PERFORMANCE EVALUATION FOR GRADUAL TYPING

Northeastern University

Asumu Takikawa, Daniel Feltey, Ben Greenman, Max S. New, Jan Vitek, Matthias Felleisen

GRADUAL TYPING is for software maintenance

Fact 1: developers use untyped languages

Fact 2: type annotations enable safety checks and serve as documentation

Thesis: stable untyped code + type annotations = happy future maintainers

PROMISES

Freedom to add types **incrementally**

Soundness: type invariants are enforced at runtime . . . **What about performance?**

PERFORMANCE LATTICE

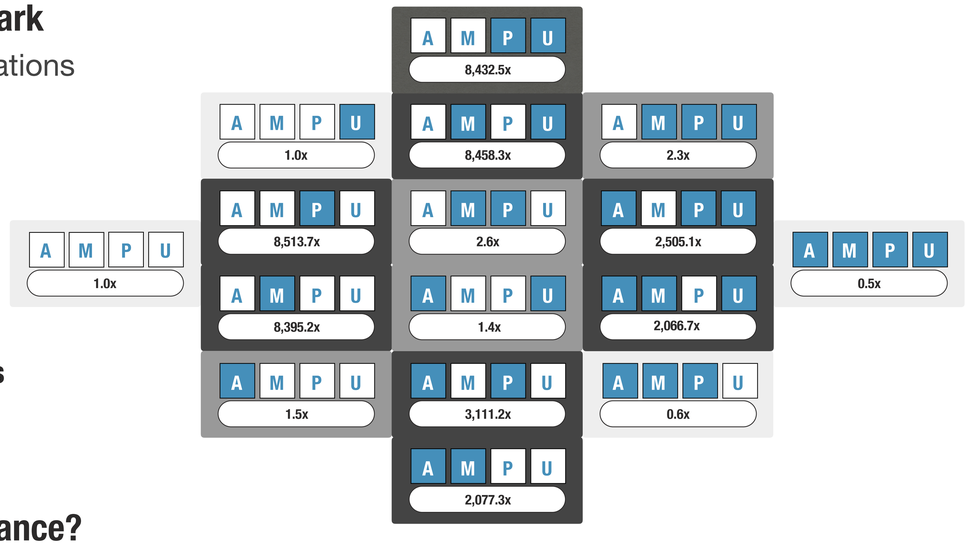
Visualizing all possible gradually-typed configurations

Example: FSM benchmark

4 modules, 16 configurations

- **A. automata.rkt** — *Interface & basic strategies*
- **M. main.rkt** — *Runs a simulation*
- **P. population.rkt** — *Models groups of automata*
- **U. utilities.rkt** — *Helper functions*

Untyped runtime: **182ms**



Is this "good" performance?

Yes

+ Fully typed is **2x** faster
+ **50%** of all configurations have **< 3x** overhead
+ Can avoid worst-cases by typing **1** more module

No

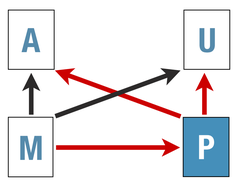
- Maximum overhead: **8,500x** (*26 hours to run*)
- Average overhead: **2,700x**
- Median overhead: **470x**
- No smooth migration paths:
  impossible to convert module-by-module
  and avoid bad (**> 2,000x**) configurations

Open Question

How to help developers avoid performance valleys (without exploring the whole lattice)?

Configuration A M P U in depth

- Type boundaries are checked at runtime
- Key boundary: main.rkt and population.rkt



main.rkt

```
require "automata.rkt"
require "population.rkt"
require "utilities.rkt"

define (evolve pop count)
  if (zero? count)
    null
    evolve (step pop)
           (count - 1)

evolve (create 100) 5
```

population.rkt

```
require/typed "automata.rkt"
  [#:opaque Automaton automaton?]
  ....
require/typed "utilities.rkt"

define-type Population
  (Vectorof (Vectorof Automaton))

provide:
  step   (-> Population Population)
  create (-> Natural Population)
```

Each call to `step` wraps `pop` with a higher-order contract
After `N` calls, each vector operation suffers `N` indirections

EVALUATION METHOD

Report the relative performance of the **untyped** and **fully-typed** configurations

Report the **proportion** of typed/untyped configurations:

- with "**deliverable**" overhead (at most **N**x slowdown)
- with "**usable**" overhead (at most **M**x slowdown)
- within **L** conversion steps from an **N**x or **M**x configuration

L-N/M FIGURES

Summarizing performance lattices