CS1632, Lecture 4: Traceability Matrices + Smoke , Exploratory Testing, and Path-Based Testing

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Traceability Matrices

- Answer the questions - how do I know that my tests are checking all of the requirements, AND/OR that all of my requirements are being checked by tests?
- Simply a list of requirements and the associated test case

Example - Good Matrix

LOGIN-REQ: GOOD-LOGIN-TEST, BAD-LOGIN-TEST, THREE-TIMES-ERROR-TEST

DATABASE-REQ: VALID-QUERY-TEST, INVALID-QUERY-TEST, DB-DOWN-TEST

LOGIN-SCREEN-REQ: LOW-BANDWIDTH-TEST, HIGH-BANDWIDTH-TEST

CALC-REQ: ADD1-TEST, ADD2-TEST, ADD3-TEST, SUBTRACT1-TEST

Example - Requirement Not Tested!

LOGIN-REQ:

DATABASE-REQ: VALID-QUERY-TEST, INVALID-QUERY-TEST, DB-DOWN-TEST

LOGIN-SCREEN-REQ: LOW-BANDWIDTH-TEST, HIGH-BANDWIDTH-TEST

CALC-REQ: ADD1-TEST, ADD2-TEST, ADD3-TEST, SUBTRACT1-TEST

Example - Tests Not Checking Any Reqs

LOGIN-REQ: GOOD-LOGIN-TEST, BAD-LOGIN-TEST, THREE-TIMES-ERROR-TEST

DATABASE-REQ: VALID-QUERY-TEST, INVALID-QUERY-TEST, DB-DOWN-TEST

LOGIN-SCREEN-REQ: LOW-BANDWIDTH-TEST, HIGH-BANDWIDTH-TEST

CALC-REQ: ADD1-TEST, ADD2-TEST, ADD3-TEST, SUBTRACT1-TEST

: DEFROBALIZE-TEST, ANTI-DEFROBALIZE-TEST

Exploratory Testing

- We have developed a very formal manner of testing
  - Develop requirements
  - Write test plan
  - Create and check traceability matrix
  - Execute tests

Exploratory Testing

- But we have assumed that we know the EXACT expected behavior, EXACTLY how to cause it, and it is necessary to DEFINE all of these behaviors
  - Works fine in some circumstances!
  - But not others!
- If I asked you to “test a poker program”, what would you do?

Sometimes, we don’t know exactly what the expected behavior is! Why not?

- Subjective
- Domain-specific
- Uncertain of exact reproduction steps
- Uncertain of interface
- Unfamiliarity with general interaction
- Implicit requirements

Exploratory Testing

- Definition: testing without a specific test plan, in which the goals are to both learn more about the system and inform the development of system by finding defects and possible enhancements

Sometimes called “*ad hoc*” *testing*

- Personally, I don’t like this term
- It implies carelessness
- Less rigid != more careless
- Faith in the testers is required
    - To not go down blind alleys
    - To use their best judgment

How To Do It

1. Use your best judgment
2. If in doubt about next step, see Step 1.

Faith in Testers

Exploratory testing has faith that you instinctively "know" that there's a defect, or at least that you know something doesn't seem quite right.

Tips:

1. Try to accomplish important tasks
2. Think of edge cases on the fly
3. Try doing different things together
4. If I were the programmer, what wouldn't I have thought of?
5. Write down defects IMMEDIATELY
6. You can keep track of your steps and write them down later as formal tests.

Benefits of Exploratory Testing

1. Fast
2. Flexible
3. Relies on testers’ knowledge, and helps improve it
4. Very easy to update!

Drawbacks to Exploratory Testing

1. Unregulated
2. Possibly unrepeatable
3. Hard to say how much coverage there is
4. Difficult to automate

Smoke Testing

Smoke Testing (plumbing)

- Send smoke down the pipes to find leaks BEFORE sending water or other fluids
- Why?
  - If there is a leak, much easier to clean up / find smoke
  - Won't waste effort
  - Won't cause further damage (high pressure water going through a hole means a bigger hole will be formed)

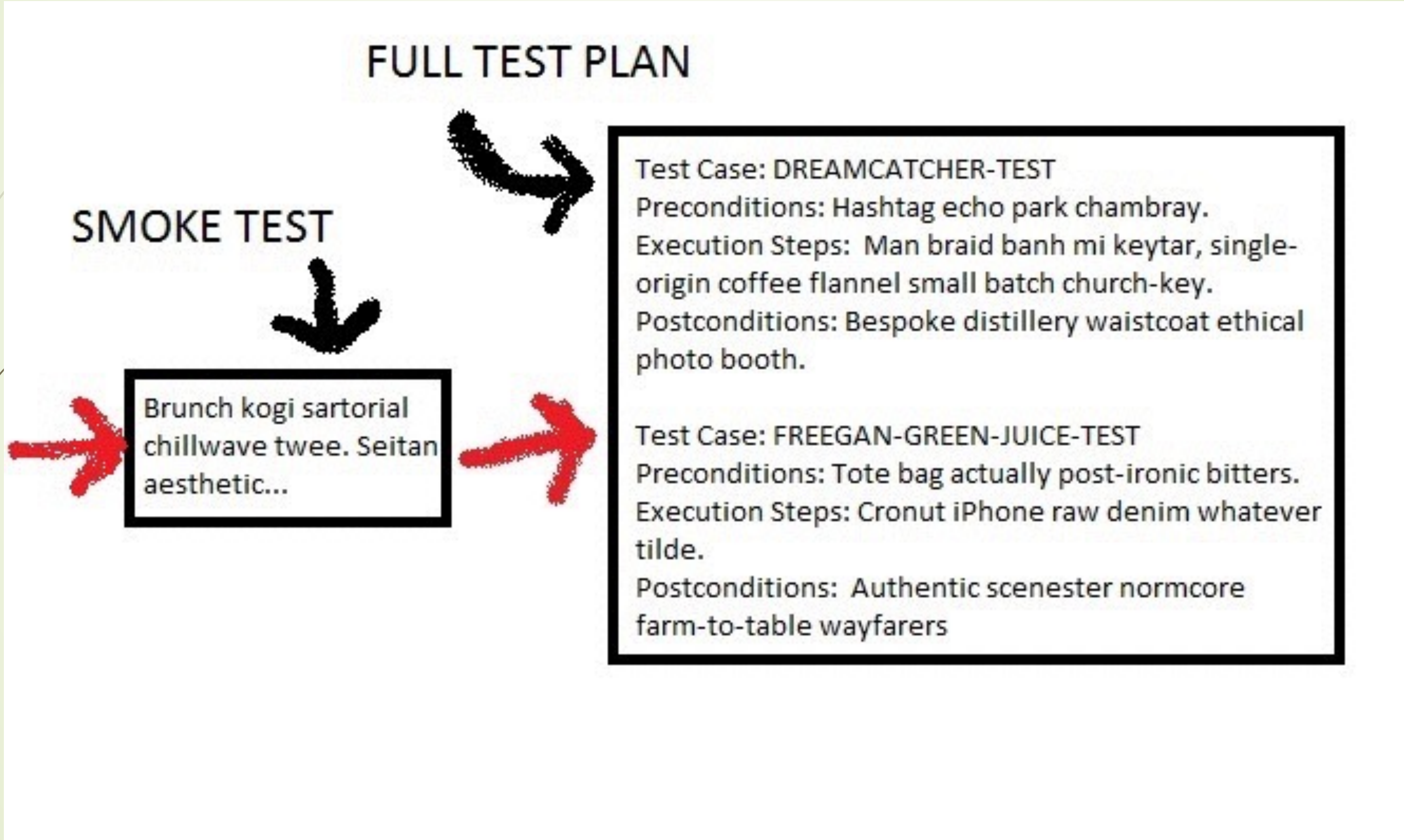
Smoke Testing (software)

- Do some minimal testing to ensure that the system is, in fact, testable or ready to be released
- Why?
  - No need to test system that can't perform minimal acceptable functionality
  - Setting up test harnesses / installing software may be non-trivial
  - Avoid wasting testers' time

Smoke Testing can be:

- **Scripted**: A few small but important test cases are run before the software is ready to be tested. These can be automated or manual.
- **Unscripted**: An experienced tester does exploratory testing for a small amount of time to ensure that it meets minimum standards.

Smoke Testing is a GATEWAY



Media Check

- A really, really basic smoke test
  - Can the CD be read?
  - Do files exist on server?
  - Etc.

A Note on “Sanity Testing”

- Note: Some texts use the term “sanity testing” for “smoke testing”. I avoid this because:
  - It could be offensive
  - I think the parallel with smoke testing in plumbing is much more apt
- However, you may come across the term so I wanted to cover it

Path-Based Testing

- What are all the possible paths through a program/method/etc.?
- Then test all of the paths
- Similar to equivalence class partitioning

Path-Based Testing Example

- Racing game: user can select Red Car (fast acceleration, low top speed) or Blue Car (slow acceleration, high top speed). One or the other car always wins.
- Possible paths:
  - Red Car -> Win -> “You win, Blue Car loses”
  - Red Car -> Lose -> “You lose, Blue Car wins”
  - Blue Car -> Win -> “You win, Red Car loses”
  - Blue Car -> Lose -> “You lose, Red Car wins”

Complexity Increases Superlinearly As We Add Variables / Pathways

- Add "Easy / Hard" modes to previous game
- Hard mode rewards you with an exclamation point
- Now there are EIGHT paths to test
- One Boolean variable doubles the number of paths/tests

Possible Paths

- Easy -> Red Car -> Win -> “You win, Blue Car loses”
- Easy -> Red Car -> Lose -> “You lose, Blue Car wins”
- Easy -> Blue Car -> Win -> “You win, Red Car loses”
- Easy -> Blue Car -> Lose -> “You lose, Red Car wins”
- Hard -> Red Car -> Win -> “You win, Blue Car loses!”
- Hard -> Red Car -> Lose -> “You lose, Blue Car wins!”
- Hard -> Blue Car -> Win -> “You win, Red Car loses!”
- Hard -> Blue Car -> Lose -> “You lose, Red Car wins!”

Possible paths in a method

```
// How many paths?

public int doSomething(boolean a, boolean b) {
    int toReturn = -1;
    if (a || b) {
        toReturn = 5;
    } else {
        toReturn = 97;
    }
    return toReturn;
}
```

Possible paths in a method

```
// How many paths?

public int somethingElse(boolean a, boolean b) {
    int toReturn = 0;
    if (a) {
        toReturn = 5;
    } else if (b) {
        toReturn = 97;
    } else {
        toReturn = 6;

    }

    return toReturn;
}
```

Possible paths in a method

```
// How many paths?

public int somethingElse(boolean a, boolean b) {
   int toReturn = 5;
   toReturn += (int) Math.cos(100);
   toReturn *= 3;
   return toReturn;
}
```

McCabe Cyclomatic Complexity

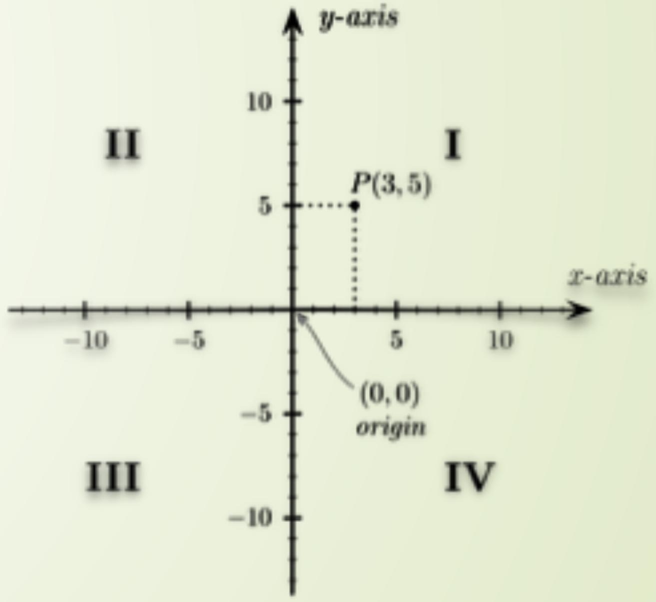
- A measure of the number of paths through a method, function, or other unit of control flow
- Analysis of method from the perspective of graph theory
- Higher complexity -> more chance of defects
- More details: http://www.mccabe.com/pdf/mccabe-nist235r.pdf

McCabe cyclomatic complexity

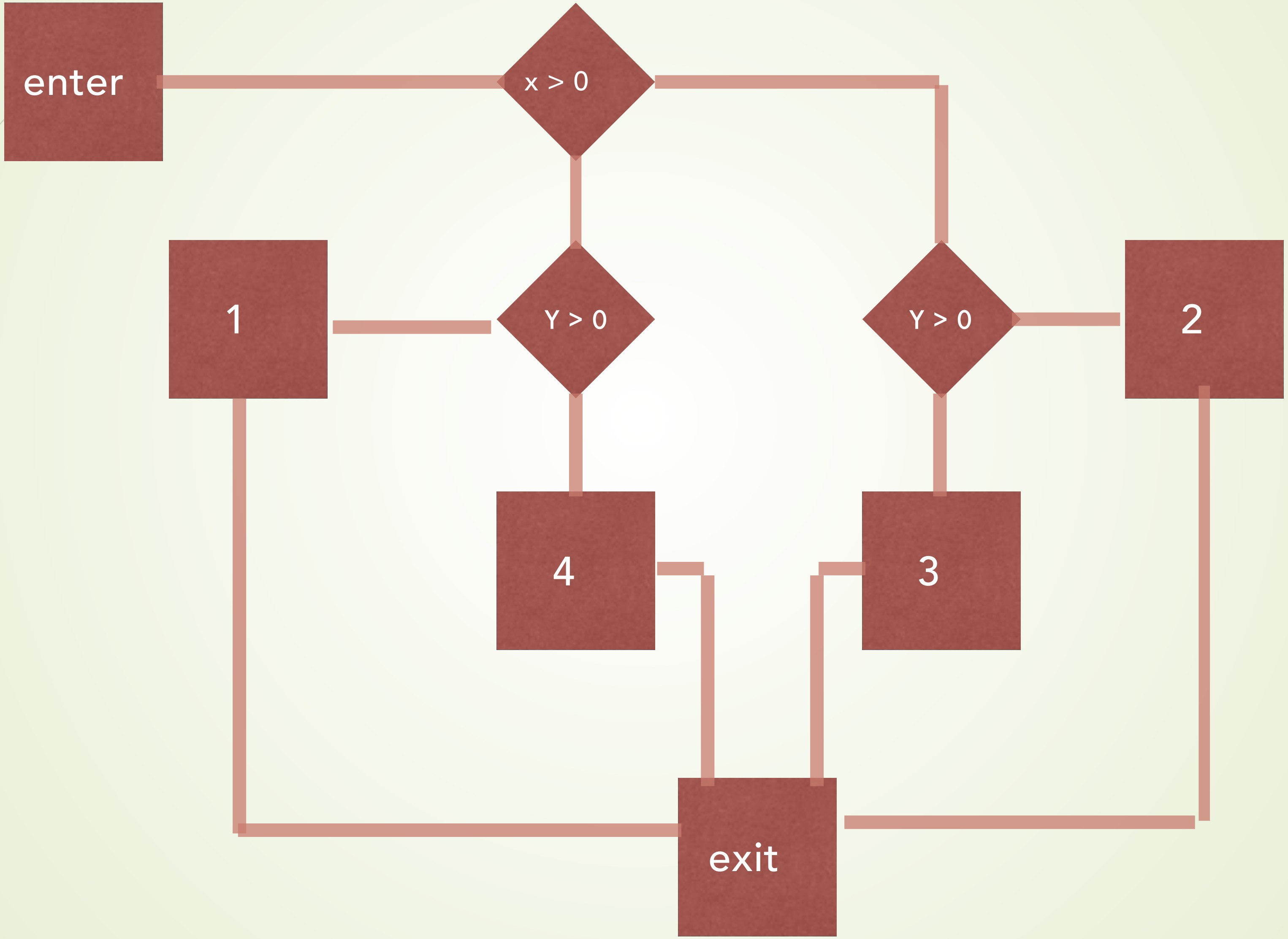
- Views a program's control flow through the lens of graph theory
- Given a method's control flow, calculate:
  - E = number of edges of graph
  - N = number of nodes of graph
  - p = number of connected components (usually 1)
  - Cyclomatic complexity = E - N + 2p
  - Also equal to the number of possible paths through a method

Cyclomatic Complexity Example

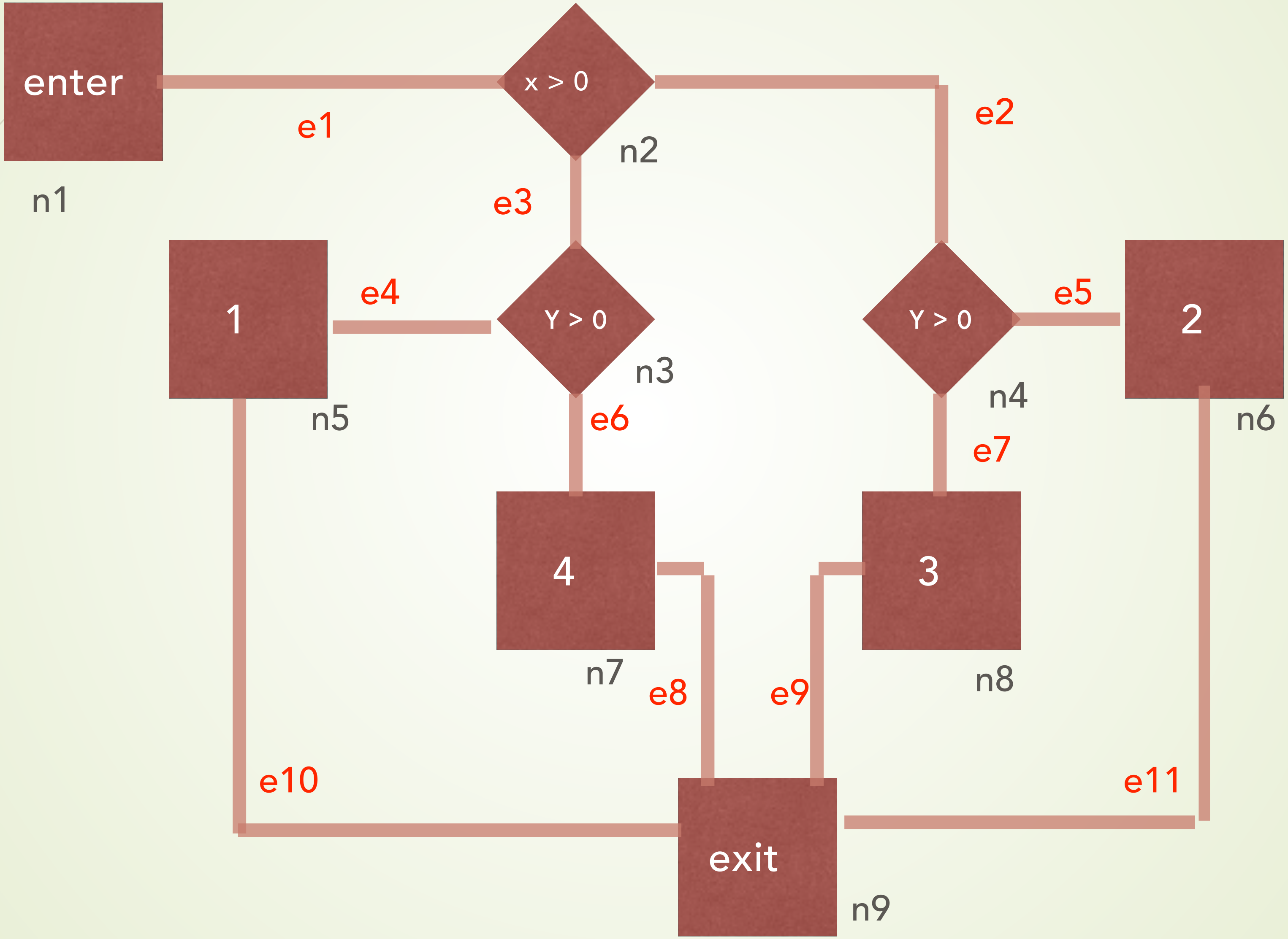
```
public int whichQuadrant(int x, int y) {
  int toReturn = -1;
  if (x > 0) {
     if (y > 0) {
        toReturn = 1;
     } else {
        toReturn = 4;
     }
  } else {
     if (y > 0) {
        toReturn = 2;
     } else {
        toReturn = 3;
     }
  }
  return toReturn;
}
```



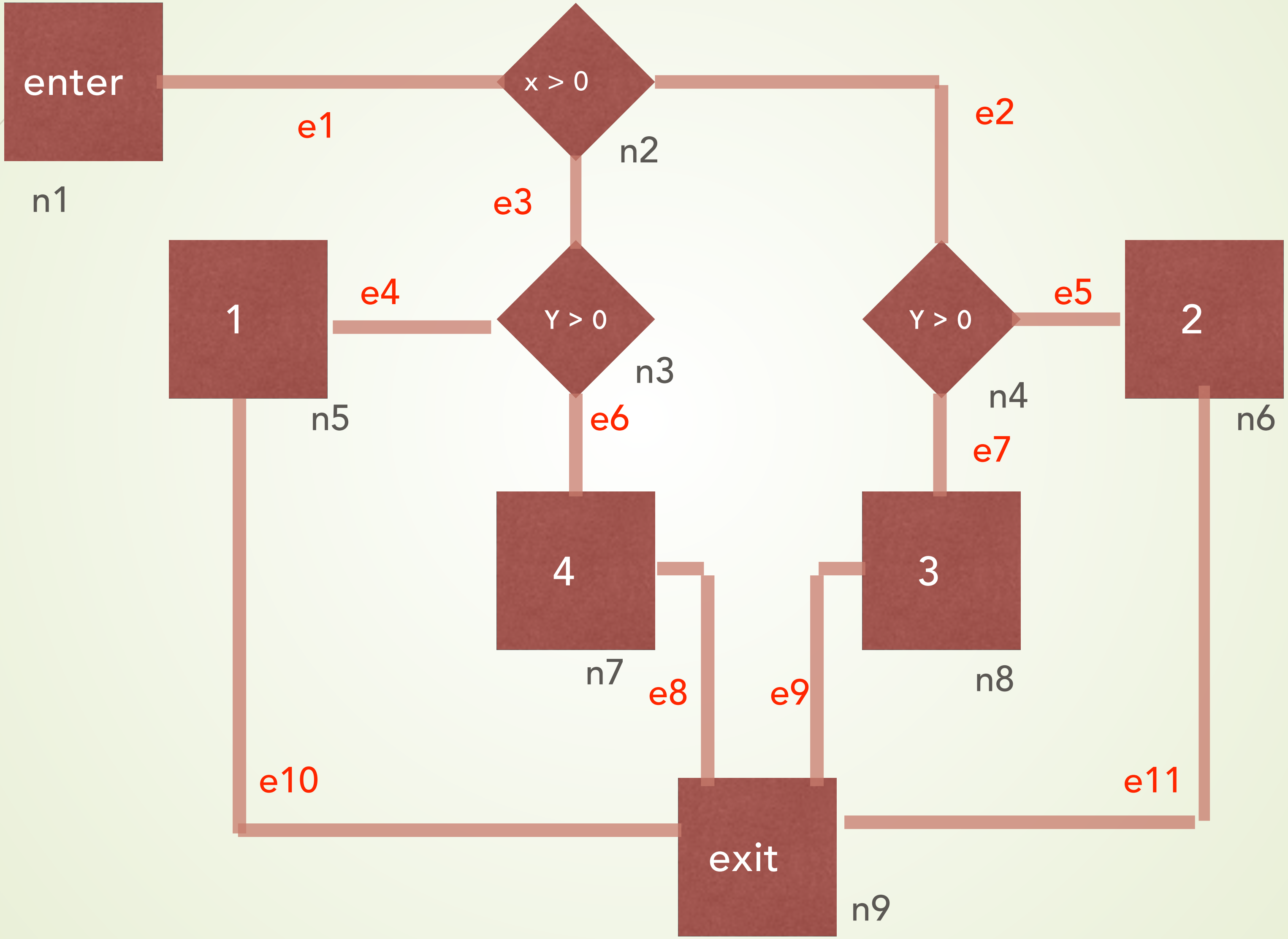
Cyclomatic Complexity Example



Cyclomatic Complexity Example



Cyclomatic Complexity Example



Edges = 11

Nodes = 9

p = 1

E - N + 2p

11 - 9 + 2 * 1

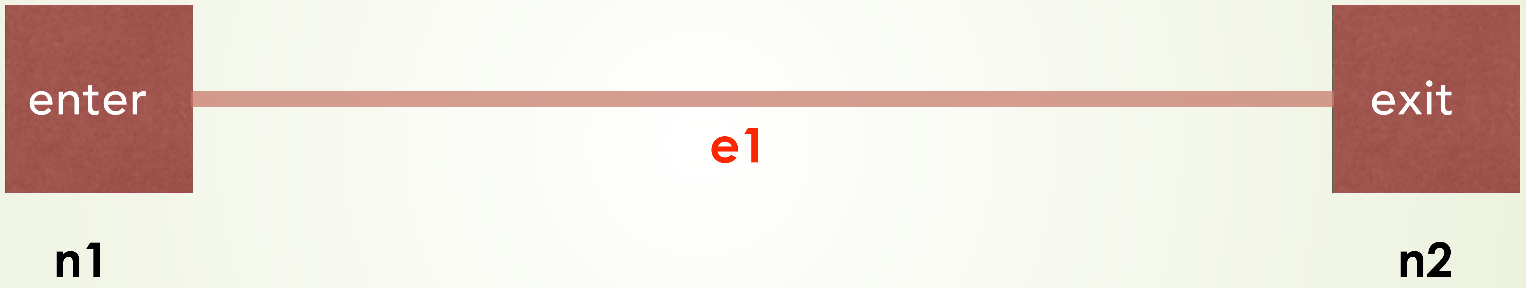
CC = 4

Cyclomatic Complexity Example

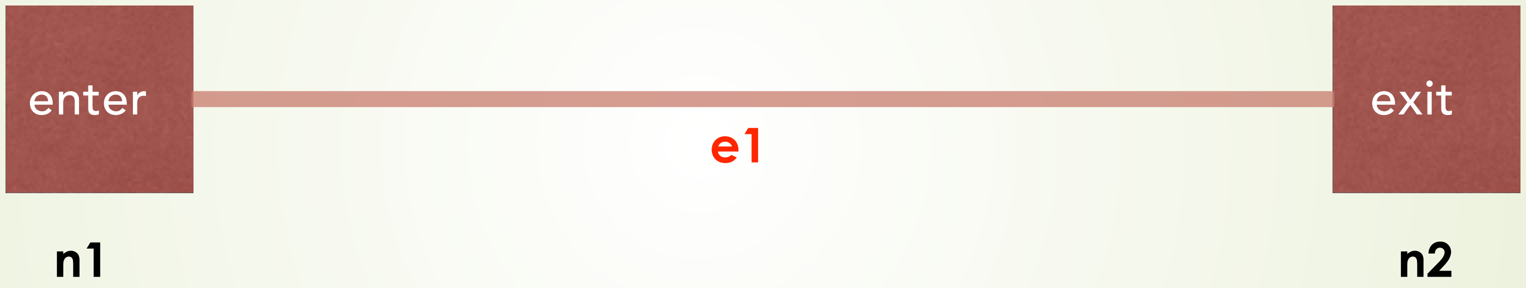
```
public int laboonify(int x, int y) {
   int initialVal = x + y;
   int m = x - 1;
   int n = y + 1;
   int normalized = m + n;
   int combo = toReturn + normalized;
   int z = combo * 2;
   return z;
}
```

Cyclomatic Complexity Example

Cyclomatic Complexity Example



Cyclomatic Complexity Example



Edges = 1

Nodes = 2

p = 1

E - N + 2p

1 - 2 + 2 * 1

CC = 1

Understanding Cyclomatic Complexity

- The maximum number of linearly independent paths through the control flow of the method
- Lower cyclomatic complexity = lower risk, easier to understand
- < 10 = very simple, low risk
- > 50 = very complex, high risk