

CS 3250: Software Testing (Summer 2026)

Activity: Graph for source code (Data flow) – NumOccurrences

(no submission)

Purpose: Create graph representation for source code; understand Defs, Uses, DU-pairs, DU-paths; apply data flow graph coverage to source code; get ready for the learning portfolio.

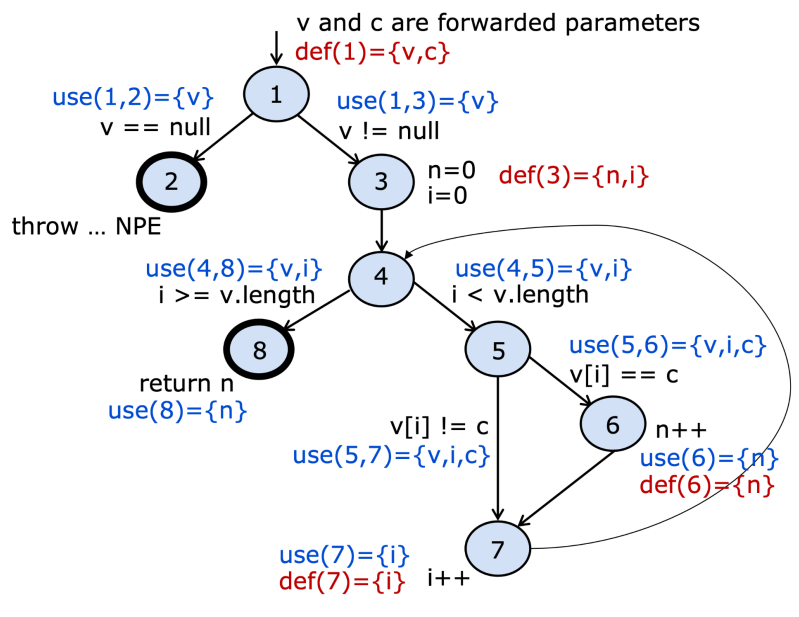
You may make a copy of a worksheet and complete this activity, or type your answers in any text editor. You may work alone or with at most two other students in this course.

Consider the following Java method

```
public static int numberOccurrences(char[] v, char c)
{
    if (v == null)
        throw new NullPointerException();

    int n = 0;
    for (int i=0; i<v.length; i++)
    {
        if (v[i] == c)
            n++;
    }
    return n;
}
```

1. Draw a **Control Flow Graph** for the numberOccurrences method. Annotate **all** information (i.e., source code, defs and uses).



2. List all **du-pairs**, then derive **du-paths** (the du-paths then can be used as test requirements)

DU-pairs	DU-paths
Variable v [1, (1,2)] [1, (1,3)] [1, (4,5)] [1, (4,8)] [1, (5,6)] [1, (5,7)]	[1,2] [1,3] [1,3,4,5] [1,3,4,8] [1,3,4,5,6] [1,3,4,5,7]
Variable c [1, (5,6)] [1, (5,7)]	[1,3,4,5,6] [1,3,4,5,7]
Variable n [3,6] [3,8] [6,6] <i>use before def</i> [6,8]	[3,4,5,6] [3,4,8] [6,7,4,5,6] [6,7,4,8]
Variable i [3,7] [3, (4,5)] [3, (4,8)] [3, (5,6)] [3, (5,7)] [7,7] <i>use before def</i> [7, (4,5)] [7, (4,8)] [7, (5,6)] [7, (5,7)]	[3,4,5,7] [3,4,5,6,7] [3,4,5] [3,4,8] [3,4,5,6] [3,4,5,7] [7,4,5,7] [7,4,5,6,7] [7,4,5] [7,4,8] [7,4,5,6] [7,4,5,7] <i>some du-paths are repeated between du-pairs</i>

3. Apply **All-Defs** to design tests

	Test requirements	Test paths	Test cases (input values and expected output)
Variable v	[1,3,4,8]	[1,3,4,8]	input: ([], 'a'), expected output: 0
Variable c	[1,3,4,5,6]	[1,3,4,5,6,7,4,8]	input: (['a'], 'a'), expected output: 1
Variable n	[3,4,8], [6,7,4,8]	[1,3,4,8], [1,3,4,5,6,7,4,8]	input: ([], 'a'), expected output: 0 input: (['a'], 'a'), expected output: 1
Variable i	[3,4,5,7], [7,4,8]	[1,3,4,5,7,4,8] <i>toured by the above path</i>	input: (['a'], 'b'), expected output: 0

4. Apply **All-Uses** to design tests

	Test requirements	Test paths	Test cases (input values and expected output)
Variable v	[1,2] [1,3] [1,3,4,5] [1,3,4,8] [1,3,4,5,6] [1,3,4,5,7]	[1,2] [1,3,4,8] [1,3,4,5,7,4,8] <i>toured by [1,3,4,8]</i> [1,3,4,5,6,7,4,8] <i>toured by [1,3,4,5,7,4,8]</i>	input: (null, 'a'), expected output: NPE input: ([], 'a'), expected output: 0 input: (['a'], 'b'), expected output: 0 input: (['a'], 'a'), expected output: 1
Variable c	[1,3,4,5,6] [1,3,4,5,7]	[1,3,4,5,6,7,4,8] [1,3,4,5,7,4,8]	input: (['a'], 'a'), expected output: 1 input: (['a'], 'b'), expected output: 0
Variable n	[3,4,5,6] [3,4,8] [6,7,4,5,6] [6,7,4,8]	[1,3,4,5,6,7,4,8] [1,3,4,8] [1,3,4,5,6,7,4,5,6,7,4,8] <i>toured by [1,3,4,5,6,7,4,8]</i>	input: (['a'], 'a'), expected output: 1 input: ([], 'a'), expected output: 0 input: (['a', 'a'], 'a'), expected output: 2
Variable i	[3,4,5] [3,4,8] [3,4,5,6] [3,4,5,7] [7,4,5] [7,4,8] [7,4,5,6] [7,4,5,6,7]	[1,3,4,5,7,4,8] [1,3,4,8] [1,3,4,5,6,7,4,8] <i>toured by [1,3,4,5,7,4,8]</i> [1,3,4,5,7,4,5,7,4,8] <i>toured by [1,3,4,5,7,4,8]</i> [1,3,4,5,7,4,5,6,7,4,8] <i>toured by [1,3,4,5,7,4,5,6,7,4,8]</i>	Input: (['a'], 'b'), expected output: 0 input: ([], 'a'), expected output: 0 input: (['a'], 'a'), expected output: 1 input: (['a', 'a'], 'b'), expected output: 0 input: (['a', 'b'], 'b'), expected output: 1

5. Apply **All-DU-Paths** to design tests

	Test requirements	Test paths	Test cases (input values and expected output)
Variable v	[1,2]	[1,2]	Input: (null, 'i'), expected output: NPE
	[1,3] [1,3,4,8]	[1,3,4,8]	input: ([], 'a'), expected output: 0
	[1,3,4,5] [1,3,4,5,7]	[1,3,4,5,7,4,8]	input: (['a'], 'b'), expected output: 0
	[1,3,4,5,6]	[1,3,4,5,6,7,4,8]	input: (['a'], 'a'), expected output: 1
Variable c	[1,3,4,5,6]	[1,3,4,5,6,7,4,8]	input: (['a'], 'a'), expected output: 1
	[1,3,4,5,7]	[1,3,4,5,7,4,8]	input: (['a'], 'b'), expected output: 0
Variable n	[3,4,8]	[1,3,4,8]	input: ([], 'a'), expected output: 0
	[3,4,5,6]	[1,3,4,5,6,7,4,8]	input: (['a'], 'a'), expected output: 1
	[6,7,4,5,6] [6,7,4,8]	[1,3,4,5,6,7,4,5,6,7,4,8]	input: (['a', 'a'], 'a'), expected output: 2
Variable i	[3,4,5,7] [3,4,5]	[1,3,4,5,7,4,8]	Input: (['a'], 'b'), expected output: 0
	[3,4,8]	[1,3,4,8]	input: ([], 'a'), expected output: 0
	[3,4,5,6] [3,4,5,6,7]	[1,3,4,5,6,7,4,8]	input: (['a'], 'a'), expected output: 1
	[7,4,5] [7,4,8] [7,4,5,7]	[1,3,4,5,7,4,5,7,4,8]	input: (['a', 'a'], 'b'), expected output: 0
	[7,4,5,6] [7,4,5,6,7]	[1,3,4,5,7,4,5,6,7,4,8]	input: (['a', 'b'], 'b'), expected output: 1