Types for Flexible Objects

Building a Typed Scripting Language

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Objective

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Static typing, inference, etc.

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  - Dynamic lookup, update, etc. based on runtime conditions
- Minimal semantic clutter (for readability)
- Good for ad-hoc, situational requirements

Examples of Flexibility

Add a method to an existing object:

```
class A:
  def foo(): return 1
a = A()
a.bar = types.MethodType(
            lambda self: 2, a)
```

Examples of Flexibility

Rely on execution path invariants:

```
def neg(x):
  if type(x) is int:
    return -x
  else:
    return not x
print neg(2) + 3
```

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- We want both!

Options?

- Powerful traditional type system
  - ☺ Captures static invariants (monads, dep. types)
  - ☹ Often incurs semantic clutter
  - ☹ High barrier to entry
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- **Design a language to include statically-typed flex**

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    - Powerful record combinators
    - First-class match clauses
    - Refinement on pattern matching
- Result: flexible language with static typing

Outline

- Semantics
  - Powerful records and record combinators
  - First-class match clauses
  - Object encoding using variants
- Static typing
  - Overview
  - Union elimination
  - Polymorphism
- Summary

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- Asymmetry is fundamental in several encodings

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- Encodes `match`!
- Operator `&` uniformly concatenates records, match clauses: `(`x 1) & (int -> 0)`

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Variant-Based Object Encoding

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let rec seal = (see paper) in
let prePoint =
  `x 2 & `y 4 &
  (`mg & `self slf -> slf `gx + slf `gy ) &
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in let point = seal prePoint in
point `mg    // returns 6
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- All statically typed!

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- *Variant-based* objects
- Operator overloading
- Classes, inheritance, subclasses, etc.
- Mixins, dynamic functional object extension
- First-class cases
- Optional arguments
- etc.

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And we can type them!

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  - Concession: it's whole-program typing

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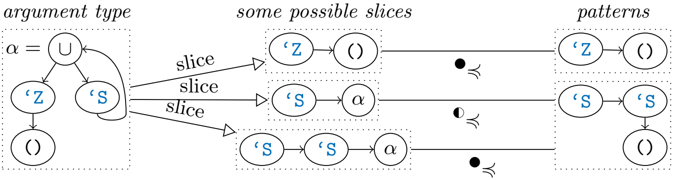

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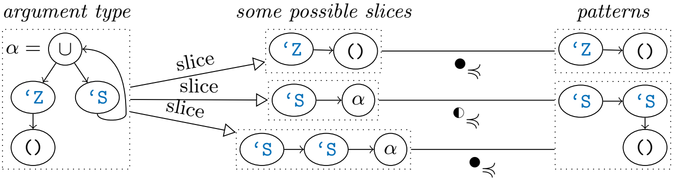

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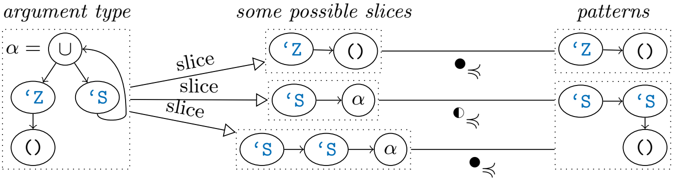

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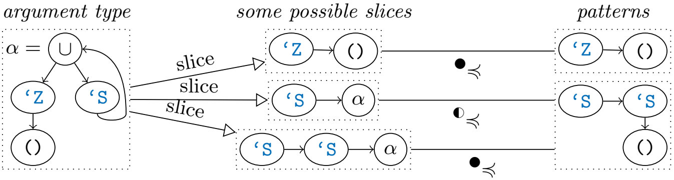

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let f = (x:'A () -> x.B) &
        (y:'P () -> 1)
in f ('A () & 'B 5) + f 'P ()
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  - Limits polymorphism of recursion but nothing else
  - Similar to DCPA and ΔCFA, but optimistic

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- So, start with ML and add “principled flex”
- TinyBang is our initial result
  —supports flex but more safely/declaratively

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- http://big-bang-lang.org

Related Work

- Re-sealing objects generalizes [Fisher Bono '98]
- Unifying records and variants from [Pottier '00]
- Type-indexed records [Shields Meijer '01]
- First-class match generalizes [Blume et. al. '06]
- CDuce [Castagna et. al. '14]
  - Similar expressiveness in several dimensions
  - CDuce: type *checking*; TinyBang: type *inference*

Questions?