Testing Extensible Language Debuggers

1st International Workshop on Executable Modeling

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Agenda

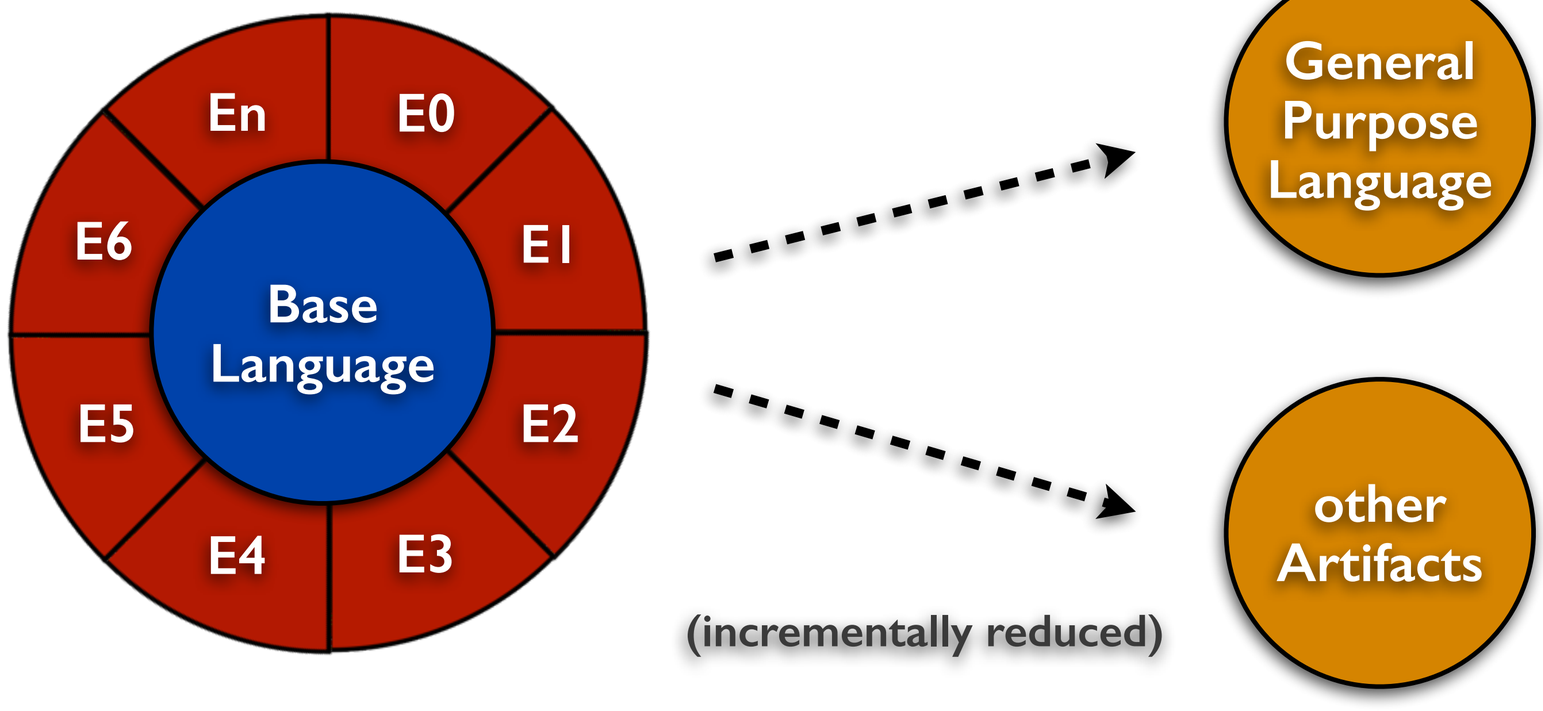
* Extensible Languages and Debuggers
* Requirements on the Testing DSL
* Testing Debugger Extensions

Extensible Languages

the context

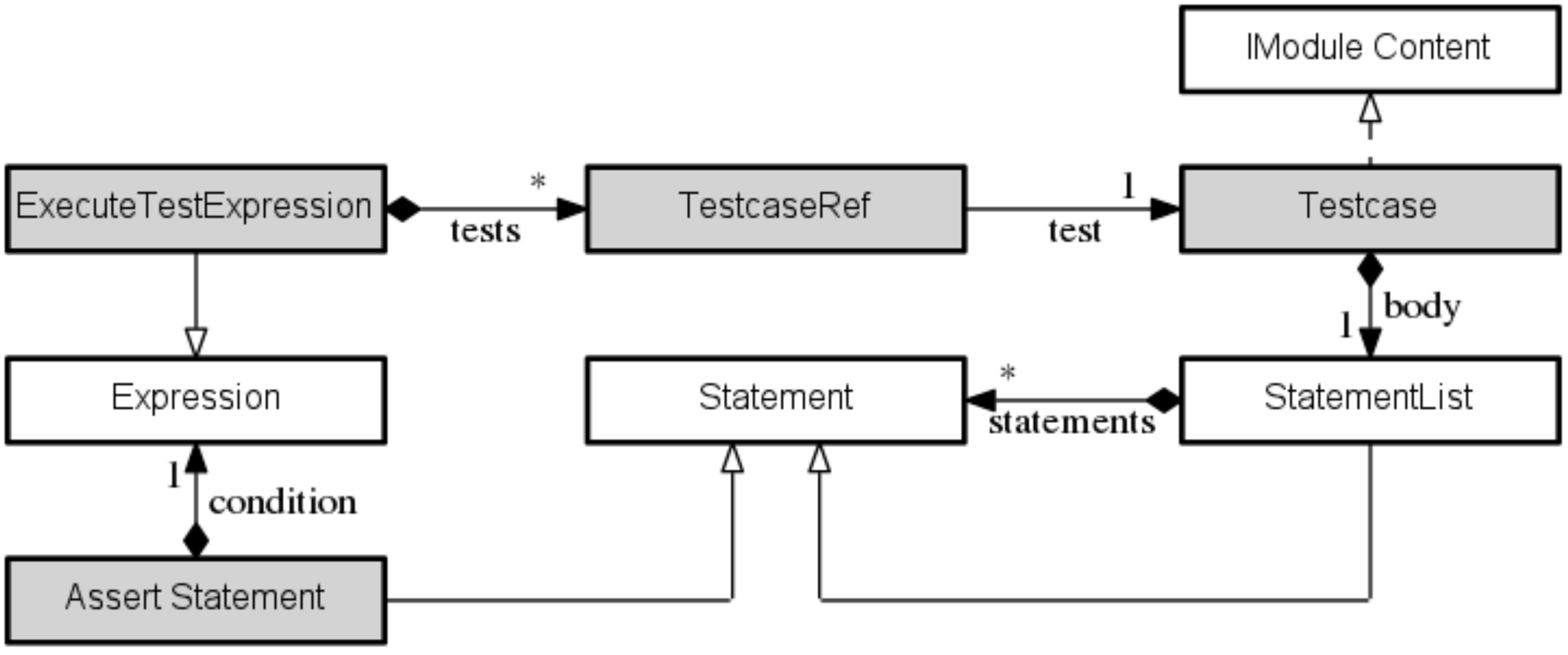
Extensible Languages

enable integration of new language extensions



Example Language Extension

we extend mbeddr with unit testing



Code Generator

generating an example program

Extension-Level

```
1  int32 main(int32 argc,
2      string[] argv) {
3     return test[ forTest ];
4  }
5
6
7
8
9
10
11
12 testcase forTest {
13
14    int32 sum = 0;
15    assert: sum == 0 ;
16    int32[] nums = {1, 2, 3};
17    for(int32_t i=0;i<3;i++){
18      sum += nums[i];
19    }
20    assert: sum == 6 ;
21
22 }
```

```
1  int32_t main(int32_t argc,
2      char *(argv[])) {
3     return blockexpr_2() ;
4  }
5
6  int32_t blockexpr_2(void) {
7    int32_t _f = 0;
8    _f += test_forTest();
9    return _f;
10 }
11
12 int32_t test_forTest() {
13   int32_t _f = 0;
14   int32_t sum = 0;
15   if(!( sum == 0 )) { _f++; }
16   int32_t[] nums = {1, 2, 3};
17   for(int32_t i=0;i<3;i++){
18     sum += nums[i];
19   }
20   if(!( sum == 6 )) { _f++; }
21   return _f;
22 }
```

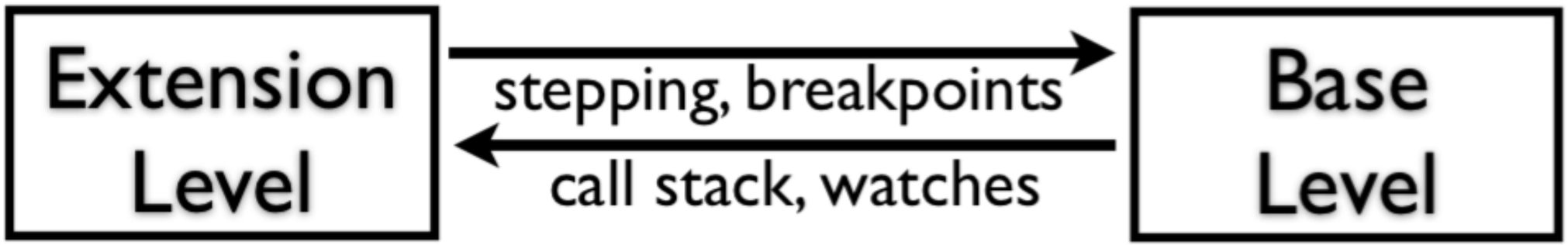
Base-Level

Extensible Language Debuggers

how we build them for mbeddr

Debugger Extensions in mbeddr

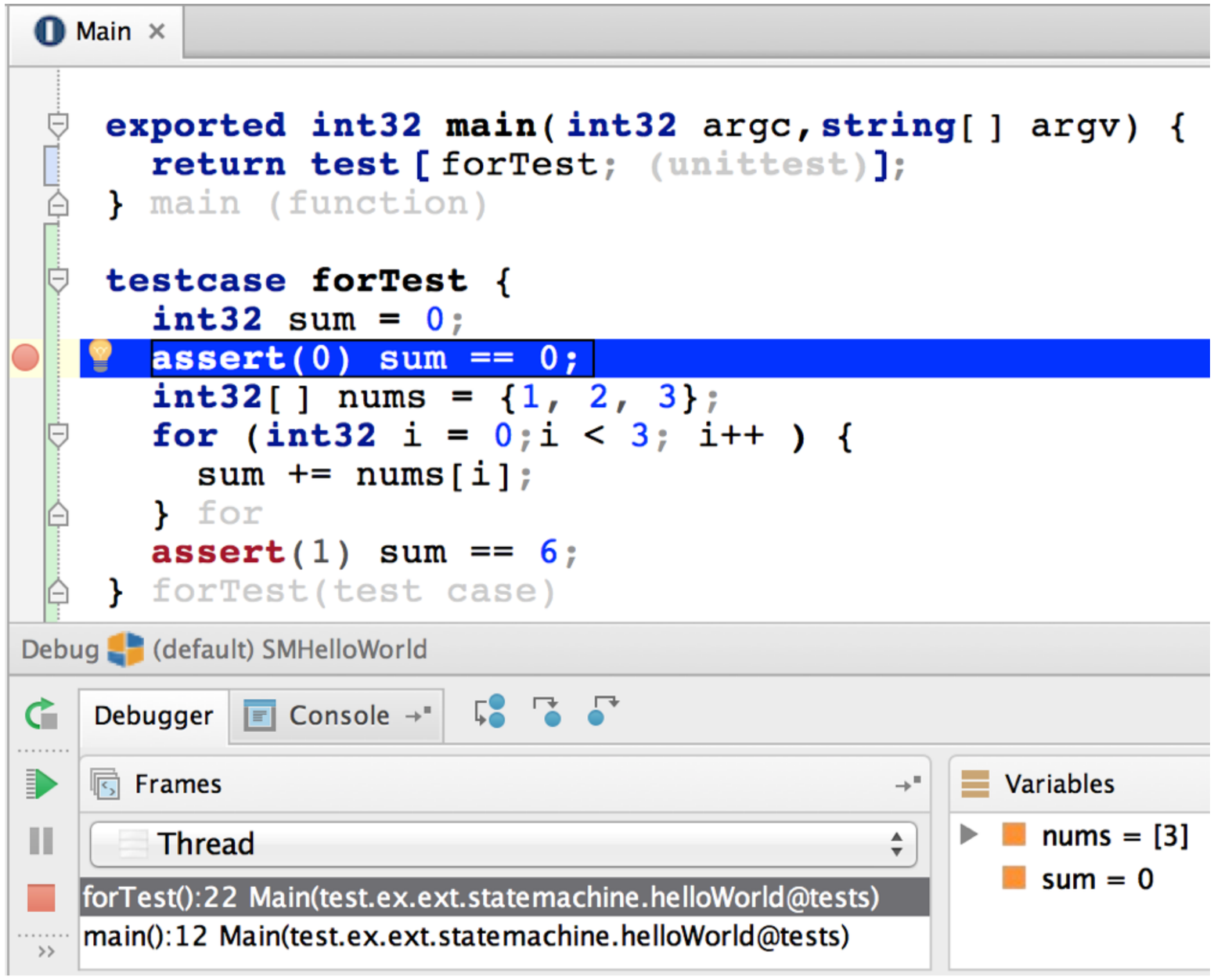
debug information is lifted/mapped



- Languages contribute Debugger Extensions
- mbeddr Debugger Framework
    - meta-model, DSL and debugger runtime
- Base-Level Debugger (GDB) used

mbeddr Debugger

debugging on extension-level



Building Debuggers in mbeddr

lifting the call stack

lift stack frame name

```
12  testcase forTest {
13
14    int32 sum = 0;
15    assert: sum == 0 ;
16    int32[] nums = {1, 2, 3};
17    for(int32_t i=0;i<3;i++){
18      sum += nums[i];
19    }
20    assert: sum == 6 ;
21
22  }
```

```
12  int32_t test_forTest() {
13    int32_t _f = 0;
14    int32_t sum = 0;
15    if(!( sum == 0 )) { _f++; }
16    int32_t[] nums = {1, 2, 3};
17    for(int32_t i=0;i<3;i++){
18      sum += nums[i];
19    }
20    if(!( sum == 6 )) { _f++; }
21    return _f;
22  }
```

```
public void contributeFrameMappings(list<IMWMappingStackFrame> frames) {
  string name = "test_" + this.name;
  contribute frame mapping for frames.selectFrame(name=name) { << ... >> };
}
```

Building Debuggers in mbeddr

mapping stepping behavior

step-into

```
1  int32 main(int32 argc,
2      string[] argv) {
3    return test[ forTest ] ;
4  }
5
6
7
8
9
10
11
12 testcase forTest {
13
14   int32 sum = 0;
15   assert: sum == 0 ;
16   int32[] nums = {1, 2, 3};
17   for(int32 t i=0;i<3;i++){
```

```
1  int32_t main(int32_t argc,
2      char *(argv[])) {
3    return blockexpr_2() ;
4  }
5
6  int32_t blockexpr_2(void) {
7    int32_t _f = 0;
8    _f += test_forTest();
9    return _f;
10 }
11
12 int32_t test_forTest() {
13   int32_t _f = 0;
14   int32_t sum = 0;
15   if(!( sum == 0 )) { _f++; }
16   int32_t[] nums = {1, 2, 3};
17   for(int32_t i=0;i<3;i++){
```

step-into

```
public void contributeStepIntoStrategies(list<IDebugStrategy> resultStrategies)
  overrides ISteppable.contributeStepIntoStrategies {
  this.tests.forEach({~testRef => break on node: testRef.test.body.statements.first; });
}
```

Debugger Extensions are written manually and therefore error-prone

testing is required …

Using a DSL to test Debugger Extension

the important requirements ..

Requirements

the important ones …

1. Test debugging behavior
   * Program state, call stack, breakpoints & stepping
2. Reuse information
   * Test data, validation rules & structure of tests
3. Execute tests automatically
   * IDE & build server

Using the Testing DSL

we test step-into for Testcases …

Testing Debugger Extensions

1. annotate the program under test

```
Main                                                    constraints
model    test.ex.ext.statemachine.helloWorld            imports        nothing

exported int32 main(int32 argc,string[] argv) {
  [return test[forTest; (unittest)];]onReturnInMain
} main (function)

testcase forTest {
  [int32 sum = 0;]onSumDecl
  [assert(0) sum == 0;]firstAssert
  [int32[] nums = {1, 2, 3};]onArrayDecl
  for (int32 i = 0;i < 3; i++ ) {
    sum += nums[i];
  } for
  [assert(1) sum == 6;]secondAssert
} forTest(test case)
```

Testing Debugger Extensions

2. specify an expected CallStack: after step-into

```
int32 main(int32 argc,string[] argv) {
  [return test[forTest;];]onReturnInMain
} main (function)
testcase forTest {
  [int32 sum = 0;]onSumDecl
  [assert(0) sum == 0;]firstAssert
  [int32[] nums = {1, 2, 3};]onArrayDecl
  for (int32 i = 0;i < 3; i++ ) {
    sum += nums[i];
  } for
  [assert(1) sum == 6;]secondAssert
} forTest(test case)
```

```
call stack csInTest {
  1 forTest
  0 main
}
```

```
name:
  forTest
location:
  <any location>
watches:
  watches inForTest {
    sum
    nums
  }
```

Testing Debugger Extensions

3. write the DebuggerTestcase

```
int32 main(int32 argc,string[] argv) {
  [return test[forTest;];]onReturnInMain
} main (function)
testcase forTest {
  [int32 sum = 0;]onSumDecl
  [assert(0) sum == 0;]firstAssert
  [int32[] nums = {1, 2, 3};]onArrayDecl
  for (int32 i = 0;i < 3; i++ ) {
    sum += nums[i];
  } for
  [assert(1) sum == 6;]secondAssert
} forTest(test case)
```

```
test case stepIntoTestcase {
  suspend at:
    onReturnInMain
  then perform:
    step into 1 times
  finally validate:
    call stack OnSumDecl extends csInTest {
      1 forTest
      0 main
    }
}
inherited name:
  forTest
overwrite inherited location:
  onSumDecl
inherited watches:
  watches inForTest {
    sum
    nums
  }
```

Testing Debugger Extensions

4. execute the test

UnitTesting ×

```
Debugger Test UnitTesting      tests binary:  UnitTestingBinary
                               uses debugger: gdb
                               imports:       <none>

call stack csInTestcase {
  1 forTest
  0 main
}
test case stepIntoTestcase {
  suspend at:
    onReturnInMain
  then perform:
    step into 1 times
  finally validate:
    call stack csOnSumDeclInTestcase extends csInTestcase {
      1 forTest
      0 main
    }
}
```

Run UnitTesting

UnitTesting (test.debugging.core.testcase)

test_stepIntoTestcase

Done: 1 of 1

Test	Time...	Usage...	Usag...	Usage...	Results
Total:	3,087 s	-238...	9288...	9049...	...
test.deb	3,087 s	-238...	9288...	9049...	...
test_s	3,087 s	-238...	928808 Kb	49...	Pass...

Language Evolution

your debugger extension will break …

Evolving the Testcase Generator

prefix of generated C Function is changed

Extension-Level

```
1  int32 main(int32 argc,
2      string[] argv) {
3    return test[ forTest ];
4  }
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9
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11
12 testcase forTest {
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14   int32 sum = 0;
15   assert: sum == 0;
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```
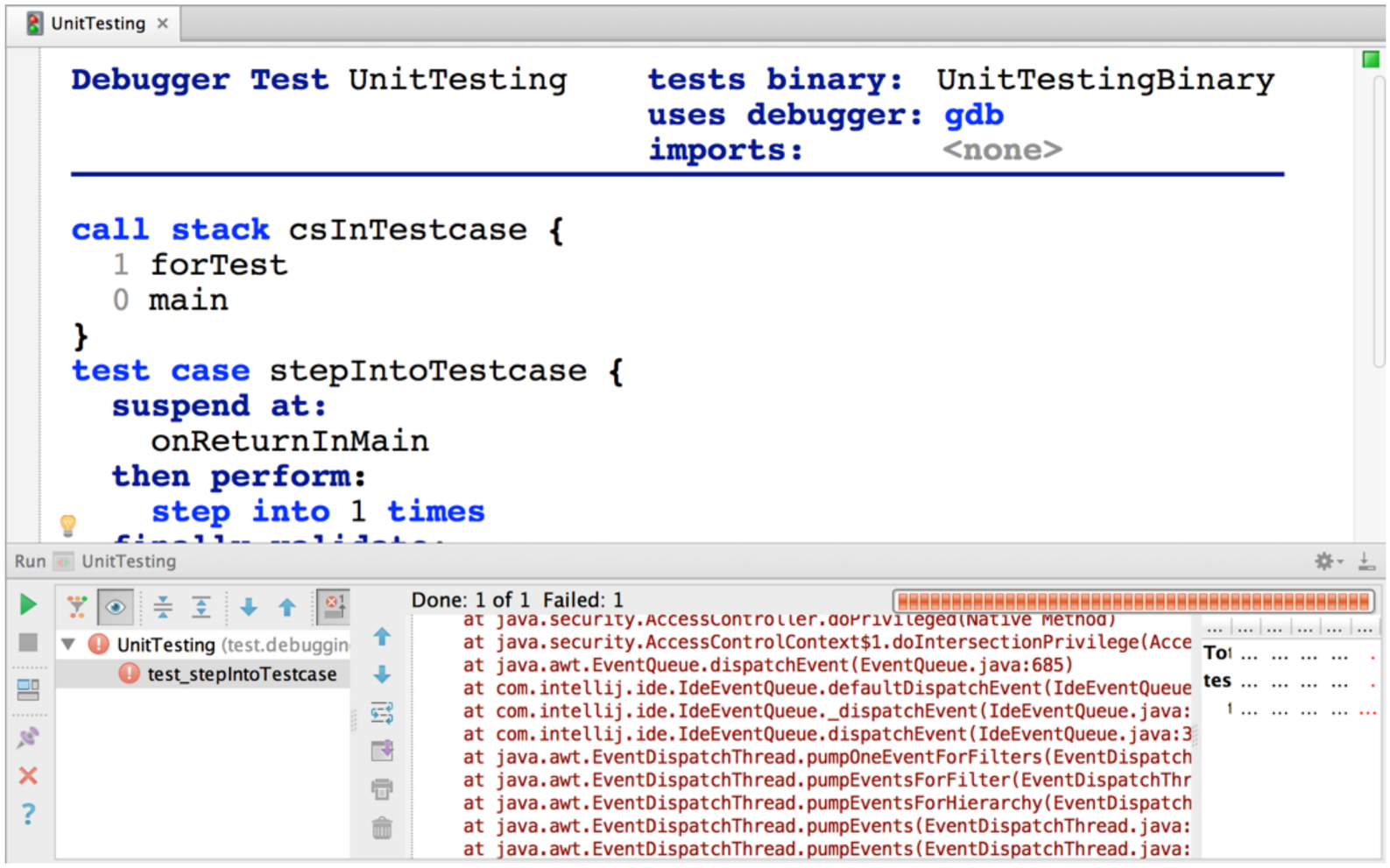

```
1  int32_t main(int32_t argc,
2      char *(argv[])) {
3    return blockexpr_2();
4  }
5
6  int32_t blockexpr_2(void) {
7    int32_t _f = 0;
8    _f += testcase_forTest();
9    return _f;
10 }
11
12 int32_t testcase_forTest() {
13   int32_t _f = 0;
14   int32_t sum = 0;
15   if(!( sum == 0 )) { _f++; }
16   int32_t[] nums = {1, 2, 3};
```

Base-Level

Evolving the Testcase Generator

debugger test fails



➜ Tests are fine, call stack construction is invalid!

Evolving the Testcase Generator

call stack construction fails

Debugger Extension must use different name:

```
public void contributeFrameMappings(list<IMWMappingStackFrame> frames) {
  string name = "testcase_" + this.name;
  contribute frame mapping for frames.selectFrame(name=name) { << ... >> };
}
```

return „any Questions?“;