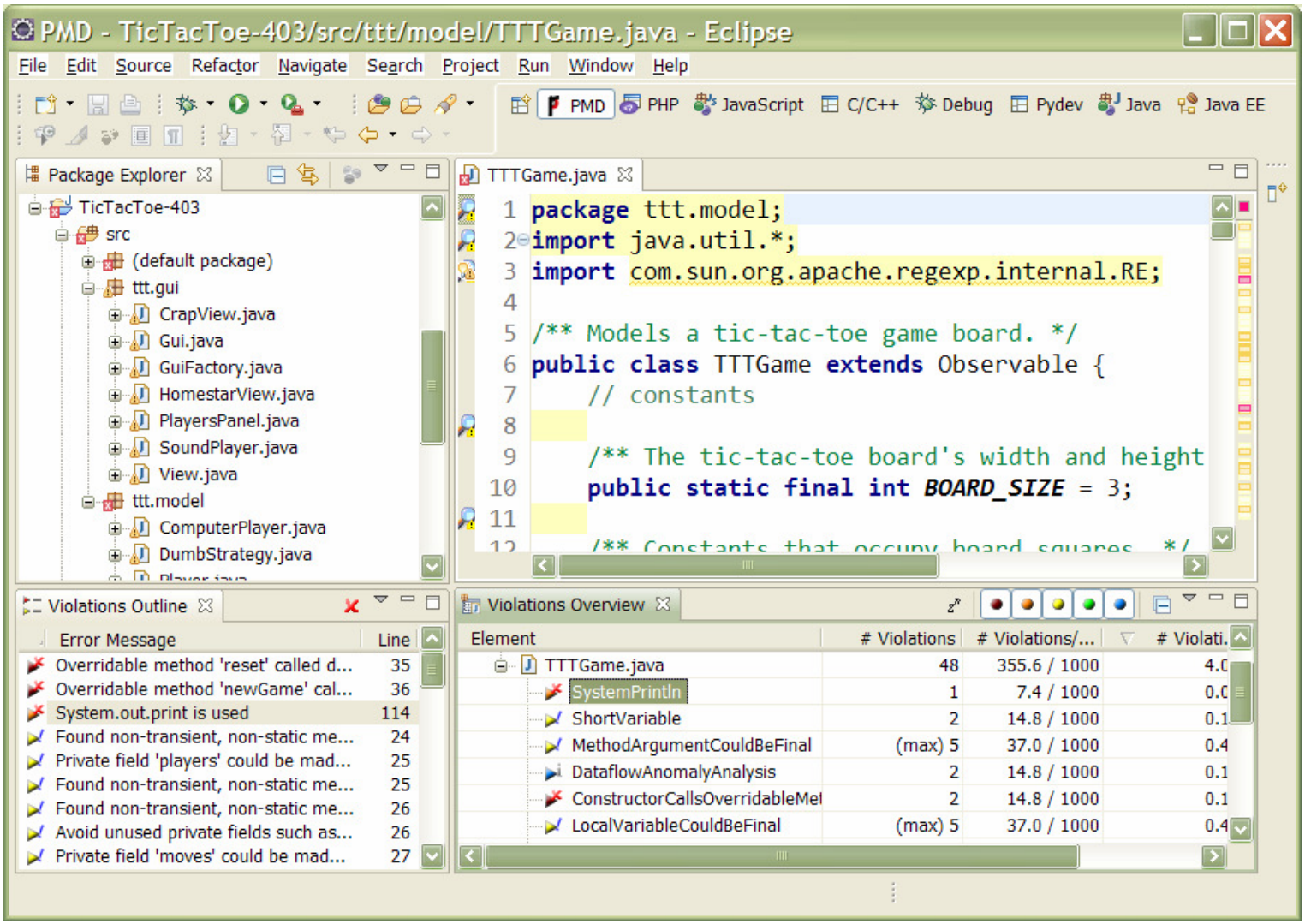
Some kinds of white box testing don't involve unit tests:

- "static testing"
  - code walkthroughs, inspections, code reviews
  - static analysis tools
    - Lint (and variants) — JiveLint, JLint, PMD, CheckR, JSLint, `php -l`
    - CheckStyle — http://checkstyle.sourceforge.net/
    - FindBugs — http://findbugs.sourceforge.net/
  - code complexity analysis tools
    - PMD, CheckStyle, etc.

Static analysis example



Complexity analysis



Path testing

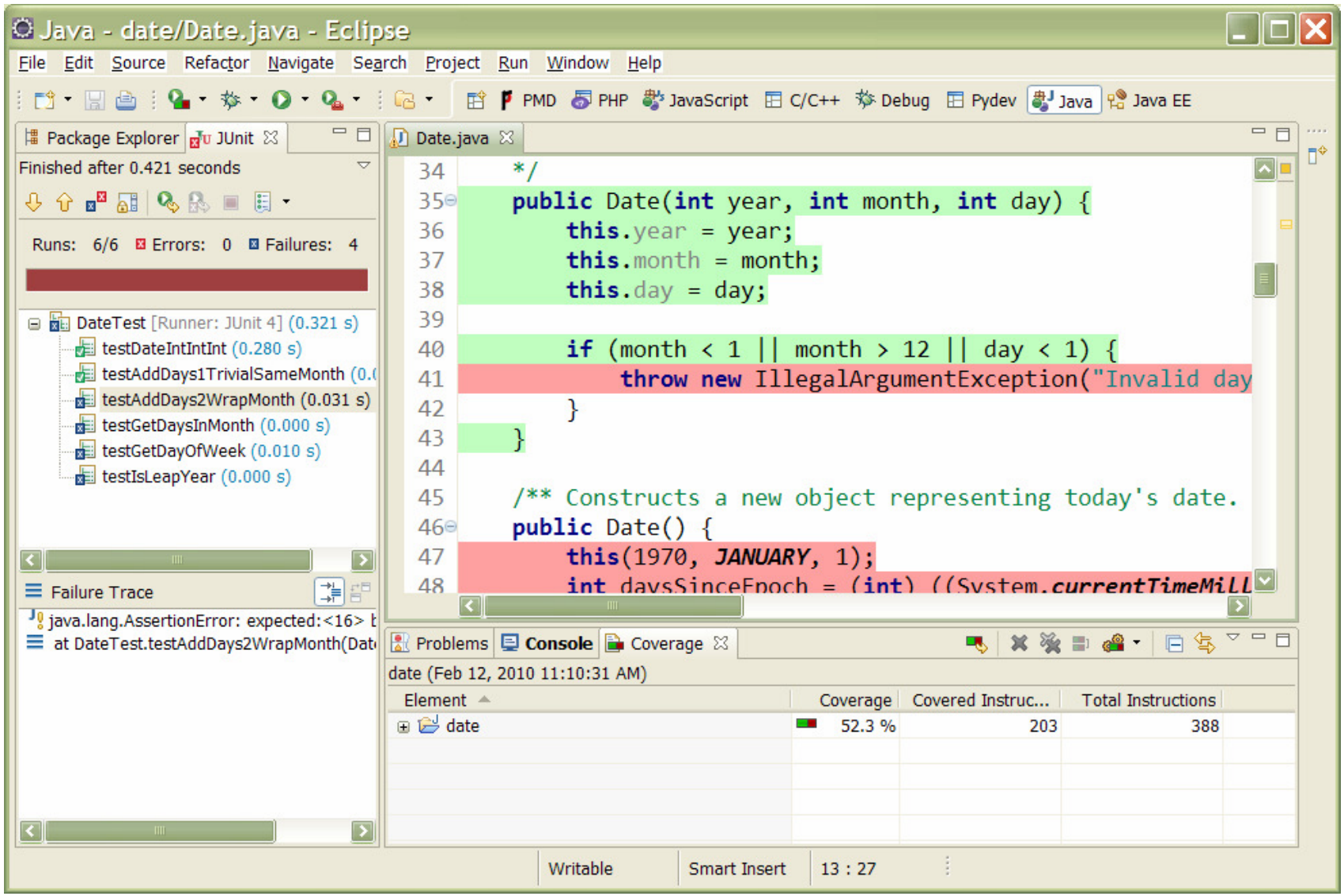
- **path testing**: an attempt to use test input that will pass once over each path in the code
  - path testing is *white* box
  - What would be path testing for daysInMonth(month, year)?
    some ideas:
    - error input: year < 1, month < 1, month > 12
    - one month from [1, 3, 5, 7, 10, 12]
    - one month from [4, 6, 9, 11]
    - month 2
      - in a leap year, not in a leap year

Code coverage testing

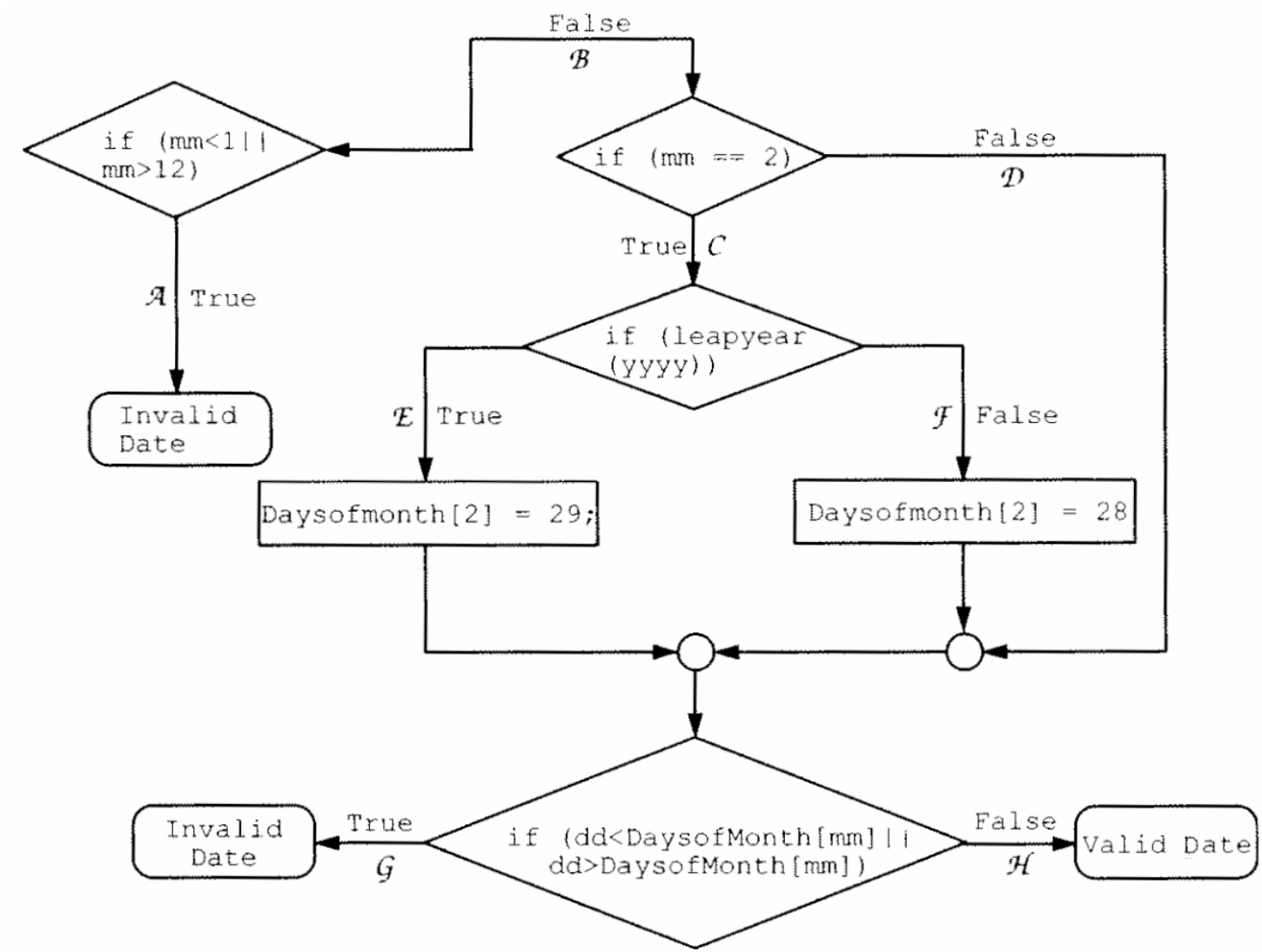
- **code coverage testing**: Examines what fraction of the code under test is reached by existing unit tests.
  - statement coverage - tries to reach every line (impractical)
  - path coverage - follow every distinct branch through code
  - condition coverage - every condition that leads to a branch
  - function coverage - treat every behavior / end goal separately

- Several nice tools exist for checking code coverage
  - EclEmma, Cobertura, Hansel, NoUnit, CoView ...

Code coverage example



Path coverage example



White box testing is hard

- Developers can't easily spot flaws in their own code.
- Test cases that are too focused on code may not be thinking about how the class is actually going to be used.
- Code coverage tools can give a false sense of security.
  - Just because code is "covered" doesn't mean it is free of bugs.
- Code complexity can be misleading.
  - Complex code is not always bad code.
  - Complexity analysis tools can be overly picky or cumbersome.

Testing exercise 1

- Imagine that we have a Date class with working methods called isLeapYear(year) and daysInMonth(month, year).
  - Question: What is the pseudo-code for the algorithm for an addDays(days) method that moves the current Date object forward in time by the given number of days. A negative value moves the Date backward in time.
  - Question: Come up with a set of test values for your addDays method to test its correctness.

Testing exercise 2

- Consider tests to determine whether a Scrabble move is legal:
  - Are all tiles in a straight line?
  - Are the tiles contiguous or separated only by existing old tiles?
  - Are the tiles touching an existing old tile?

  - On each of the words made:
    - What is the score of this word?
    - Is this word in the dictionary?

- Question: What is/are some suitable Scrabble test board configuration(s) and moves that check each of these conditions?
  - Make both passing and failing tests.