CIS 842: Specification and Verification of Reactive Systems

Lecture INTRO-Bogor-Simulation: Executing (Simulating) Concurrent Systems in Bogor

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Objectives

- Understand how a model-checker’s random simulation and user-guided simulation mode can be applied to explore paths through a system’s computation tree.
- Be able to apply Bogor in both random simulation mode and user-guided simulation mode.
Outline

- Bogor random simulation mode
- Bogor user-guided simulation mode

SumToN

```
system SumToN {
    const PARAM { N = 3 };  
    typealias byte int wrap (0,255);
    byte x;
    byte t1;
    byte t2;

    thread Thread1() {
        loc loc0:
        when x != 0 do { t1 := x; }
        goto loc1;

        loc loc1:
        do { t2 := x; }
        goto loc2;

        loc loc2:
        do { x := t1 + t2; }
        goto loc0;
    }

    thread Thread2() {
        loc loc0:
        when x != 0 do { t1 := x; }
        goto loc1;

        loc loc1:
        do { t2 := x; }
        goto loc2;

        loc loc2:
        do { x := t1 + t2; }
        goto loc0;
    }

    thread Thread0() {
        loc loc0:
        do { x := 1; }
        goto loc1;

        loc loc1:
        do { assert (x != PARAM.N); }
        return;
    }
}
```
Assessment

- Even though this is a very small system, it is already tedious for us to try to find a violating trace.
- Bogor can act as a simulator to help us find a violating trace.
- Bogor simulates in two ways:
  - random simulation
  - user-guided simulation
- Same as many other model-checkers (e.g., Spin)

Random Simulation

- In a random simulation, Bogor randomly chooses a branch at a choice point.

At choice points, Bogor randomly chooses one of the enabled transitions.
Guided Simulation

- In a guided simulation, Bogor asks the user which transition to take at a choice point.

For You To Do...

- Pause the lecture...
- The computation tree for the SumToN example depicted on earlier slides is five levels deep. Extend the diagram to six levels.
- Download the file `sumton.bir` from the examples page.
- Run Bogor in random simulation mode.
  - Edit `sumton.bir` and change the assertion to `x != 1`.
  - Do you understand Bogor's output? Was Bogor able to find a violating trace? Why/why-not?
  - Edit `sumton.bir` and change the assertion to `x != 3`.
  - Run Bogor in random simulation mode several times. Do you understand Spin's output? Was Bogor able to find a violating trace each time?
- Edit `sumton.bir` and change the assertion to `x != 5`.
  - Using Bogor in guided simulation mode, construct a trace that leads to an assertion violation. Is this the shortest trace that leads to a violation? How can you be sure?
- Edit `sumton.bir` and change the assertion to `x != 7`.
  - Using Bogor in guided simulation mode, construct a trace that leads to an assertion violation. Is this the shortest trace that leads to a violation? How can you be sure?
Assessment

- Bogor in random simulation mode...
  - sometimes it can find an error
    - e.g., when assertion read $x \neq 1$
  - most of the time it won’t find an error
    - e.g., when assertion read $x \neq 3$
    - in this case, Bogor runs forever, and you can notice the overflow error messages associated with the variables of type `byte`

Assessment

- Bogor in guided simulation mode...
  - the user can guide Bogor to the error
    - but this requires that the user already know or at least have a good idea about how the error can occur!
    - tedious and error prone
    - infeasible on all but very short traces
    - cannot be used in practice to obtain an exhaustive search of all possible traces
    - can be useful in practice if the user simply wants to explore the behavior, e.g., of a particularly troublesome section of code
On To Exhaustive Exploration...

- Bogor’s random simulation
  - isn’t that useful for finding bugs
  - only explores one execution trace
- Bogor’s guided simulation
  - is only useful on short traces where the user already has a good idea of how a property violation might arise
  - only feasible to explore a few execution traces
- The main strength of Bogor is its automatic exhaustive search capabilities
  - this is why people use model-checkers!
  - this is what this course is all about