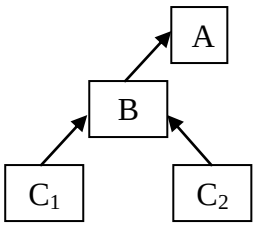
Exercise 6

Bytecode verification

1) Consider the following type hierarchy:



Suppose that the method `f` of class `E` has the following signature:

```
A f(boolean b1, boolean b2);
```

and three local variables `x, y, z`. It is known that the initial state is

```
([], [E,boolean,boolean,C1,C2,A])
```

The maximal stack size is equal to 1.

The method `f` has the following body:

```
 0:    iload_1
 1:    ifeq  22
 4:    iload_2
 5:    ifeq  12
 8:    aload_3
 9:    goto  14
12:    aload_4
14:    astore_3
15:    aload_5
17:    astore_4
19:    goto 0
22:    aload_3
23:    areturn
```

- Verify that the program is type safe.
- Provide the minimal type information that enables verification of the bytecode without a fixpoint computation.

Note: In this example, `ifeq x` pops an integer from the stack and jumps to line `x` if the integer is equal to zero.

2) The method `f` of class `E` has the following signature:

```
void f();
```

and one local variable `v`. The maximal stack size is equal to 1.

It has the following body:

```
 0:     iconst_5
1:      istore_1
2:      aload_0
3:      astore_1
4:      iload_1
5:      iconst_1
6:      iadd
7:      istore_1
8:      return
```

Can the provided byte code be verified? If so then verify it, otherwise explain which line of the code causes the problem and why.

3) Consider the following code:

```
interface IFace {
  void m();
}
class Cl1 implements IFace {
   public void m() { System.out.println("Cl1.m"); }
}
class Cl2 implements IFace {
  public void m() { System.out.println("Cl2.m"); }
}
public class Test1 {
  public static void main( String[] args ) {
     xxx(true);
     xxx(false);
   }

  public static void xxx( boolean param ) {
     IFace iface = null;
     if( param ) { iface = new Cl1();}
     else { iface = new Cl2(); }
     iface.m(); }}
```

- What type will be calculated for the variable `iface` of the method `xxx` during the bytecode verification?
- When can we decide that `iface.m()` is safe to call? During bytecode verification, or execution?
- What if `IFace` was a class instead of an interface? What if it was an abstract class?

4) The Java bytecode verifier is more permissive than the Java type system. Provide a program that demonstrates it.

5) The bytecode type inference algorithm assumes that maximal stack size is provided.

- Is it possible to drop this requirement and infer the maximal stack size?
- If the answer is yes, then describe how the bytecode verification algorithm can be updated.
- If the answer is no, then show that it can't be done.

6) The bytecode type inference algorithm rejects a verified program if there are different stack sizes for input values of a join point.

- Provide a bytecode program that is rejected because of this limitation.
- Is it possible to construct a bytecode verification algorithm that avoids this limitation? If yes, then provide an updated algorithm. If no, then show that it can't be done.
- How essential is this restriction from a pragmatic perspective?