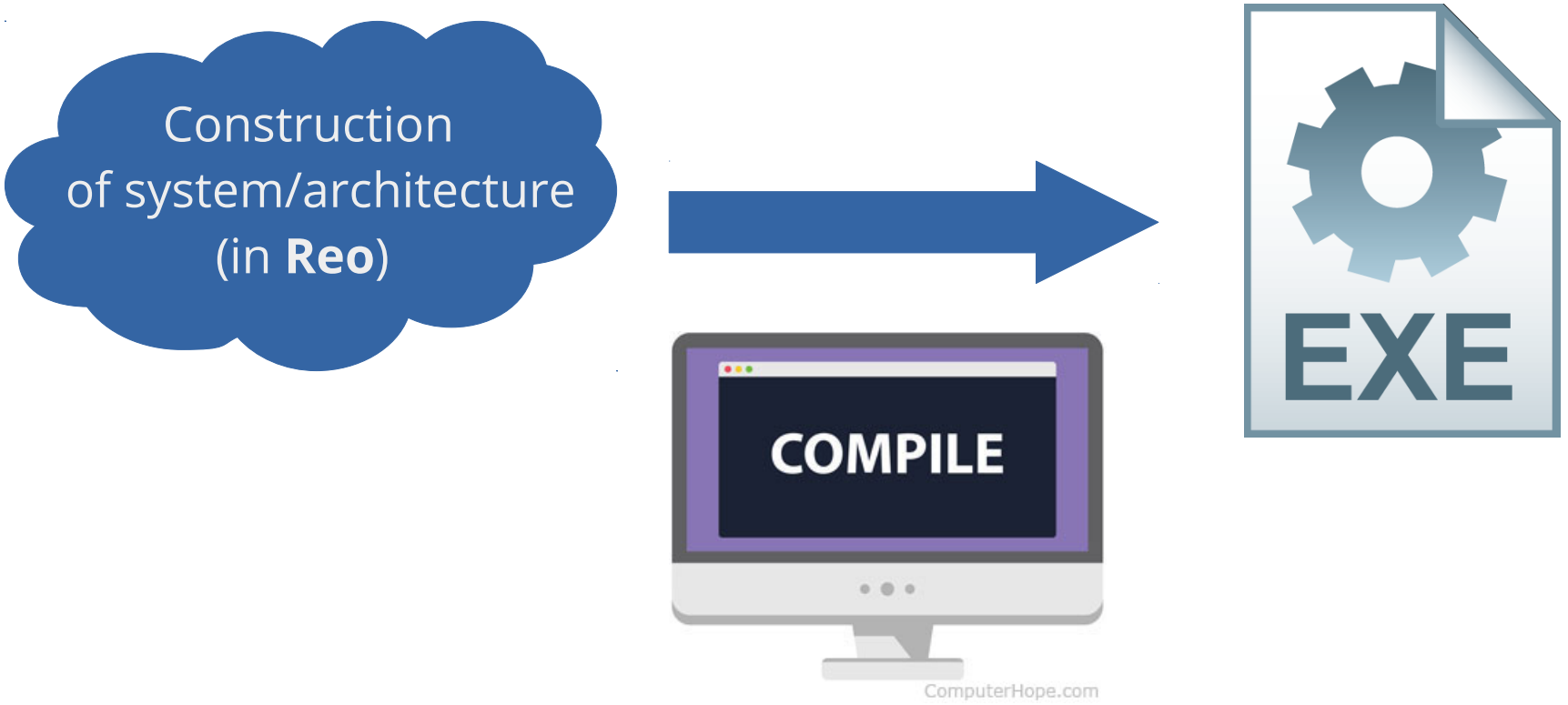
Treo: Textual Syntax of Reo

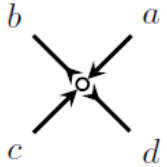
Kasper Dokter and Farhad Arbab

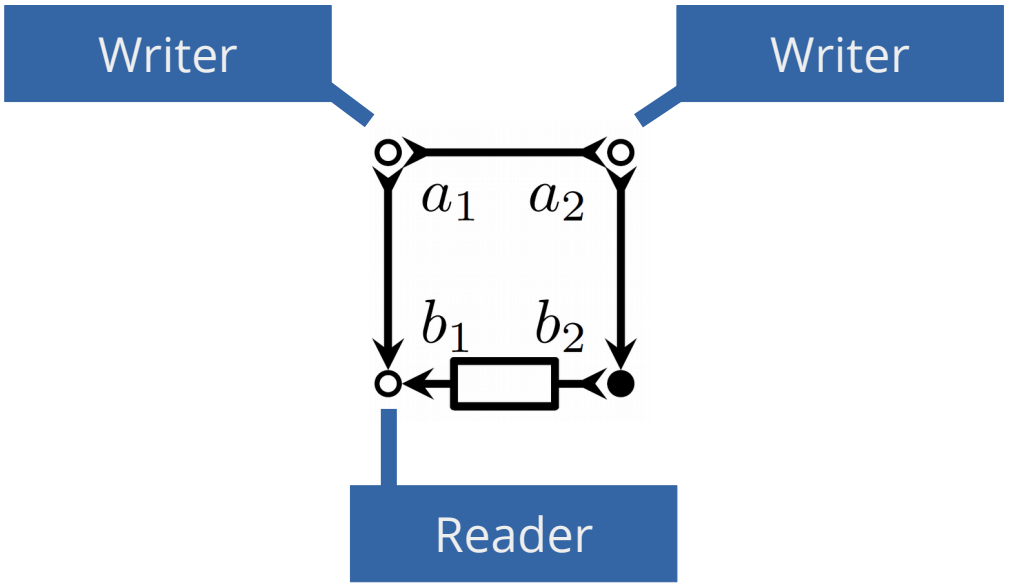
Context

Component-based software engeneering

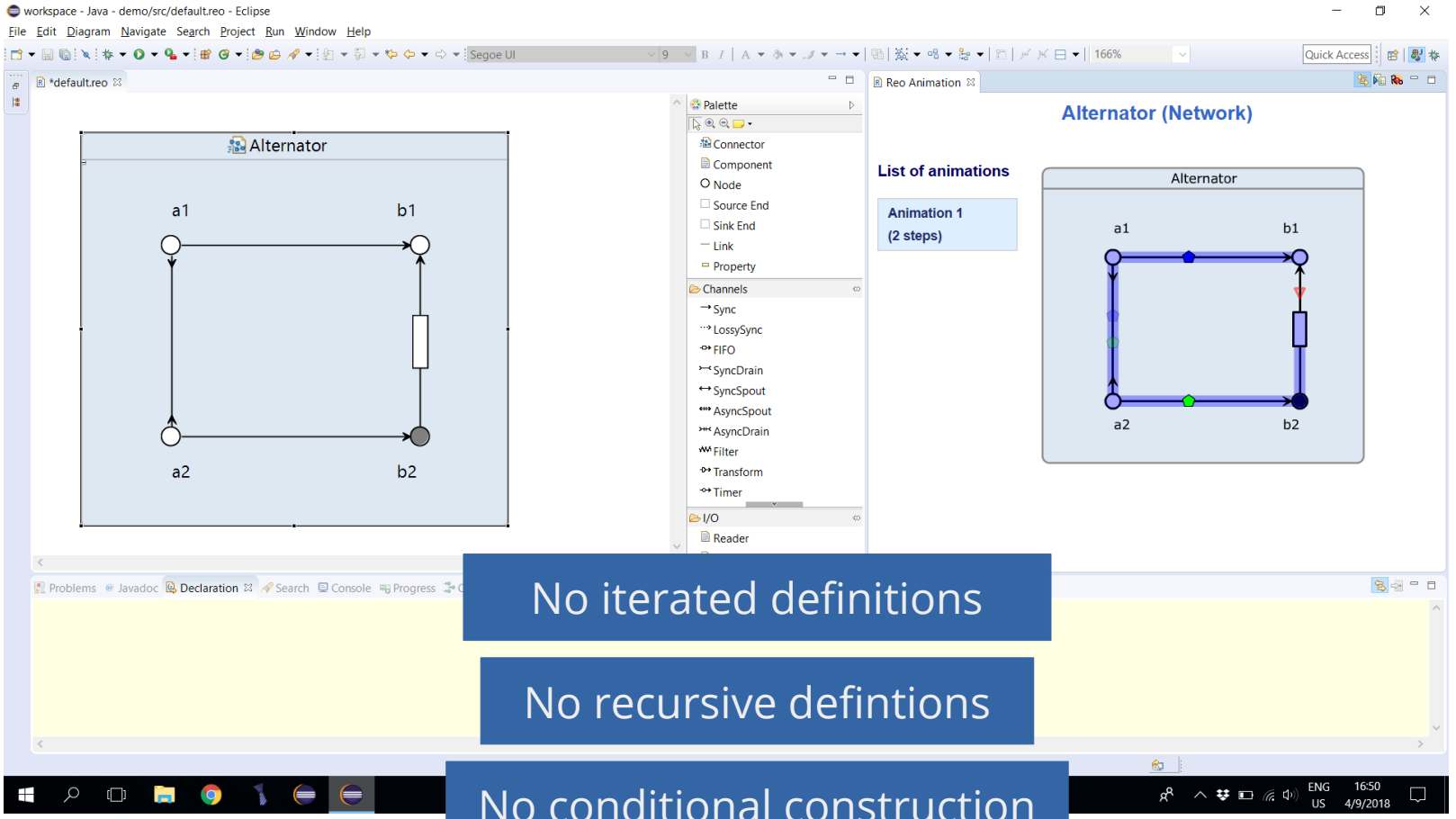


Reo

	A Sync channel accepts datum from its source end a, when its simultaneous offer of this datum at its sink end b succeeds.
	A SyncDrain channel simultaneously accepts data from both its source ends a and b and loses the data.
	An empty FIFO_1 accepts data from its source end a and becomes a full FIFO_1. A full FIFO_1 offers its stored data at its sink end b and, when its offer succeeds, it becomes an empty FIFO_1 again.
	A Reo node accepts a datum from one of its coincident sink ends (a or c), when its simultaneous offer to dispense a copy of this datum through every one of its coincident source ends (b and d) succeeds.

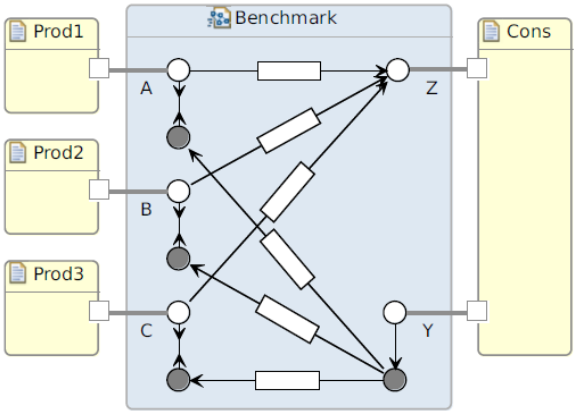


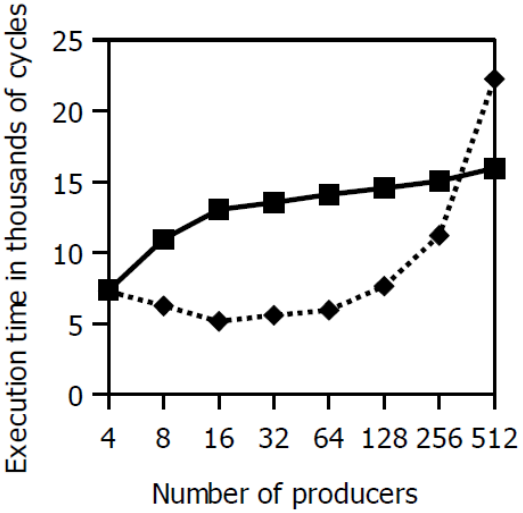
Graphical editor (ECT)



FOCAML

Used by Jongmans for a Reo compiler



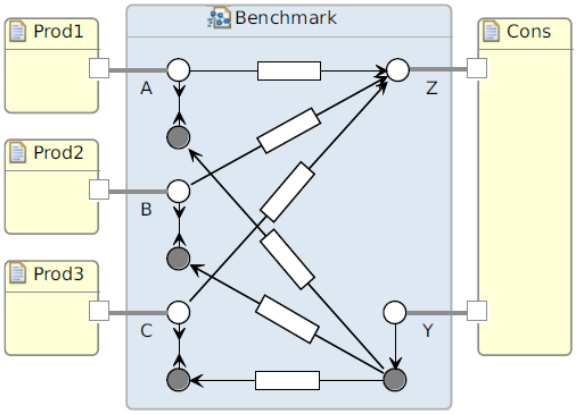


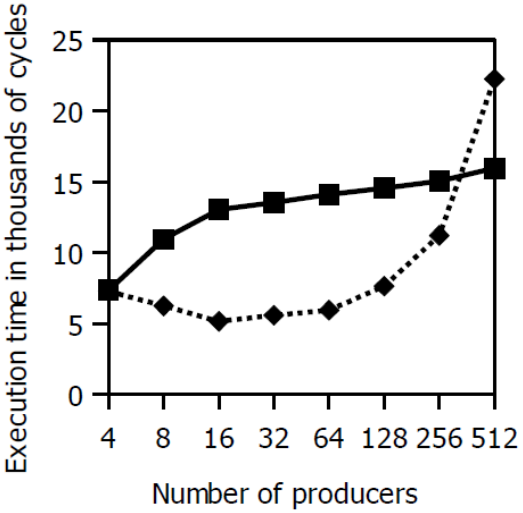
Source: Jongmans, S. S. T., Halle, S., & Arbab, F. (2014). Automata-based optimization of interaction protocols for scalable multicore platforms. Proc. of COORDINATION (pp. 65-82). Springer, Berlin, Heidelberg.

Primitive components are **constraint automata**.

FOCAML

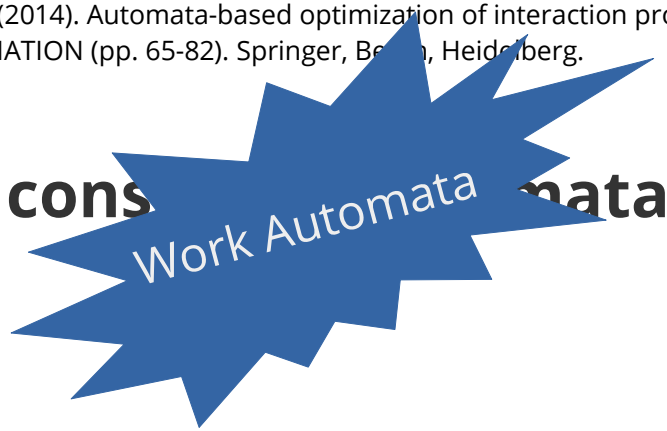
Used by Jongmans for a Reo compiler





Source: Jongmans, S. S. T., Halle, S., & Arbab, F. (2014). Automata-based optimization of interaction protocols for scalable multicore platforms. Proc. of COORDINATION (pp. 65-82). Springer, Berlin, Heidelberg.

Primitive components are **constraint automata**.



Why Treo

“users/devs usually enrich the input language for driving the code generator. **Avoid** the burden of **changing** the **core grammar** as this is very often **overkill**.”

developer reference BIP2-compiler

Why Treo

"users/devs usually enrich the input language for driving the code generator. **Avoid** the burden of **changing** the **core grammar** as this is very often **overkill**."

developer reference BIP2-compiler

We need a stable core grammar.

***Treo** is a language for **compositional** construction of **systems** from user-defined primitives.*

Structure of Treo code

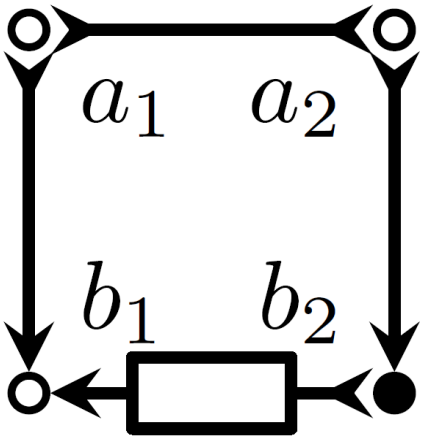
```
import syncdrain;
import sync;

fifo1(a?,b!) {
    empty -{a},true-> full;
    full -{b},true-> empty;
}

alternator2(a1,a2,b1) {
    sync(a1,b1)
    syncdrain(a1,a2)
    sync(a2,b2)
    fifo1(b2,b1)
}
```

Imports

Primitive component
(in user-defined syntax)

Composite
component

Writes to b1



User-defined primitives

```
myPrimitive1(a?,b!) {
    b’(t) = x(t) * b(t)^2
    x’(t) = a(t)
}

myPrimitive2(a?,b!) {
    empty -{a},true-> full;
    full -{b},true-> empty;
}

myPrimitive3(a?,b!) {
    “com.example.MyJavaClass”
}

myPrimitive4(a?,b!) { ... }
```

Component type:
systems of differential equations

Labeled transition systems

Source files

Generic component type T

User-defined primitives

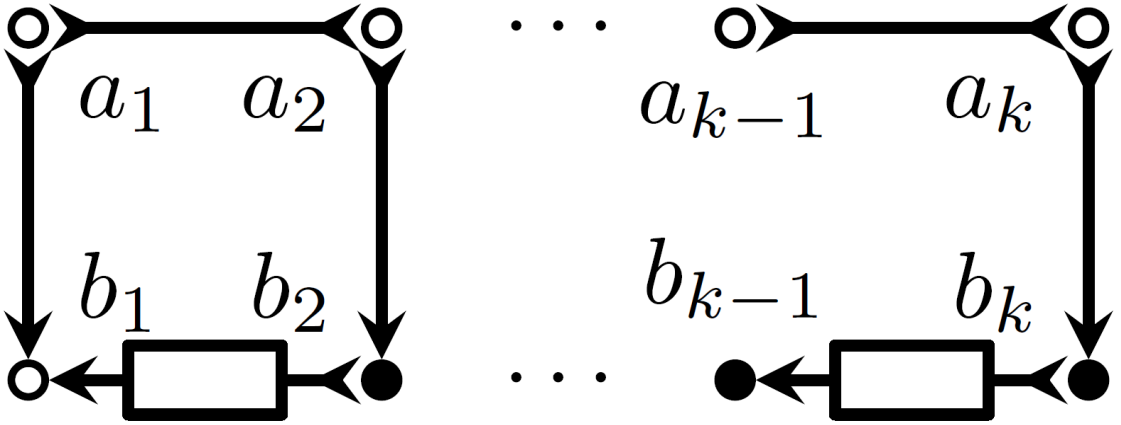
Definition (informal):

A *component type* is a **collection** of composable component **instances** with interfaces

Examples:

- All systems of differential equations
- All Petri-nets (with suitable composition)
- All temporal formulas (TLA+)
- ...

Parameters and iteration




```
import syncdrain;
import sync;
import fifo1;

alternator<k>(a[1:k],b[1]) {
    sync(a[1],b[1])
    {   syncdrain(a[i-1],a[i])
        sync(a[i],b[i])
        fifo1(b[i],b[i-1]) | i in [2..k] }
}
```

Parametrized definitions

Variable number of nodes in interface

Iteration via set comprehension (if-then-else & for-loops are syntactic sugar)

Enriched parameter passing

Definition passing

```
import myDef;

pattern1<C>() {
    C(a,b)
}

main1() {
    pattern<myDef>()
    pattern<myDef>()
}
```

Instance passing

```
import myDef;

pattern2<C>() {
    C
}

main2() {
    pattern<myInst>()
    pattern<myInst>()
|
    myInst = myDef(a,b)
}
```

Recursion

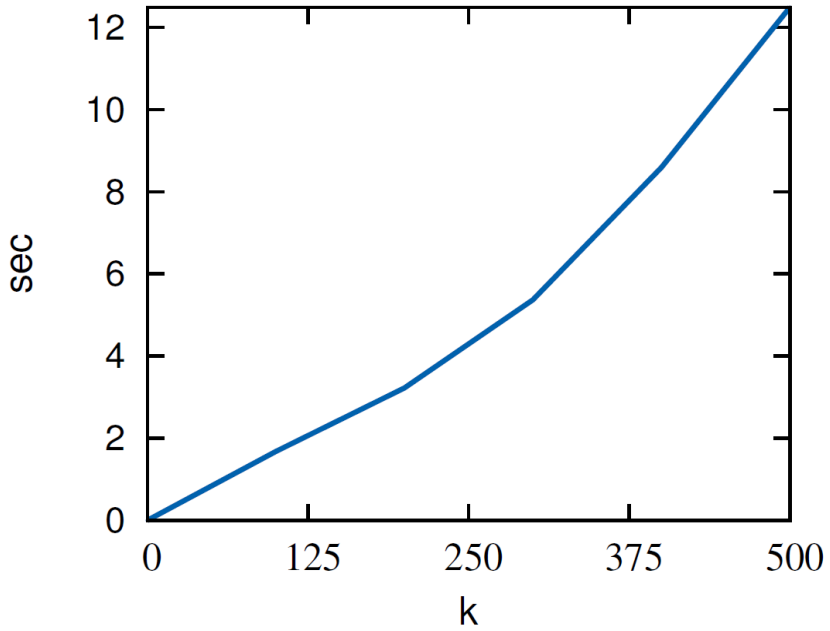
```
import fifo1;
import sync;

buffer<k>(a,b) {
    if (k > 0) {
        buffer<k-1>(a,x)
        fifo1(x,b)
    } else {
        sync(a,b)
    }
}
```

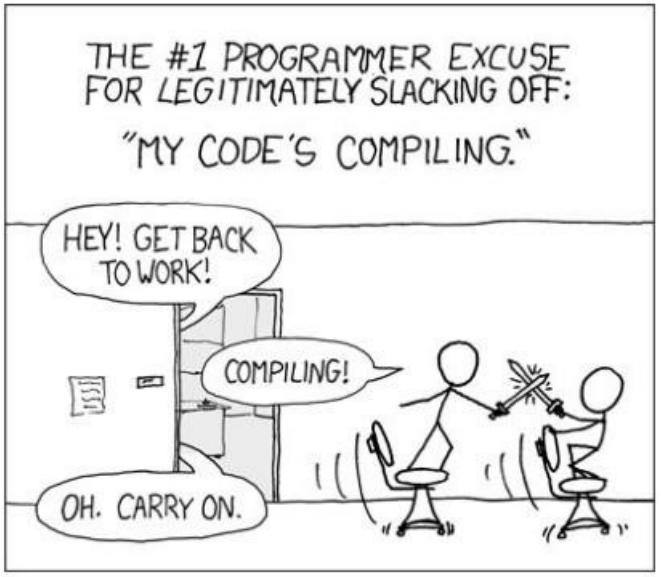
Recursion is syntactically allowed, but the current semantics does not yet support this feature.

The current implementation already supports bounded recursion.

Applications

We use Treo in ongoing work on a Reo compiler





`alternator<500>()` has **1.6*10^150 states** and compiles in **12 sec.**

Conclusion

- Treo = composition
- User-defined primitives → use your favorite type!
- Iteration, recursion, enriched parameter passing

- Future work
  - Semantics of **recursive** definitions & instance **identities**.
  - Dynamic reconfiguration
  - Implement BIP to Reo translator

Kasper Dokter, Sung-Shik T. Q. Jongmans, Farhad Arbab, Simon Bliudze: Combine and conquer: Relating BIP and Reo. J. Log. Algebr. Meth. Program. 86(1): 134-156 (2017)