A flexible Prolog interpreter in Python

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Outline

Pyrolog

- Pyrolog is a Prolog interpreter written in RPython
- RPython (“Restricted Python”) is a subset of Python translatable to other languages
- RPython is designed to be significantly faster than regular Python
- translation part done with the help of the PyPy project

What is PyPy?

- started as a Python VM implementation in Python
- Python itself is too dynamic to translatable to other languages, need a subset
- includes a translation tool-chain for RPython
- is becoming a general environment for writing interpreters (JavaScript, Prolog started)
- Open Source project (MIT license)
- received EU funding for 2.5 years

VMs are still hard

Hard to reconcile:

- flexibility
- maintainability
- performance (needs dynamic compilation techniques)

Especially with limited resources (like Open Source projects, research projects)

The Python case (i)

CPython (the reference implementation) is a straightforward, portable VM.

- Pervasive decisions: reference counting, global lock ...
- No dynamic compilation

Extensions:

- Stackless (unlimited recursion, coroutines, serializable continuations)
- Psyco (run-time specializer)
- Jython, IronPython

The Python case (ii)

Problems of Extensions:

- hard to maintain: need to keep track of CPython
- Psyco very hard to port to other hardware architectures
- tedious to write them, Python semantics need to be re-implemented

- The community wants Python to run everywhere: Jython (Java), IronPython (.NET). Lots of effort and duplication.
- At various points various incompatibilities between the implementations

The Prolog case (i)

- problem mitigated by the fact that Prolog the language does not change
- the core of Prolog is very simple (at least compared to Python)
- a lot of implementations out there
- well-tuned mature C implementations (Sicstus, XSB, SWI, GNU-Prolog)
- on CLR (P#) and JVM (Prolog Café, tuProlog)

The Prolog case (ii)

mature C implementations

- interfacing with libraries is tedious
- changing the language to experiment is hard
- often extensions to core Prolog, incompatible between each other
- fixed implementation decisions (GC, how to generate code, etc.)

implementations on CLR and JVM

- interfacing with libraries of the platform mostly easy
- no extensions to core Prolog (like tabling, coroutines)
- slow, compared to good C implementations

PyPy's Approach

Goal: generate VMs from a single high-level description of the language, in a retargettable way.

- Write an interpreter for a dynamic language (Python, Prolog, JavaScript, whatever) in a high-level language (Python)
- Leave out low-level details
- Favour simplicity and flexibility
- Define a mapping to low-level targets
- Generate VMs from the interpreter

Mapping to low-level targets

- Mechanically translate the interpreter to multiple lower-level targets
  - C-like
  - Java
  - .NET
- Insert low-level aspects into the code as required by the target (Object layout, memory management)
  - object layout
  - memory management
- Optionally insert new pervasive features not expressed in the source
  - continuations, “micro-threads”
  - dynamic compilation

Translation Aspects (i)

Features not present in the source can be added during translation.

- memory management: use different GC strategies (Boehm collector, custom mark-n-sweep)
- Stackless transformation: allows program to control its stack (continuations, . . .)

Translation Aspects (ii)

A JIT compiler as a translation aspect

- Transform the interpreter into a JIT compiler, using partial evaluation and specialization techniques
- Some hints in the interpreter source needed
- Current prototype applied to Python interpreter gives impressive speedups

Prolog Interpreter Implementation

- naive, very simple interpreter
  - uses "structure copying"
  - interprets Prolog terms directly, no bytecode
- uses continuation passing style inspired by BinProlog
- Prolog calls mapped to RPython calls
- implements large parts of the ISO standard (some builtins missing)

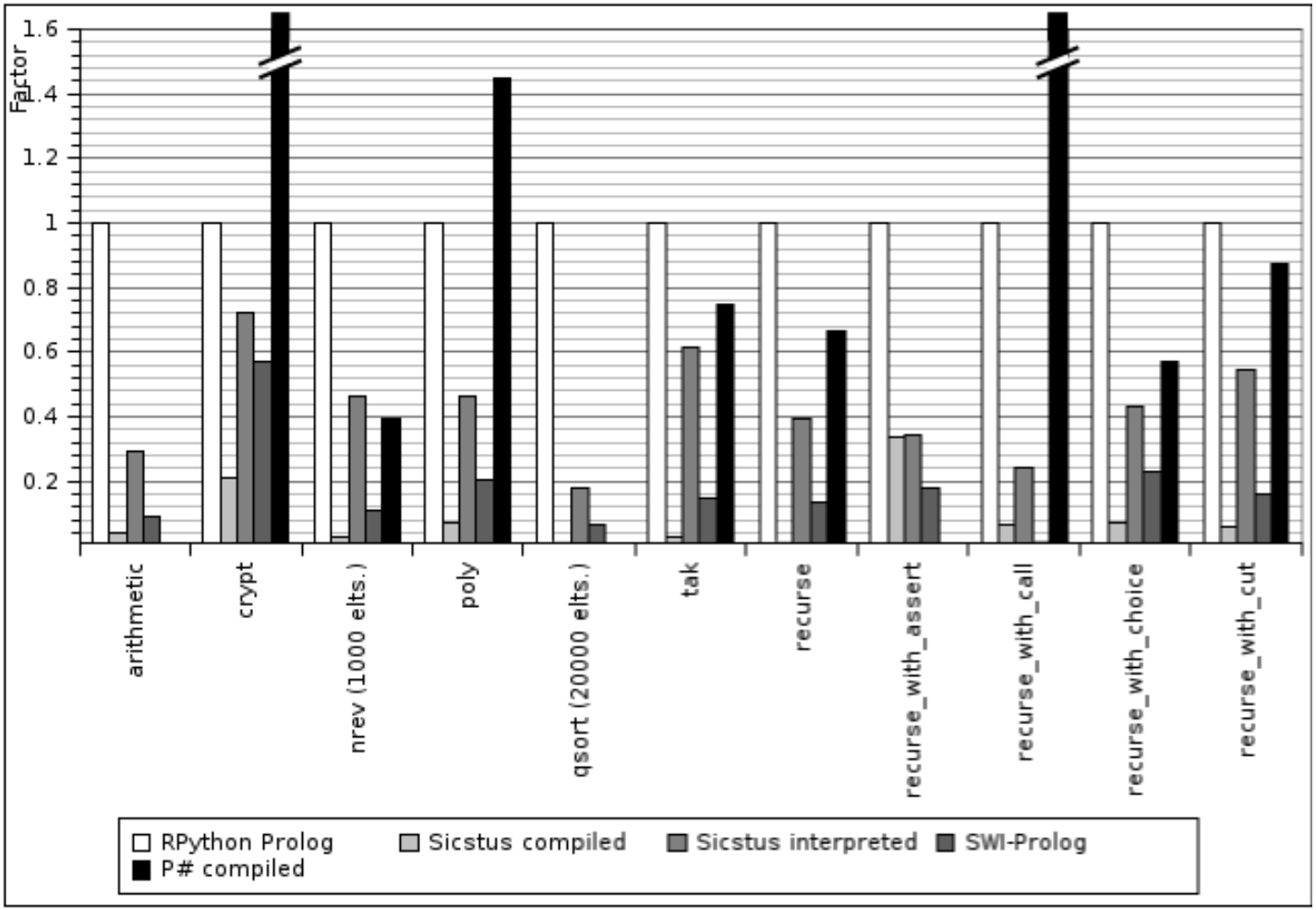
Builtins

- builtins implemented in Python
- easy to add new ones to interface with libraries
- application-specific builtins
- examples:
  - functions to download and analyze webpages
  - an imperative hashmap

Interpreter Facts

- 2500 lines of Python code in total
- 700 of those are for builtins
- after translation to C: 14000 line of C code
- part of the PyPy distribution at:
  `http://codespeak.net/pypy`

Performance (i)



Performance (ii)

- performance is quite bad compared to tuned C implementations
- performance is pretty good compared to Java and .NET implementations
- surprising, since those are often based on the WAM
- maybe the WAM model does not match these VMs very well?

Summary

- Very simple Prolog interpreter in RPython can compete with interpreters on the JVM, CLR
- Interpreter implementation eased by use of a high-level language
- Low-level details abstracted away but re-inserted later

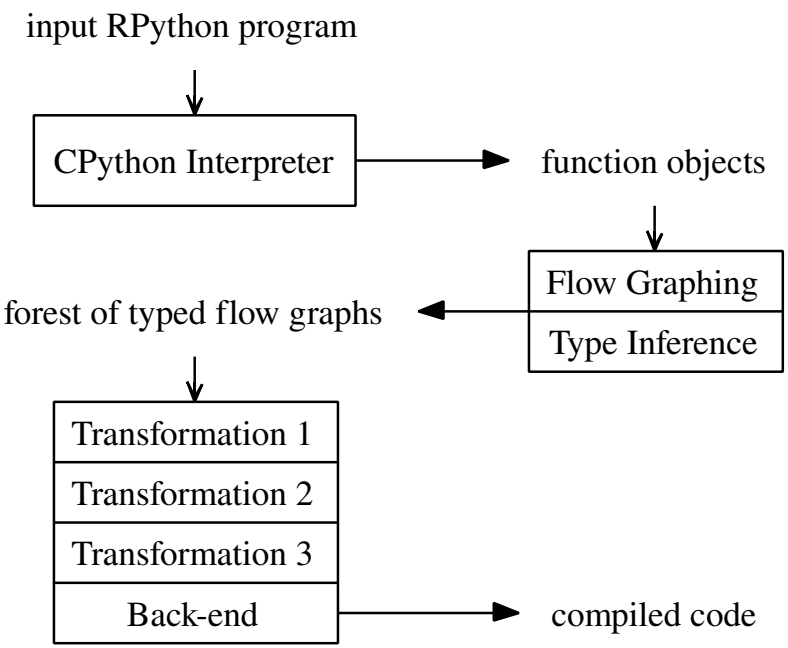
Outlook

- complete the set of builtins
- tight language integration between Prolog and Python
- apply the dynamic compiler generator to the Prolog interpreter

Backup slides

. . .

Translation Steps



- Generate flow graphs from the RPython program
- Peform global type inference on the flow graphs
- Transform flow graphs through several steps until they match the level of the target environment
- Weave in translation aspects in the process

Title