

HÁSKÓLI ÍSLANDS

Iðnaðarverkfræði-, vélaverkfræði- og tölvunarfræðideild

HBV205M: Prófun hugbúnaðar / Software Testing · Spring 2021

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Assignment 4 · Due 14.2.2021, 10:00 · Gradescope, no template

Objectives: Train creating and annotating non-trivial (e.g. loops and arrays) CFGs, finding data flow anomalies, calculating Cyclomatic complexity and level of nesting.

Consider the Java¹ method `insertionSort` below:

```
1  void insertionSort(int array[], int size) {
2      int j;
3      int key;
4      for (int i = 1; i < size; i++) {
5          j = i;
6          while ((j > 0) && (array[j - 1] > key)) {
7              key = array[i];
8              array[j] = array[j - 1];
9              j--;
10         }
11         array[j] = key;
12     }
13 }
```

1. Draw the control flow graph (CFG) of this method! Use one node per line: a node shall contain the corresponding line number (split `for` loops into multiple nodes such as “4init”, “4cond”, etc.). No need to have nodes for closing brackets, unless you anyway need them, e.g., as end node or target to jump to.

Hint: While you may, e.g., use the flowcharts of <https://www.diagrams.net/>, you are welcome to simply do a hand drawing and take a photo of it.

2. Annotate in your CFG each node that is relevant for some variable x with its type of usage: $d(x)$, $u(x)$, or $r(x)$! *Hints:* 1) You can consider all data passed in as defined; 2) Leaving a scope makes all variables undefined that exist only in that scope; 3) Aligning the annotations into columns for each variable helps later finding patterns of anomalies.

3. Identify any ur , du , or dd data flow anomaly that is possible along *any* path! For any identified anomaly, discuss whether it is really a problem or not!

Hints: 1) For arrays, `a[1]` and `a[2]` refer of course to different data, hence a $d(a[1])$ followed by $d(a[2])$ is not a dd anomaly! If rather `a[i]` and `a[j]` are used, this depends on the concrete values of `i` and `j` and you need to analyse how they relate to each other. 2) Accessing data at `a[i]` involves internally of course reading `a` and `i`. 3) In general, it is not sufficient to go simply straight from the top to the bottom of your CFG, but you have to follow the possible paths along the CFG edges, e.g. one path with not entering the `for` loop at all, another path with entering the `for`-loop, but not the `while`-loop, etc.

4. Calculate the McCabe Cyclomatic number $v(\text{insertionSort})$!

5. Determine intuitively the Cyclomatic number (based on the underlying basic idea that each branching increments it): does it match your $v(\text{insertionSort})$?

6. What is the maximum level of nesting (assuming that line 1 has a nesting level of 0)?

¹Note: In Java, fields that are declared but not initialized will be set to a default value. Local variables are however never set to a default value, but their value is rather undefined. Basic types are passed as call-by-value; non-basic types (such as arrays) are passed as call-by-reference.