**ASSIGNMENT 5**

1. int distanceFromInterval(int x, int extremeA, int extremeB, int minLen) {

2. if (minLen <= 0) {

3. throw new IllegalArgumentException("minLen");

4. }

5. int upperB, lowerB;

6. if (extremeA > extremeB) {

7. upperB = extremeA;

8. lowerB = extremeB;

9. } else {

10. upperB = extremeB;

11. lowerB = extremeA;

12. }

13. int len = upperB - lowerB;

14. if (len < minLen) {

15. throw new RuntimeException("invalid interval");

16. }

17. if (x < lowerB) {

18. return lowerB - x;

19. } else if (x > upperB) {

20. return x - upperB;

21. } else {

22. return 0;

23. }

24. }

*Identify the path of distanceFromInterval that get executed when the three inputs are equal to* ***x=4, extremeA=1, extremeB=6, minLen=2****, and build with* ***symbolic execution*** *the path condition that characterises the path. Describe the path conditions by using the following symbols for the symbolic values of the parameters:* ***VAL*** *as the initial symbolic value of* ***x****,* ***A*** *as the initial symbolic value of* ***extremeA****,* ***B*** *as the initial symbolic value of* ***extremeB****, and* ***ML*** *as the initial symbolic value of* ***minLen***

SYMBOLIC EXECUTION IF **x=4, extremeA=1, extremeB=6, minLen=2**:

|  |  |  |
| --- | --- | --- |
| LINE EXECUTED | VALUES | PATH CONDITION |
| AFTER LINE 1 | x= 4, y extremeA=1, extremeB=6, minLen=2 | true |
| AFTER LINE 2 (JUMP TO 5) | x= 4, y extremeA=1, extremeB=6, minLen=2 | ML>0 |
| AFTER LINE 5 | x= 4, y extremeA=1, extremeB=6, minLen=2 | ML>0 |
| AFTER LINE 6 (JUMP TO 10) | x= 4, y extremeA=1, extremeB=6, minLen=2 | ML>0 && A<=B |
| AFTER LINE 10 | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6 | ML>0 && A<=B |
| AFTER LINE 11 | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1 | ML>0 && A<=B |
| AFTER LINE 13 | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5 | ML>0 && A<=B |
| AFTER LINE 14 (JUMP TO 17) | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5 | ML>0 && A<=B && ML< B-A |
| AFTER LINE 17  (JUMP TO 19) | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5 | ML>0 && A<=B && ML< B-A && VAL >= A |
| AFTER LINE 19 (JUMP TO 22) | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5 | ML>0 && A<=B && ML< B-A && VAL >= A && VAL <= B |
| AT LINE 22 | x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5 | ML>0 && A<=B && ML< B-A && VAL >= A && VAL <= B |

The path that gets executed when x=4, extremeA=1, extremeB=6, and minLen=2 is:

**1, 5, 10, 11, 13, 22**

Since the path was generated by fixed inputs we can say it is feasible.

*Then, working in the style of* ***dynamic symbolic execution****, identify the path conditions of the alternative subpaths, and use those path conditions to identify test cases that execute those subpaths.*

The path condition that will be used to derive the other possible paths is:

**ML>0 && A<=B && ML< B-A && VAL >= A && VAL <= B**

The alternative (sub-)paths are:

1. ML<=0
2. **ML>0** && A>B
3. **ML>0 && A<=B** && ML>=B-A
4. **ML>0 && A<=B && ML< B-A** && VAL<A
5. **ML>0 && A<=B && ML< B-A && VAL>=A** && VAL>B

In order to check if theese paths are feasible or not we need to find if exists an input that satisfies all the conditions in the sub-paths:

1. ML<=0: a test case that executes this path would be **x=4, extremeA=1, extremeB=6, minLen= -2**.The consequent path conditions generated by theese inputs will be:

|  |  |  |
| --- | --- | --- |
| LINE EXECUTED | VALUES | PATH CONDITION |
| AFTER LINE 1 | x= 4, y extremeA=1, extremeB=6, minLen=-2 | true |
| AFTER LINE 2 (JUMP TO 3) | x= 4, y extremeA=1, extremeB=6, minLen=-2 | ML<=0 |
| AT LINE 3 | x= 4, y extremeA=1, extremeB=6, minLen=-2 | ML<=0 |

The path that gets executed when **x=4, extremeA=1, extremeB=6, minLen= -2** is:

**1, 3**

1. **ML>0** && A>B: a test case that executes this path would be **x=4, extremeA=6, extremeB=1, minLen= 2**.The consequent path conditions generated by theese inputs will be:

|  |  |  |
| --- | --- | --- |
| LINE EXECUTED | VALUES | PATH CONDITION |
| AFTER LINE 1 | x=4, extremeA=6, extremeB=1, minLen= 2 | true |
| AFTER LINE 2 (JUMP TO 5) | x=4, extremeA=6, extremeB=1, minLen= 2 | ML>0 |
| AFTER LINE 5 | x=4, extremeA=6, extremeB=1, minLen= 2 | ML>0 |
| AFTER LINE 6 (JUMP TO 7) | x=4, extremeA=6, extremeB=1, minLen= 2 | ML>0 && A>B |
| AFTER LINE 7 | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6 | ML>0 && A>B |
| AFTER LINE 8 | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1 | ML>0 && A>B |
| AFTER LINE 13 | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5 | ML>0 && A>B |
| AFTER LINE 14 (JUMP TO 17) | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5 | ML>0 && A>B && ML<A-B |
| AFTER LINE 17 (JUMP TO 19) | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5 | ML>0 && A>B && ML<A-B && VAL>= B |
| AFTER LINE 19 (JUMP TO 22) | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5 | ML>0 && A>B && ML<A-B && VAL>= B && VAL <= A |
| AT LINE 22 | x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5 | ML>0 && A>B && ML<A-B && VAL>= B && VAL <= A |

The path that gets executed when **x=4, extremeA=6, extremeB=1, minLen= 2** is:

**1, 5, 7, 8, 13, 22**

1. **ML>0 && A<=B** && ML>=B-A: a test case that executes this path would be **x=4, extremeA=1, extremeB=6, minLen= 6**.The consequent path conditions generated by theese inputs will be:

|  |  |  |
| --- | --- | --- |
| LINE EXECUTED | VALUES | PATH CONDITION |
| AFTER LINE 1 | x=4, extremeA=1, extremeB=6, minLen= 6 | true |
| AFTER LINE 2 (JUMP TO 5) | x=4, extremeA=1, extremeB=6, minLen= 6 | ML>0 |
| AFTER LINE 5 | x=4, extremeA=1, extremeB=6, minLen= 6 | ML>0 |
| AFTER LINE 6 (JUMP TO 10) | x=4, extremeA=1, extremeB=6, minLen= 6 | ML>0 && A<=B |
| AFTER LINE 10 | x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6 | ML>0 && A<=B |
| AFTER LINE 11 | x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1 | ML>0 && A<=B |
| AFTER LINE 13 | x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B |
| AFTER LINE 14 (JUMP TO 15) | x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML>= B-A |
| AT LINE 15 | x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML>= B-A |

The path that gets executed when **x=4, extremeA=1, extremeB=6, minLen= 6** is:

**1, 5, 10, 11, 13, 15**

1. **ML>0 && A<=B && ML< B-A** && VAL<A: a test case that executes this path would be **x=0, extremeA=1, extremeB=6, minLen= 2**.The consequent path conditions generated by theese inputs will be:

|  |  |  |
| --- | --- | --- |
| LINE EXECUTED | VALUES | PATH CONDITION |
| AFTER LINE 1 | x=0, extremeA=1, extremeB=6, minLen= 2 | true |
| AFTER LINE 2 (JUMP TO 5) | x=0, extremeA=1, extremeB=6, minLen= 2 | ML>0 |
| AFTER LINE 5 | x=0, extremeA=1, extremeB=6, minLen= 2 | ML>0 |
| AFTER LINE 6 (JUMP TO 10) | x=0, extremeA=1, extremeB=6, minLen= 2 | ML>0 && A<=B |
| AFTER LINE 10 | x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6 | ML>0 && A<=B |
| AFTER LINE 11 | x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1 | ML>0 && A<=B |
| AFTER LINE 13 | x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B |
| AFTER LINE 14 (JUMP TO 17) | x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A |
| AFTER LINE 17 (JUMP TO 18) | x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A && VAL<A |
| AT LINE 18 | x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A && VAL<A |

The path that gets executed when **x=0, extremeA=1, extremeB=6, minLen= 2** is:

**1, 5, 10, 11, 13, 18**

1. **ML>0 && A<=B && ML< B-A && VAL>=A** && VAL>B: a test case that executes this path would be **x=9, extremeA=1, extremeB=6, minLen= 2**.The consequent path conditions generated by theese inputs will be:

|  |  |  |
| --- | --- | --- |
| LINE EXECUTED | VALUES | PATH CONDITION |
| AFTER LINE 1 | x=9, extremeA=1, extremeB=6, minLen= 2 | true |
| AFTER LINE 2 (JUMP TO 5) | x=9, extremeA=1, extremeB=6, minLen= 2 | ML>0 |
| AFTER LINE 5 | x=9, extremeA=1, extremeB=6, minLen= 2 | ML>0 |
| AFTER LINE 6 (JUMP TO 10) | x=9, extremeA=1, extremeB=6, minLen= 2 | ML>0 && A<=B |
| AFTER LINE 10 | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6 | ML>0 && A<=B |
| AFTER LINE 11 | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1 | ML>0 && A<=B |
| AFTER LINE 13 | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B |
| AFTER LINE 14 (JUMP TO 17) | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A |
| AFTER LINE 17 (JUMP TO 19) | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A && VAL>=A |
| AT LINE 19 (JUMP TO 20) | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A && VAL>=A && VAL>B |
| AT LINE 20 | x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5 | ML>0 && A<=B && ML< B-A && VAL>=A && VAL>B |

The path that gets executed when **x=9, extremeA=1, extremeB=6, minLen= 2** is:

**1, 5, 10, 11, 13, 20**