Assignment 1 — Control Flow Graph

Due Date — 1PM on 21 Februaray 2013

1 Goal

Understand control flow graphs and how they can be generated from code.

2 Background

You are to construct a control-flow graph from the bytecode of a given Java class using the Bytecode Engineering Library (`http://jakarta.apache.org/bcel/`).

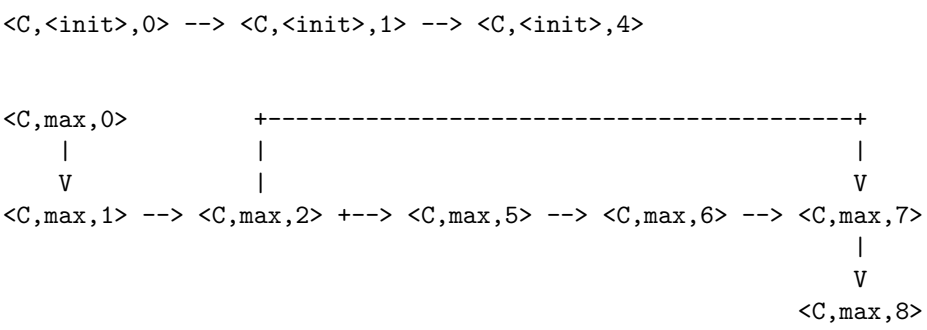
To illustrate, consider the following class C:

```
public class C {
  int max(int x, int y) {
    if (x < y) {
      return y;
    } else return x;
  }
}
```

You can run `javap -c` to see the corresponding bytecode in readable form.

```
Compiled from "C.java"
public class pset1.C extends java.lang.Object{
public pset1.C();
  Code:
   0:   aload_0
   1:   invokespecial   #1; //Method java/lang/Object."<init>":()V
   4:   return
int max(int, int);
  Code:
   0:   iload_1
   1:   iload_2
   2:   if_icmpge       7
   5:   iload_2
   6:   ireturn
   7:   iload_1
   8:   ireturn
}
```

Ignoring method invocations and representing a node as the tuple `<class,method,position>` we get the following CFG.



3 Inerface to Implement

```
class CFG {
  class Node {
    int position;
    Method method;
    JavaClass theclass;
  }
  public void addNode(int pos1, Method m1, JavaClass c1) {}
  public void addEdge(int pos1, Method m1, JavaClass c1,
                      int pos2, Method m2, JavaClass c2) {}
  public boolean isReachable(int pos1, Method m1, JavaClass c1,
                      int pos2, Method m2, JavaClass c2) {}
}

class CFGGenerator {
  public CFG createCFG(String className)
    throws ClassNotFoundException {}
  public static void main(String[] args) {}
};
```

4 Details

First implement the class `CFG` which represents a control flow graph. Implement the class `Node` with necessary helper methods (e.g. constructor, `isEquals`, `toString` etc.). Note that we are ignoring any labels that are traditionally annotated on nodes and edges of a CFG for simplification. Also ignore, for now, edges that correspond to method invocations, or `jsr[w]` or `*switch` bytecodes.

Use the adjacency list representation to store the directed graph. The `addNode` function should add a new node (but not if the node is already there).

The `addEdge` function should add a new edge keeping nodes and edges consistent. The `isReachable` function should return `true` only if both nodes are in the graph and control can flow from the first node to the second node.

In the `main` method, use the first command line argument as the class name to load. In `createCFG` use the following code as a hint to traverse methods and instructions of the loaded class file.

```
JavaClass jc = Repository.lookupClass(className);
ClassGen cg = new ClassGen(jc);
// loop on all methods of this class
for (Method m: cg.getMethods()) {
  // loop on all instructions in this method
  for (InstructionHandle ih:
         new MethodGen(m, cg.getClassName(), cg.getConstantPool())
         .getInstructionList().getInstructionHandles()) {
    int position = ih.getPosition();
    // at this point you have enough information to make a node
    Instruction inst = ih.getInstruction();
    // based on the instruction you may or may not have to add an edge
  }
}
```

5 What's coming up!

In the next assignment, you will extend this to support method invocations and automatic generation of JUnit tests. A better implementation of this assignment will prepare you best for the next assignment.