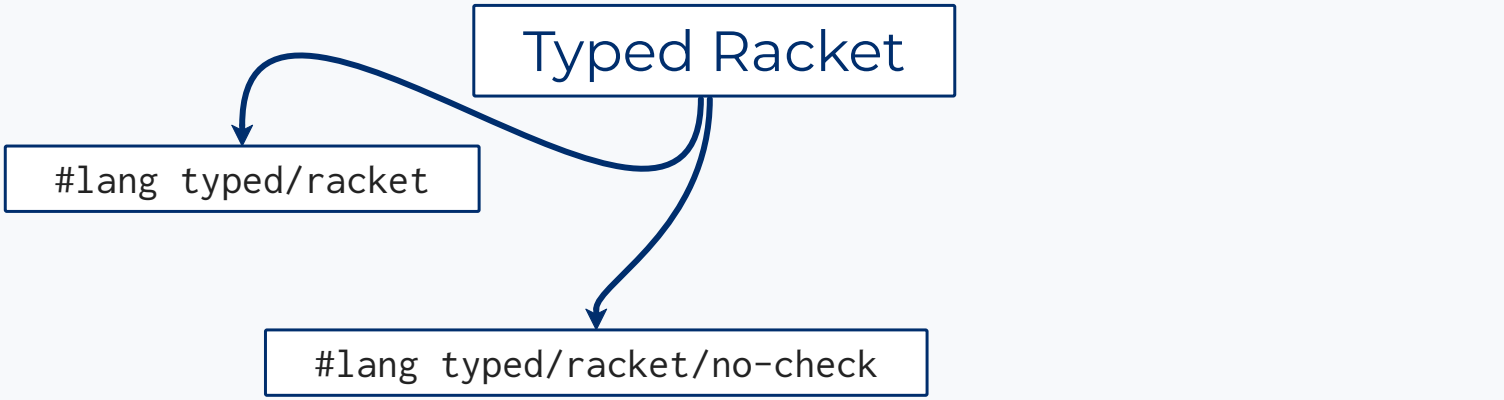
Shallow and **Optional** Types for Typed Racket

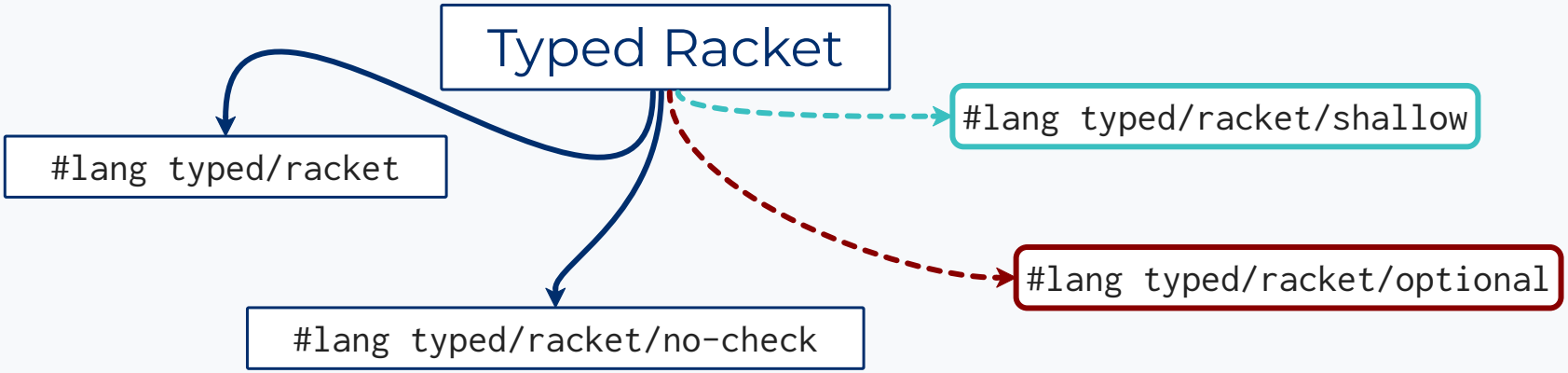
in Racket 8.7

Ben Greenman

RacketCon 2022

Typed Racket


Typed Racket
#lang typed/racket
#lang typed/racket/no-check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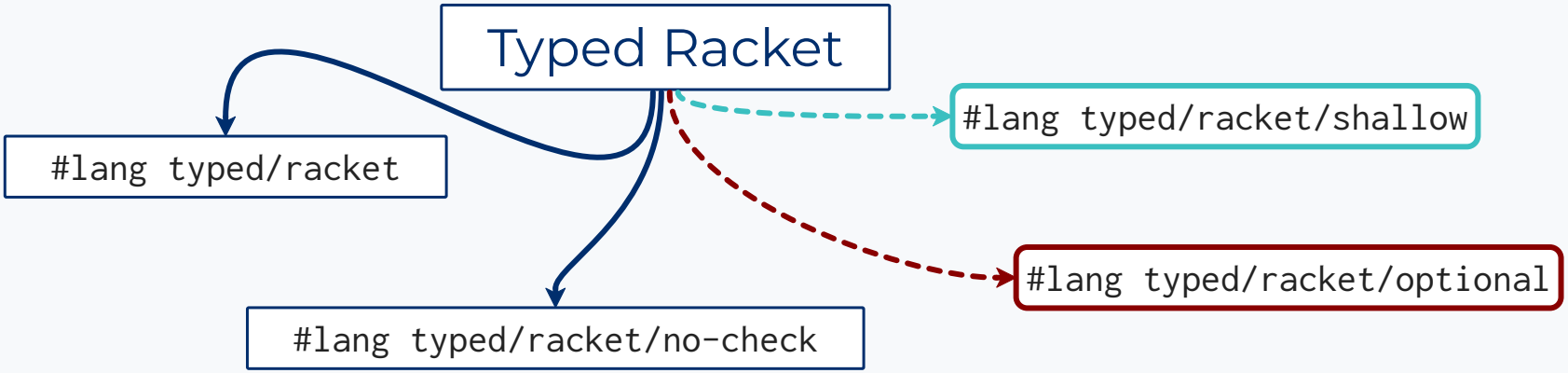
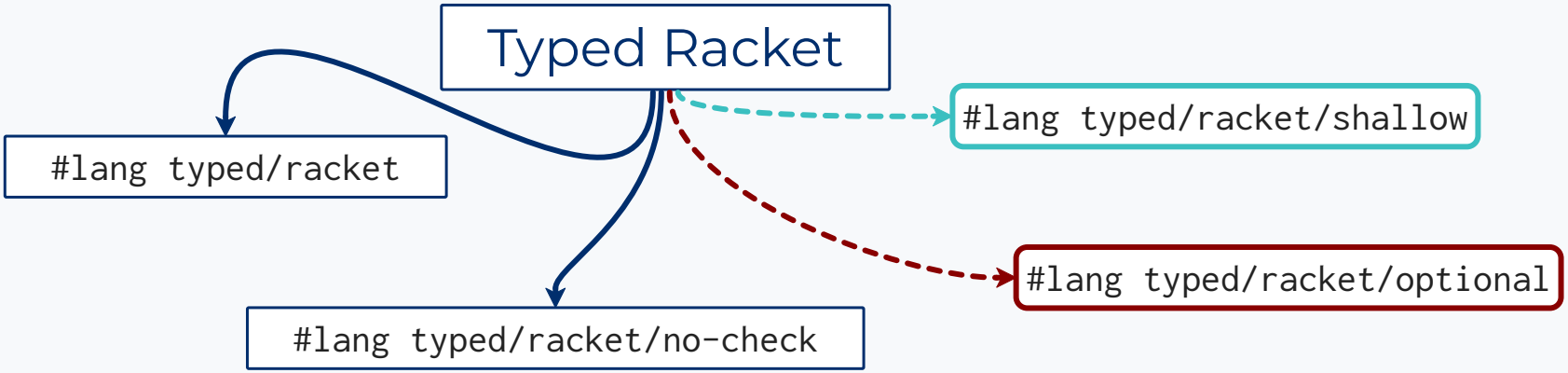


1. Two New Languages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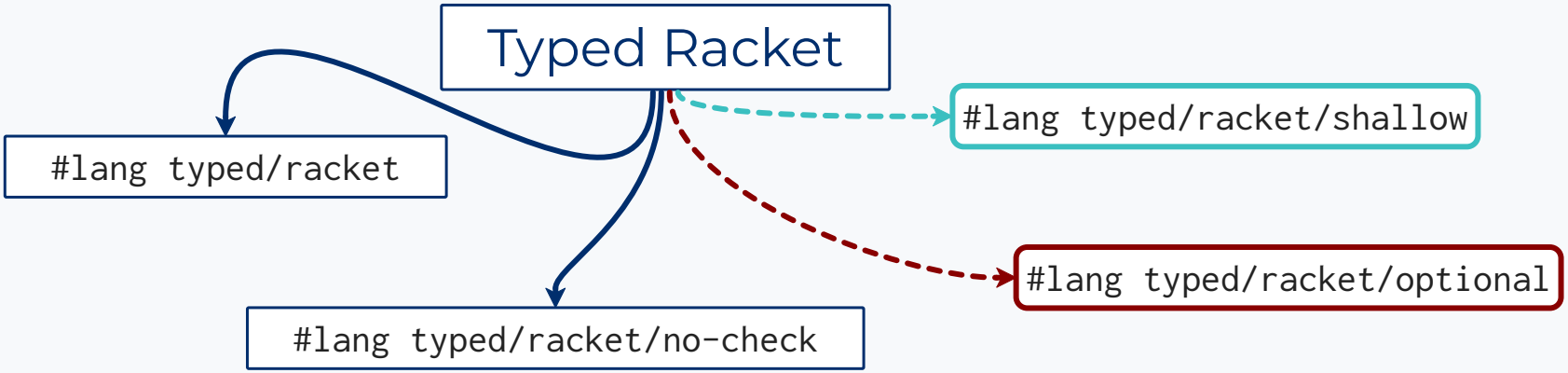
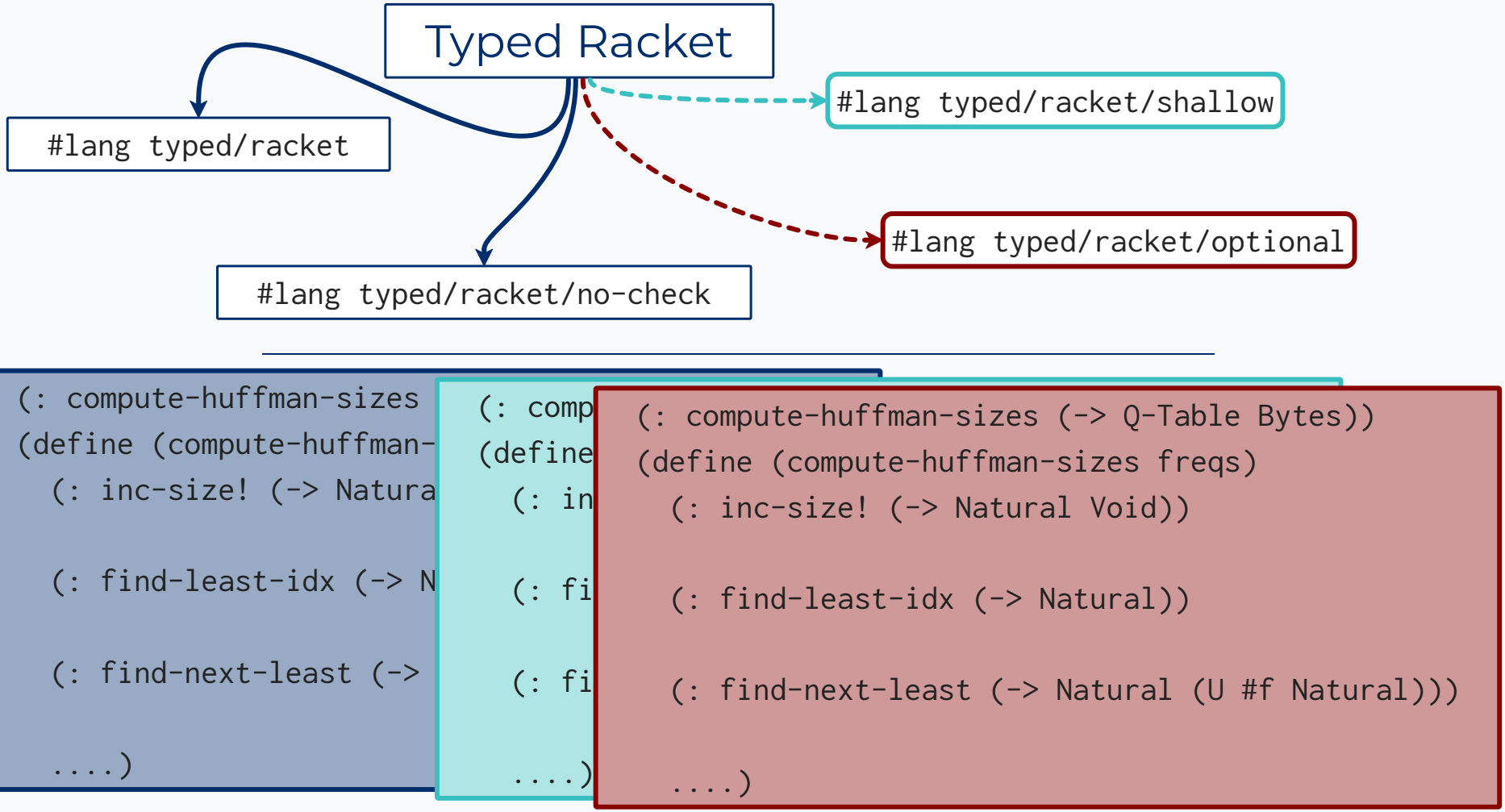



```
(: compute-huffman-sizes (-> Q-Table Bytes))
(define (compute-huffman-sizes freqs)
  (: inc-size! (-> Natural Void))

  (: find-least-idx (-> Natural))

  (: find-next-least (-> Natural (U #f Natural)))

  ....)
```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(: find-least-idx (-> N
(: find-next-least (->
....)
(: comp
(define
(: in
(: fi
(: fi
....)
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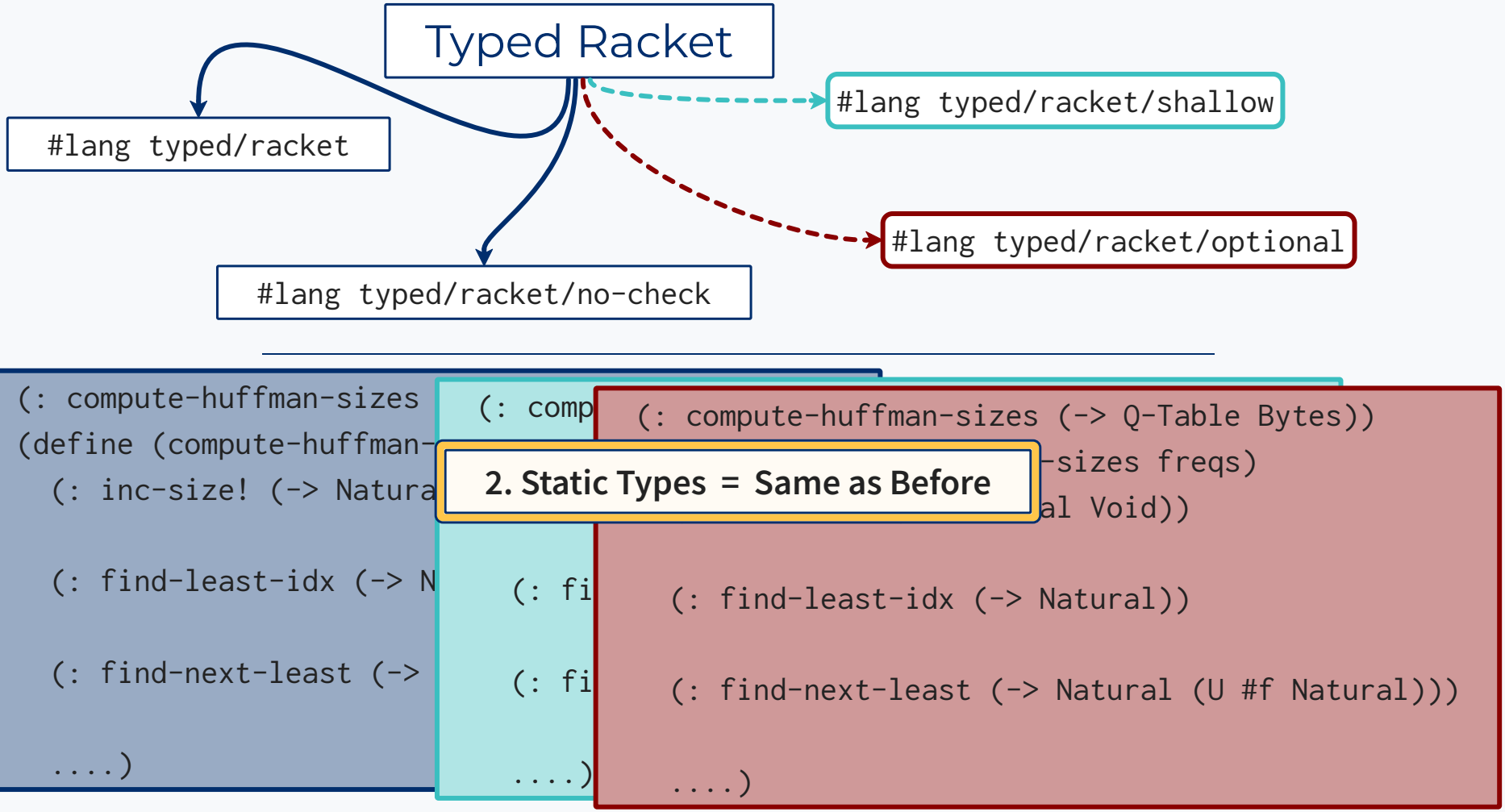
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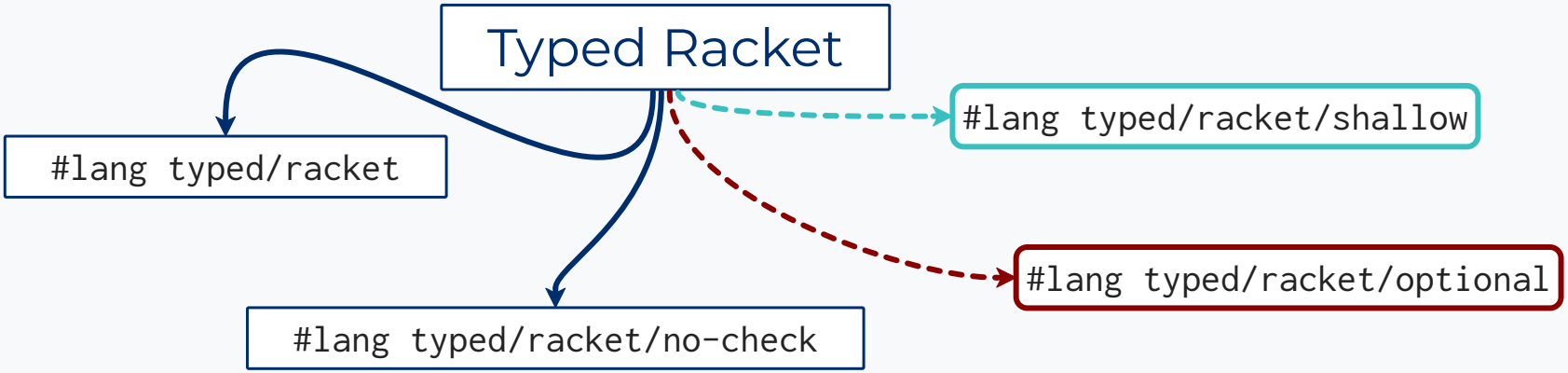
2. Static Types = Same as Before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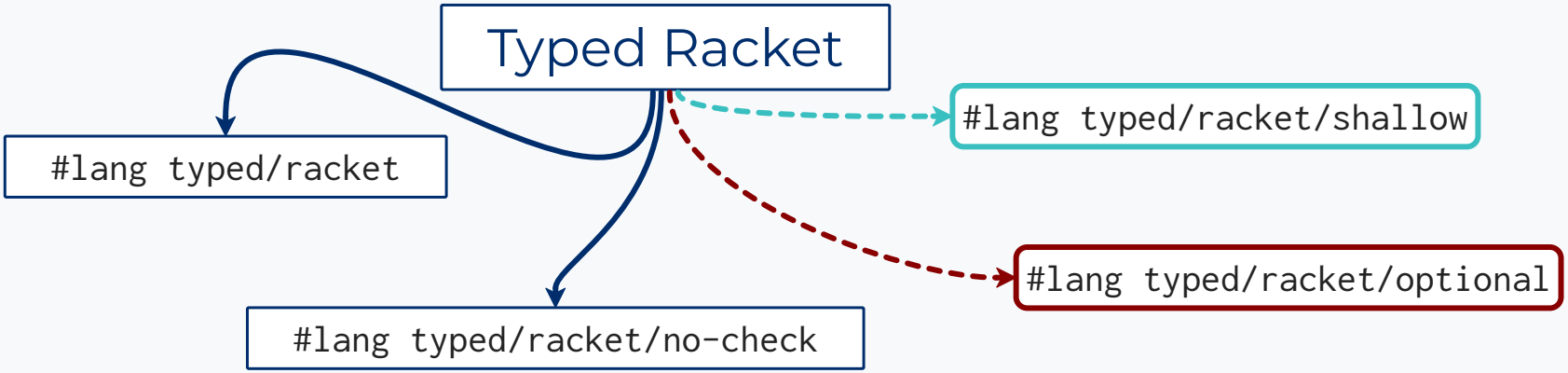
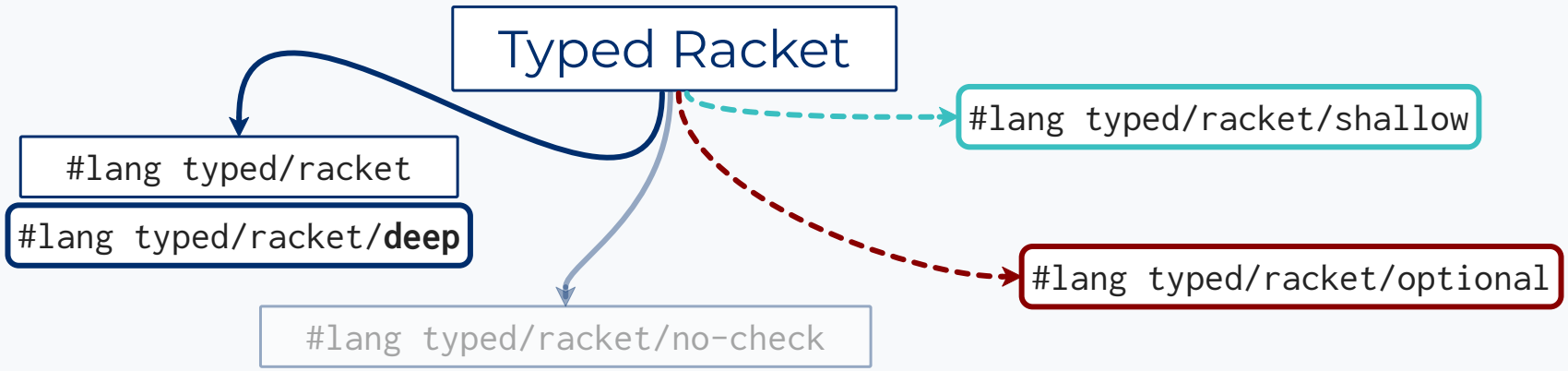


3. Better Performance at Type Boundaries



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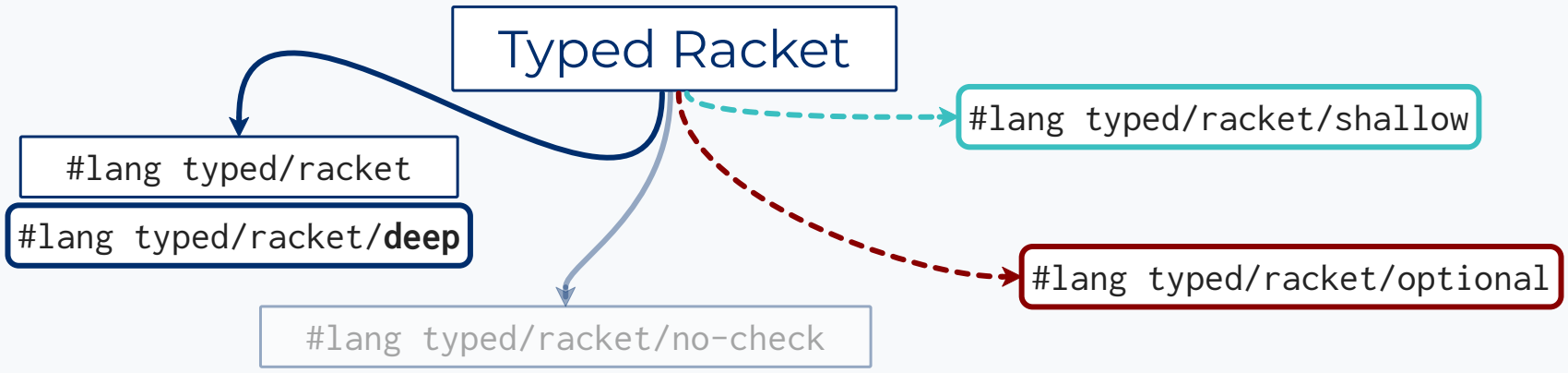
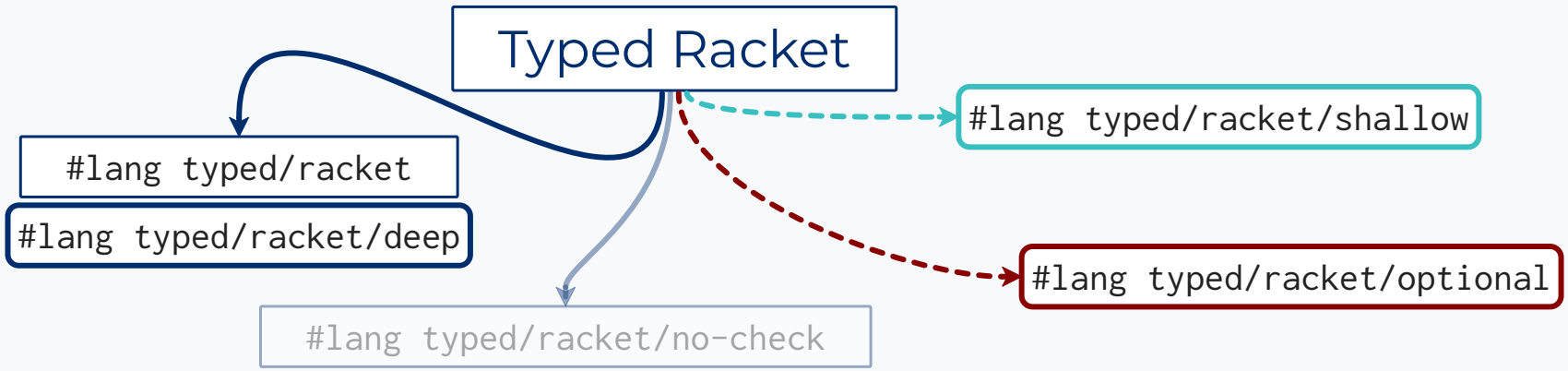


3. Better Performance at Type Boundaries

`deep`	Check everything
`shallow`	Check top-level shapes
`optional`	Check nothing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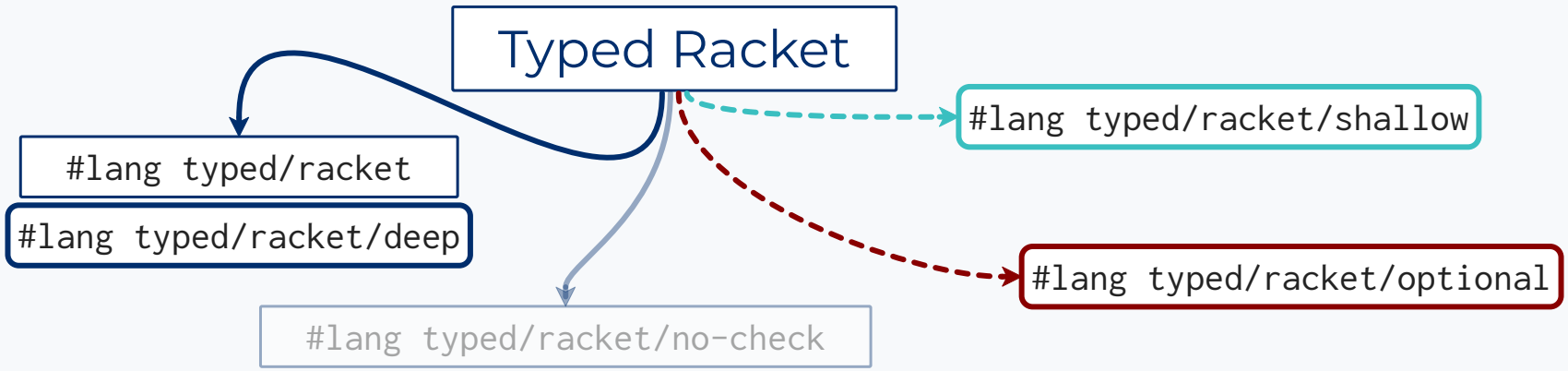

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Typed Racket

Strong Guarantees,
High Overhead

Weak Guarantees,
Low Overhead

---

1. Two New Languages

2. Static Types = Same as Before

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Example 1 D

Example 1 D

```
(: says-moo? (-> (Listof Symbol)
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Untyped Code

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(says-moo? '(A B moo C D E F G))
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Guarantee: list of symbols

Cost: check the **entire list**

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deep : contracts at boundaries

Example 1S

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Guarantee: a list
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Guarantee: a symbol
Cost: `symbol?`

Untyped Code

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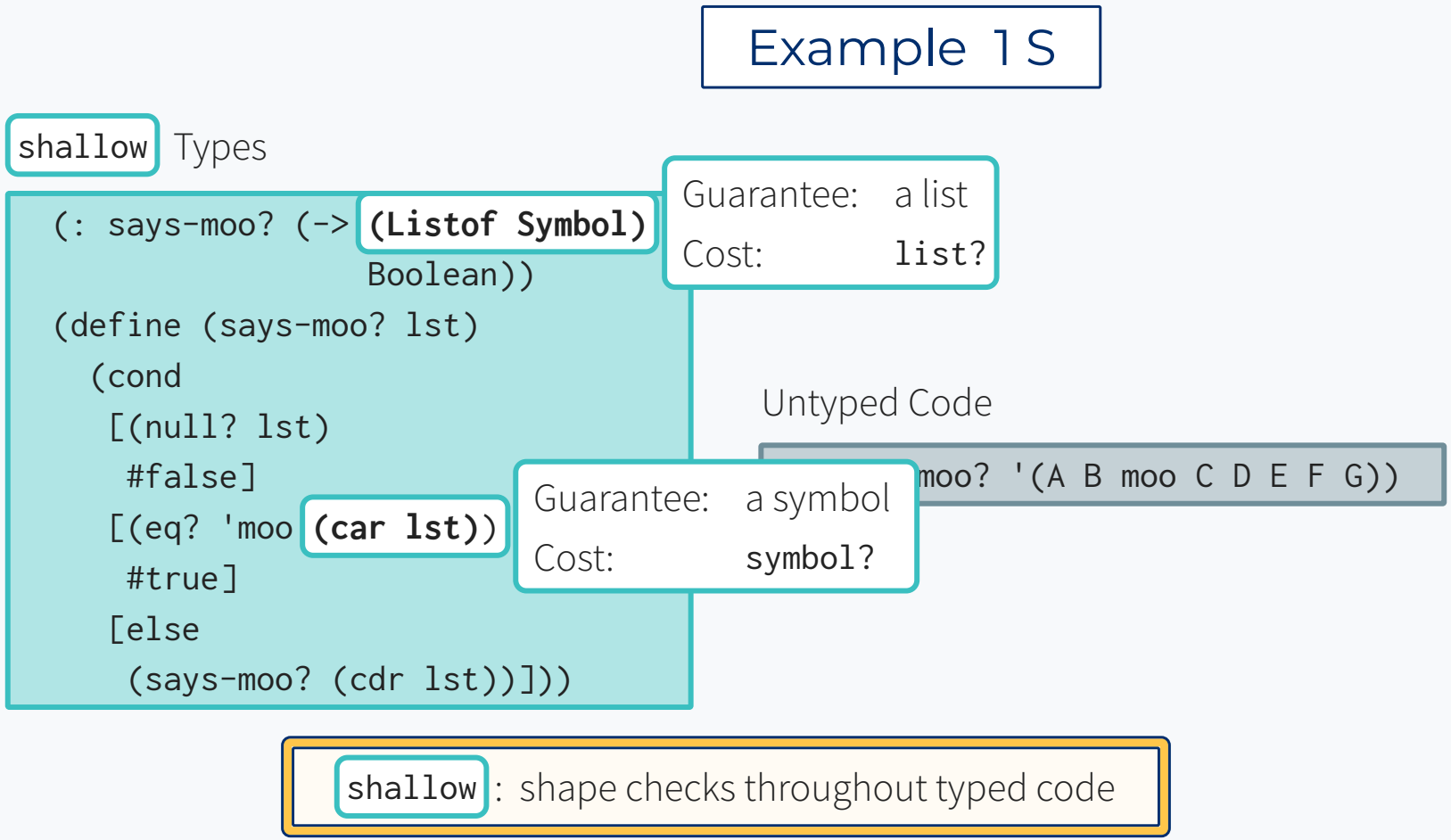
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Untyped Code
moo? '(A B moo C D E F G))
Guarantee: a symbol
Cost: symbol?
shallow : shape checks throughout typed code

Example 10

`optional` Types

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Guarantee: any value
Cost: **free**

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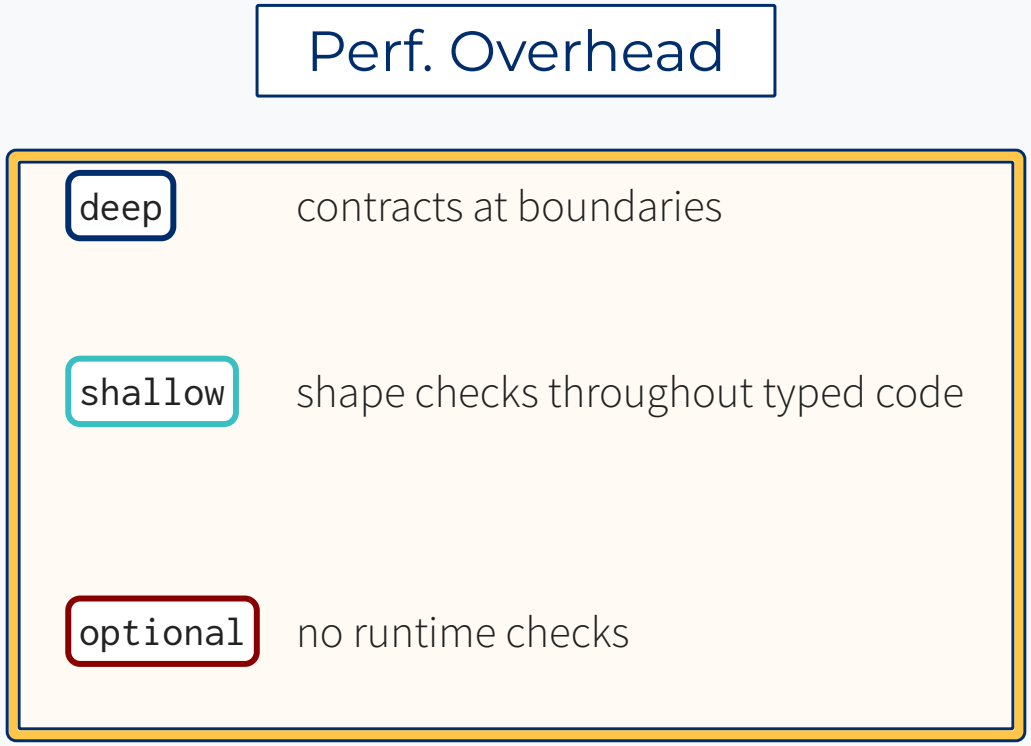
Guarantee: any value
Cost: **free**

Untyped Code

```
(says-moo? '(A B moo C D E F G))
```

`optional`: no runtime checks


Perf. Overhead
deep
contracts at boundaries
shallow
shape checks throughout typed code
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no runtime checks

Perf. Overhead

`deep` contracts at boundaries

- can be expensive: `->`, `HashTable`, ...

`shallow` shape checks throughout typed code

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Perf. Overhead

`deep` contracts at boundaries

- can be expensive: `->`, `HashTable`, ...

`shallow` shape checks throughout typed code

- often cheap, but add up!

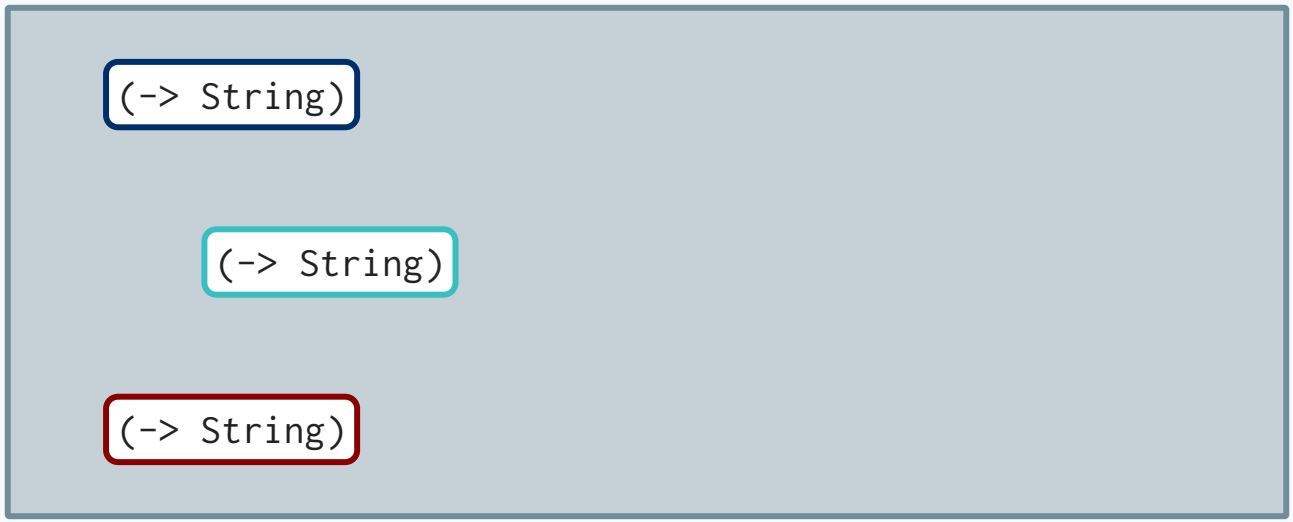
`optional` no runtime checks

Example 2

Untyped Codebase

Example 2

Untyped Codebase ... with a few Types



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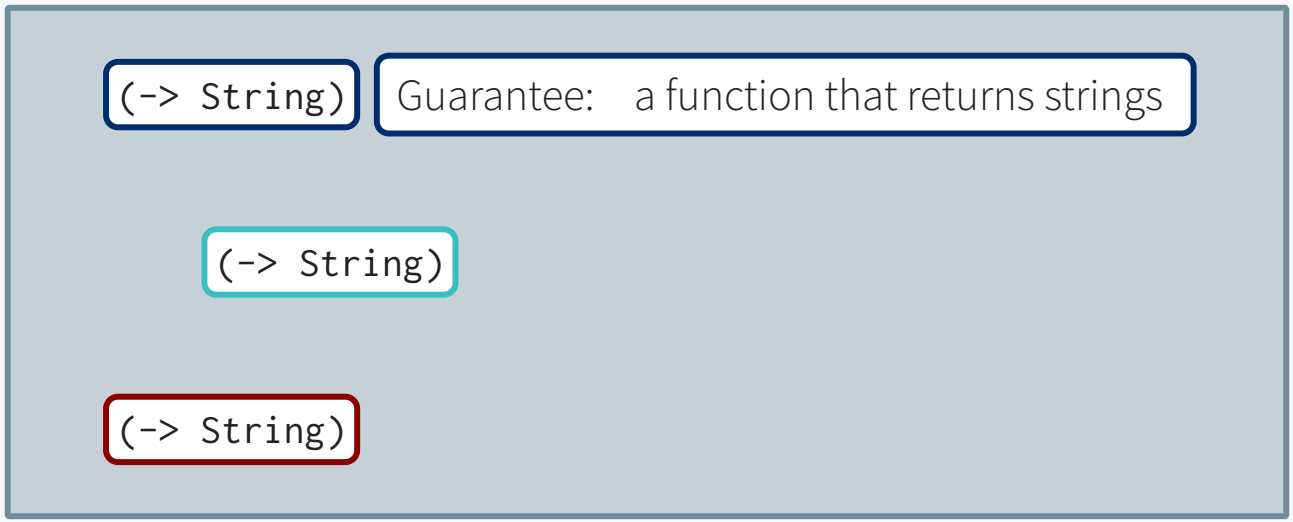

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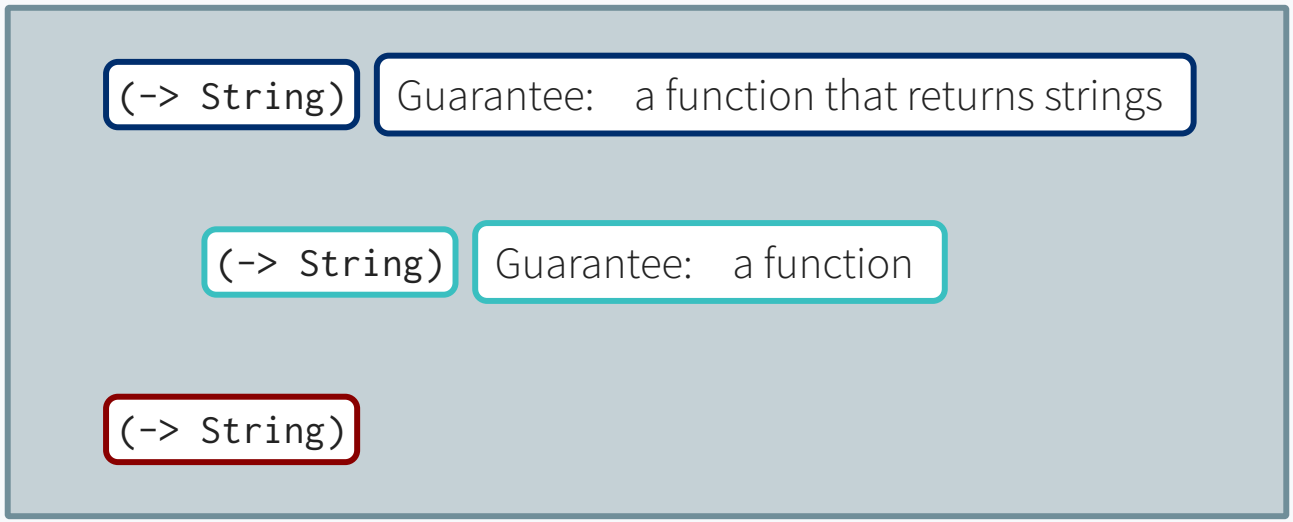

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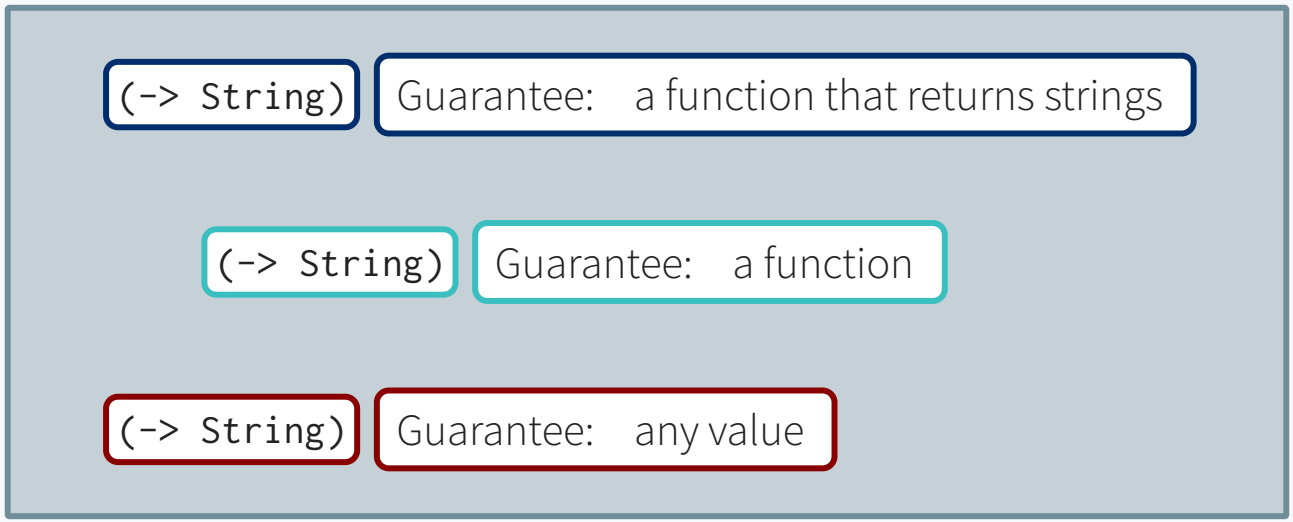

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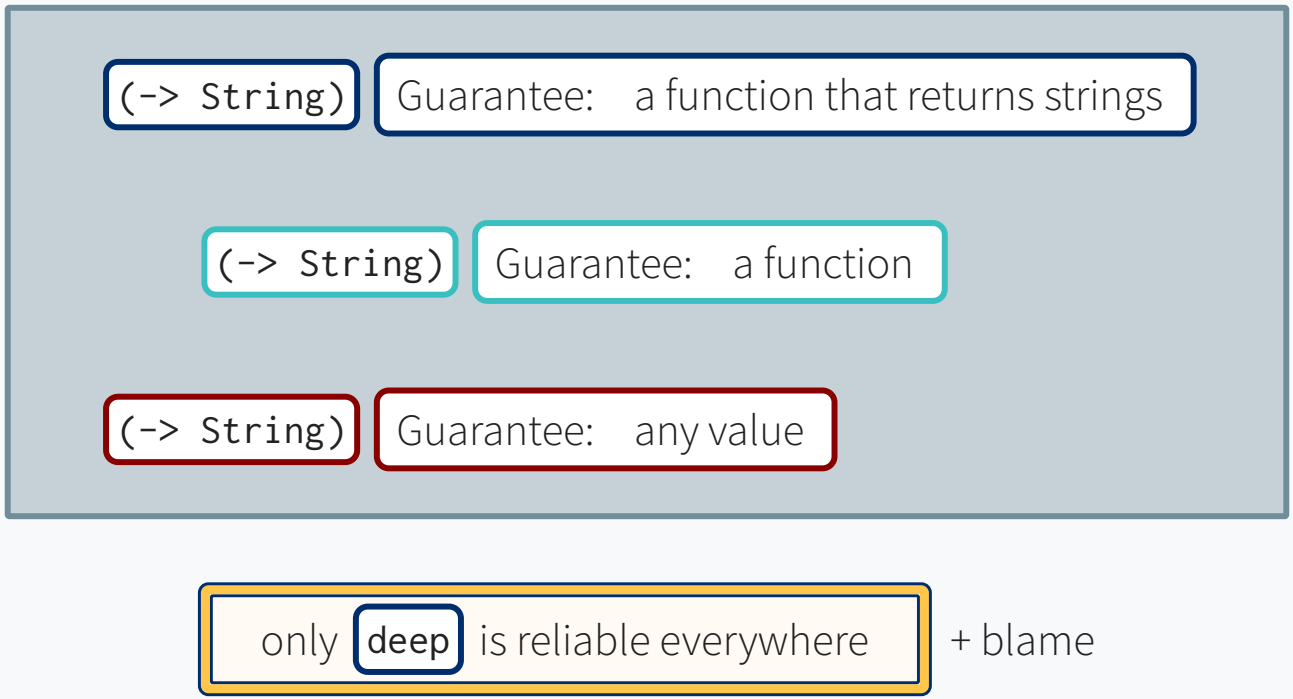
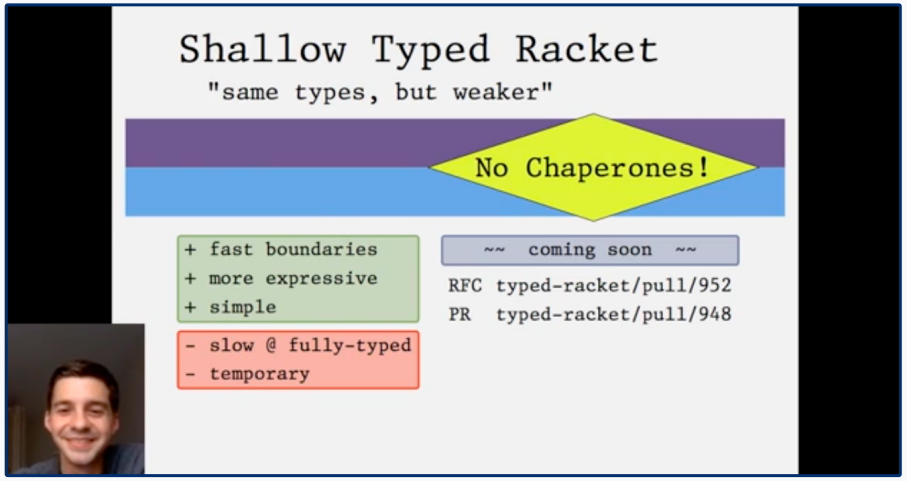


only `deep` is reliable everywhere + blame

Typed Racket


in
Racket 8.7

Announced in 2020 ...



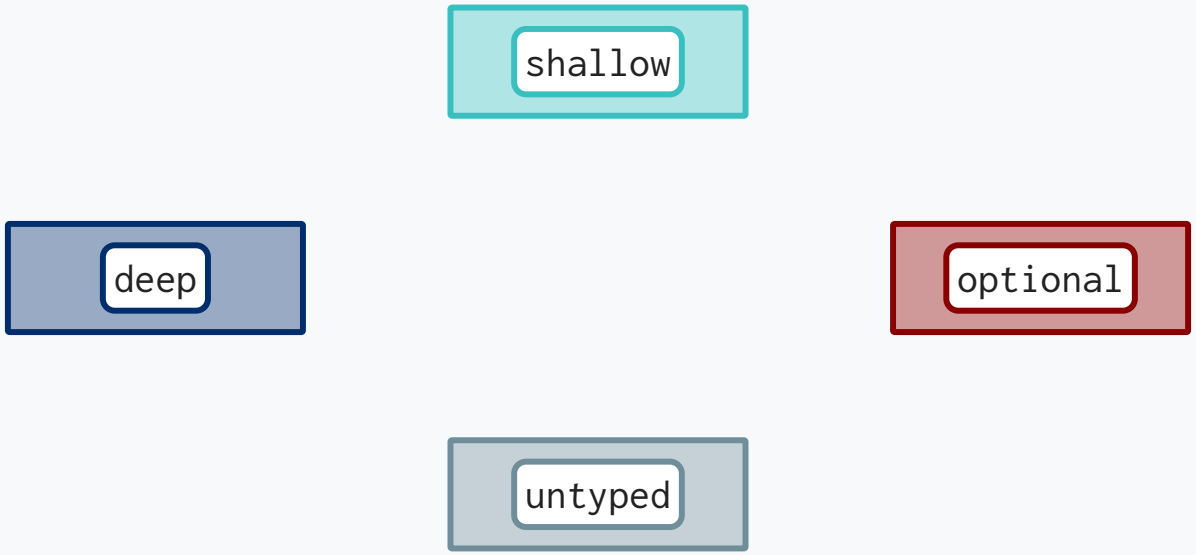
What took so long?

1. Life Stuff

BROWN

1. Life Stuff

2. Well-Typed Interactions



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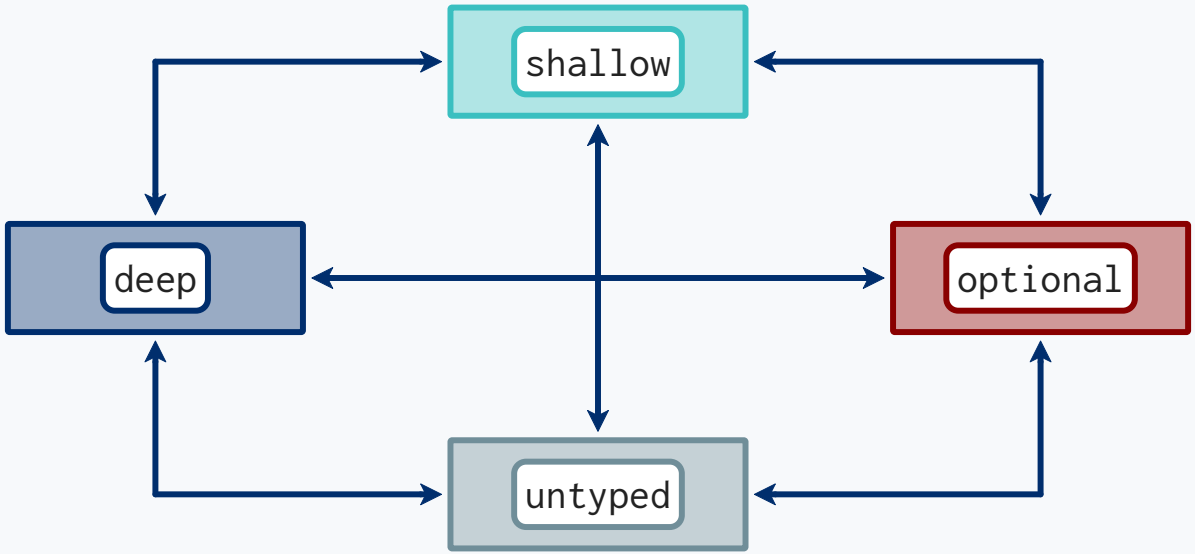

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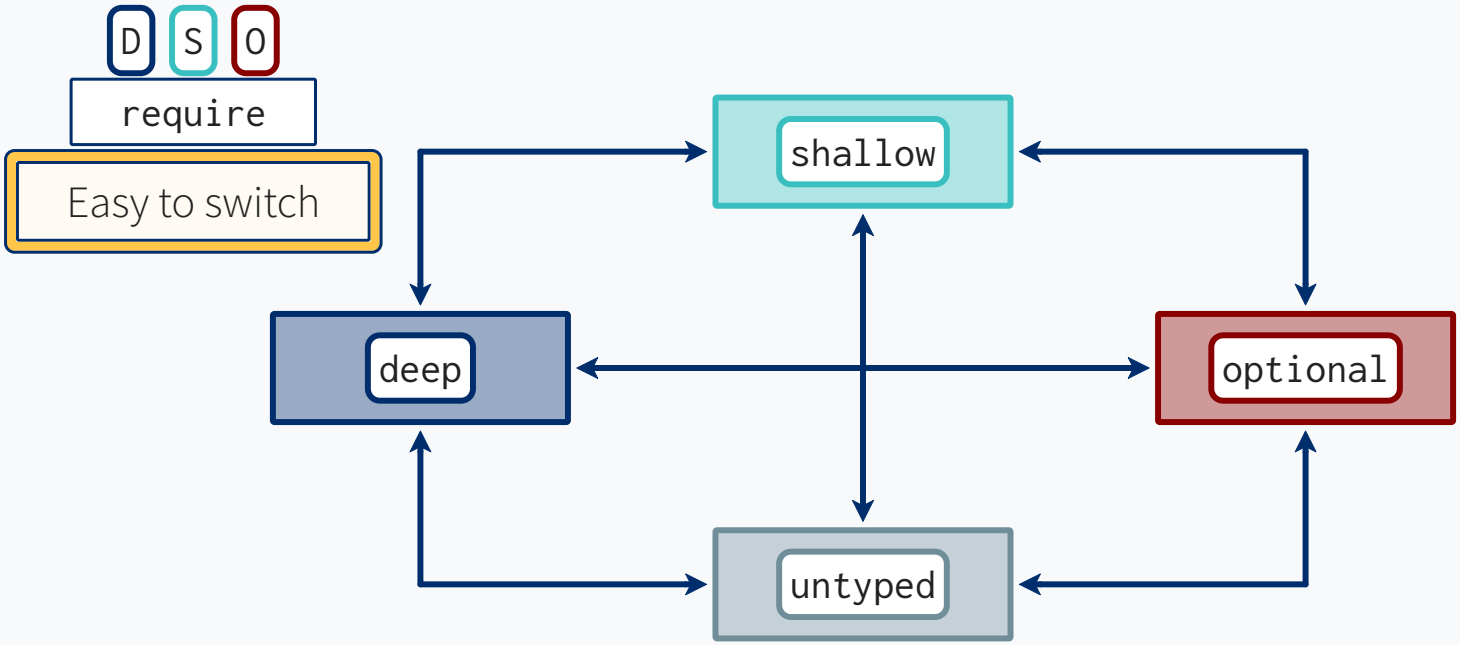

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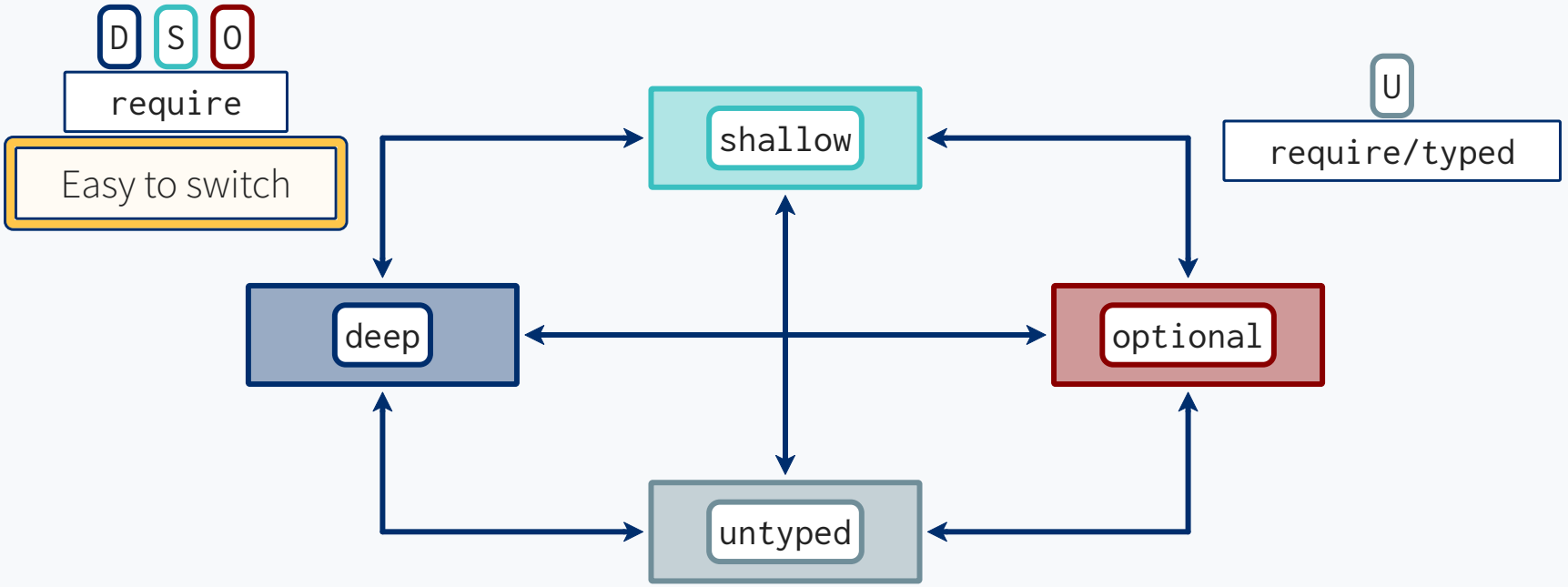

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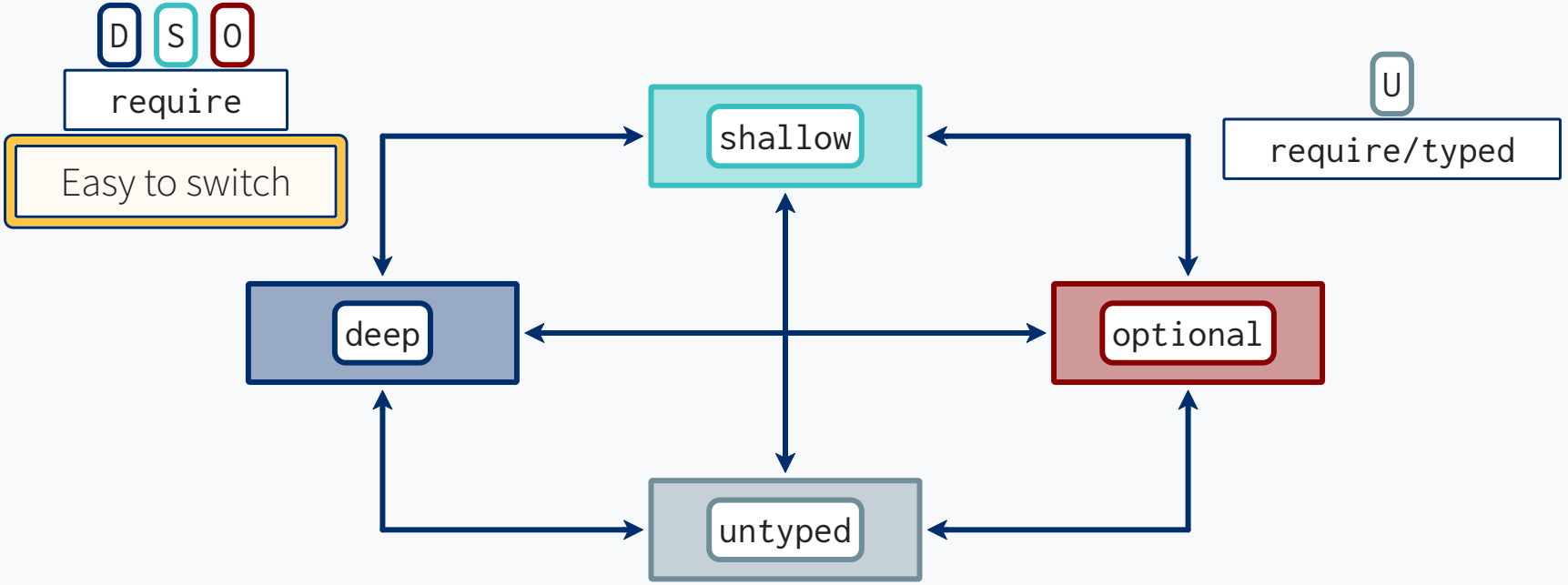

PLDI '22

* macros, define-typed/untyped-id, ...

3. Faster Shallow

Better base types, fewer shape checks

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Problem: every function call **might** need a shape check

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No check

Yes check

No check

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No check

Yes check

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Old Solution: trust specific IDs

New Solution: type-based, compositional

++ Well-Typed Interactions

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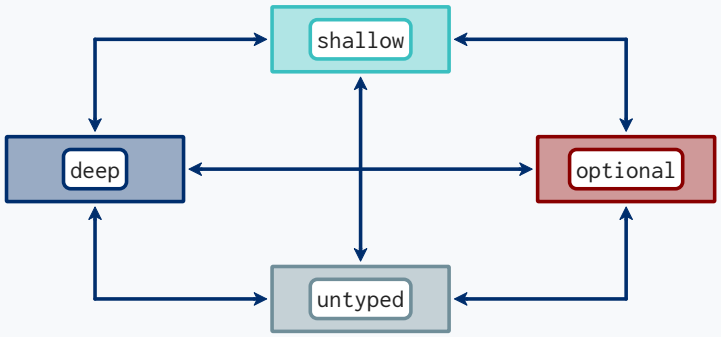

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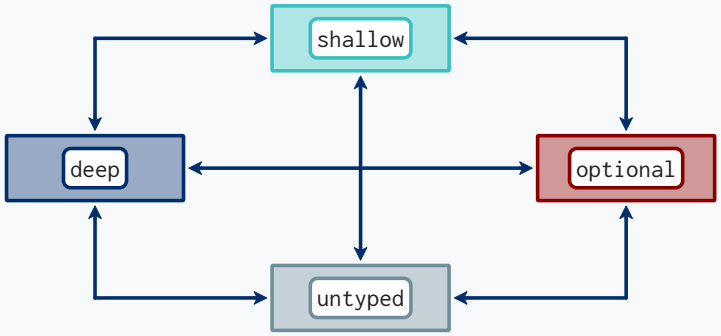

More to Come

- D/S Cooperation
- Even Faster Shallow
- Macro Reuse
- Occurrence Type Boundaries

Faster Math?

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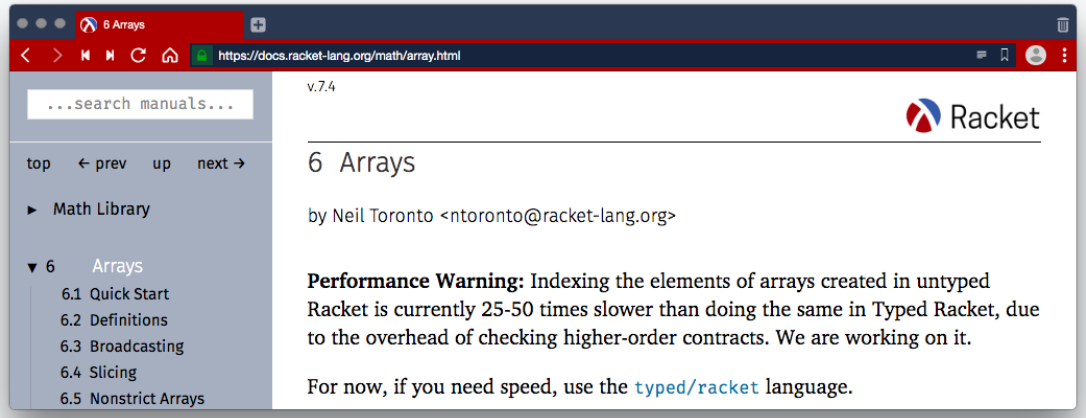
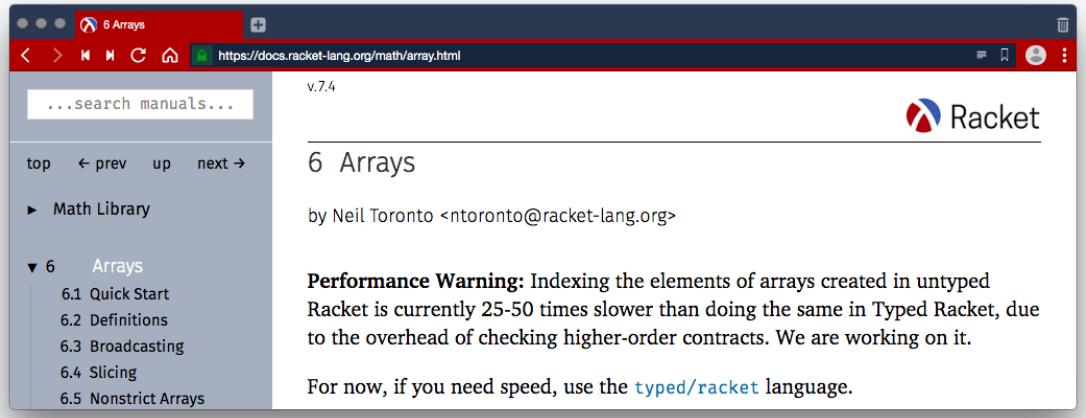
Untyped slowdown: **25x to 50x**



Faster Math?

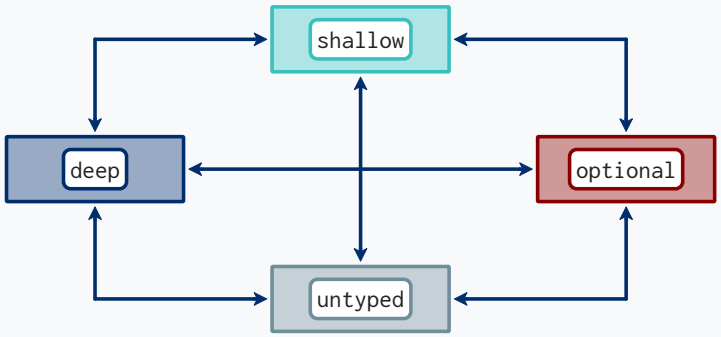
Untyped slowdown: **25x to 50x**



Not easy, but there's hope: `github.com/racket/math/issues/75`

++ Well-Typed Interactions

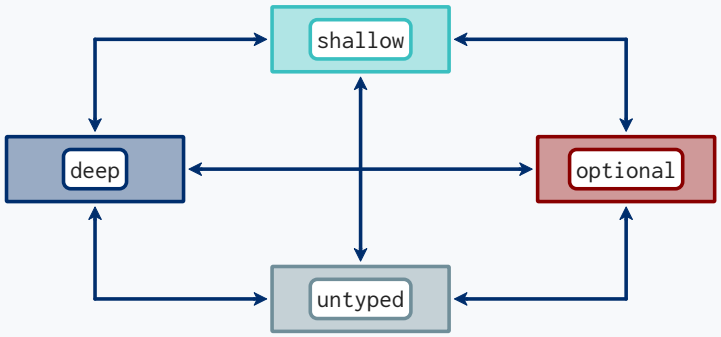
++ Faster Shallow



in Racket 8.7

++ Well-Typed Interactions

++ Faster Shallow



Shallow and **Optional** Types for Typed Racket

1. Two New Languages
2. Static Types = Same as Before
3. Better Performance at Type Boundaries

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