CS 5154: Software Testing

Applying Graph Based Coverage to Source Code

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Implementing Graph-based MDTD

- Develop a model of the software as a graph
- Require tests to visit/tour sets of nodes, edges, or sub-paths
- Choose inputs that satisfy the test requirements
- Implement and automate tests based on the inputs chosen

Relating “Abstract Design” to Source Code

- Test Graph : usually the control flow graph (CFG)
- Nodes: statements or statement sequences (basic blocks)
- Edges : transfers of control
- Loops : structures such as for loops, while loops, etc

Relating Graph Coverage Criteria to Source Code

- Node coverage : Execute every statement (i.e., statement coverage)
- Edge coverage : Execute every branch (i.e., branch coverage)
- Edge-pair coverage : ??
- Prime-path Coverage : Execute every statement, branch, loop

An essential concept for creating CFGs

- Basic Block : A sequence of statements such that if the first statement is executed, all statements in the sequence will be executed (no branches)

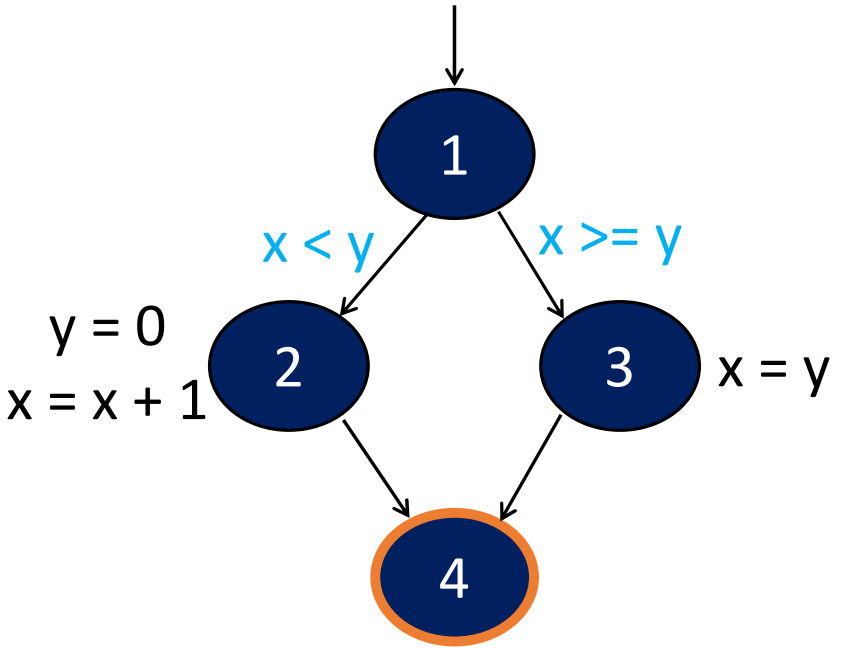
- Implication: Put all statements in a basic block in one CFG node
  - We will see one exception to the rule

Rules for creating CFG from Java source code

- We show one rule/template for commonly used Java features
- There are other sets of rules that can be used
- Differences in the sets of rules are usually not so important for testing

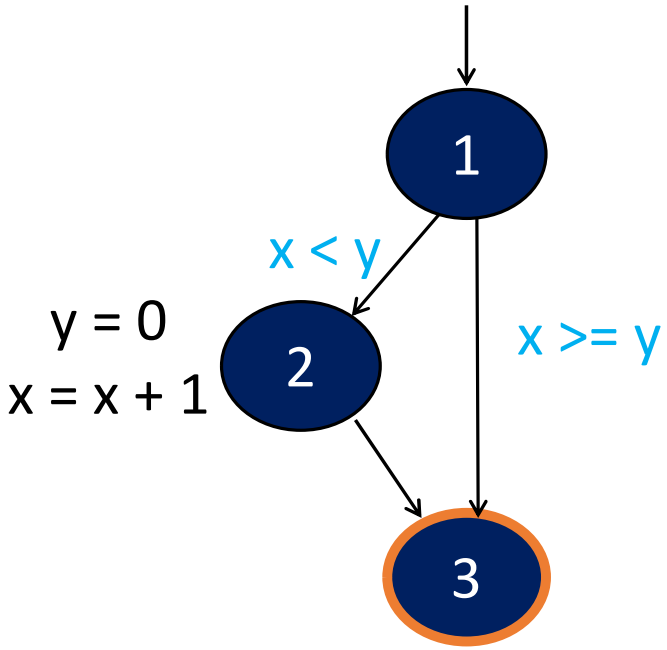
Rule 1: if-then-else

```
if (x < y)
{
  y = 0;
  x = x + 1;
}
else
{
  x = y;
}
```



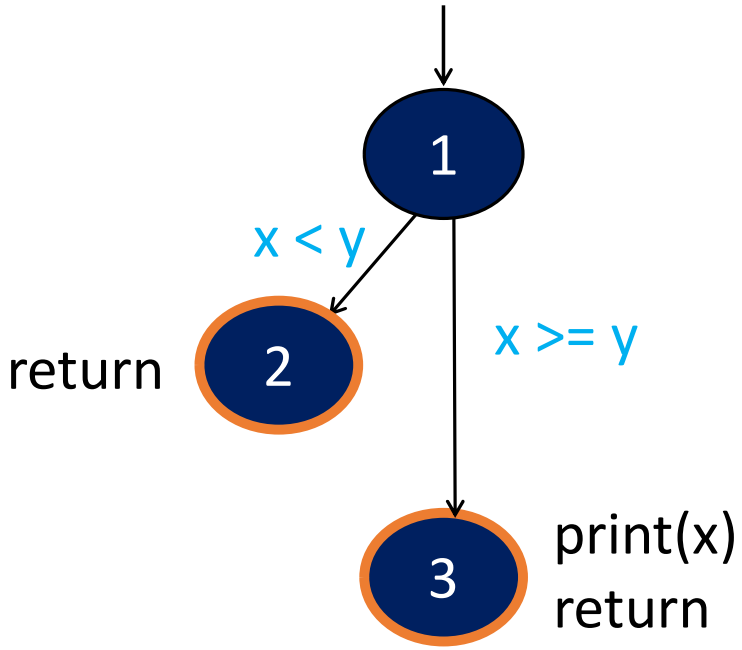
Rule 2: if-then

```
if (x < y)
{
   y = 0;
   x = x + 1;
}
```



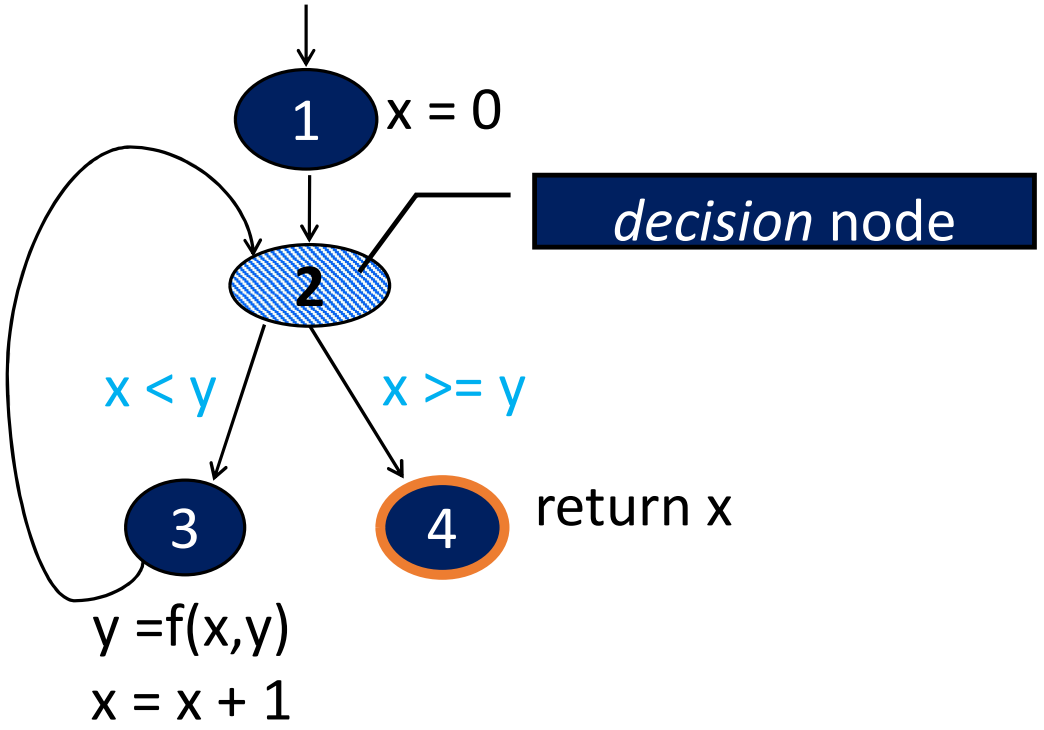
Rule 3: if-with-return

```
if (x < y)
{
   return;
}
print (x);
return;
```



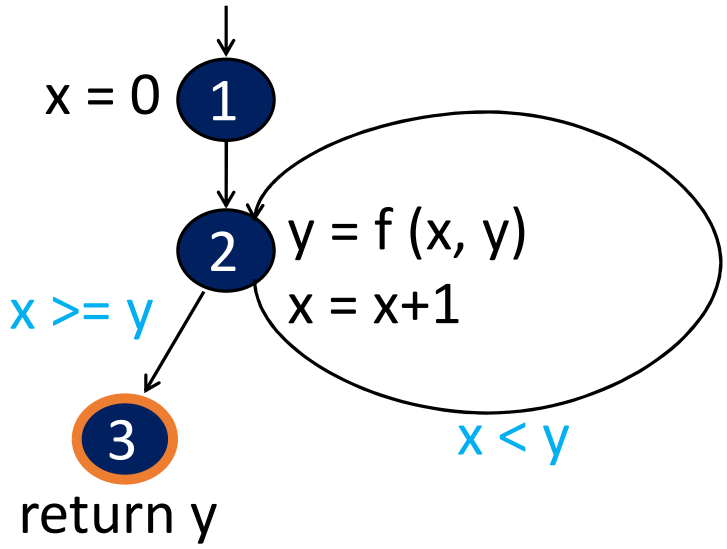
Rule 4: while

```
x = 0;
while (x < y)
{
   y = f (x, y);
   x = x + 1;
}
return x;
```



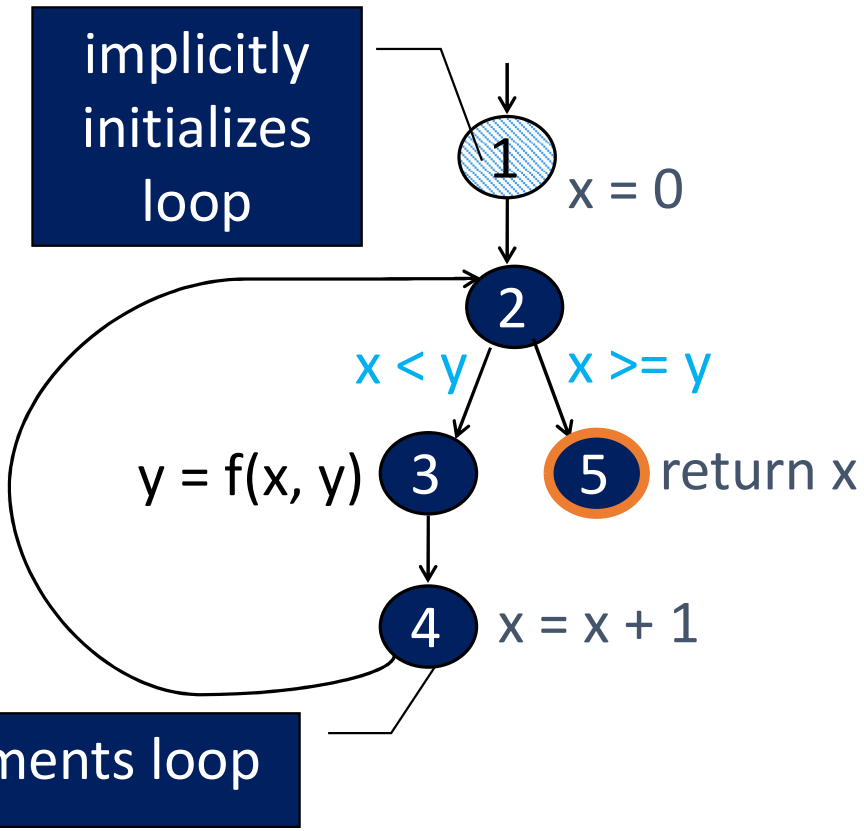
Rule 5: do-while

```
x = 0;
do
{
   y = f (x, y);
   x = x + 1;
} while (x < y);
return y;
```



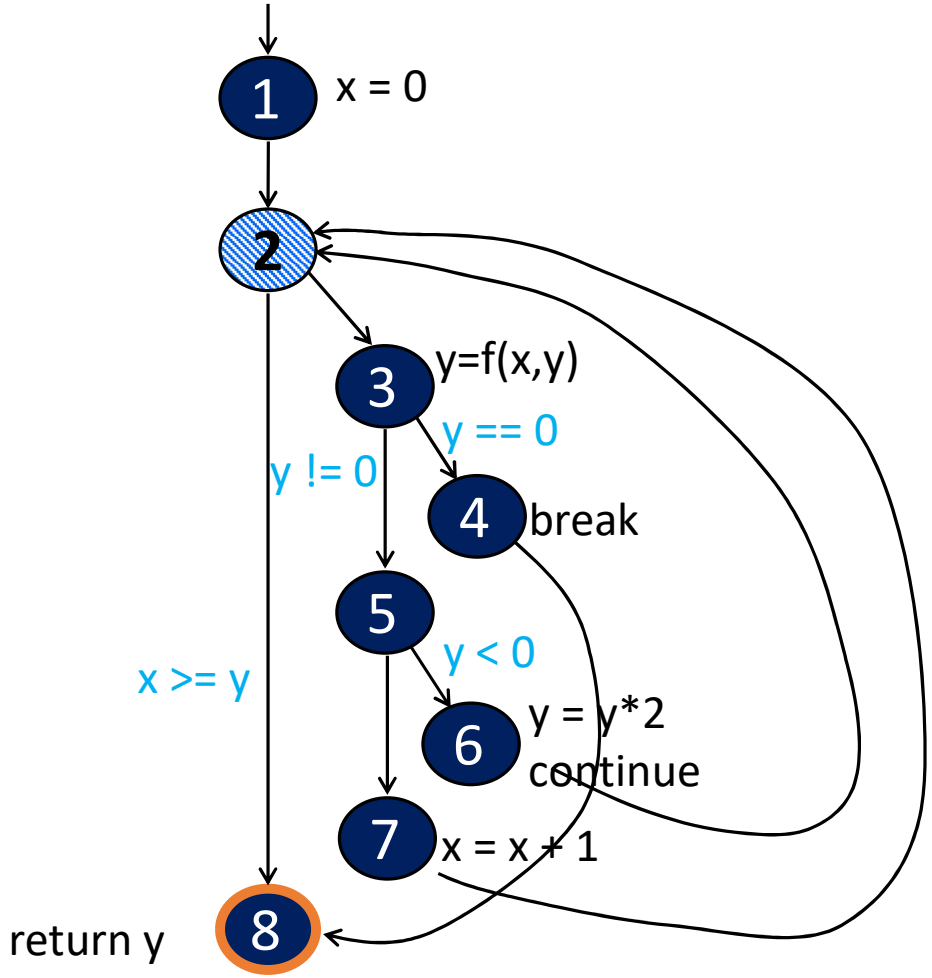
Rule 6: for

```
for (x = 0; x < y; x++)
{
   y = f (x, y);
}
return x;
```



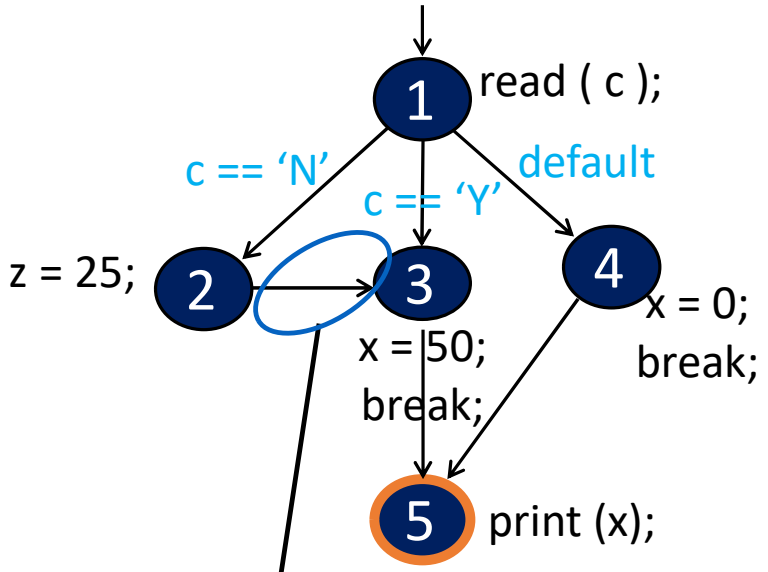
Rule 7: break and continue

```
x = 0;
while (x < y) {
  y = f (x, y);
  if (y == 0) {
    break;
  } else if (y < 0)  {
    y = y*2;
    continue;
  }
  x = x + 1;
}
return y;
```



Rule 8: switch

```
read ( c) ;
switch ( c )
{
  case ‘N’:
    z = 25;
  case ‘Y’:
    x = 50;
    break;
  default:
    x = 0;
    break;
}
print (x);
```



Cases without breaks fall through to the next case

Example 2: branch coverage criterion

- What elements of software should tests exercise?

control branches (if, while)

- What rule do we want to impose on the tests?

each branch must eval to T & F

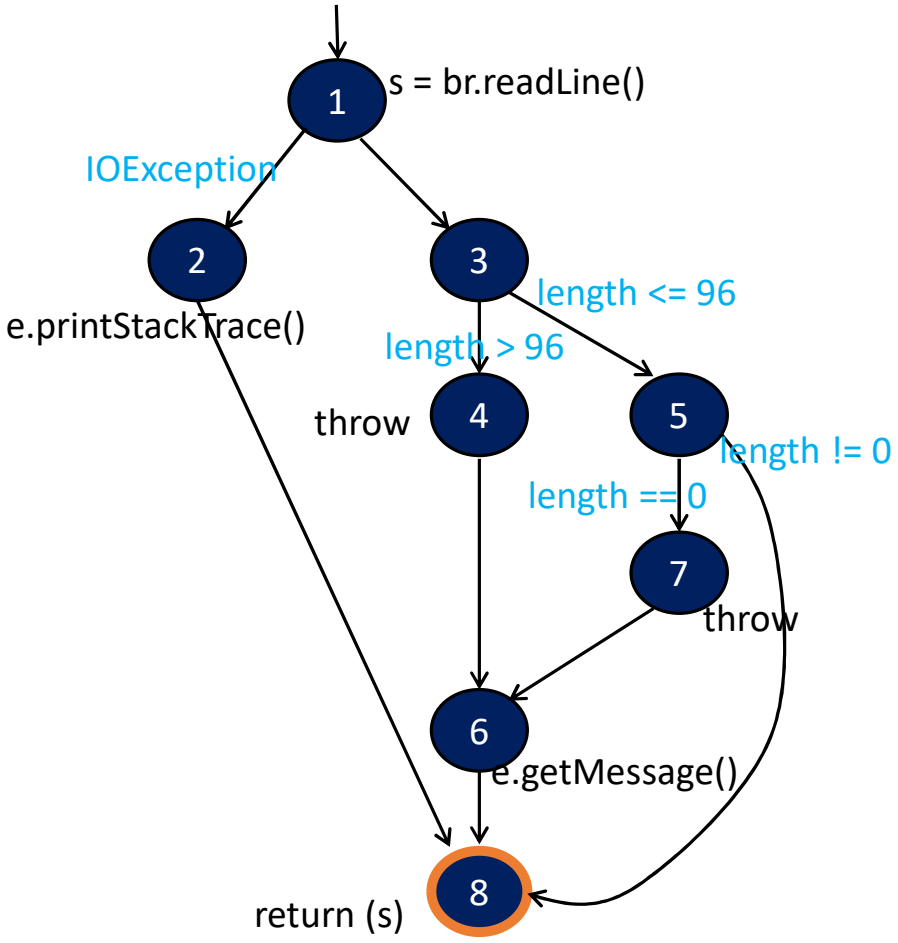
- How do we check if the rule is satisfied?

~~how many branches satisfy the rule?~~

or: how many test requirements are satisfied?

Rule 9: exceptions

```
try {
   s = br.readLine();
   if (s.length() > 96)
      throw new Exception (“too long”);
   if (s.length() == 0)
      throw new Exception (“too short”);
} (catch IOException e) {
   e.printStackTrace();
} (catch Exception e) {
   e.getMessage();
}
return (s);
```



Rule 10: putting it all together

- Real programs will require using more than one of these rules
- Real programs can get very large
- Real programs may require features that we do not cover
  - Recursion
  - Inter-procedural calls

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Apply Graph-based MDTD to indexOf (use PPC)

```
/** Return first index of Node n in path, or
 * -1 if n is not present in path */
public int indexOf (Node n, List<Node> path){
  for (int i=0; i < path.size(); i++){
    if (path.get(i).equals(n))
      return i;
  }
  return -1;
}
```

Summary

- Basic definition and terminology
- Graph Coverage Criteria and their relationships
- Obtaining graphs from source code
- You may apply Graph coverage on the next homework

Next

- Logic-based testing