Note

These slides were mangled by a Keynote “upgrade” after the talk was given.There may be display issues.

Profile-Guided Meta-Programming

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What is …

Meta-Programming

- Extended syntax
- Generate source code
- Embedded DSLs

What is …

Profile-Guided

(Optimization)

- Collect profile at runtime
- Use profile as oracle
- Write optimizations

What is …

Profile-Guided

- Collect profile at runtime *for*
- Use profile as oracle *to*
- Write optimizations *from*

Meta-Programming

- Extended syntax
- Generate source code
- Embedded DSLs

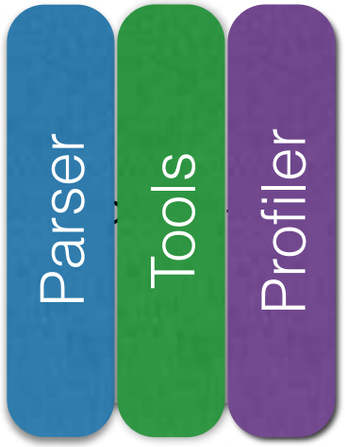
Profile-Guided Meta-Program

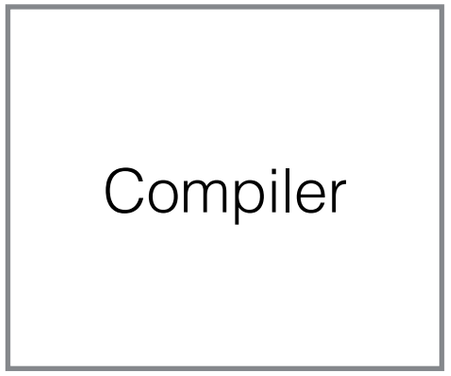
An example

```
define-syntax if-r(test t-branch f-branch):
if profile(t-branch) < profile(f-branch):
  generate(#'(if not(test) f-branch t-branch))
else:
  generate(#'(if test t-branch f-branch))
```

Problems

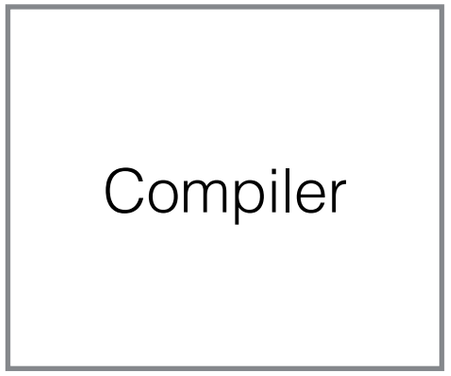
For Optimization **Writers**





Problems

For Optimization **Writers**



Problems

For Optimization **Users**

Problems

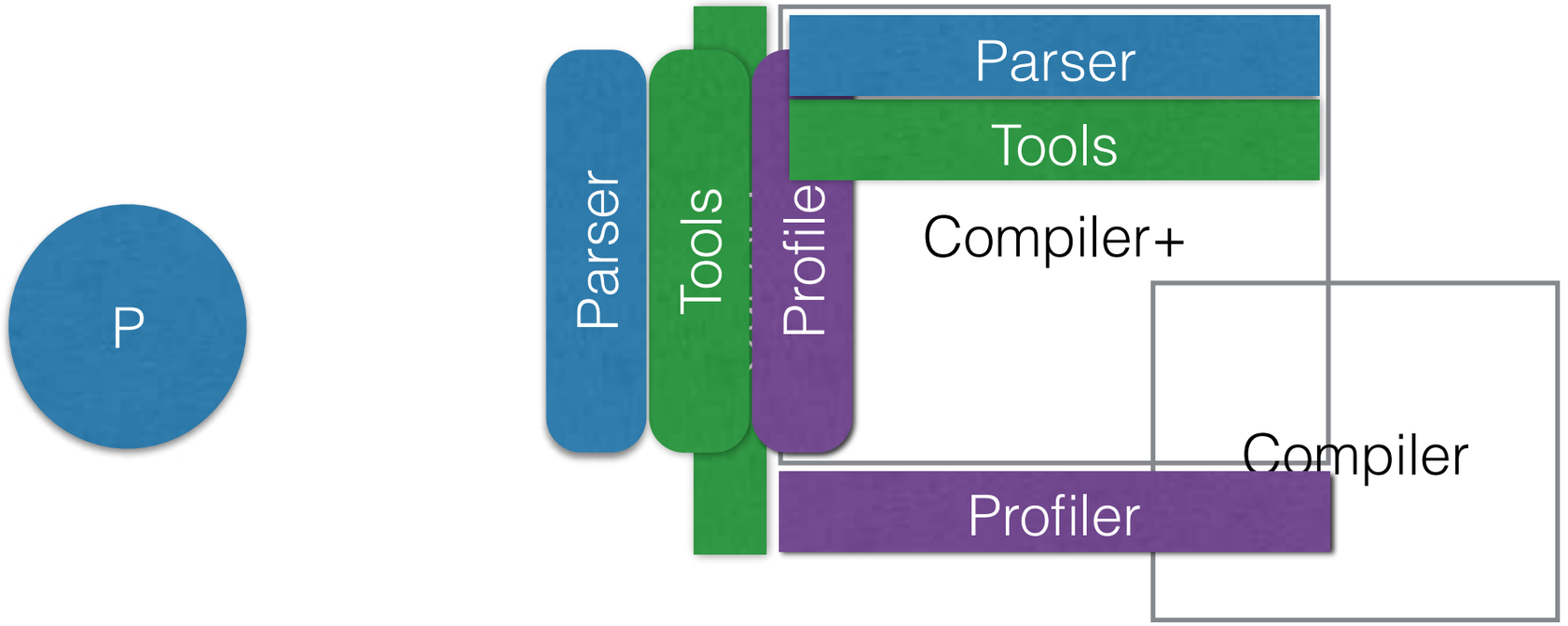
For Optimization **Users**

Our Design…

- Saves PGO writers effort
- Saves PGO users effort
- Simple to implement
- Expresses standard optimizations
- Enables new optimizations

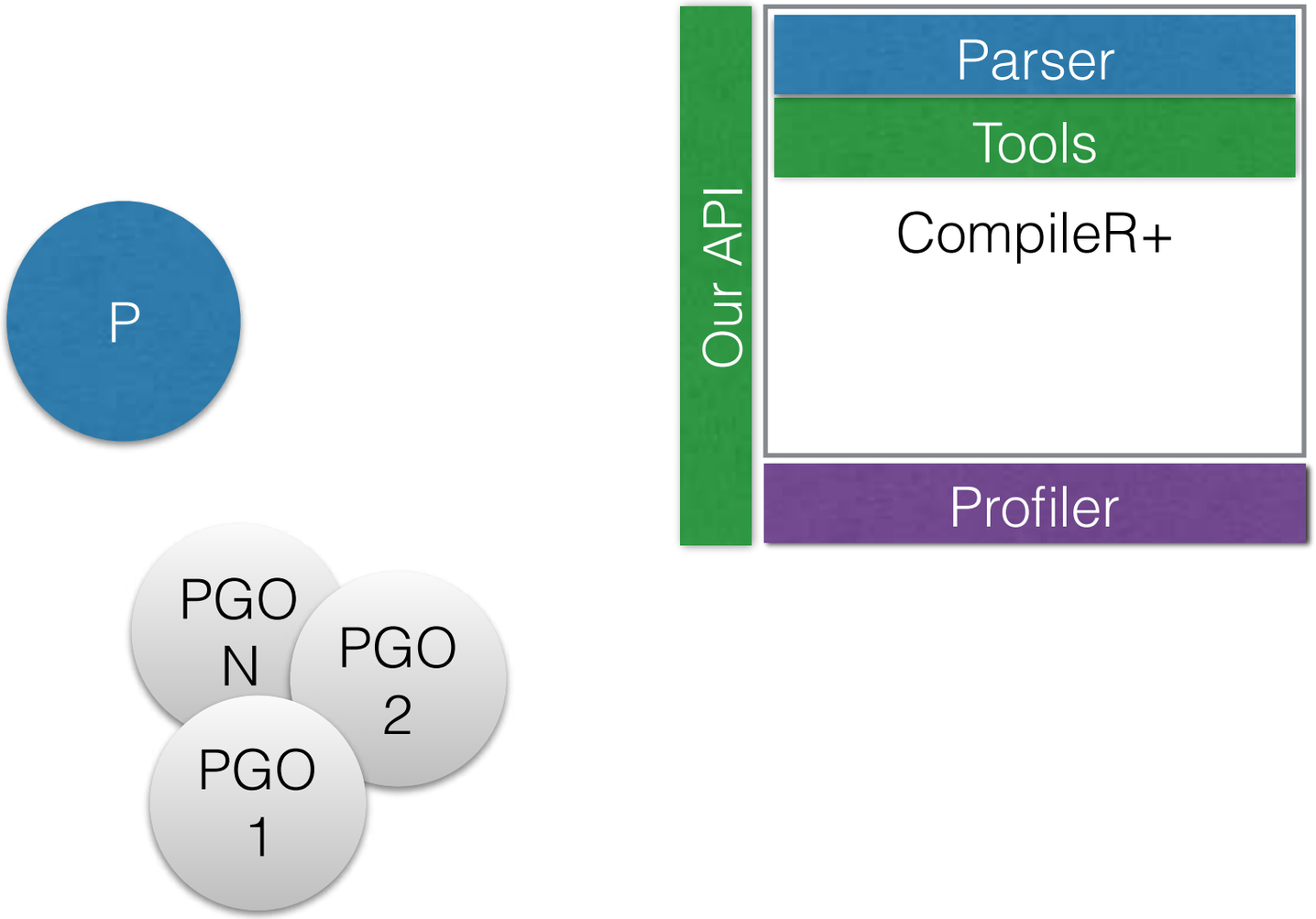
Solutions

For everyone!



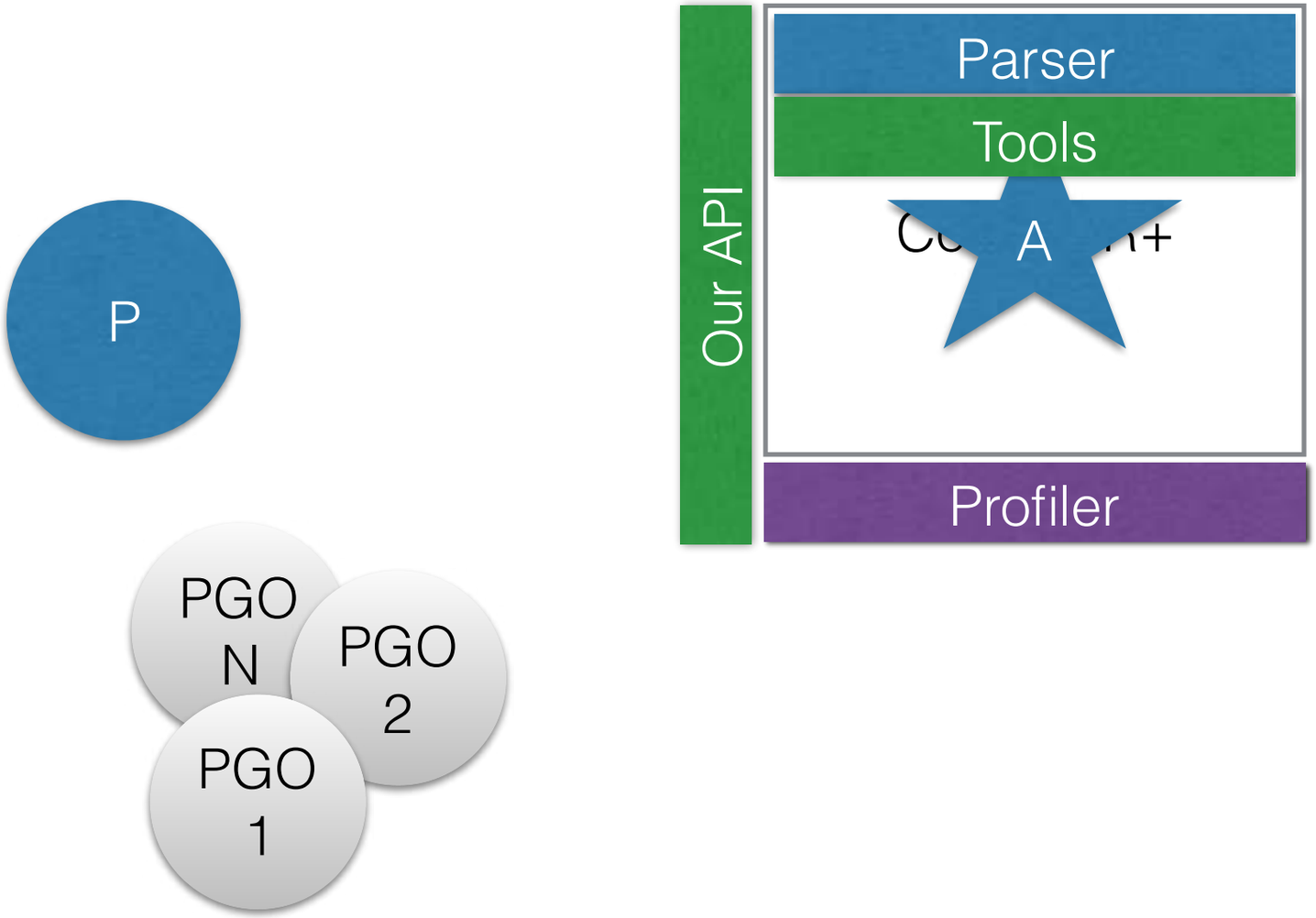
Solutions

For everyone!



Solutions

For everyone!



Design highlights

- Profile Points
- Profile Weights
- API

Profile Points

What the profiler Cares about

- Abstraction of source expressions for profiler
- Profile Point <-> Source Expression
- Create new profile points
- Attach profile points to source expressions

Profile Points

An Example

Source Loc.	Profile Point
File a Line 2 Char 3	1
File A Line 4 Char 3	2
<GEN3>	3

- Profile Points via source location
- Generate new points (deterministically)

Profile Weight

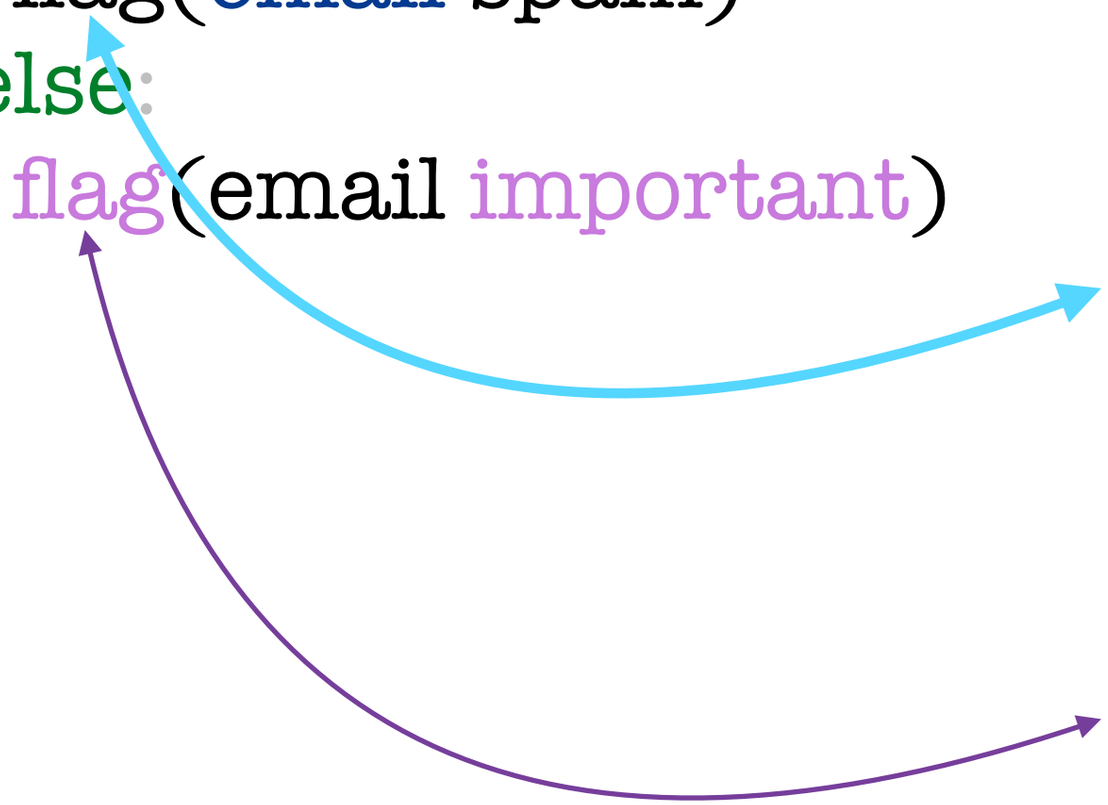
What the Meta-Program Cares about

- Abstraction of profile information for PGMPs
- Profile Point <-> Profile Weight
- Single value for relative importance
- Easy to combine multiple data sets

Profile Weights

An Example

```
if-r (subject-contains? "PLDI
  flag(email spam)
else:
  flag(email important)
```



Source Loc.	DS1	DS2	Merged
File a Line 2 Char 3	10/10 = 1	10/100 = .1	(1 + .1)/2 = 0.55
File A Line 4 Char 3	5/10 = .5	100/100 = 1	(.5 + 1)/2 = 0.75

The API

A brief look at

Evaluation

- We implemented it.
- Profiler: unchanged
- Meta-programming: unchanged
- Racket API: 134 lines

Evaluation

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- Profiler: unchanged
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- Racket API: 134 lines

Evaluation

Profile-Guided …

- Conditional Branch Optimization:
  81 lines
- Receiver Class Prediction:
  44* lines
- Data Structure Specialization:
  111 lines

Conditional Branch Reordering

```
(define (parse stream)
 (case (peek-char stream)
  [(#\space #\tab) (white-space stream)]
  [(0 1 2 3 4 5 6 7 8 9) (digit stream)]
  [(#\() (start-paren stream)]
  [(#\)) (end-paren stream)]
  ....))
```

Conditional Branch Reordering

```
(define (parse stream)
 (let ([t (peek-char stream)])
  (cond
   [(key-in? t '(#\space #\tab))
    (white-space stream)]
   [(key-in? t '(0 1 2 3 4 5 6 7 8 9))
    (digit stream)]
   [(key-in? t '(#\())) (start-paren stream)]
   [(key-in? t '(#\))) (end-paren stream)]
   ....)))
```

Conditional Branch Reordering

```
(define (parse stream)
 (let ([t (peek-char stream)])
  (exclusive-cond
   [(key-in? t '(#\space #\tab))
    (white-space stream)]
   [(key-in? t '(0 1 2 3 4 5 6 7 8 9))
    (digit stream)]
   [(key-in? t '(#\())) (start-paren stream)]
   [(key-in? t '(#\))) (end-paren stream)]
   ....)))
```

Exclusive-Cond

```
(define-syntax (exclusive-cond syn)
  ; Internal definitions
  (define (clause-weight clause)
    (syntax-case clause ()
      [(test e1 e2 ...) (profile-query #'e1)]))
  (define (sort-clauses clause*)
    ; Sort clauses greatest-to-least by weight
    (sort clause* > #:key clause-weight))
  ; Start of code transformation
  (syntax-case x ()
    [(_ clause ...)
     ; Splice sorted clauses into a cond expression
     #`(cond #,@(sort-clause #'(clause ...)))]))))))
```

Take a Step bAck

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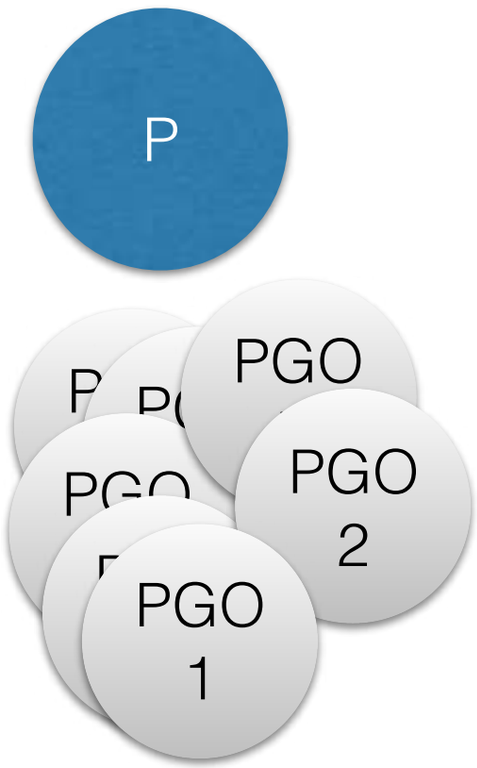

Meta-Programming

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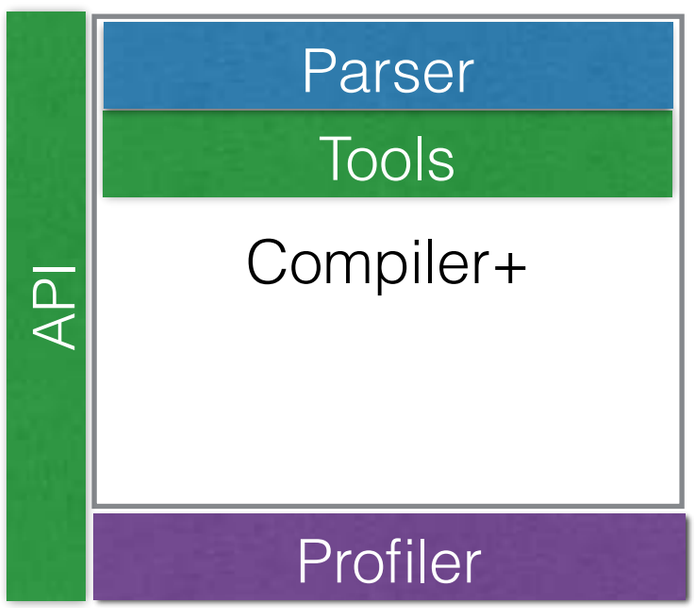

Why No Benchmarks?

- I do not claim to make anything faster.
  As I do not make that claim, I do not support it.

- I do claim a design that reduces programmer effort.
  As I make that claim, I support it.
  Effort was measured with lines of code.

Non-Scheme languages?

- Yes. See the paper.

optimizations with dependency

- If one PGO depends on another?
  Then the user doesn’t get composition for free.

C/C++?

- Maybe, with extensions to templates or macros.

Path Profiling?

- Our design may not work with path profiling.

- It is unclear how to apply profile points to paths.

Staged Meta-PRogramming?

- Should work with staged meta-programming. See the paper.