

# 2P-KT: logic programming with objects & functions in Kotlin

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21<sup>st</sup> Workshop “From Objects to Agents” (WOA)  
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# Next in Line...

- 1 Motivation & Context
- 2 Kotlin DSL for Prolog
- 3 Behind the scenes
- 4 Conclusions & future works



# Context

## AI side

- AI is shining, brighter than ever
  - mostly thanks to the advances in ML and sub-symbolic AI
- ⇒ symbolic AI is gaining momentum because of XAI
  - ! hybrid solution mixing logic & data-driven AI are flourishing [3]

## MAS side

The MAS community is eager for logic-based technologies [2]

- to support agents' knowledge representation, reasoning, or execution
- or to prove MAS properties
- ! despite few mature tech exist, and even fewer are actively maintained

# Motivation

## The problem with logic-based technologies

There is technological barrier slowing

- the adoption of logic programming (LP) as paradigm
- the exploitation of logic-based technologies

while programming *in the large*

*e.g. Scala, Kotlin, Python, C#*

- mainstream programming languages are blending several paradigms  
*e.g.* imperative, object-oriented (OOP), and functional programming (FP)
  - except LP!
- mainstream platforms are poorly interoperable with logic-based tech.  
*e.g. JVM, .NET, JS, Python*

# Motivating example – SWI-Prolog's FLI for Java

- Prolog [4] implementors rely on Foreign Language Interfaces (FLI) [1]
  - (mostly targetting Java, or C)
- For instance, SWI-Prolog comes with a FLI for Java<sup>1</sup>:

---

```
Query query = new Query("parent", new Term[] {
    new Atom("adam"),
    new Variable("X")
});
// ?- parent(adam, X).
Map<String,Term> solution = query.oneSolution();
System.out.println("The child of Adam is " + solution.get("X"));
```

---

→ No paradigm harmonization between Prolog and the hosting language

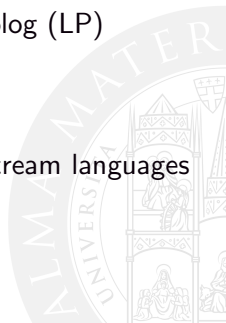
*i.e. Java*

---

<sup>1</sup><https://jpl7.org>

# Contribution of the paper

- Show that OOP, FP, and LP can be blended into a single language
- Propose a DSL blending Kotlin (OOP + FP) and Prolog (LP)
- Pave the way to the creation of similar DSL in mainstream languages



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# Focus on. . .

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  - **Overview**
  - Principles
  - Functioning
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# Whet your appetite

## Our Kotlin DSL for Prolog vs. actual Prolog

---

```

prolog {
    staticKb(
        rule {
            "ancestor"(X, Y) `if` "parent"(X, Y)           // ancestor(X, Y) :- parent(X, Y).
        },
        rule {
            "ancestor"(X, Y) `if` (
                "parent"(X, Z) and "ancestor"(Z, Y)         // ancestor(X, Y) :-
                                                            // parent(X, Z), ancestor(Z, Y).
            )
        },
        fact { "parent"("abraham", "isaac") },           // parent(abraham, isaac).
        fact { "parent"("isaac", "jacob") },              // parent(isaac, jacob).
        fact { "parent"("jacob", "joseph") }              // parent(jacob, joseph).
    )

    for (sol in solve("ancestor"("abraham", D)))         // ?- ancestor(abraham, D),
        if (sol is Solution.Yes)                          // write(D), nl.
            println(sol.substitution[D])
    }

```

---

! try it here: <https://github.com/tuProlog/prolog-dsl-example>

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# Design Principles

**P<sub>1</sub>** – The DSL **strictly extends** the hosting language

→ no feature of the hosting language is forbidden within the DSL

**P<sub>2</sub>** – The DSL is **interoperable** with hosting language

→ all features of the hosting language are allowed within the DSL

→ LP is *harmonised* with the hosting language paradigm(s)

**P<sub>3</sub>** – The DSL is **well encapsulated** within the hosting language

→ i.e. only usable within well-identifiable sections

**P<sub>4</sub>** – The DSL is **as close as possible** to Prolog

→ both syntactically & semantically

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# Functioning in the Kotlin case I

The DSL is only enabled within `prolog {  $\langle DSL\ block \rangle$  }` expressions

Expressions of the form: `"functor"( $\langle e_1 \rangle$ ,  $\langle e_2 \rangle$ , ...)`

are interpreted as terms: `functor( $t_1$ ,  $t_2$ , ...)`

provided that  $\forall i : \langle e_i \rangle$  can be converted into  $t_i$

Expressions of the form:

`rule { "head"( $\langle e_1 \rangle$ , ...,  $\langle e_N \rangle$ ) `if` ( $\langle e_{N+1} \rangle$  and ... and  $\langle e_M \rangle$ ) }`

are interpreted as rules: `head( $t_1$ , ...,  $t_N$ ) :-  $t_{N+1}$ , ...,  $t_M$`

provided that  $\forall i : \langle e_i \rangle$  can be converted into  $t_i$

- similar syntax for facts

# Functioning in the Kotlin case II

## Within `prolog { ... }` blocks

- `staticKb(Clause1, Clause2, ...)` sets up the local **static** KB
- `dynamicKb(Clause1, Clause2, ...)` sets up the local **dynamic** KB
- `solve(Query, Timeout)` returns a *lazy stream* of solutions
- `assert(Clause)` appends a new clause to the local **dynamic** KB
- ...



# Kotlin to Prolog conversions

Kotlin	Prolog
lowercase string	atom
uppercase string	variable
int, long, short, byte	integer
double, float	real
boolean	atom
list, array, iterable	list



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# Recipe for a Prolog-like DSL

- ① A language with a flexible API
- ② Full fledged API for Prolog, supporting that language
- ③ Exploit flexibility to hide the exploitation of the API



# Kotlin mechanisms

- ➊ Operator overloading
- ➋ Block-like lambda expressions
- ➌ Function types/literals with receivers
- ➍ Extension methods



# 2P-KT – Overview

- ➊ Operator overloading
- ➋ Block-like lambda expressions
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# DSL design on top of 2P-KT

- 1 Onion scopes
- 2 Layered views



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# Conclusions & future works

## Summing up

Summarise the most relevant contributions of this study:

- conclusion 1
- conclusion 2
- conclusion 3

## Future works

Sketch some future research directions

- future work 1
- future work 2

(may be split into 2 slides)

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