

# Lab 9

## Mutual Testing

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## Code:

```
Vector doGraham(Vector p) {
    int i,j,min,M;

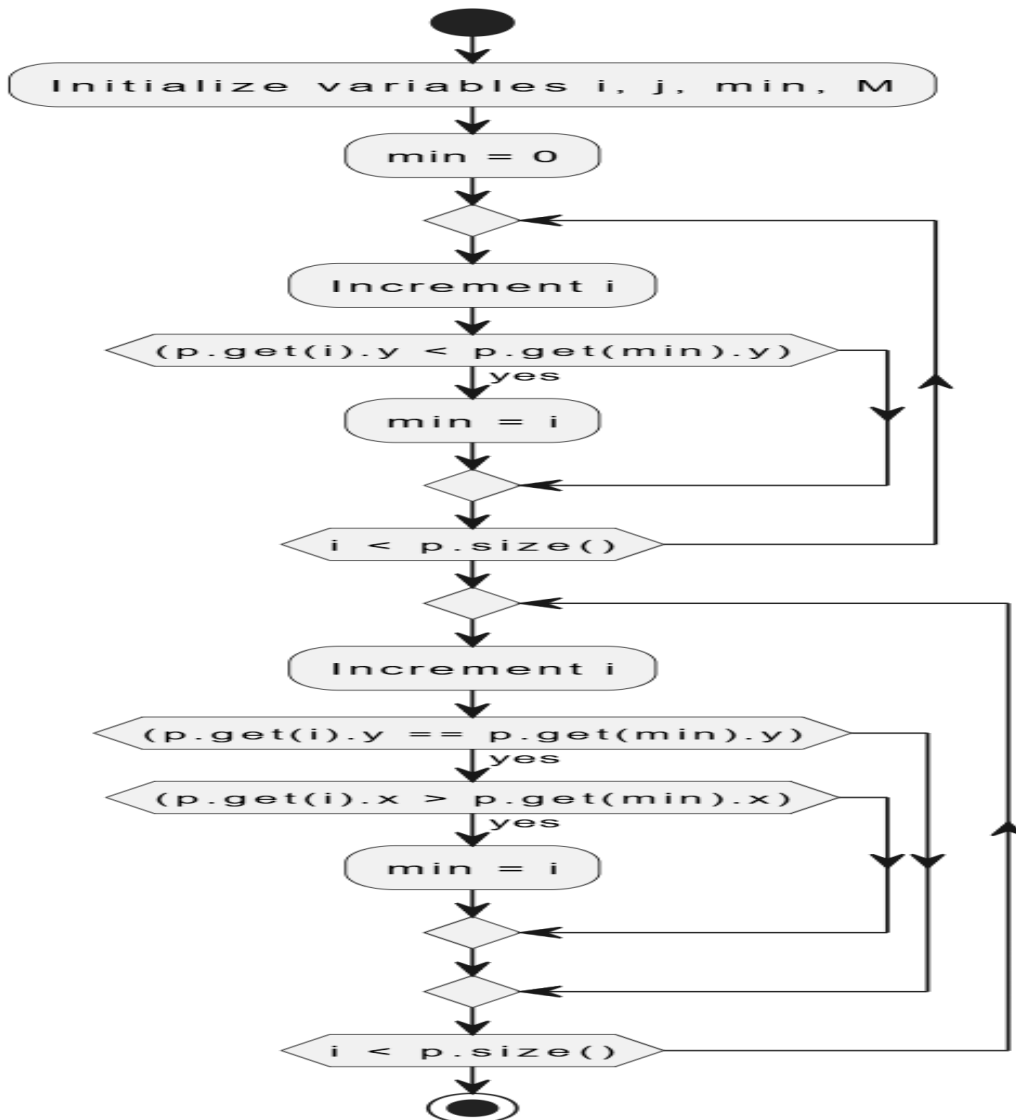
    Point t;
    min = 0;

    // search for minimum:
    for(i=1; i < p.size(); ++i) {
        if( ((Point) p.get(i)).y <
            ((Point) p.get(min)).y )
        {
            min = i;
        }
    }

    // continue along the values with same y component
    for(i=0; i < p.size(); ++i) {
        if(( ((Point) p.get(i)).y ==
            ((Point) p.get(min)).y ) &&
            (((Point) p.get(i)).x >
            ((Point) p.get(min)).x ))
        {
            min = i;
        }
    }
}
```

## Tasks:

1. After generating the control flow graph, check whether your CFG match with the CFG generated by Control Flow Graph Factory Tool and Eclipse flow graph generator. (In your submission document, mention only “Yes” or “No” for each tool).



2. Devise the minimum number of test cases required to cover the code using the aforementioned criteria.

**Statement Coverage:**

TC1:  $p = [(1, 7), (2, 3), (8, 1)]$  Covers cases where  $p.get(i).y < p.get(min).y$  is true.

TC2:  $p = [(1, 1), (2, 1), (3, 1), (4, 1)]$  covers cases where  $p.get(i).y == p.get(min).y$  and  $p.get(i).x > p.get(min).x$

**Branch Coverage:**

TC3:  $p = [(1, 2), (3, 3), (5, 9), (10, 15)]$  covers the false branch for condition  $p.get(i).y < p.get(min).y$

TC3:  $p = [(10, 15), (5, 9), (3, 3), (1, 2)]$  covers the true branch for condition  $p.get(i).y < p.get(min).y$

TC4:  $p = [(1, 1), (2, 1), (3, 1)]$  cover both true and false branches of  $p.get(i).y == p.get(min).y$  and  $p.get(i).x > p.get(min).x$ .

**Basic Condition Coverage:**

TC5:  $p = [(1, 2), (3, 3)]$  Covers  $p.get(i).y < p.get(min).y$  as false.

TC6:  $p = [(1, 5), (1, 3)]$  Covers  $p.get(i).y < p.get(min).y$  as true.

TC7:  $p = [(1, 1), (2, 1)]$  Covers  $p.get(i).y == p.get(min).y$  as true and  $p.get(i).x > p.get(min).x$  as true.

TC8:  $p = [(2, 2), (1, 1)]$  Covers  $p.get(i).y == p.get(min).y$  as false and  $p.get(i).x > p.get(min).x$  as false.

3. This part of the exercise is very tricky and interesting. The test cases that you have derived in Step 2 are then used to identify the fault when you make some modifications in the code. Here, you need to insert/delete/modify a piece of code that will result in failure but it is not detected by your test set - derived in Step 2. Write/identify a mutation code for each of the three operation separately, i.e., by deleting the code, by inserting the code, by modifying the code.

```
[*] Start mutation process:
- targets: point
- tests: test_points
[*] 4 tests passed:
- test_points [0.36220 s]
[*] Start mutants generation and execution:
- [# 1] COI point:
-----
6:
7: def find_min_point(points):
8:     min_index = 0
9:     for i in range(1, len(points)):
- 10:         if points[i].y < points[min_index].y:
+ 10:         if not (points[i].y < points[min_index].y):
11:             min_index = i
12:     for i in range(len(points)):
13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
14:             min_index = i
-----
[0.23355 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_ties
- [# 2] COI point:
-----
9:     for i in range(1, len(points)):
-----
[0.23355 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_ties
- [# 2] COI point:
-----
9:     for i in range(1, len(points)):
10:         if points[i].y < points[min_index].y:
11:             min_index = i
12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if not ((points[i].y == points[min_index].y and points[i].x > points[min_index].x))
14:             min_index = i
15:     return points[min_index]
-----
[0.27441 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_same_y
- [# 3] LCR point:
-----
9:     for i in range(1, len(points)):
10:         if points[i].y < points[min_index].y:
11:             min_index = i
12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y == points[min_index].y or points[i].x > points[min_index].x):
14:             min_index = i
15:     return points[min_index]
```

```

-----
[0.18323 s] survived
- [# 6] ROR point:
-----
    9:     for i in range(1, len(points)):
    10:         if points[i].y < points[min_index].y:
    11:             min_index = i
    12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y != points[min_index].y and points[i].x > points[min_index].x):
    14:             min_index = i
    15:     return points[min_index]
-----

[0.18059 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_same_y
- [# 7] ROR point:
-----
    9:     for i in range(1, len(points)):
    10:         if points[i].y < points[min_index].y:
    11:             min_index = i
    12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y == points[min_index].y and points[i].x < points[min_index].x):
    14:             min_index = i
    15:     return points[min_index]
-----

[0.13933 s] killed by test_points.py::TestFindMinPoint::test_multiple_points_with_same_y
- [# 8] ROR point:
-----
    9:     for i in range(1, len(points)):
    10:         if points[i].y < points[min_index].y:
    11:             min_index = i
    12:     for i in range(len(points)):
- 13:         if (points[i].y == points[min_index].y and points[i].x > points[min_index].x):
+ 13:         if (points[i].y == points[min_index].y and points[i].x >= points[min_index].x):
    14:             min_index = i
    15:     return points[min_index]
-----

[0.11494 s] survived
[*] Mutation score [2.22089 s]: 75.0%
- all: 8
- killed: 6 (75.0%)
- survived: 2 (25.0%)
- incompetent: 0 (0.0%)
- timeout: 0 (0.0%)

```

## 1. Deletion Mutation:

Remove `min = i` in the first `if` condition.

Mutation Code:

```
// Original second loop
for (i = 0; i < p.size(); ++i) {
    if (((Point) p.get(i)).y == ((Point) p.get(min)).y &&
        ((Point) p.get(i)).x > ((Point) p.get(min)).x) {
        min = i;
    }
}

// Mutation: Delete the second loop
```

**2. Insertion Mutation:** Add `min = 0` at the beginning of the second loop

```
Mutation Code:for (i = 0; i < p.size(); ++i) {

    if (((Point) p.get(i)).y == ((Point) p.get(min)).y &&

        ((Point) p.get(i)).x > ((Point) p.get(min)).x) {

        min = i;

        i++; // Inserted mutation
    }
}
```



```
}
```

### 3. Modification Mutation:

Change `p[i].y < p[min].y` to `p[i].y > p[min].y` in the first `if` condition.

```
// Original condition
```

```
if (((Point) p.get(i)).y < ((Point) p.get(min)).y)
```

```
// Mutation: Change '<' to '<='
```

```
if (((Point) p.get(i)).y <= ((Point) p.get(min)).y)
```

4. Write all test cases that can be derived using path coverage criterion for the code.

```
import unittest
```

```
from point import Point, find_min_point
```

```
class TestFindMinPointPathCoverage(unittest.TestCase):
```

```
def test_no_points(self):
```

```
points = []
```

```
with self.assertRaises(IndexError): #Expect an IndexError due to emptylist
```

```
find_min_point(points)
```




```
def test_single_point(self):
    points = [Point(0, 0)]
    result = find_min_point(points)
    self.assertEqual(result, points[0]) # Expect the point (0, 0)

def test_two_points_unique_min(self):
    points = [Point(1, 2), Point(2, 3)]
    result = find_min_point(points)
    self.assertEqual(result, points[0]) # Expect the point (1, 2)

def test_multiple_points_unique_min(self):
    points = [Point(1, 4), Point(2, 3), Point(0, 1)]
    result = find_min_point(points)
    self.assertEqual(result, points[2]) # Expect the point (0, 1)

def test_multiple_points_same_y(self):
    points = [Point(1, 2), Point(3, 2), Point(2, 2)]
    result = find_min_point(points)
    self.assertEqual(result, points[1]) # Expect the point (3, 2)

def test_multiple_points_minimum_y_ties(self):
    points = [Point(1, 2), Point(2, 2), Point(3, 1), Point(4, 1)]
    result = find_min_point(points)
    self.assertEqual(result, points[3]) # Expect the point (4, 1)
```



```
if __name__ == "__main__":  
    unittest.main()
```