Gradual Soundness: Lessons from Static Python

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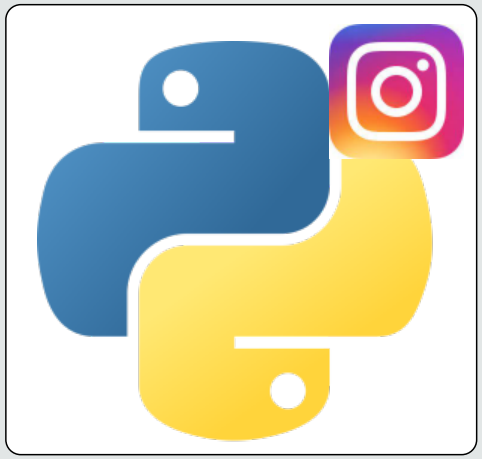
Aniket Panse Shriram Krishnamurthi


BROWN

Meta

‹Programming› 2023

Static Python



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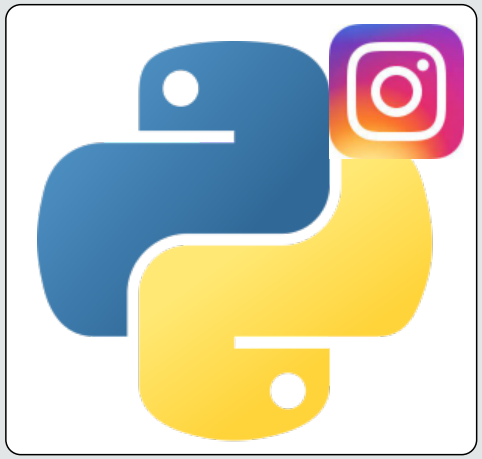

Enhanced Python, by Instagram

+2 years running **in production**

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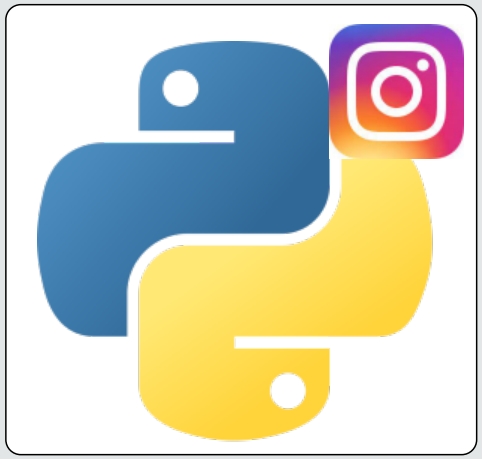

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Gradually typed
... for some value of gradual

What is Gradual Typing?

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Idea: combine the best parts of typed and untyped code

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so many parameters!

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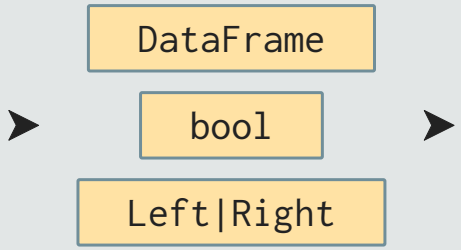

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Idea: combine the best parts of typed and untyped code

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# Python code

def join(d0,d1,sort,how):
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```

DataFrame

bool

Left|Right

```
# Python + Types
def join(d0:DataFrame,
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Great!

But, **what happens** when

typed code and untyped code

interact?

Are types sound?

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A3. Progressive static types + tags

Today!

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Experience @ Instagram Web Server

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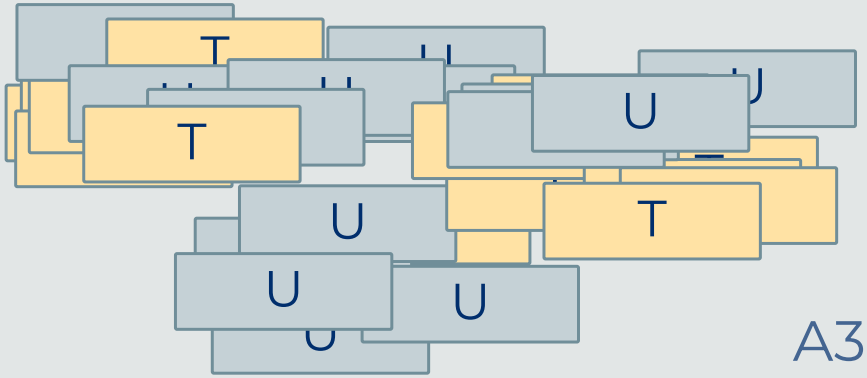
Experience @ Instagram Web Server

+500 modules with **sound types**
(upgraded from Pyre)

+30k T — U interactions



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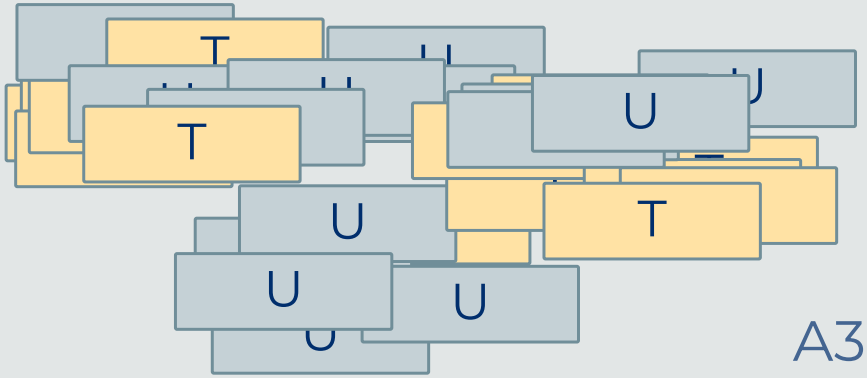

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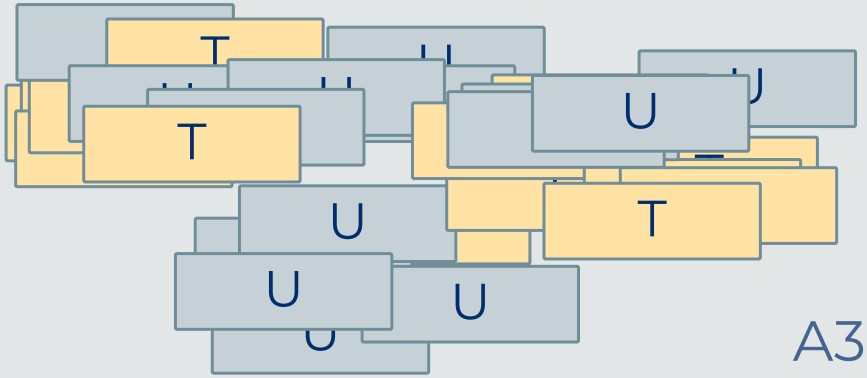

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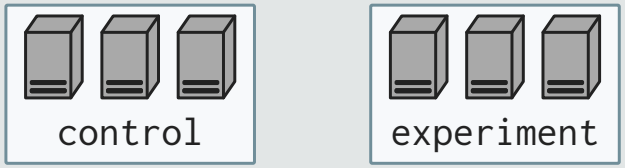

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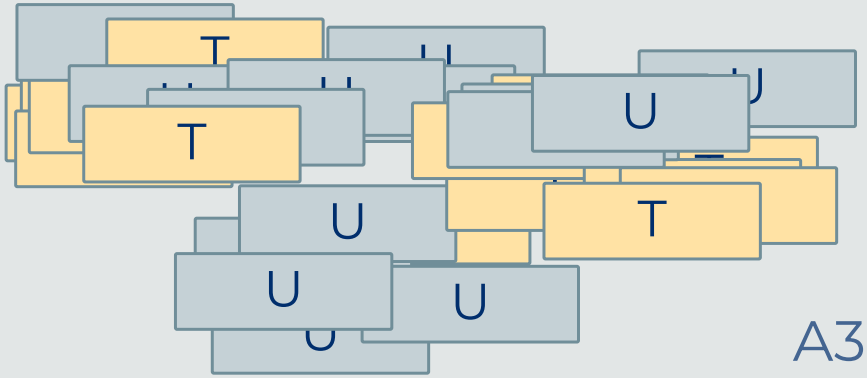

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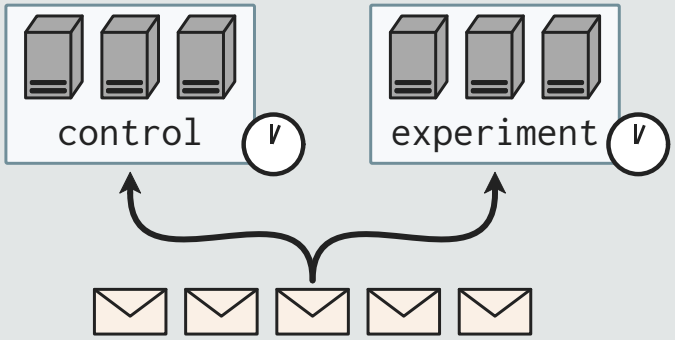

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How is Static Python so Fast?

Step 0. Better Compiler & Runtime

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https://github.com/facebookincubator/cinder

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Cinder Runtime

V Tables
Method-based JIT
...

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Cinder Runtime

V Tables
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…

Type-Aware Bytecode

`CALL_FUNCTION`	Python default
`INVOKE_METHOD`	V Table lookup
`INVOKE_FUNCTION`	direct call

Step 1. Fast Soundness Checks

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```
avg(nums)
```

```
def avg(ns:chklist[int]) -> int:
  ....
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Q. How to enforce soundness?

A. **Tag check**

Is `nums` an instance of `chklist[int]` ?

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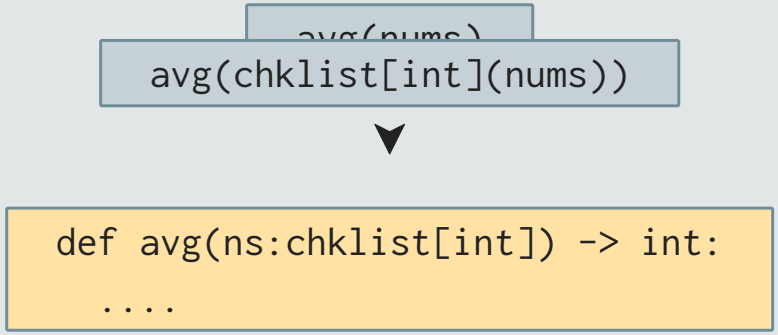

Q. How to enforce soundness?

A. **Tag check**

Is `nums` an instance of `chklist[int]` ?

✔ Fast! No traversal, no wrapper

■ Rejects built-in Python lists

Step 2. Progressive Types

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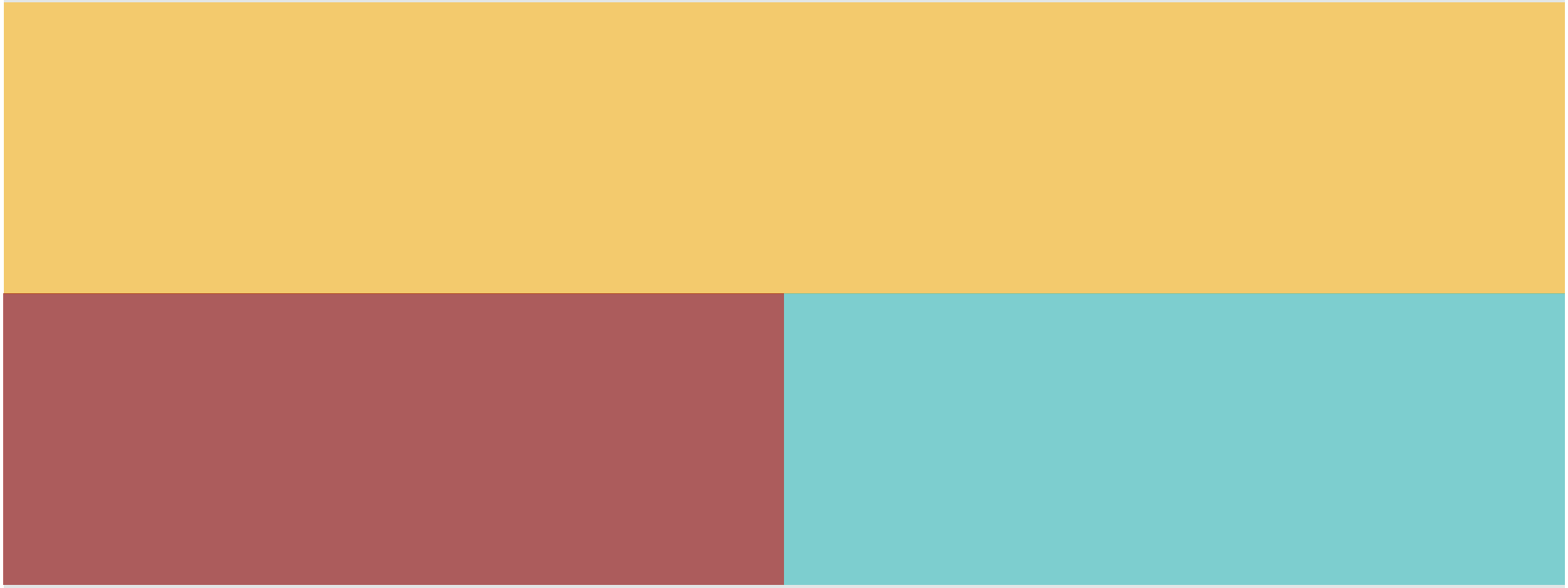

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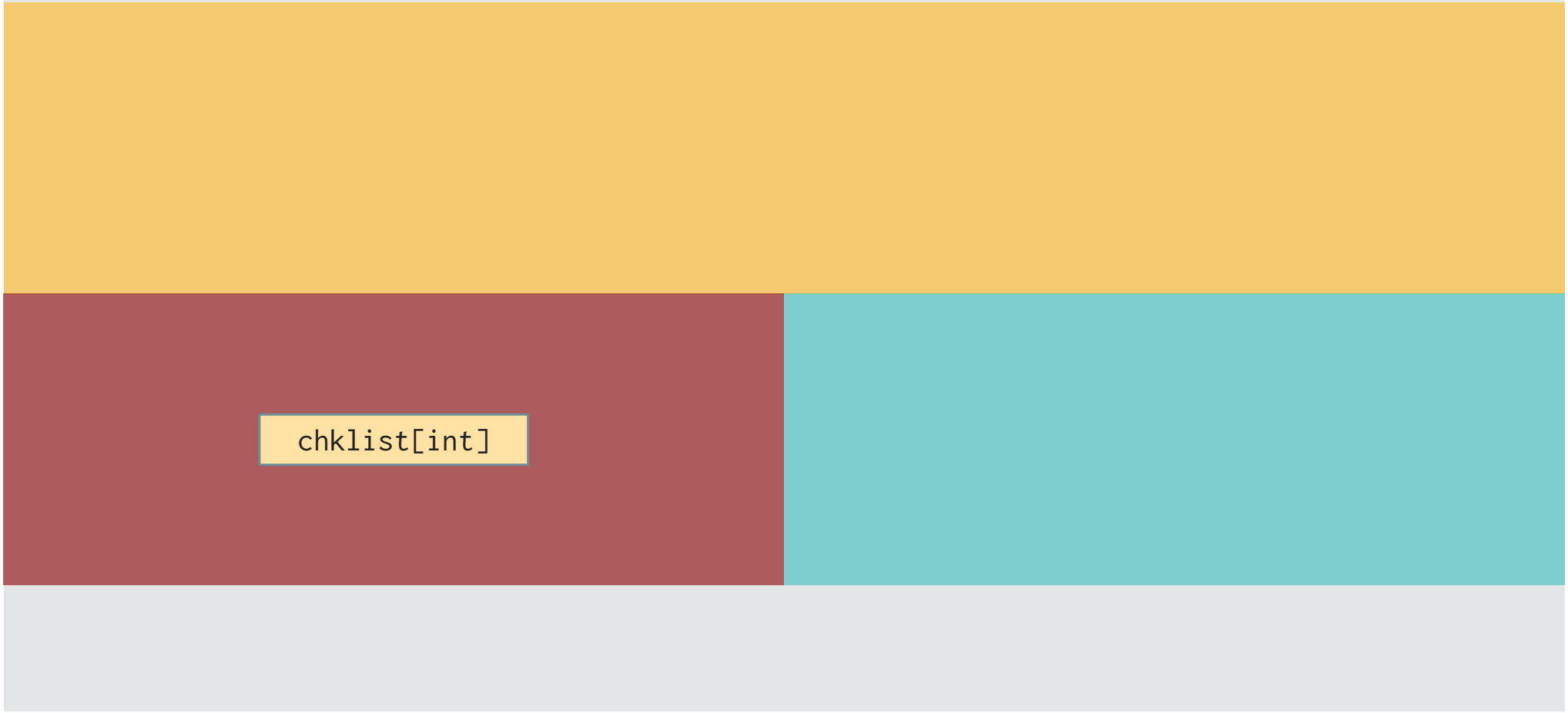

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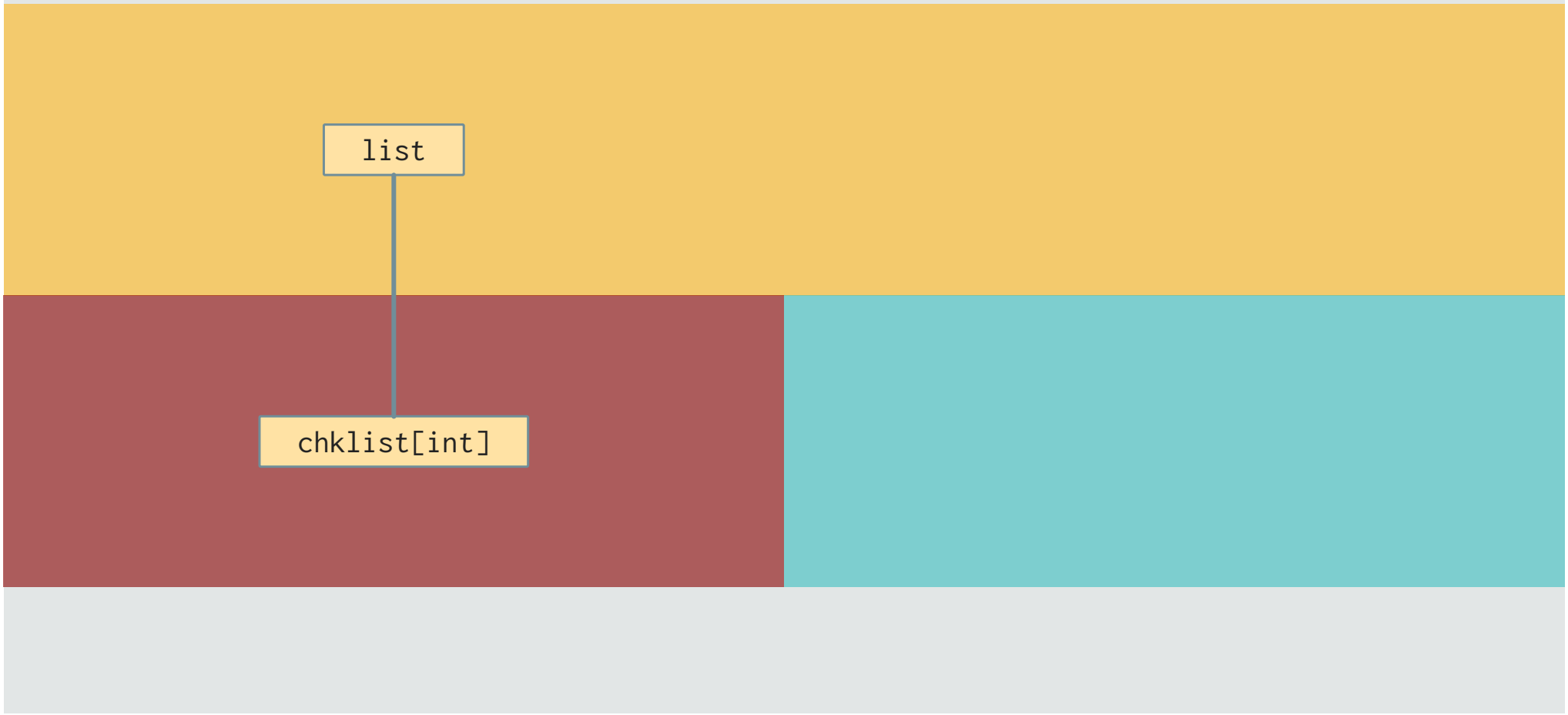

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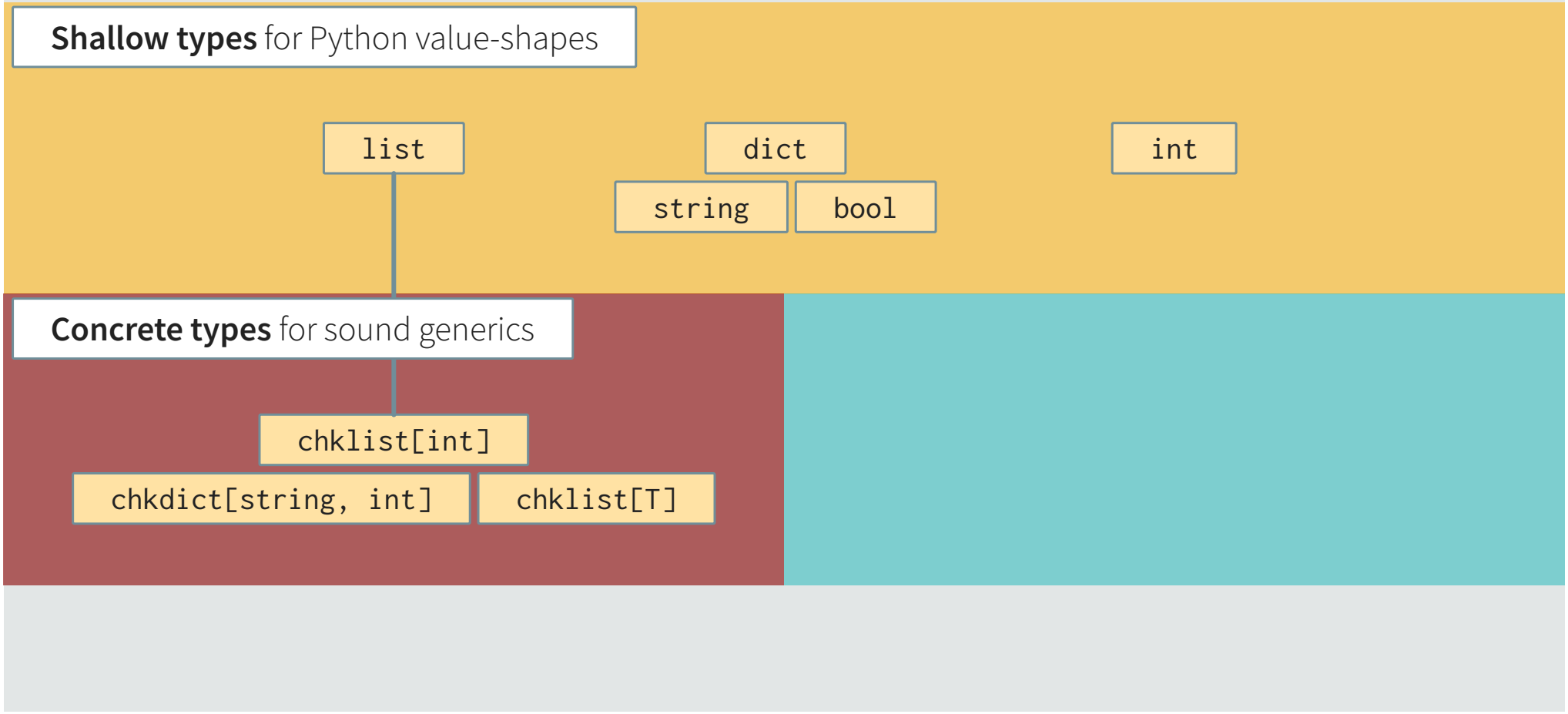

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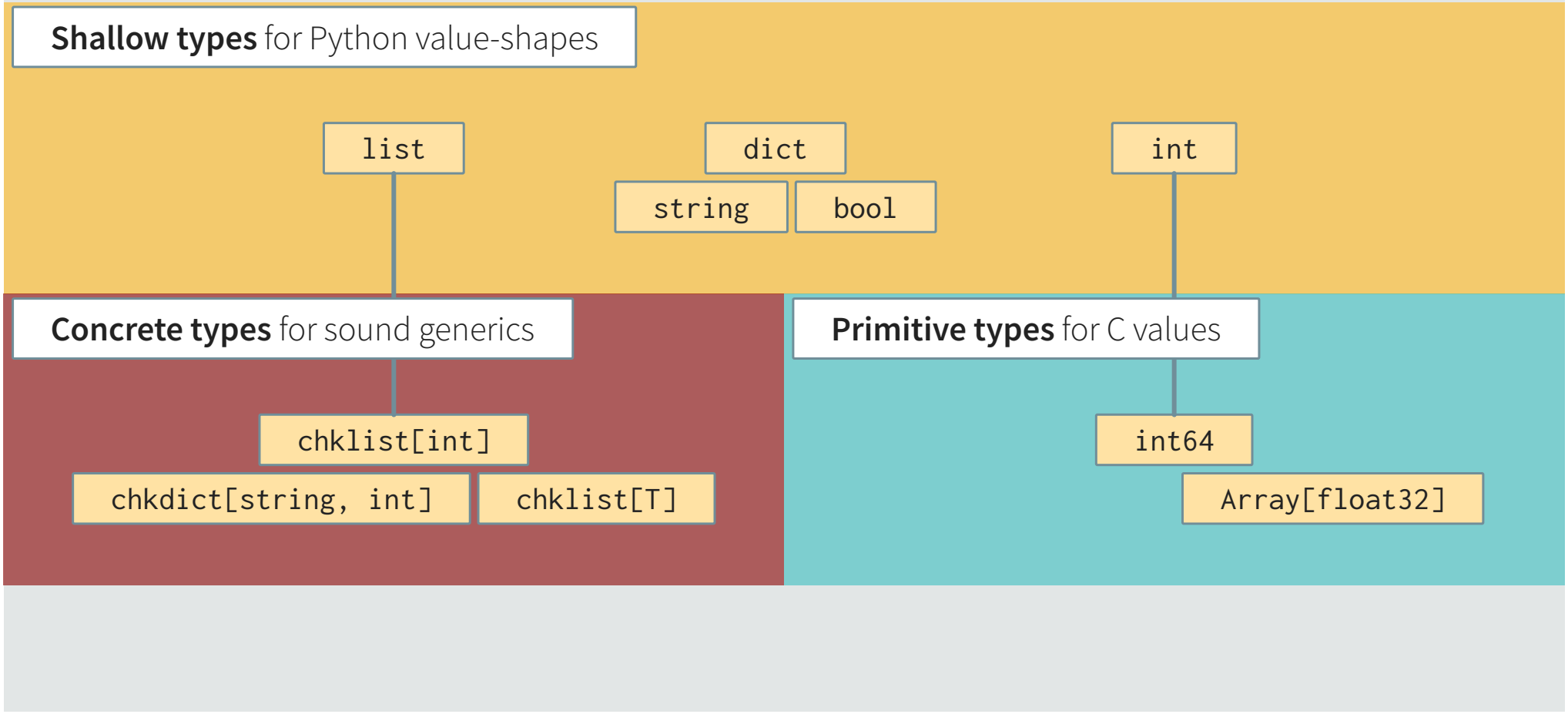

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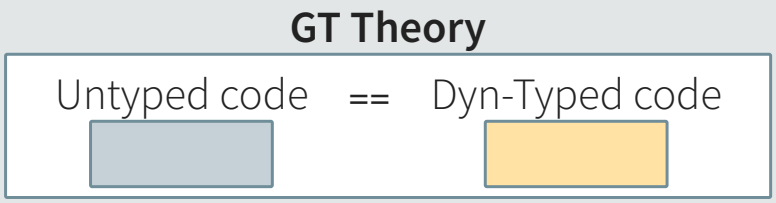

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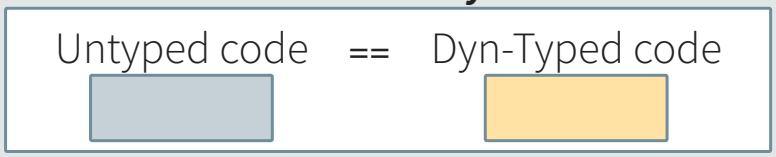
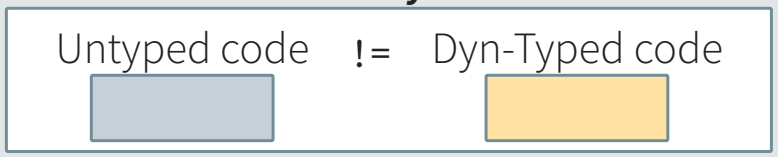
GT Theory



Static Python



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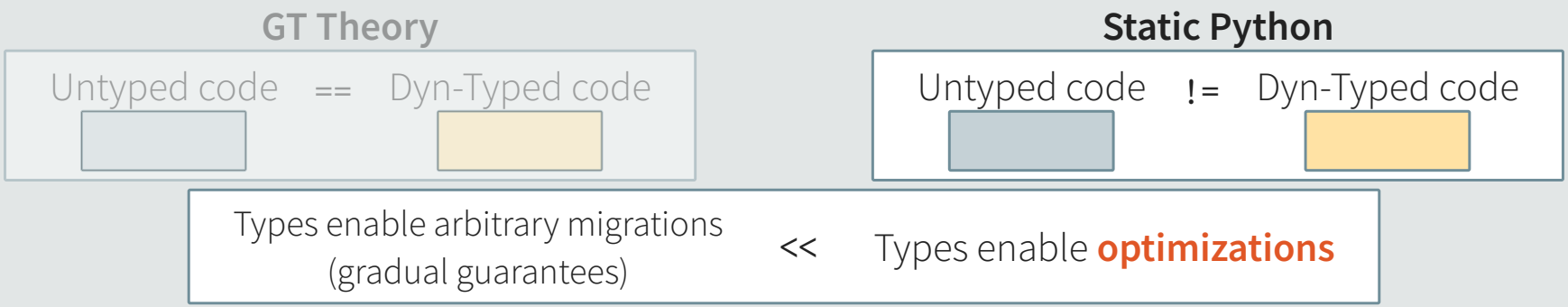

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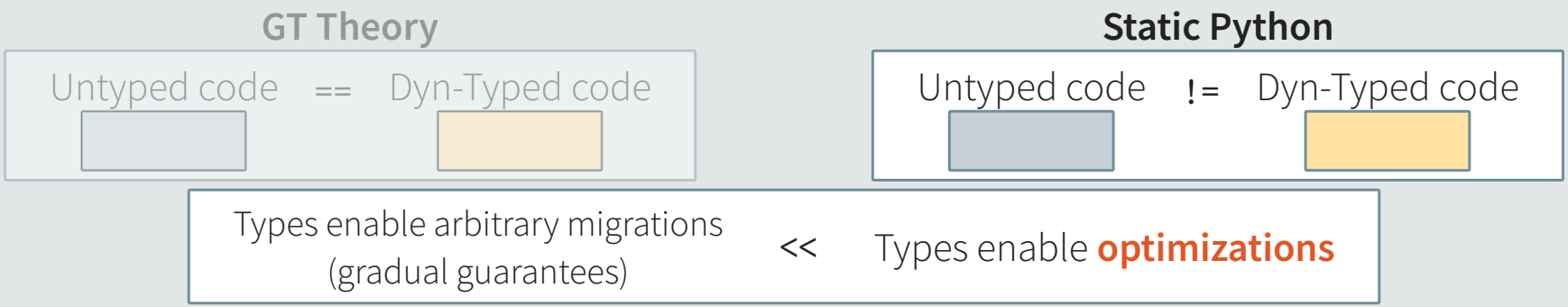

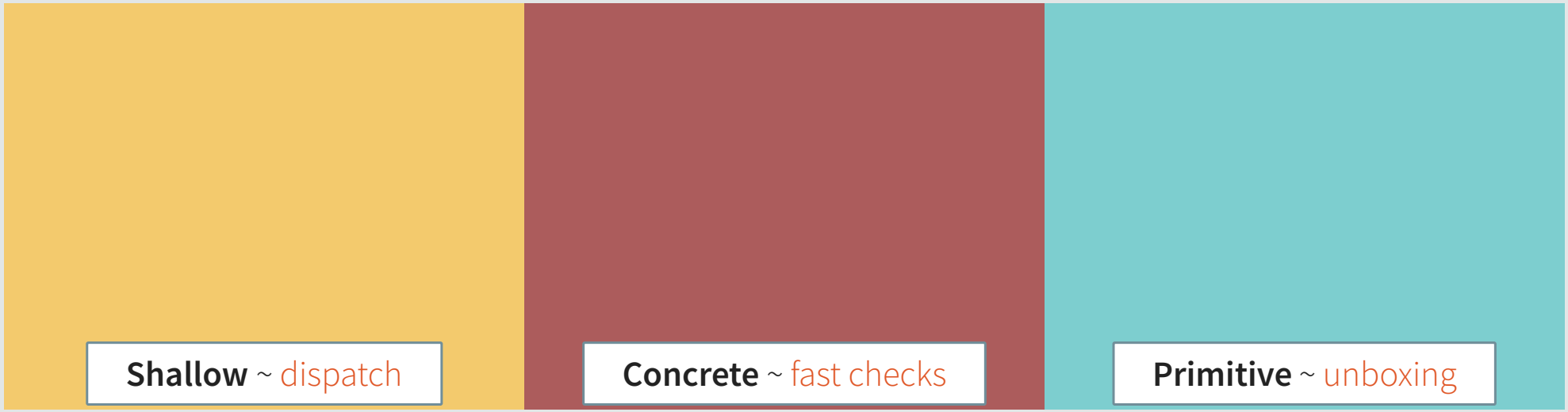

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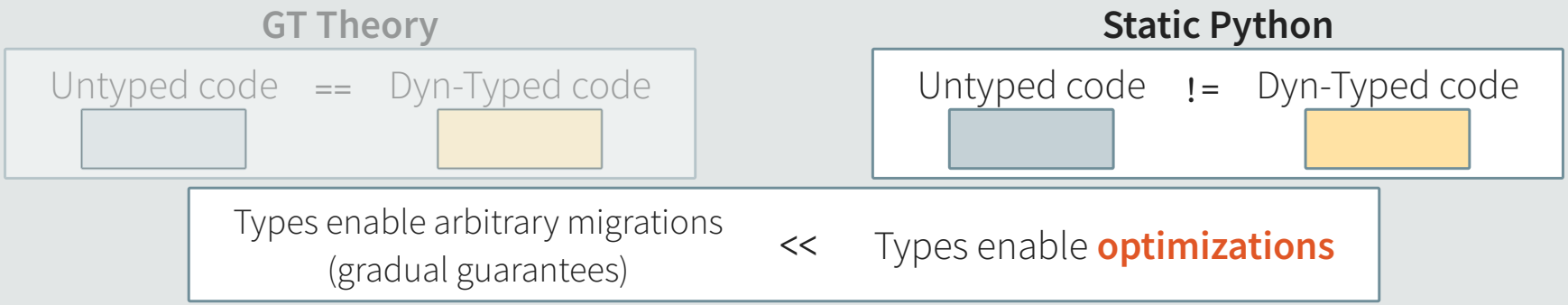


```
class A:
 def f(self)->int:
```

```
class B(A):
 def f(self):
   # Type Error
```

Shallow ~ dispatch

Concrete ~ fast checks

Primitive ~ unboxing

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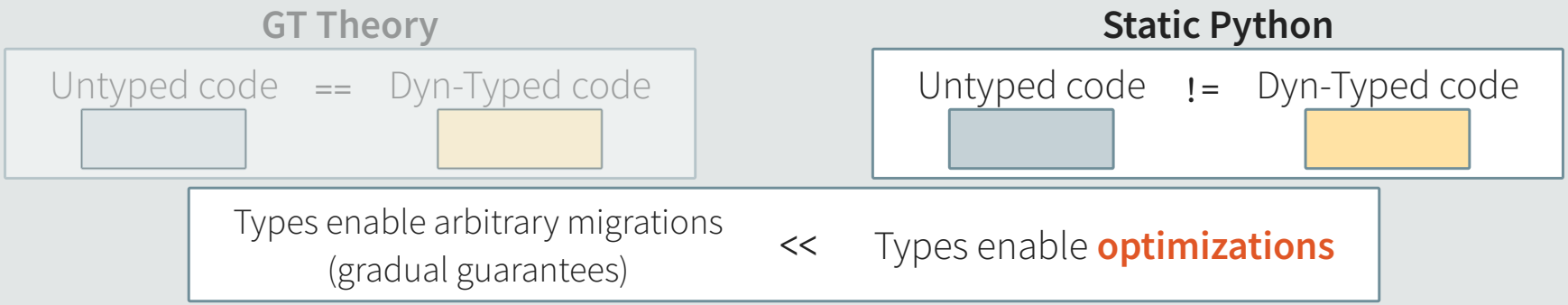


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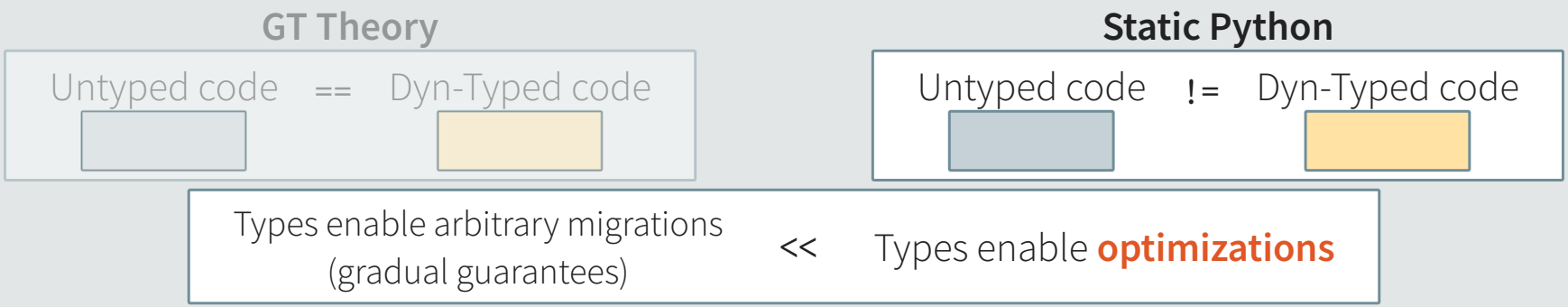


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```
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```
avg(chklist[int](1,2))
# Runtime Error
```

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Primitive ~ unboxing

Step 4. Limited Scope

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Focus on high-payoff **optimizations**
rather than feature-completeness

`eval` `first-class class`
`multiple inheritance` ==> defer to Python

`Callable[T0, T1]` `Setof[T]`
`Union[T0, T1, T2]` ==> defer to Pyre

PYRE

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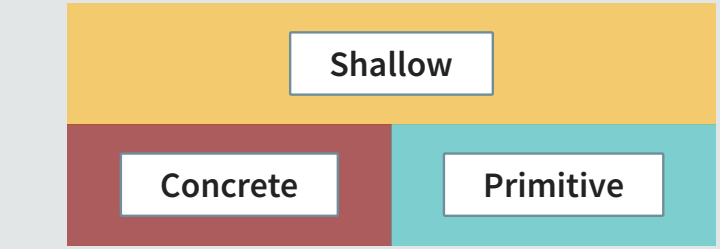
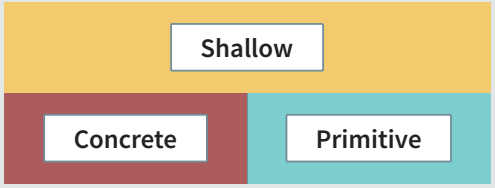


Types gradually enable optimizations
Gradual Soundness

More Experience



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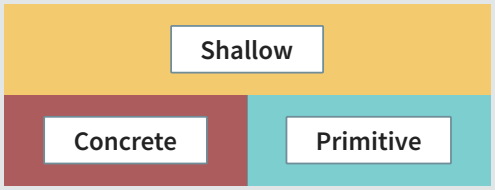

Instagram, March 2023:

959 typed modules

10 with **Concrete** (fast reads)

16 with **Primitives** (unboxed math)

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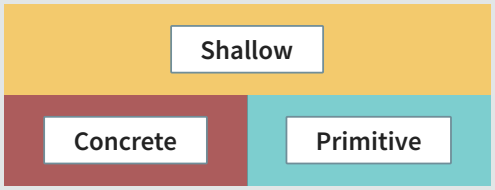

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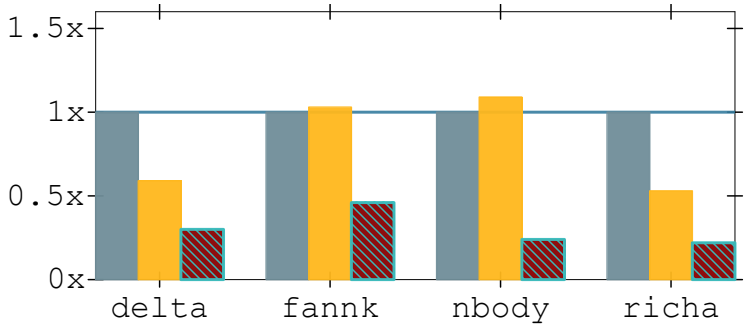
Microbenchmarks

1x = Python, **lower** is faster



Takeaways

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τλ GT Researchers

Guarantees vs. Performance?

Qs for Concrete:

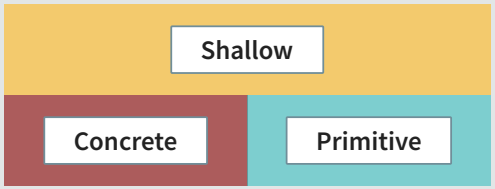
* migrating `list` to `chklist[T]` etc.
* fast tags for `Union[T0, T1, T2]`

Prior work:  

Takeaways

Practitioners

Why not your language?



Takeaways

Language Designers

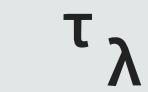
Redex model found:

5 critical soundness bugs

16 correctness issues

Takeaways

The End



New research directions

Who's next?

Model found:
5 soundness + **16** other issues

Static Python