Null safety benchmarks for object initialization

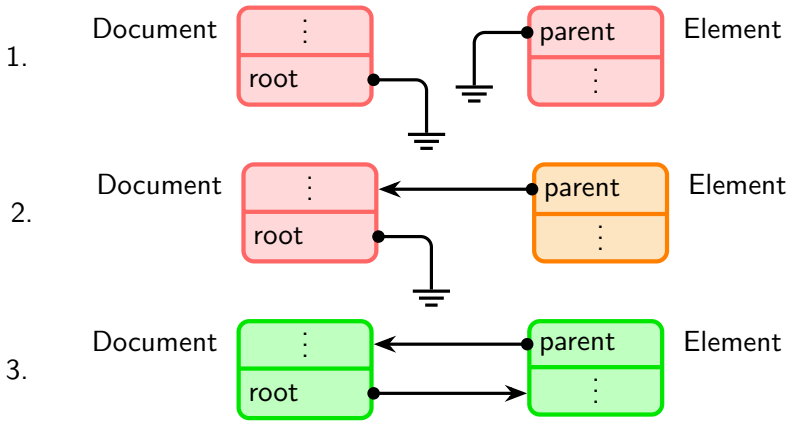
https://bitbucket.org/kwaxer/null-safety-benchmark/src/?at=2017-ispras

Alexander Kogtenkov

2017-11-30

Example: circular references in XML document

```
class Document { var root: Element ... }
class Element { var parent: Document ... }
```



Example: circular references in XML document

```
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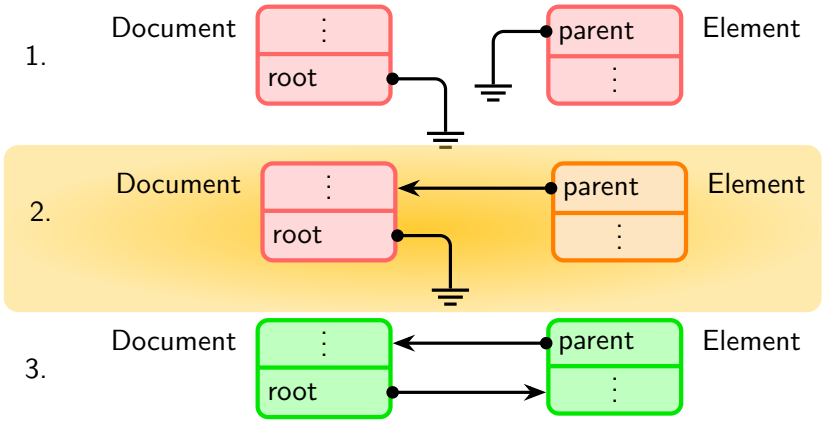
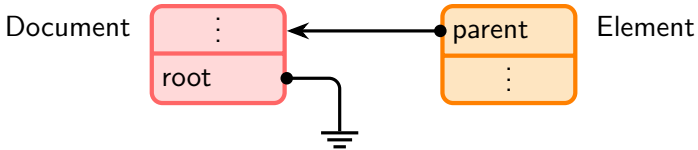


Q: What could go wrong?



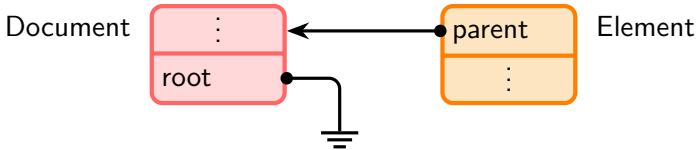

```
class Document
{
    var root: Element

    constructor ()
    {
        root = Element (this)
    }
}
```

```
class Element
{
    var parent: Document

    constructor (p: Document)
    {
        parent = p
    }
}
```

Q: What could go wrong?

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class Document
{
    var root: Element

    constructor ()
    {
        root = Element (this)
    }
}
```

```
class Element
{
    var parent: Document

    constructor (p: Document)
    {
        parent = p
        parent.root.parent
    }
}
```

Soundness vs. expressiveness

Expressive:

```
class Element
{
    var parent: Document

    constructor (p: Document)
    {
        parent = p
        [redacted] ✓
    }
}
```

Sound:

```
class Element
{
    var parent: Document

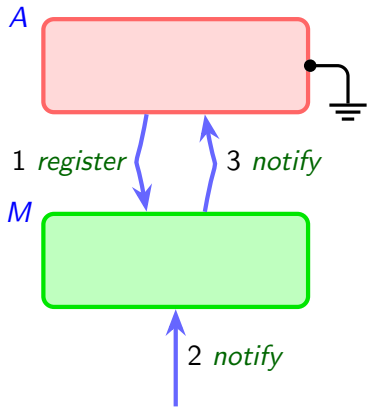
    constructor (p: Document)
    {
        parent = p
        parent.root.parent ✗
    }
}
```

Example: mediator

```
class A {
    var x: X
    constructor (m: M)
    {

        m.register (this)
        x = ...
    }
    fun notify () { x.foo () }
}

class M { ...
    fun register (a: A) { list.add (a) }
    fun notify () { list.forEach { it.notify () } }
}
```



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class A {
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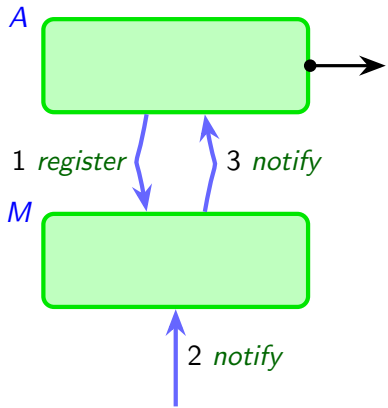

Soundness vs. expressiveness

Expressive:

```
class A {
    var x: X
    constructor (m: M)
    {
        x = ... ✓
        m.register (this)

    }
    fun notify () { x.foo () }
}
```

Sound:

```
class A {
    var x: X
    constructor (m: M)
    {

        m.register (this)
        x = ... ✗
    }
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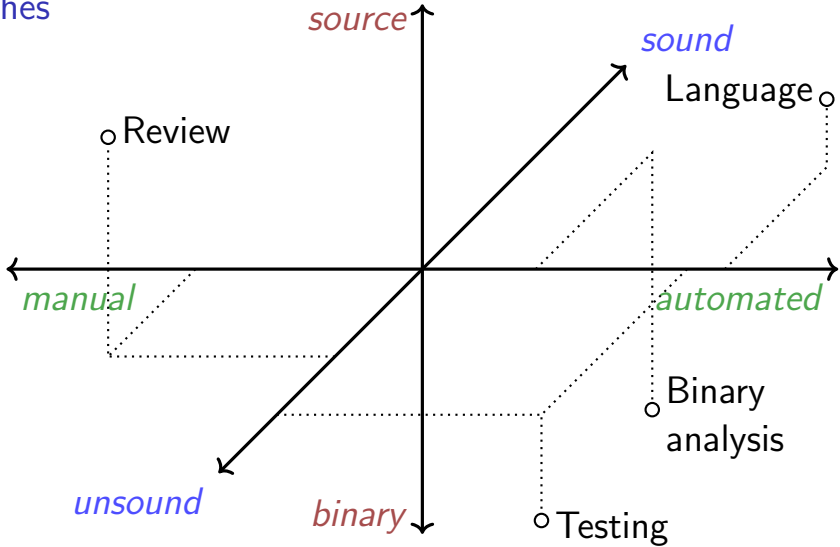
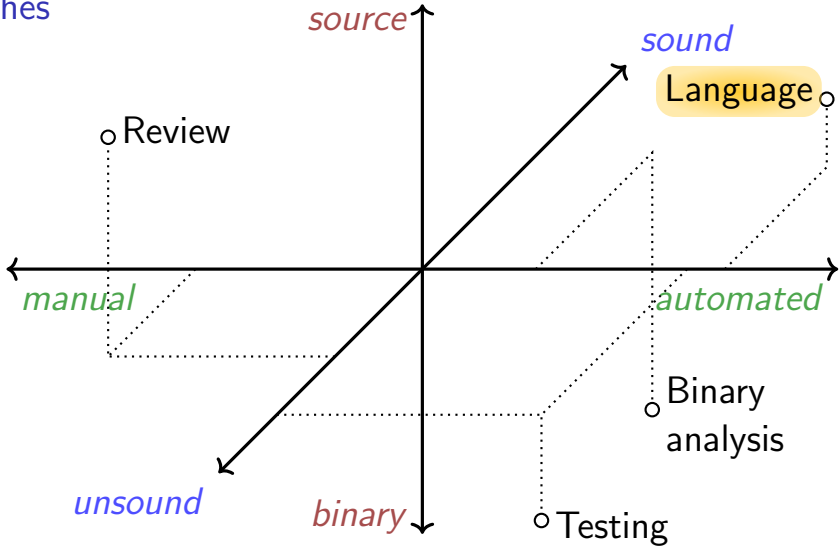
```

Approaches


source
sound
Language
Review
manual
automated
Binary
analysis
unsound
binary
Testing

Approaches


source
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Language
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Testing

Roots of the object initialization problem

1. Non-atomic initialization

```
class A {
    var x: X
    constructor (m: M)
    {
        x = ... ✓
        m.register (this)
        x = ... ✗
    }
    fun notify () { x.foo () }
}

class M { ...
    fun register (a: A) { list.add (a) }
    fun notify () { list.forEach { it.notify () } }
}
```

Roots of the object initialization problem

1. Non-atomic initialization
2. Aliasing
   - Argument
   - Context (static, global, etc.)
   - Finalizer

```
class A {
    var x: X
    constructor (m: M)
    {
        x = ... ✓
        m.register (this)
        x = ... ✗
    }
    fun notify () { x.foo () }
}

class M { ...
    fun register (a: A) { list.add (a) }
    fun notify () { list.forEach { it.notify () } }
}
```

Roots of the object initialization problem

1. Non-atomic initialization
2. Aliasing
3. Uncontrollable control flow
   - Exception
   - Concurrency
   - Cooperative execution

```
class A {
    var x: X
    constructor (m: M)
    {
        x = ... ✓
        m.register (this)
        x = ... ✗
    }
    fun notify () { x.foo () }
}

class M { ...
    fun register (a: A) { list.add (a) }
    fun notify () { list.forEach { it.notify () } }
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Roots of the object initialization problem

1. Non-atomic initialization
2. Aliasing
3. Uncontrollable control flow
4. Dereferencing

```
class A {
    var x: X
    constructor (m: M)
    {
        x = ... ✓
        m.register (this)
        x = ... ✗
    }
    fun notify () { x.foo () }
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    fun register (a: A) { list.add (a) }
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```

Results: expressiveness

Tool	Example						Score
	callback	cycle: self	cycle: mutual	uninitialized	reg.: argument	reg.: context	
Java *Checker Framework*	+	+	+	+	⊕	⊕	6*
EiffelStudio compiler	+	+	+	−	+	+	5
Kotlin compiler	+	+	+	+	+	+	6

* Expected: 4

Results: soundness

Tool	Example registration: argument	Example registration: fresh	Example registration: context	Example: reclamation	Example: transfer	Score
Java *Checker Framework*	⊖⊖	⊖⊖	⊖⊖	−	⊖	0*
EiffelStudio compiler	++	++	++	−	+	7
Kotlin compiler	−−	−−	−−	−	−	0

* Expected: 7

The next step

Today:

Theory		Practice
Small subset Formal proof	Programming language Tool	Real PL Compiler

The next step

Today:

Theory		Practice
Small subset Formal proof	Programming language Tool	Real PL Compiler

Next:

Formalized Real programming language Certified Compiler