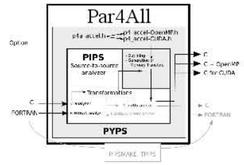
# PyPS a programmable pass manager

Serge Guelton, Mehdi Amini, Ronan Keryell, Béatrice Creusillet

# PyPS
# a programmable pass manager

PIPS4U
http://www.pips4u.org/

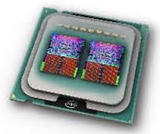


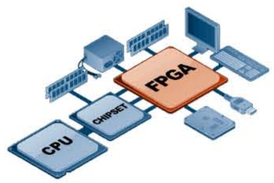

## 1 - Complex Environment

NVIDIA CUDA

OpenCL

Parallel and heterogenous hardware
Compilers must be multi-target.
collaborate, and be specialized.






OpenMP

## 2 - Source-to-Source

Many source-to-source successful compilers.
Flexible transformation systems for heterogeneous computing :
→ parallelism detection algorithm,
→ variable privatization,
→ communication generation,
→ etc.


## 3 - Model for Code Transformations

A code transformation is an application P → P that preserves the semantics of the program, that is to say:

$$\forall p \in \mathcal{P},\ \forall v_{in} \in \mathcal{V}_{in}(p), \quad \mathbf{P}(p, v_{in}) = \mathbf{P}(t(p), v_{in})$$

Sequencing of code transformations is the compiler core.
Formal point of view for interactions between passes : several transformation composition rules.

A failsafe operator :

$$\forall t \in \mathcal{T},\ \forall p \in \mathcal{P}, \quad \tilde{t}(p) = \begin{cases} t(p) & \text{if } t(p) \neq \text{error} \\ p & \text{otherwise} \end{cases}$$

A failsafe composition:

$$\forall t_0, t_1 \in \mathcal{T} \times \mathcal{T}, \quad t_1 \tilde{\circ} t_0 = \tilde{t_1} \circ \tilde{t_0}$$

A conditional composition:

$$\forall t_0, t_1, t_2 \in \mathcal{T}\times\mathcal{T}\times\mathcal{T},\ \forall p \in \mathcal{P} \quad ((t_1, t_2) \underset{\sim}{\circ} t_0)(p) = \begin{cases} (t_1 \circ t_0)(p) & \text{if } t_0(p) \neq \text{error} \\ t_2(p) & \text{otherwise} \end{cases}$$

An error propagation operator :

$$\forall t_0, t_1 \in \mathcal{T} \times \mathcal{T}, \quad t_1 \vec{\circ} t_0 = (t_1, \mathrm{id}_{\mathcal{T}}) \underset{\sim}{\circ} t_0$$

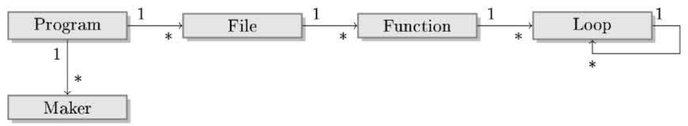
## 4 - Based on a Scripting Language

*on the shoulders of giants* python powered

```
print "Hello, world!"
```

No DSL, does not reinvent the wheel, build over a high level language with a rich ecosystem wich widens the set of possibilities.

## 5 - Abstractions




**Classes**: high level program representation
high level compilation scheme
**Methods**: compose transformations into more complex ones
**Inheritence**: compose scheme for heterogeneous targets

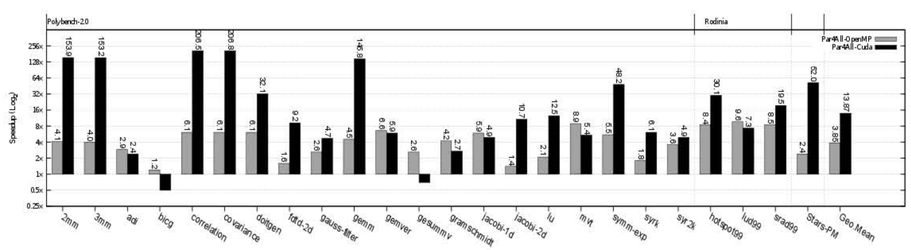
## 6 - Control Structures

**Conditionals**: manage switches, choose different compilation schemes.
**For loops**: iterate over the callgraph, loop nests.
**Exceptions**: recover from compilation failure, impossible transformations, etc.
**While loops**: look for fixed point for sequence of passes.

## 7 - Targets

**OpenMP** ; classic scheme but still illustrating basic functionalities.
**TERAPIX** is a fpga based accelerator for image processing from thales.
**SAC** vectorizer targets AVX, SSE, or NEON.
**An Iterative Compiler** ; try different compilation schemes or transformation flavors.
**Par4All** makes use of other compilers to provide automatic parallelization of applications to multiple hybrid architectures.

P4A
http://www.par4all.org/




### Related Work


**Automated Programmable Control and Parameterization of Compiler Optimizations. Yi. CGO 2011.**
**Finding effective optimization phase sequences. Kulkarni et al. LCTES 2003.**
**MILEPOST GCC: machine learning based research compiler. Fursin et al. GCC Developers' Summit, 2008.**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