Type System for Metaprogramming

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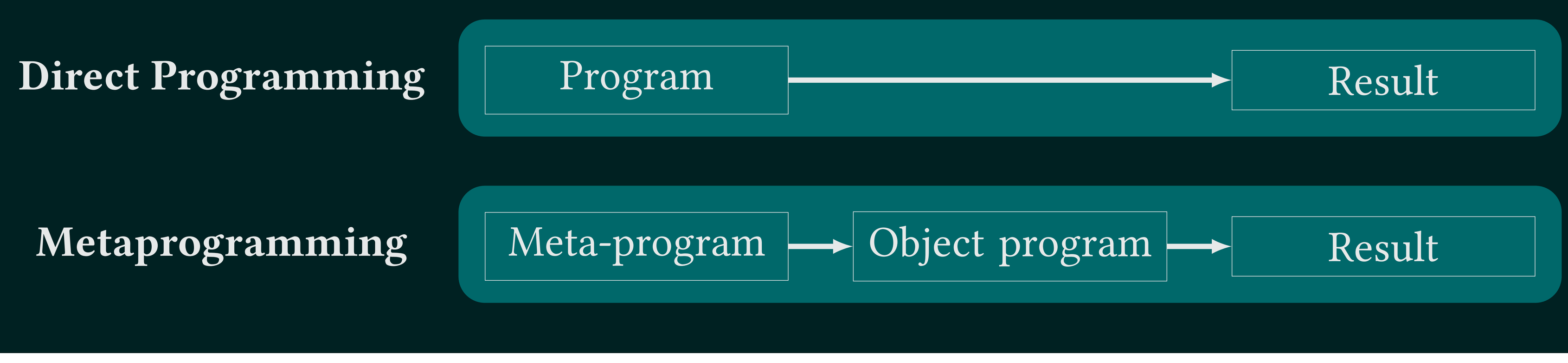
Metaprogramming

The art of generating, manipulating, and analyzing code

(Used for Compiler, Program Analyzer, Program generator, etc.)



Metaprogramming with Box/Let-box

`box(2 + 3)` A code fragment for `2 + 3`

`let box(C) = box(2 + 3) in C` Execution of code `2 + 3` to get `5`

```
untypedNth n =
  if n <= 0 then
    box(head xs)
  else
    let box(C) = untypedNth (n - 1) in
    box(let xs = tail xs in C)
```

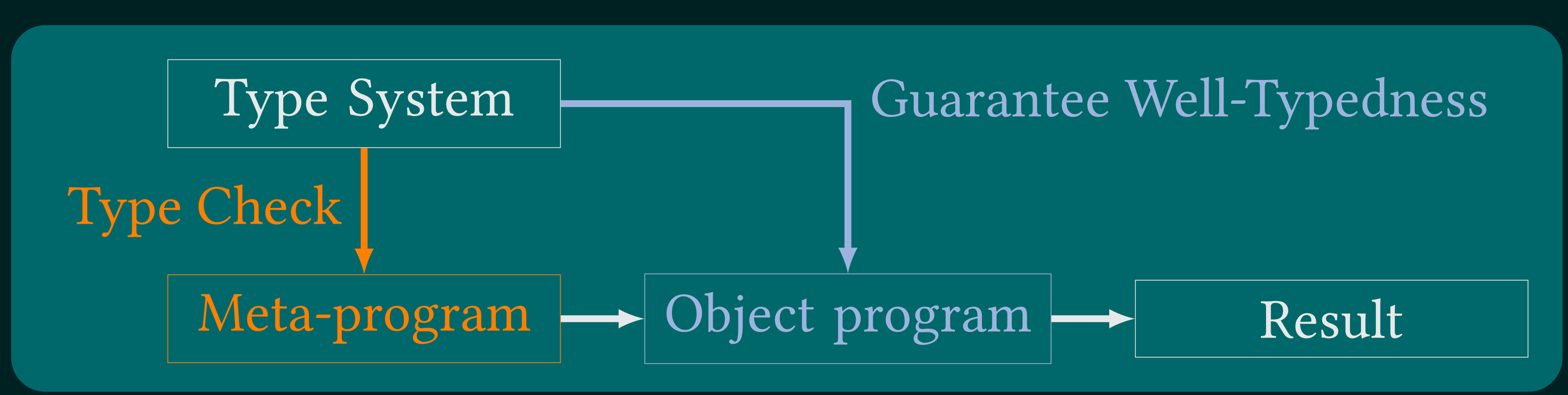
Untyped Metaprogram to get n-th item in a list

If we evaluate `untypedNth 2`, we get

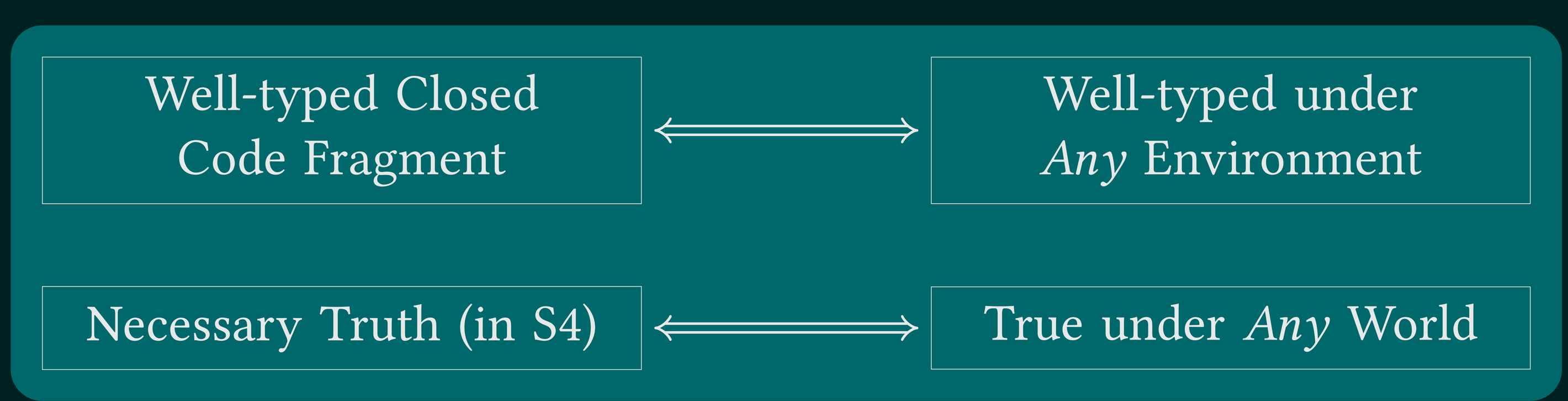
```
box(let xs = tail xs in
    let xs = tail xs in
    head xs)
```

Typed Metaprogramming

We want to ensure that generated code will be well-typed *before* executing a meta-program.



Modal Logic



`□ A` A type for code generating `A`-typed program

`box(M)` has type `□ A` — `M` has type `A` but does not use any environment-specific information

```
intNth : Int -> □ (Int list -> Int)
intNth n =
  if n <= 0 then
    box(fun xs => head Int xs)
  else
    let box(C) = intNth (n - 1) in
    box(fun xs => C (tail Int xs))
```

Typed Metaprogram to get nth item in an int list

If we execute `intNth 2`, we get

```
box(fun xs =>
      (fun xs =>
        (fun xs => head xs)
        (tail xs))
      (tail xs))
```

Problem 1 — Well-typed Open Code Fragments

`untypedNth 2` has a free variable `xs`, but we cannot type check this as-is with Simple S4. Thus, `intNth 2` has some redundant anonymous functions and function calls.

Problem 2 — Polymorphism

`intNth 2` works only for `Int` lists. The following approach to polymorphism does not work:

```
badPolyNth : ('a : Type) -> Int -> □ ('a list -> 'a)
badPolyNth 'a n =
  if n <= 0 then
    box(fun xs => head 'a xs)
  else
    let box(C) = badPolyNth 'a (n - 1) in
    box(fun xs => C (tail 'a xs))
```

Ill-typed Metaprogram to get nth item in a list

because code `fun xs => head 'a xs` depends on `'a` and thus is not closed.

Problem 3 — Pattern Matching on Code Fragments

Some text

Contextual Modality

Some text

Levels (Opt)

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Levels in Polymorphism

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Levels in Pattern Matching

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References

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