Fine-grained Language Composition: A Case Study

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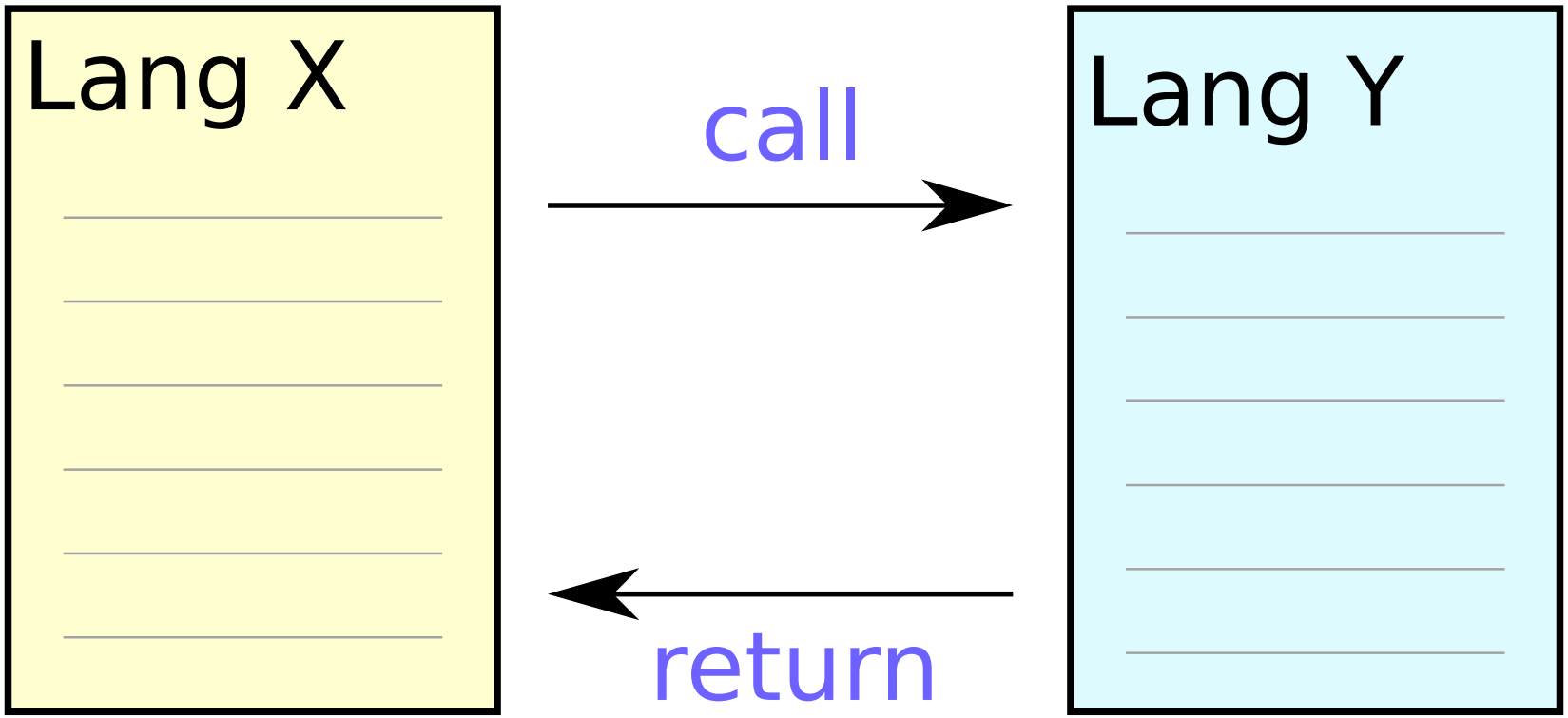
Language Composition

“The ability to write a computer program in a mix of programming languages.”

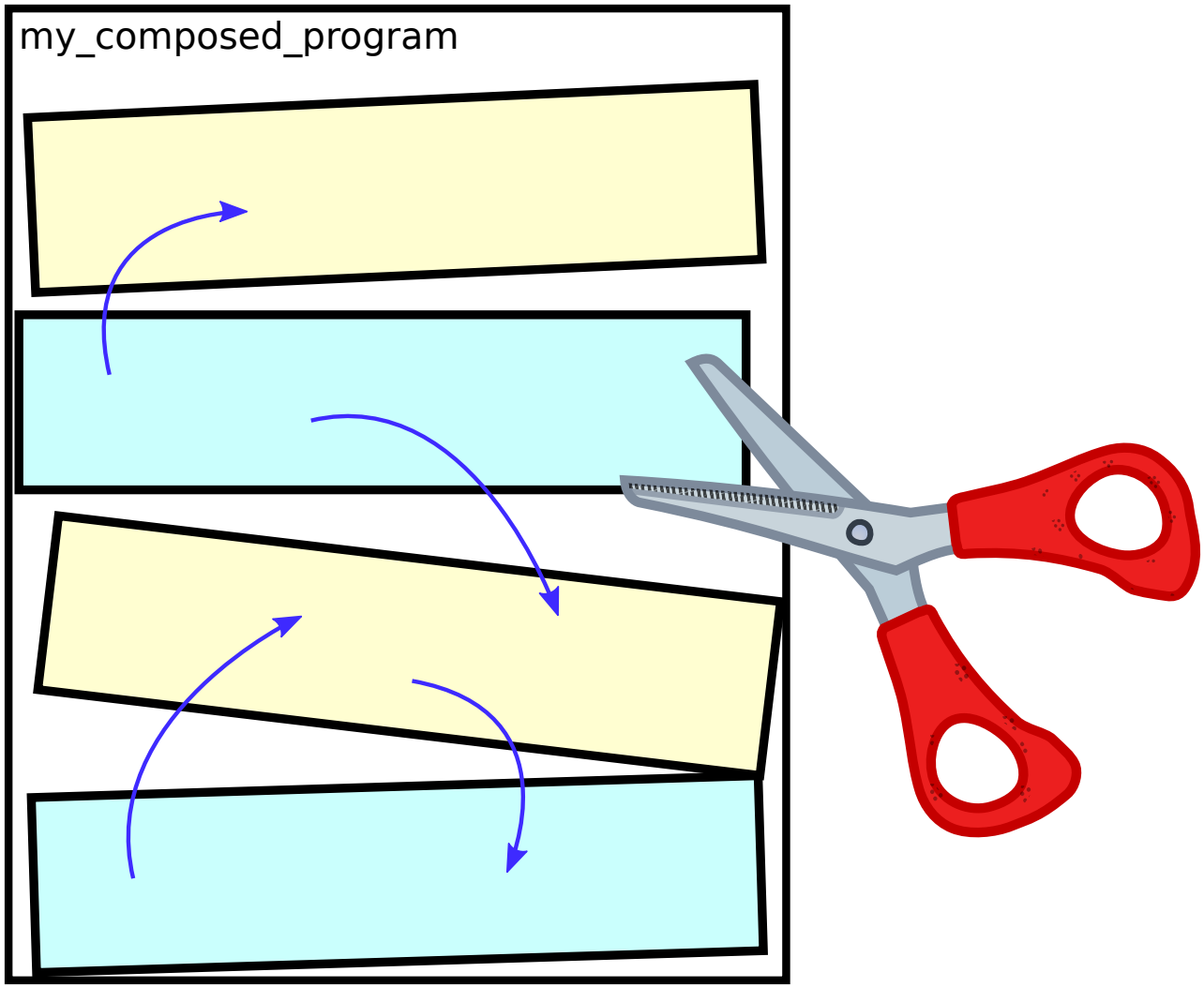
Why Compose Languages?

- Choose the best language for the job.
- Access to a broader set of libraries.
- Language migration.

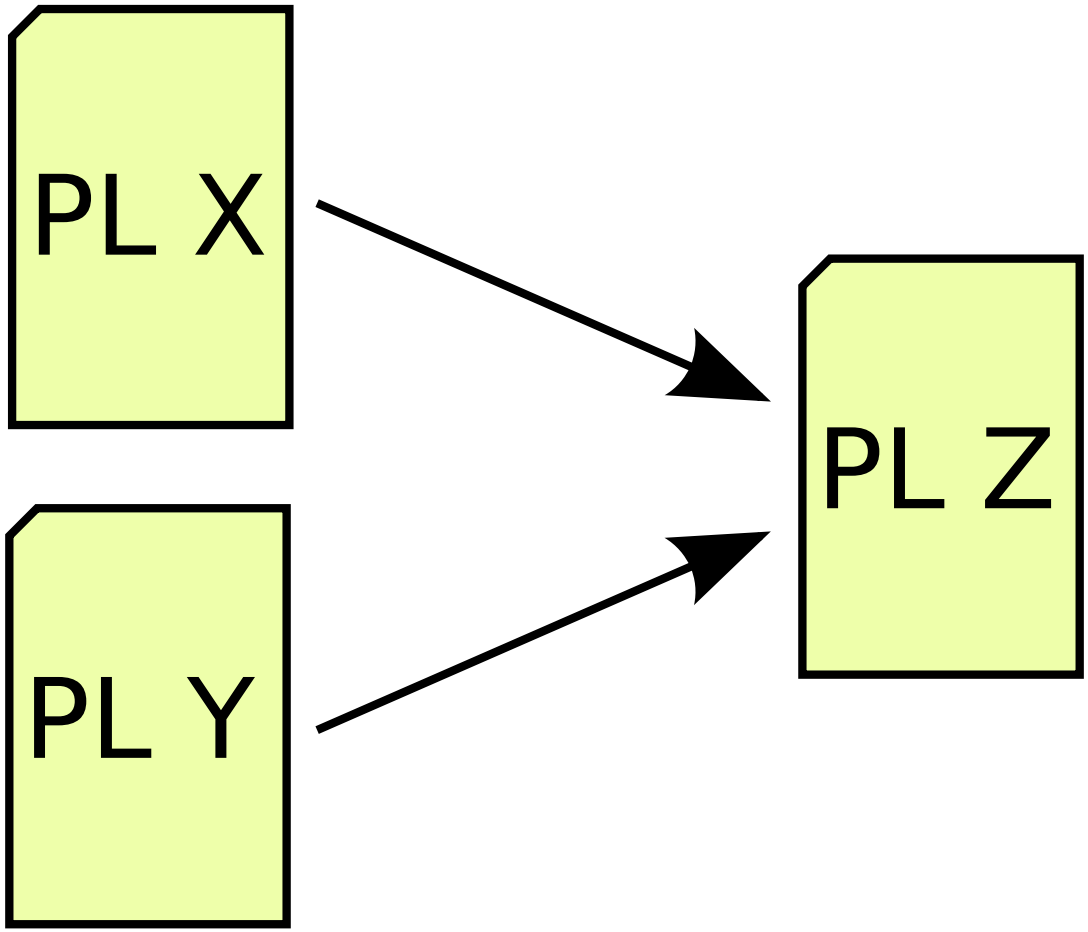
Beyond the FFI



Beyond the FFI



Breaking it Down



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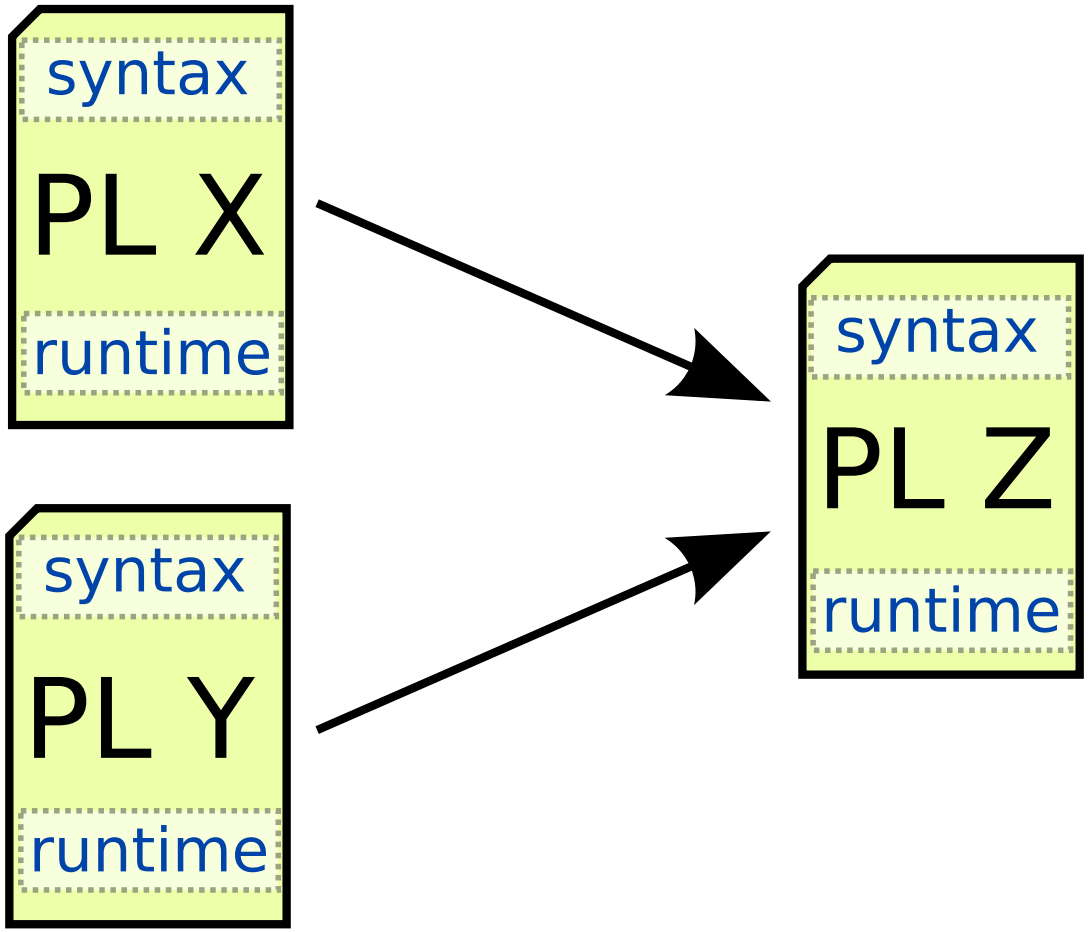
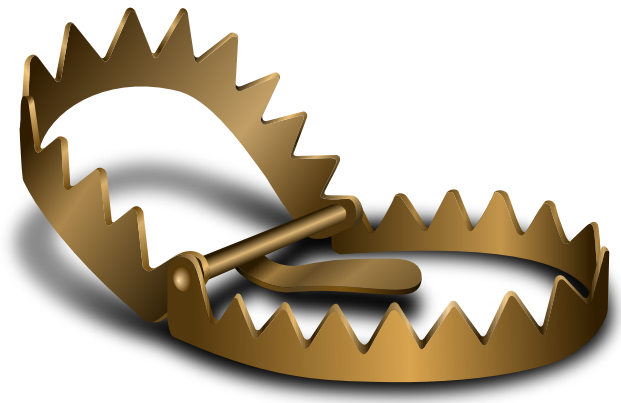


Composing Grammars

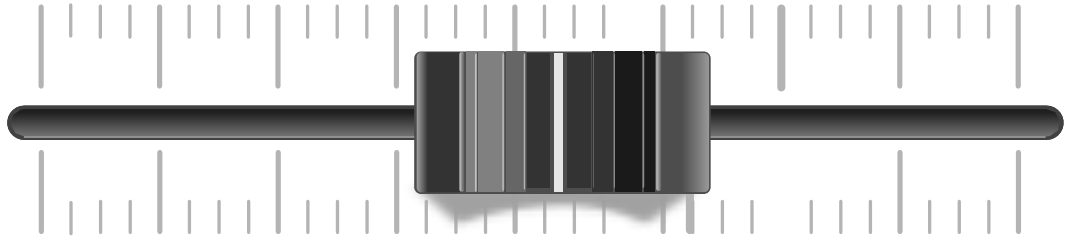
Shadowing Ambiguity Undefined



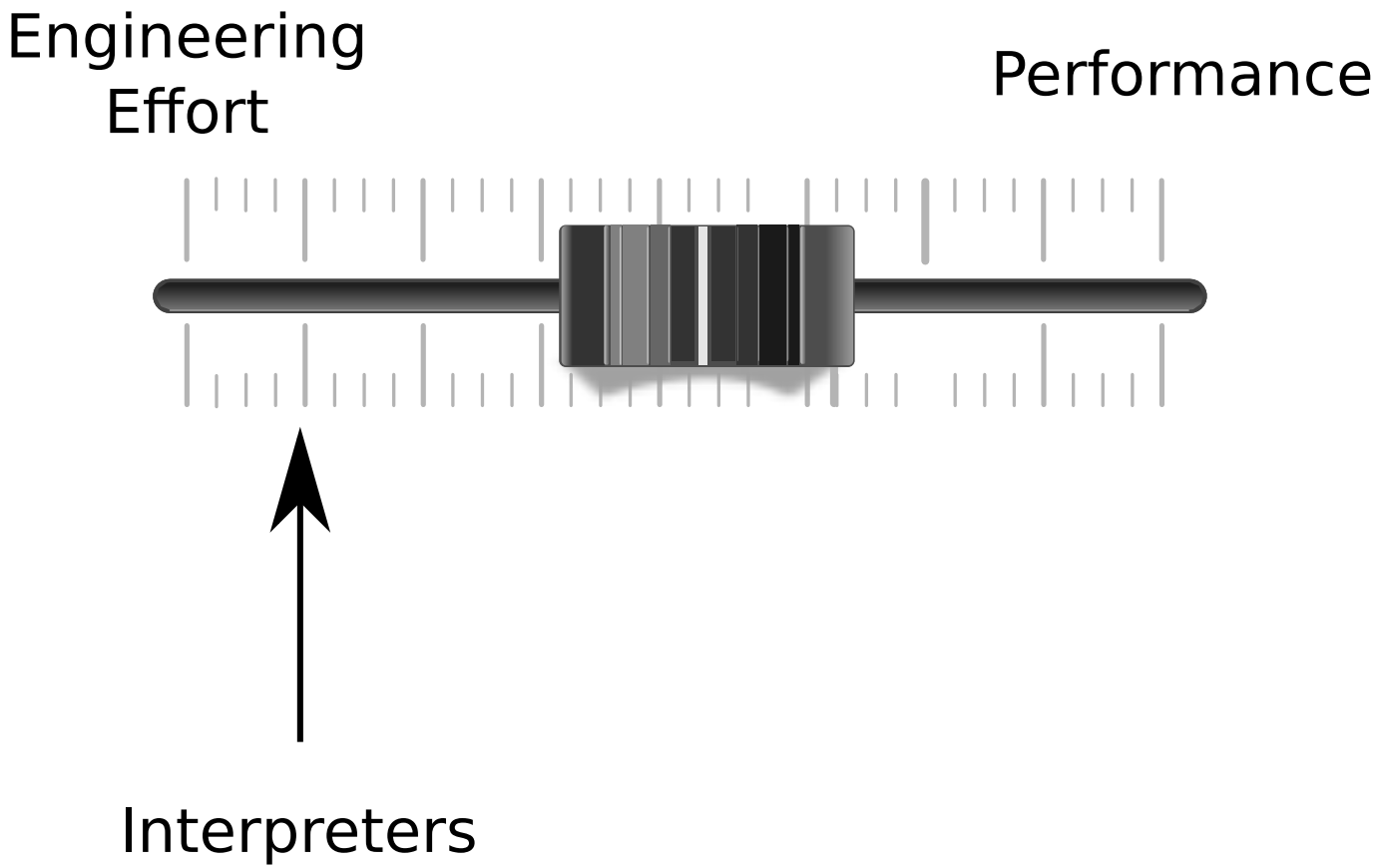
Runtime composition

Engineering Effort

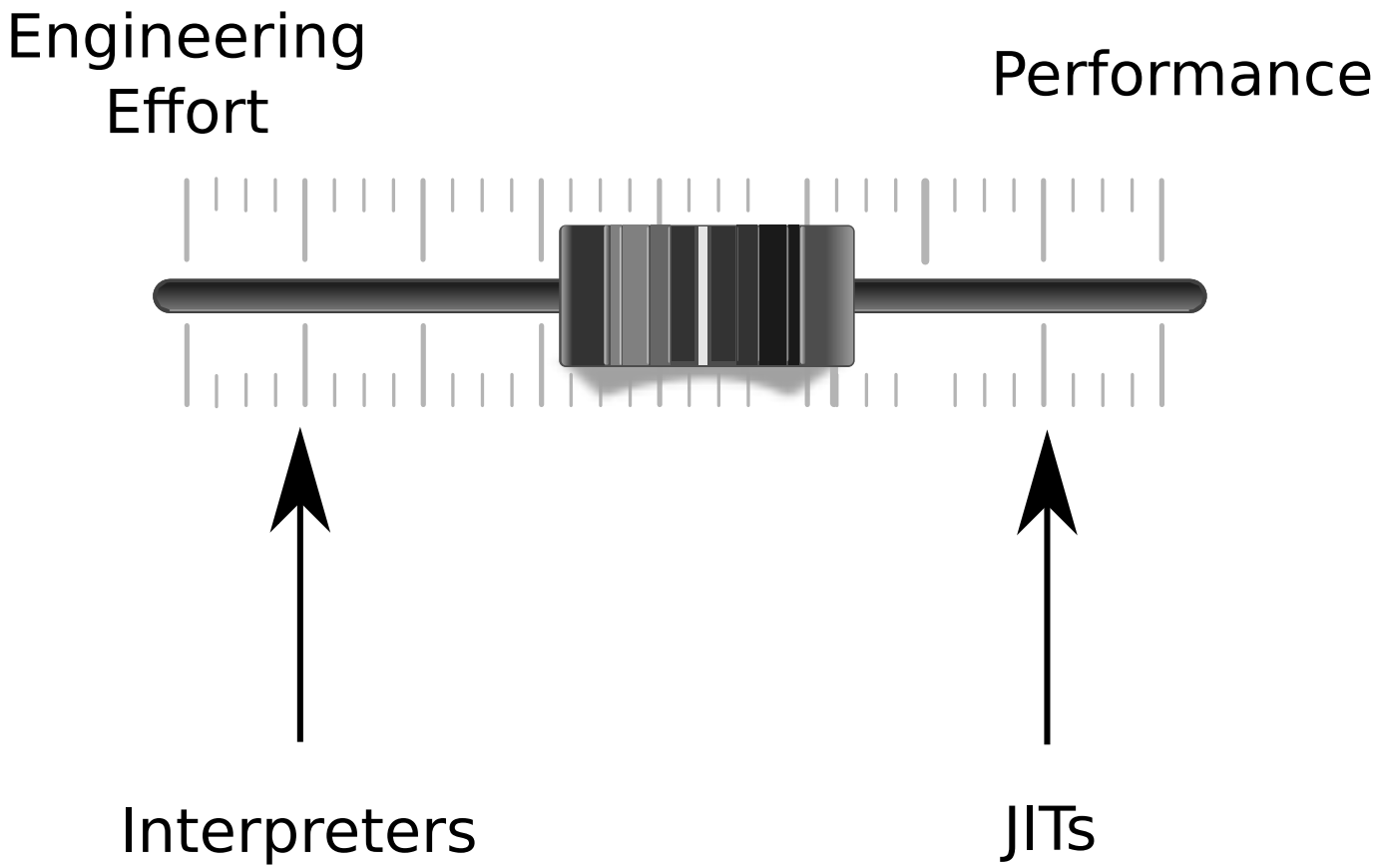
Performance



Runtime composition



Runtime composition



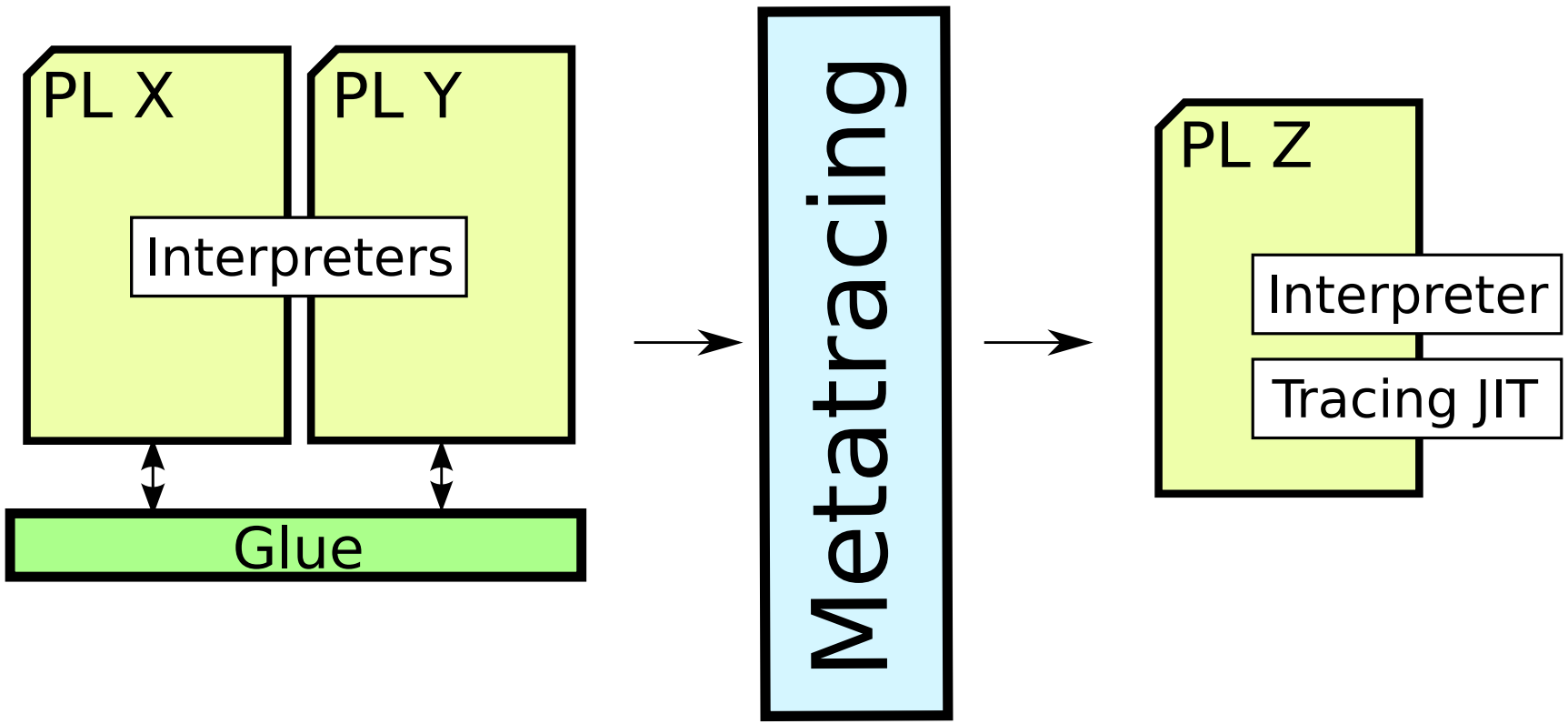
Our Approach

Language Boxes + Meta-tracing

Language Boxes to Compose Syntax

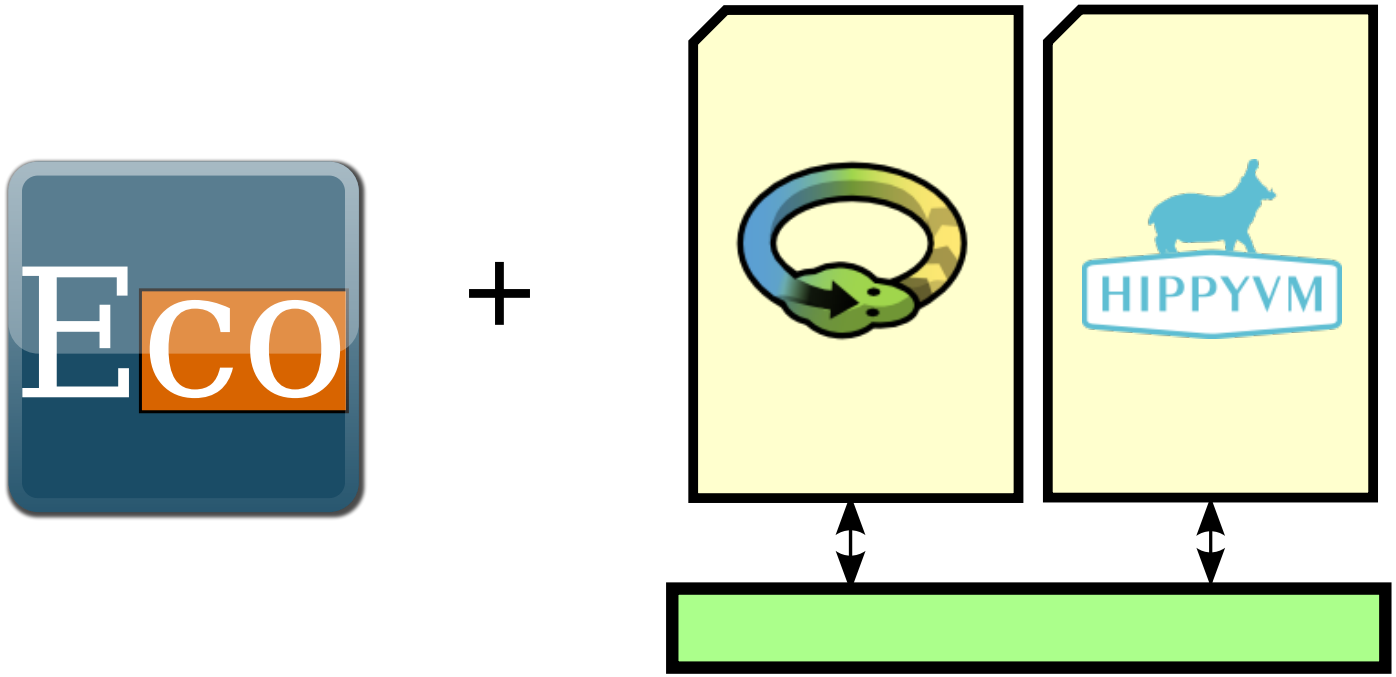
- The best bits from Syntax Directed Editing (SDE)
- Palatable editing experience

Meta-tracing to Compose Runtimes



PyHyp

PHP + Python



Features of PyHyp

- Calling Python functions and methods from PHP
- Calling PHP functions and methods from Python
- Transparent type conversions
- Arbitrary nesting of foreign functions
- Python expressions in PHP
- “Embedding” Python methods inside PHP classes
- Adds support for references to Python
- Cross-language scoping
- Cross-language exceptions

PyHyp Demo

PyHyp Performance

Benchmark	HippyVM	$\text{PyHyp}_{\text{PHP}}$	PyHyp_{Py}	PyPy
instchain	0.912 ±0.0011	1.000		0.675 ±0.0007
l1a0r	1.368 ±0.0004	1.000	1.360 ±0.0003	1.340 ±0.0106
l1a1r	1.306 ±0.0017	1.000	1.303 ±0.0016	1.140 ±0.0022
...				
total_list	0.864 ±0.0002	1.000	1.508 ±0.0004	0.587 ±0.0003
walk_list	0.779 ±0.0011	1.000	1.601 ±0.0026	1.080 ±0.0015
deltablue	4.325 ±0.0212	1.000		0.457 ±0.0026
fannkuch	1.848 ±0.0007	1.000	1.891 ±0.0005	1.005 ±0.0004
mandel	0.921 ±0.0005	1.000	0.999 ±0.0003	
richards	0.853 ±0.0010	1.000		0.488 ±0.0005
Geometric Mean	1.222 ±0.0006	1.000	0.963 ±0.0003	0.813 ±0.0007

Worst case: 2.6x overhead

Qualitative Results

Implementing desired behaviour: relatively easy

Deciding the correct behaviours: hard

“Semantic friction”

Semantic Friction: Collection Types

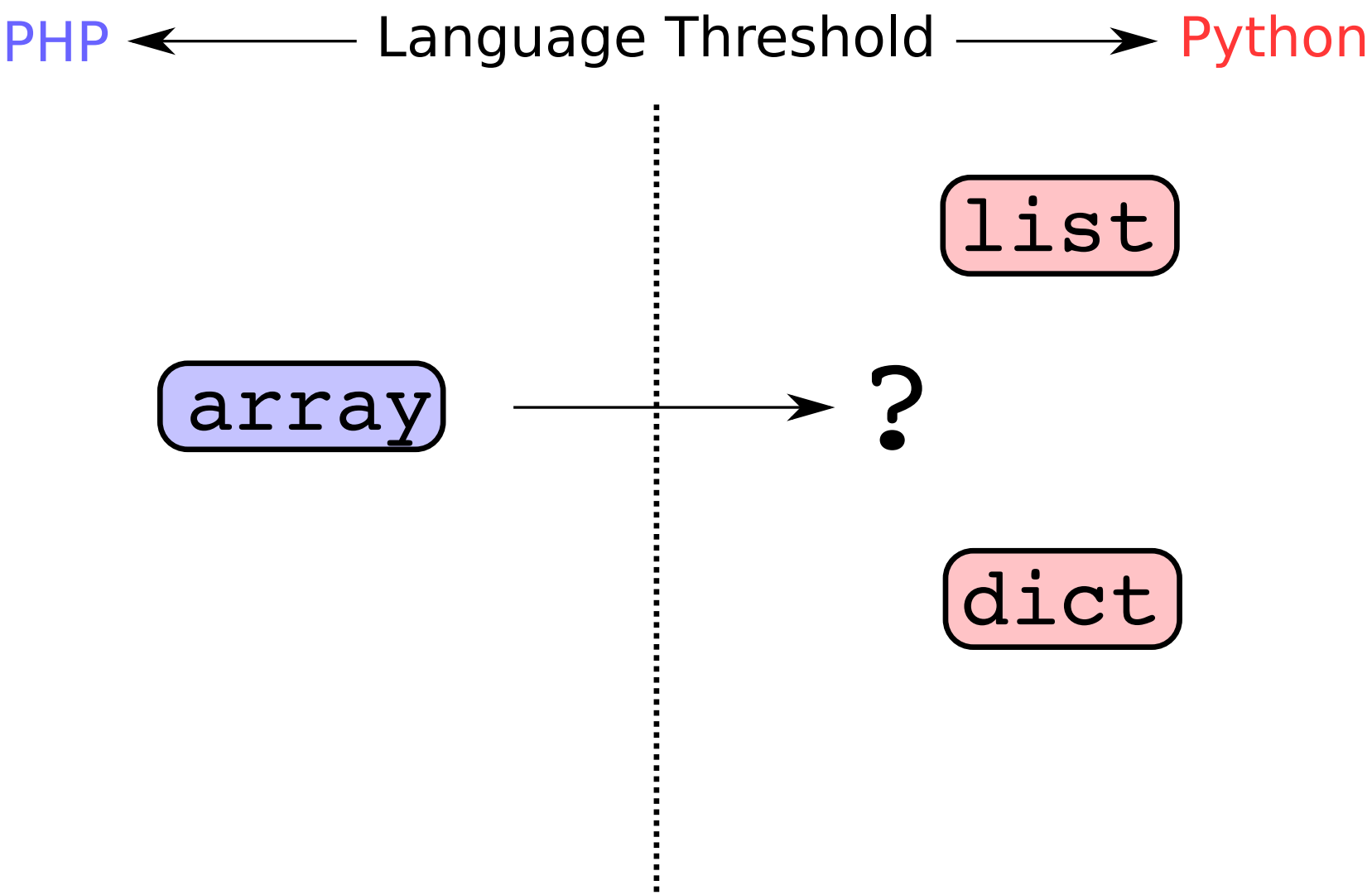
	PHP	Python
Sequence type	`array`	`list`
Mapping type	`array`	`dict`

Semantic Friction: Collection Types

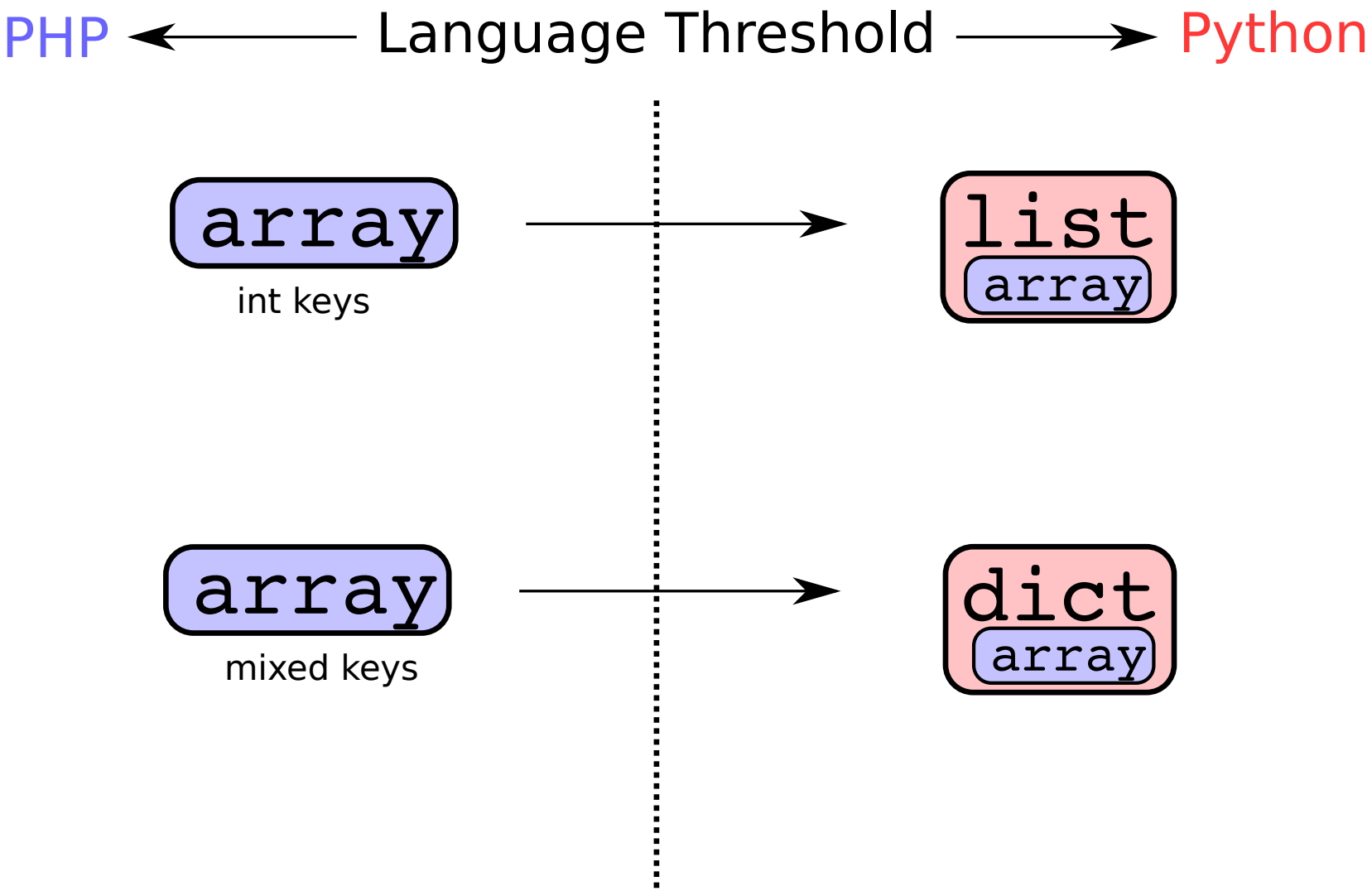
```
["a", "b", "c"]
```

```
Array ([0] => "a", [1] => "b", [2] => "c")
```

Semantic Friction: Collection Types



Semantic Friction: Collection Types



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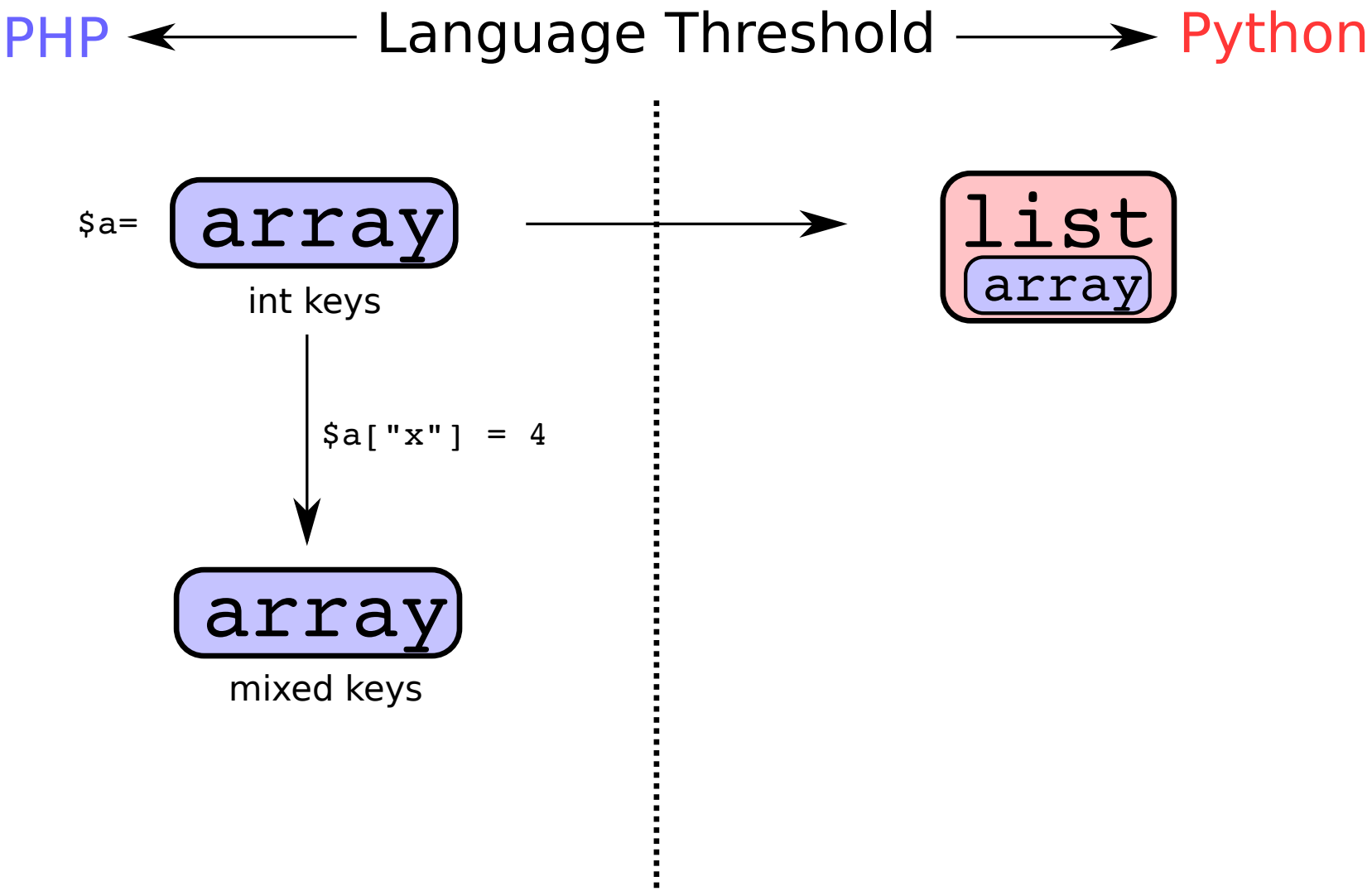

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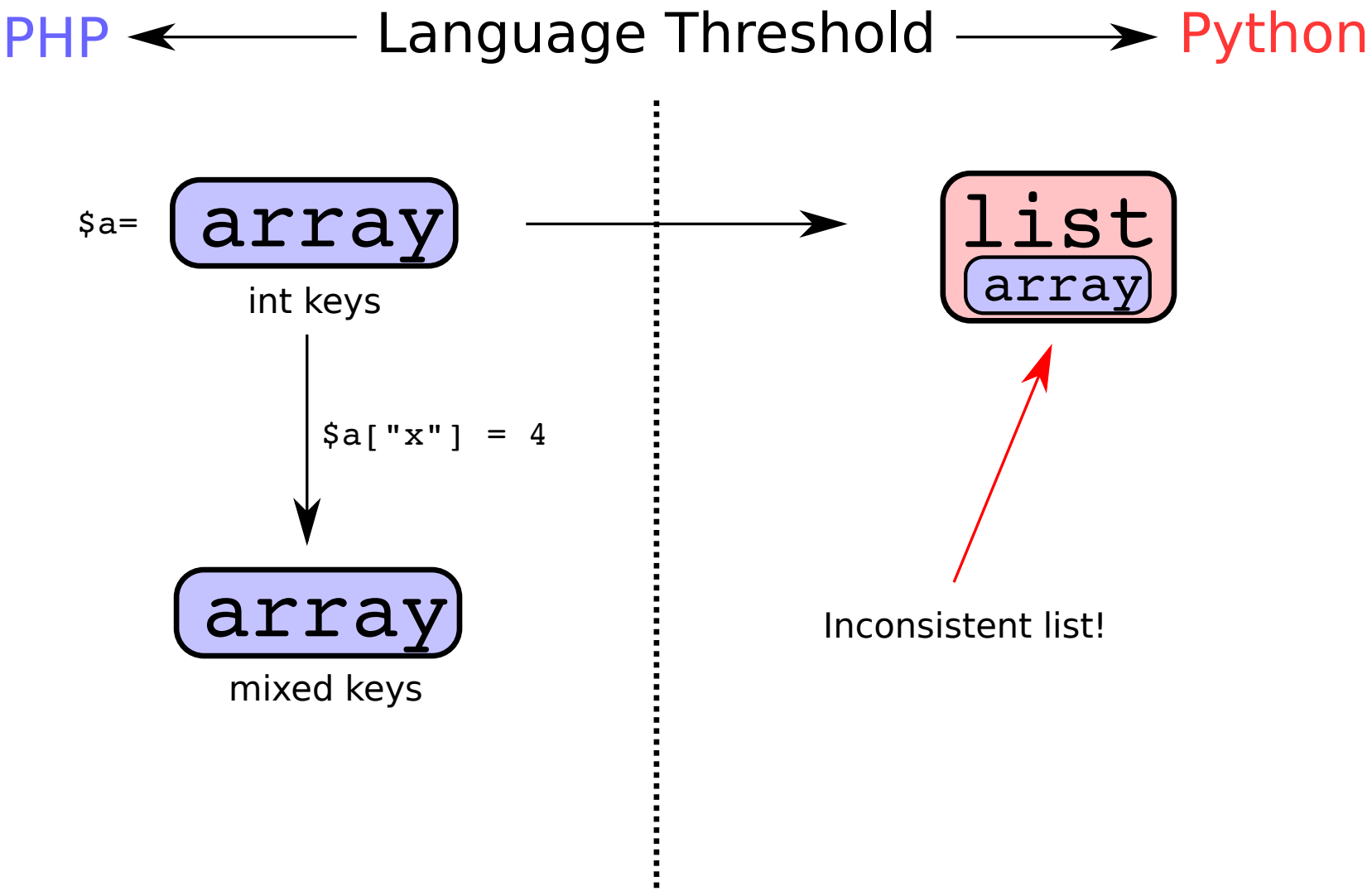

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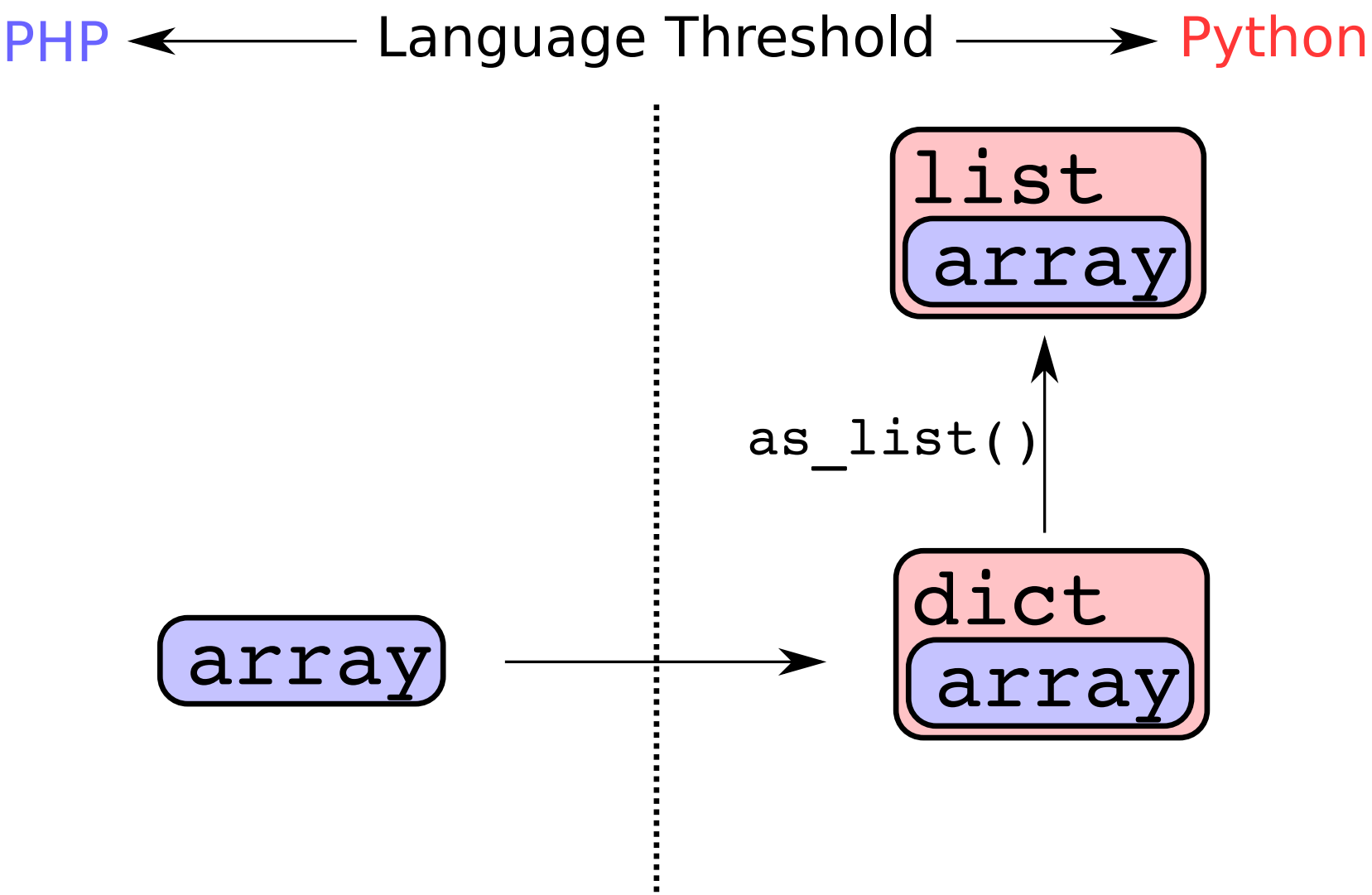


Conclusions

Language boxes and Meta-tracing:

- Fine-grained language composition
- Good editting experience
- Good Performance
- Relatively small engineering effort.

Qualitative outcomes:

- Implementing x-lang behaviours is easy.
- Designing x-lang behaviours is hard.

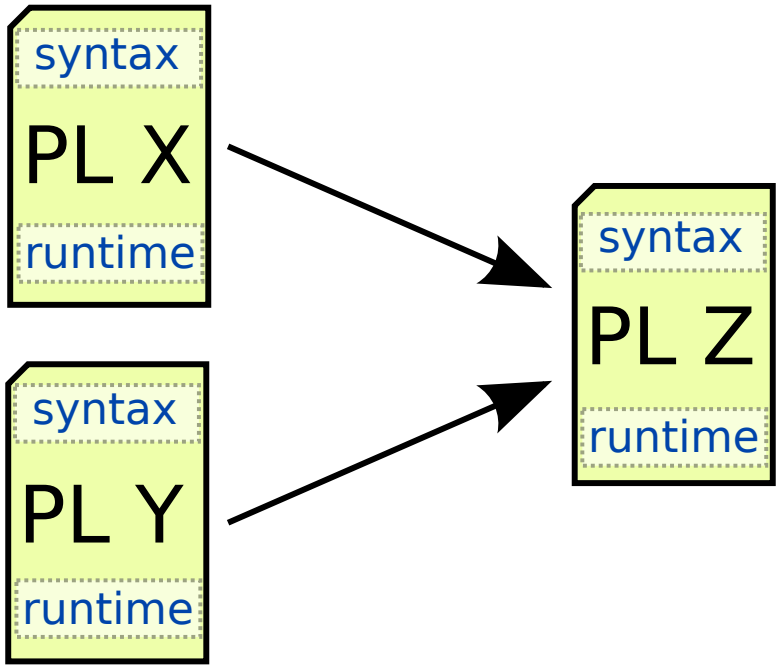
Future Work

- Tools for composed programs
  - Debugging
  - Profiling
  - Version control
  - ...
- Statically typed/functional languages.
- Compositions with >2 languages involved.

References

- *Parsing Composed Grammars with Language Boxes* Lukas Diekmann, Laurence Tratt.
- *Eco: A Language Composition Editor* Lukas Diekmann, Laurence Tratt.
- *Unipycation: A Case Study in Cross-language Tracing*, Edd Barrett, Carl Friedrich Bolz and Laurence Tratt
- *Approaches to Interpreter Composition*, Edd Barrett, Carl Friedrich Bolz and Laurence Tratt
- *Fine-grained Language Composition: A Case Study*, Edd Barrett, Carl Friedrich Bolz, Lukas Diekmann, Laurence Tratt
- *Making an Embedded DBMS JIT-friendly*, Carl Friedrich Bolz, Darya Kurilova, Laurence Tratt

Thanks



Language Boxes + Meta-tracing