

Concurrency

EECS 4315

www.eecs.yorku.ca/course/4315/

Question

Is the developed class `Database` correct?

Question

Is the developed class `Database` correct?

Answer

Maybe.

Question

Is the developed class `Database` correct?

Answer

Maybe.

Let us use JPF to try to find bugs in the `Database` class.

```
target=concurrency.ReadersAndWriters  
classpath=/courses/4315/workspace/concurrency/bin/
```

```
JavaPathfinder core system v8.0 (rev 2+) - (C) 2005-2014 U
===== syst
concurrency.ReadersAndWriters.main()
===== sear
===== resu
no errors detected
===== stat
elapsed time:      00:00:11
states:           new=28983,visited=64764,backtracked=93747
search:           maxDepth=49,constraints=0
choice generators: thread=28983 (signal=2517,lock=8221,shar
heap:             new=400,released=157142,maxLive=386,gcCyc
instructions:     470903
max memory:       372MB
loaded code:      classes=61,methods=1381
===== sear
```

Question

How can we use JPF to check that there is no writer writing when a reader is reading?

Question

How can we use JPF to check that there is no writer writing when a reader is reading?

Answer

Add `assert !this.writing` in the `read` method where the database is read. If the assertion fails, an exception is thrown. JPF detects exceptions that are thrown and not caught.


```
JavaPathfinder core system v8.0 (rev 2+) - (C) 2005-2014 U
===== syst
concurrency.ReadersAndWriters.main()
===== sear
===== erro
gov.nasa.jpf.vm.NoUncaughtExceptionsProperty
java.lang.AssertionError
at concurrency.Database.read(Database.java:28)
at concurrency.Reader.run(Reader.java:25)
===== snap
thread concurrency.Reader:{id:2,name:Thread-2,status:RUNNING}
call stack:
at concurrency.Database.read(Database.java:28)
at concurrency.Reader.run(Reader.java:25)

thread concurrency.Writer:{id:4,name:Thread-4,status:RUNNING}
call stack:
at concurrency.Database.beginWrite(Database.java:78)
```

Smallest instance

Try to find the smallest instance for which the error occurs.

Smallest instance

Try to find the smallest instance for which the error occurs.

```
READER = 1  
WRITERS = 1  
no errors detected
```

```
READER = 2  
WRITERS = 1  
no errors detected
```

```
READER = 1  
WRITERS = 2  
error
```

Locating the error

```
===== error
gov.nasa.jpf.vm.NoUncaughtExceptionsProperty
java.lang.AssertionError
at concurrency.Database.read(concurrency/Database.java:28)
at concurrency.Reader.run(concurrency/Reader.java:25)
```

Line 28 of the `Database` class.

```
assert !this.writing;
```

Locating the error

```
===== snapshot
thread concurrency.Reader:{id:1,name:Thread-1,status:RUNNING}
  call stack:
    at concurrency.Database.read(Database.java:28)
    at concurrency.Reader.run(Reader.java:25)

thread concurrency.Writer:{id:3,name:Thread-3,status:RUNNING}
  call stack:
    at concurrency.Database.beginWrite(Database.java:78)
    at concurrency.Database.write(Database.java:61)
    at concurrency.Writer.run(Writer.java:25)
```

A **Reader** thread is at line 28 of the **Database** class (assertion), while a **Writer** thread is at line 78 of the **Database** class (end of **beginWrite**).

Question

How can we get a more detailed report?

Question

How can we get a more detailed report?

Answer

By configuring the report.

Configuring the report

```
report.class=gov.nasa.jpf.report.Reporter  
report.publisher=console
```

`console` is a symbolic name and the default value for the property `report.publisher`. The other values currently supported for this property are `html` and `xml`.

Configuring the report

The symbolic name `console` is part of the following properties.

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces no output.

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=jpf
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
JavaPathfinder core system v8.0 (rev 2+) - (C) 2005-2014 U
===== search started
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=sut
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
===== system under t
concurrency.ReadersAndWriters.main()
===== search started
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=platform
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
===== platform
hostname: montreal
arch: amd64/4
os: Windows 7/6.1
java: Oracle Corporation/1.8.0_25
----- search_start
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=dtg
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
started: Mon Mar 12 20:23:36 EDT 2018
```

```
===== search
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=config
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
===== JPF configurat
property source: E:\courses\4315\.jpf\site.properties
property source: E:\courses\4315\jpf\jpf-core\jpf.properties
property source: E:\courses\4315\workspace\concurrency\src\
properties:
    branch_start=1
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=error
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
===== error 1
gov.nasa.jpf.vm.NoUncaughtExceptionsProperty
java.lang.AssertionError
    at concurrency.Database.read(concurrency/Database.java:2
    at concurrency.Reader.run(concurrency/Reader.java:25)
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=output
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
===== output #1
no output
```


Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=snapshot
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=
```

This configuration produces the following output.

```
===== snapshot #1
thread concurrency.Reader:{id:1,name:Thread-1,status:RUNNING}
call stack:
  at concurrency.Database.read(Database.java:28)
  at concurrency.Reader.run(Reader.java:25)
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=trace
report.console.show_steps=false
report.console.show_method=
report.console.show_code=
report.console.finished=
```

Configuring the report

```
===== trace #1
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"ROOT" ,1/1,
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"START" ,1/2,
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"START" ,1/3,
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"START" ,1/4,
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"TERMINATE"
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"LOCK" ,2/3,
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"LOCK" ,2/3,
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"SHARED_OBJE
----- tran
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=trace
report.console.show_steps=true
report.console.show_method=
report.console.show_code=false
report.console.finished=
```

Configuring the report

```
===== trace #1
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"ROOT" ,1/1
[3701 insn w/o sources]
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"START" ,1/2
[17 insn w/o sources]
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"START" ,1/3
[11 insn w/o sources]
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"START" ,1/4
[8 insn w/o sources]
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"TERMINATE"
[7 insn w/o sources]
----- tran
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"LOCK" ,24/36
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=trace
report.console.show_steps=true
report.console.show_method=false
report.console.show_code=true
report.console.finished=
```

Configuring the report

```
===== trace #1
gov.nasa.jpfd.vm.choice.ThreadChoiceFromSet {id:"ROOT" ,1/1}
  invokestatic java.lang.Boolean.<clinit>()V
  new java.lang.Boolean@bc
  dup
  iconst_1
  invokespecial java.lang.Boolean.<init>(Z)V
  aload_0
  invokespecial java.lang.Object.<init>()V
  return java.lang.Object.<init>()V
  aload_0
  iload_1
  putfield java.lang.Boolean.value
  return java.lang.Boolean.<init>(Z)V
  putstatic java.lang.Boolean.TRUE
  new java.lang.Boolean@bd
  dup
  iconst_0
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=trace
report.console.show_steps=true
report.console.show_method=true
report.console.show_code=true
report.console.finished=
```


Configuring the report

```
===== trace #1
----- tran
gov.nasa.jpff.vm.choice.ThreadChoiceFromSet {id:"ROOT" ,1/1,
  java.lang.Boolean.<clinit>
    invokestatic java.lang.Boolean.<clinit>()V
  java.lang.Boolean.<clinit>()V
    new java.lang.Boolean@bc
    dup
    iconst_1
    invokespecial java.lang.Boolean.<init>(Z)V
  java.lang.Boolean.<init>(Z)V
    aload_0
    invokespecial java.lang.Object.<init>()V
  java.lang.Object.<init>()V
    return java.lang.Object.<init>()V
  java.lang.Boolean.<init>(Z)V
    aload_0
    iload 1
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=result
```

This configuration produces the following output.

```
===== results
error #1: gov.nasa.jpf.vm.NoUncaughtExceptionsProperty "java
at concurrency.Database...."
===== search finished
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=
report.console.show_steps=
report.console.show_method=
report.console.show_code=
report.console.finished=statistics
```

This configuration produces the following output.

```
===== statistics
elapsed time:      00:00:01
states:           new=395,visited=361,backtracked=733,end=2
search:           maxDepth=29,constraints=0
choice generators: thread=394 (signal=41,lock=115,sharedRet
heap:             new=409,released=927,maxLive=382,gcCyc
```

Configuring the report

```
report.console.class=gov.nasa.jpf.report.Reporter
report.console.start=jpf
report.console.transition=
report.console.constraint=
report.console.probe=
report.console.property_violation=error,trace
report.console.show_steps=true
report.console.show_method=true
report.console.show_code=true
report.console.finished=statistics
```

Configuring the report

```
JavaPathfinder core system v8.0 (rev 2+) - (C) 2005-2014 U
===== search started
===== error 1
gov.nasa.jpf.vm.NoUncaughtExceptionsProperty
java.lang.AssertionError
  at concurrency.Database.read(concurrency/Database.java:28)
  at concurrency.Reader.run(concurrency/Reader.java:25)
===== trace #1
----- transition #0
gov.nasa.jpf.vm.choice.ThreadChoiceFromSet {id:"ROOT" ,1/1}
  java.lang.Boolean.<clinit>()V
    invokestatic java.lang.Boolean.<clinit>()V
  java.lang.Boolean.<clinit>()V
  ...
===== statistics
elapsed time:      00:00:01
states:           new=395,visited=361,backtracked=733,end=2
search:           maxDepth=29,constraints=0
```

The dining philosophers problem

In the dining philosophers problem, due to Dijkstra, five philosophers are seated around a round table. Each philosopher has a plate of spaghetti. A philosopher needs two forks to eat it. The layout of the table is as follows.



The life of a philosopher consists of alternative periods of eating and thinking. When philosophers get hungry, they try to pick up their left and right fork, one at a time, in either order. If successful in picking up both forks, the philosopher eats for a while, then puts down the forks and continues to think.

The dining philosophers problem

```
public class Philosopher extends Thread {
    private int id;
    private Table table;
    public Philosopher(int id, Table table) {
        this.id = id;
        this.table = table;
    }
    public void run() {
        while (true) {
            this.table.pickUp(id);
            this.table.pickUp(id + 1 % 5);
            // eat
            this.table.putDown(id);
            this.table.putDown(id + 1 % 5);
        }
    }
}
```

The dining philosophers problem

```
public class Table {  
    public void pickUp(int id) { ... }  
    public void putDown(int id) { ... }  
}
```