Formale Entwicklung objektorientierter Software

Praktikum im Wintersemester 2007/2008

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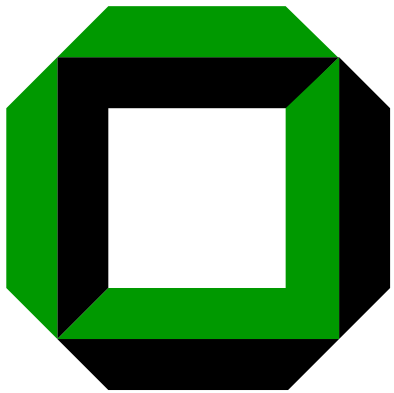
Institut für Theoretische Informatik
Universität Karlsruhe

21. November 2007



ESC/Java2

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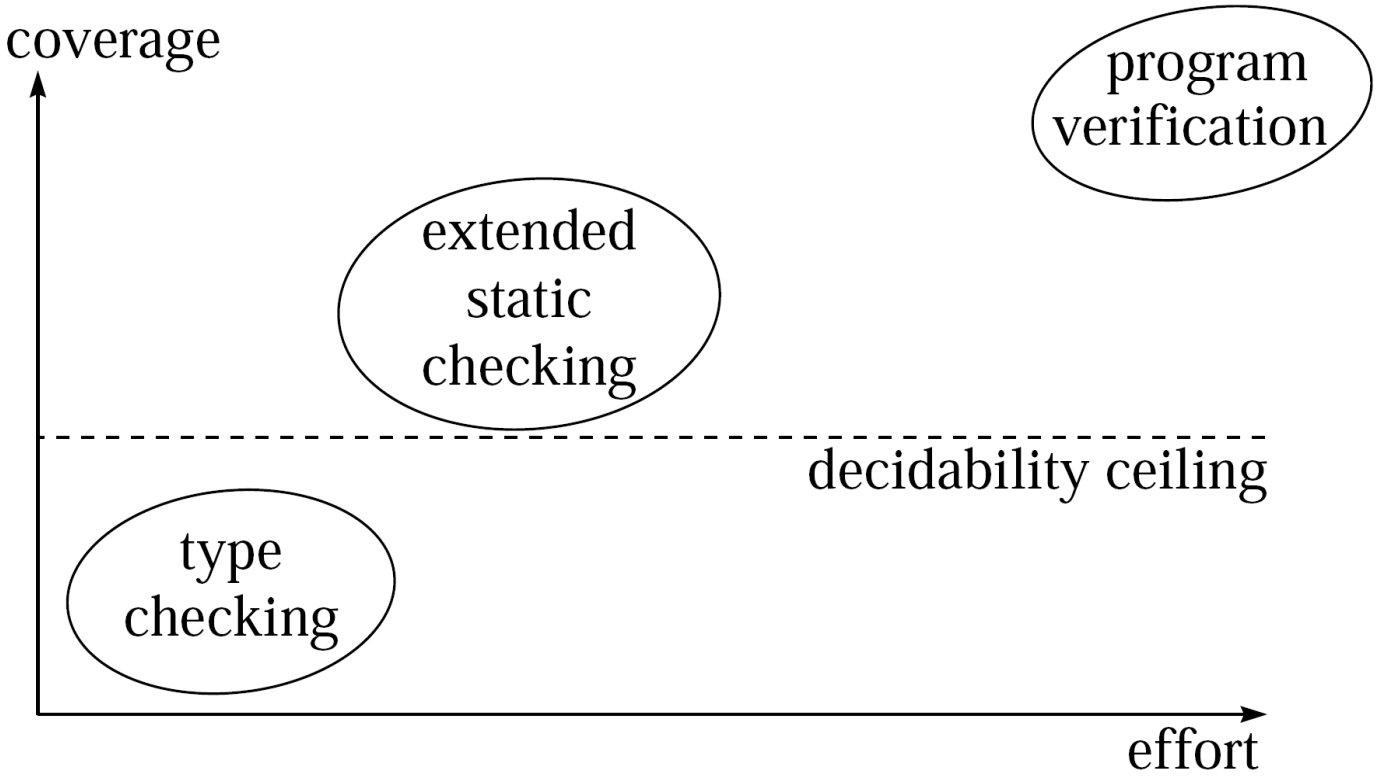

(source: Flanagan et al., "Extended Static Checking for Java")

History of ESC

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  - DEC / Compaq Research, -1996

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Example

```
/*@ ensures
  @  (\forall int x; 0<=x && x<a.length; a[x]<=\result);
  @*/
int getMaximum(int[] a) {
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[0.162 s 10333000 bytes] passed

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Possible runtime exceptions:

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Inner Workings

Java + JML

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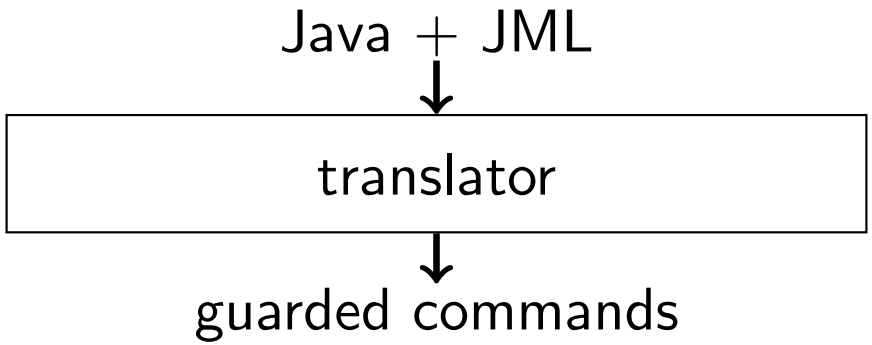

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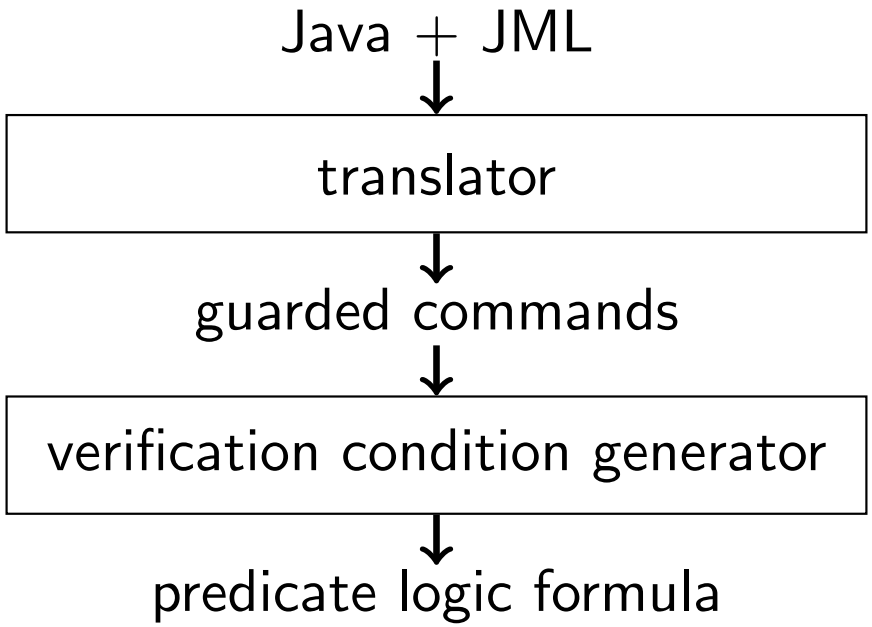

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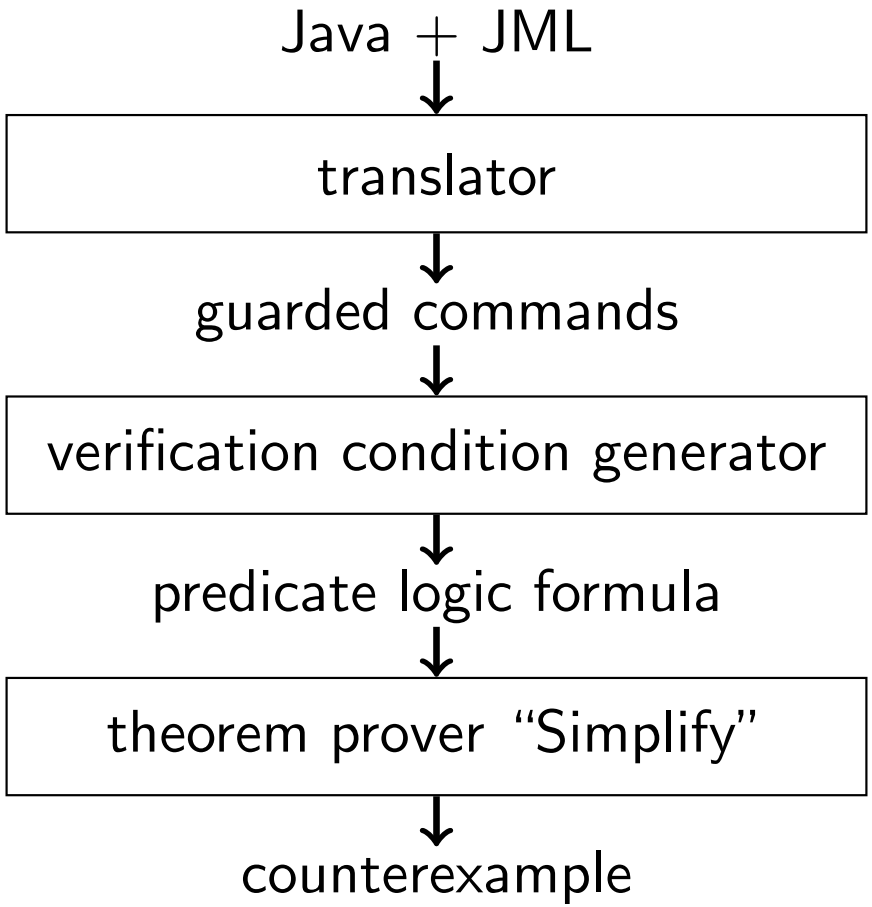

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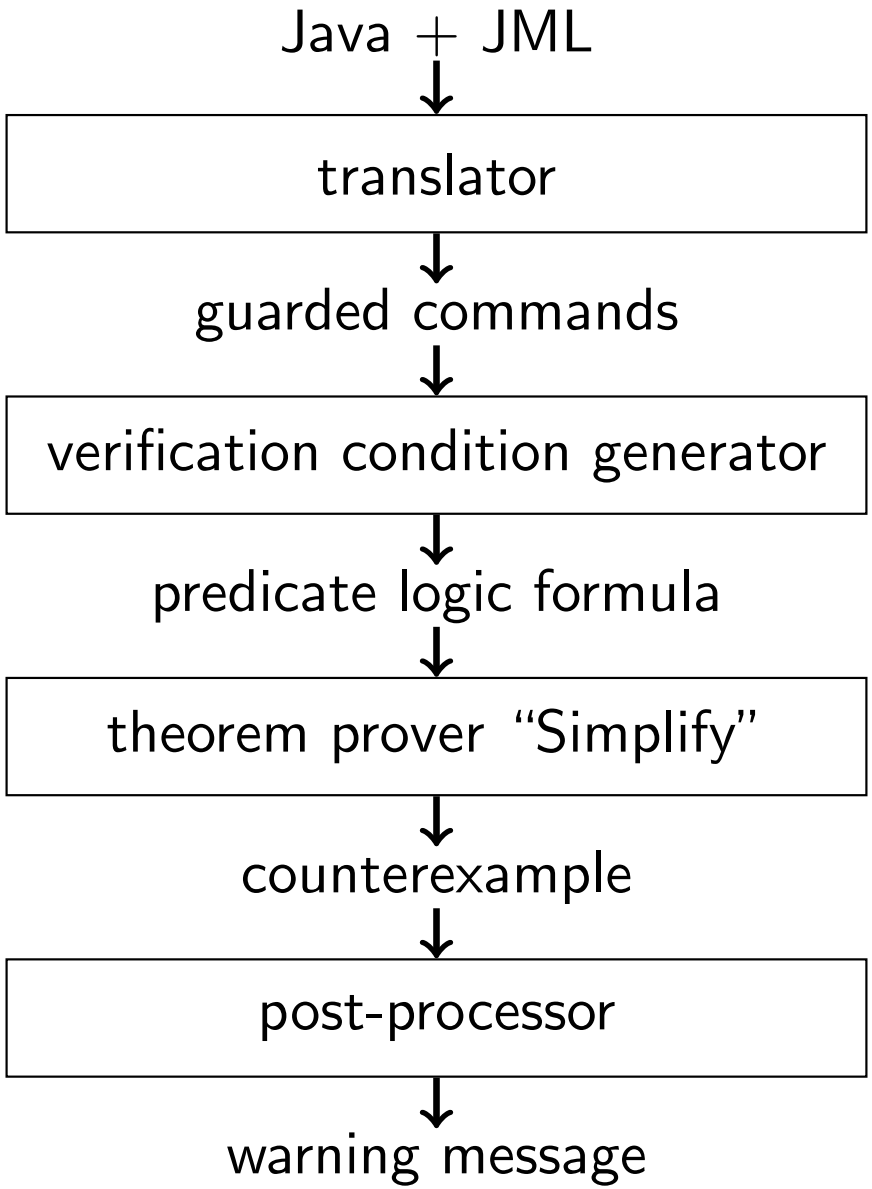

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```
{  ASSUME integralGT(i:2.15, j:2.18);
   ASSUME (\lblpos trace.Then^0,5.11 true);
   max:2.21 = i:2.15;
   state = state:6.9
 []
   ASSUME boolNot(integralGT(i:2.15, j:2.18));
   ASSUME (\lblpos trace.Else^1,7.8 true);
   max:2.21 = j:2.18;
   state = state:8.9
};
ASSERT (\lblneg Assert@10.12 boolAnd(integralGE(max:2.21, i:2.15),
                                     integralGE(max:2.21, j:2.18)));
```

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```
(EXPLIES
  (LBLNEG |vc.MyClass.max.4.4|
    (IMPLIES
      (AND
        (EQ |max@pre:2.21| |max:2.21|)
        (EQ |@true|
          (is |max:2.21| T_int)
          )
        (EQ |j@pre:2.18| |j:2.18|)
        ...
```

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- Not complete: A reported counterexample may be wrong
- Written in Modula-3 for ESC/Modula-3
- Also available as an external decision procedure in KeY

Post-processor

Analyses Simplify's counterexample to produce human readable warning, including

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```
MyClass.java:18: Warning: Possible violation of object invariant (Invariant)
    }
    ^
Associated declaration is "MyClass.java", line 12, col 26:
    static int i = 1; //@ invariant i > 0;
                          ^
Execution trace information:
    Executed then branch in "MyClass.java", line 15, col 18.
```

Counterexamples

```
o1.f = 1;
o2.f = 2;
//@ assert o1.f == 1;
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excerpt of counterexample

```
(o1:2.37).(f:7.9) == 1
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typeof(o1:2.37) <: T_MyClass
o1:2.37 == o2:3.37
T_bigint == T_long
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Counterexamples

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o1.f = 1;
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//@ assert o1 != o2 ==> o1.f == 1;
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[0.077 s 10045712 bytes] passed

Aliasing

```
int[] a = new int[10]; //@ invariant a!=null && a.length>0;
int x;                 //@ invariant x==a[0];

void m() {
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brokenObj != this
brokenObj.(a@pre:2.10) == tmp0!a:6.8
this.(a@pre:2.10) == tmp0!a:6.8
```

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int[] a = new int[10]; //@ invariant a!=null && a.length>0;
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MyClass() {
    //@ set a.owner = this;
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[0.145 s 10129336 bytes] passed

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i = 0;
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[0.129 s 10099544 bytes] passed

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```
i = 0;
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```
[0.129 s 10099544 bytes] passed
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i = j + 1;
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```
[0.049 s 10406944 bytes] passed
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for(i = 0; i < 2; i++) {}
//@ assert i == 567;
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[0.048 s 10407744 bytes] passed

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[0.048 s 10407744 bytes] passed
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[0.048 s 10407744 bytes] passed

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```
//@ assignable \everything;
void setTo42() {i = 42;}
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setTo42();
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[0.024 s 10941408 bytes] passed

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//@ assert "Hello_World".charAt(0) == 'H';
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```
//@ assert 1.0 != 2.0;
```

Warning: Possible assertion failure

- Strings are not well supported

```
//@ assert "Hello_World".charAt(0) == 'H';
```

Warning: Possible assertion failure

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END