Balance in programming research

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Parsifal, INRIA Saclay

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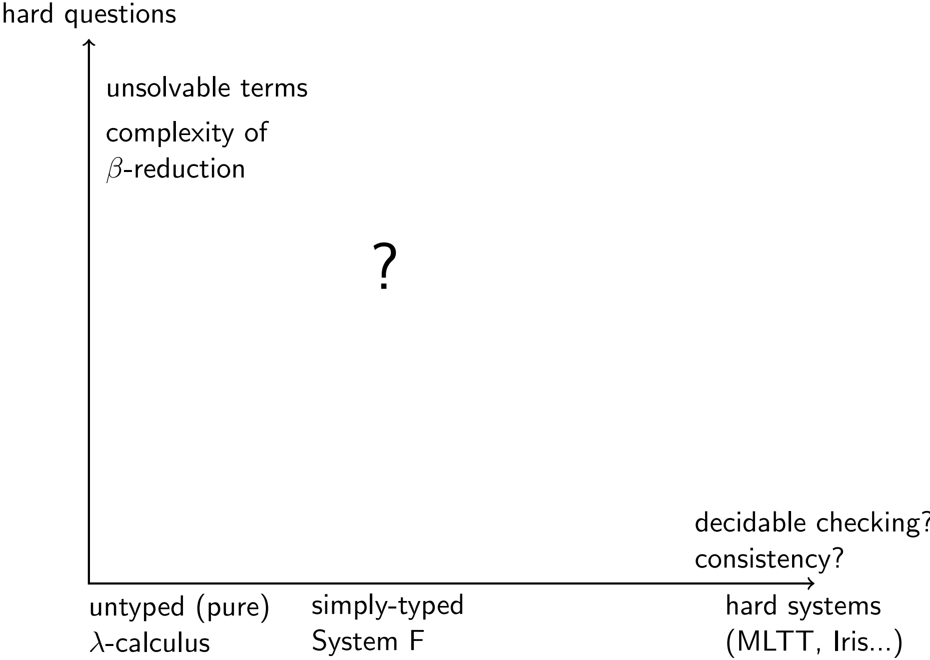
hard questions
unsolvable terms
complexity of
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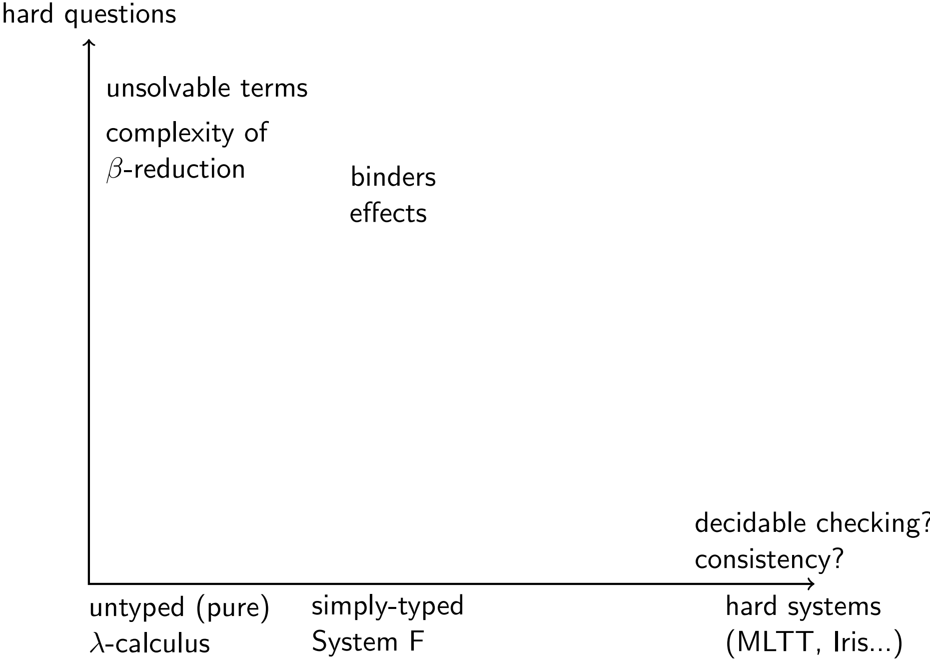
consistency?
untyped (pure)
λ-calculus
simply-typed
System F
hard systems
(MLTT, Iris...)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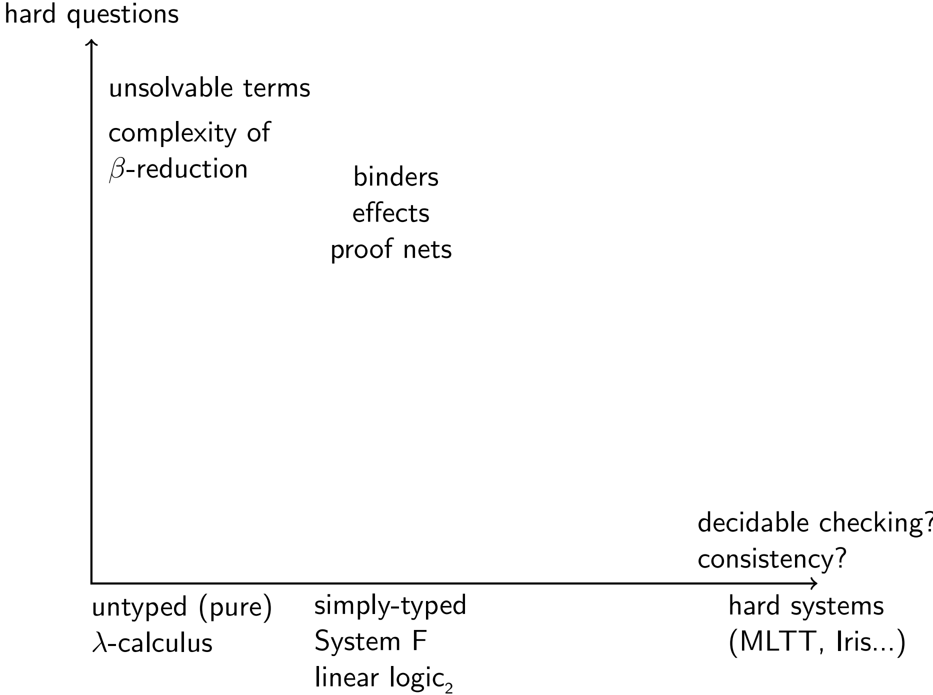
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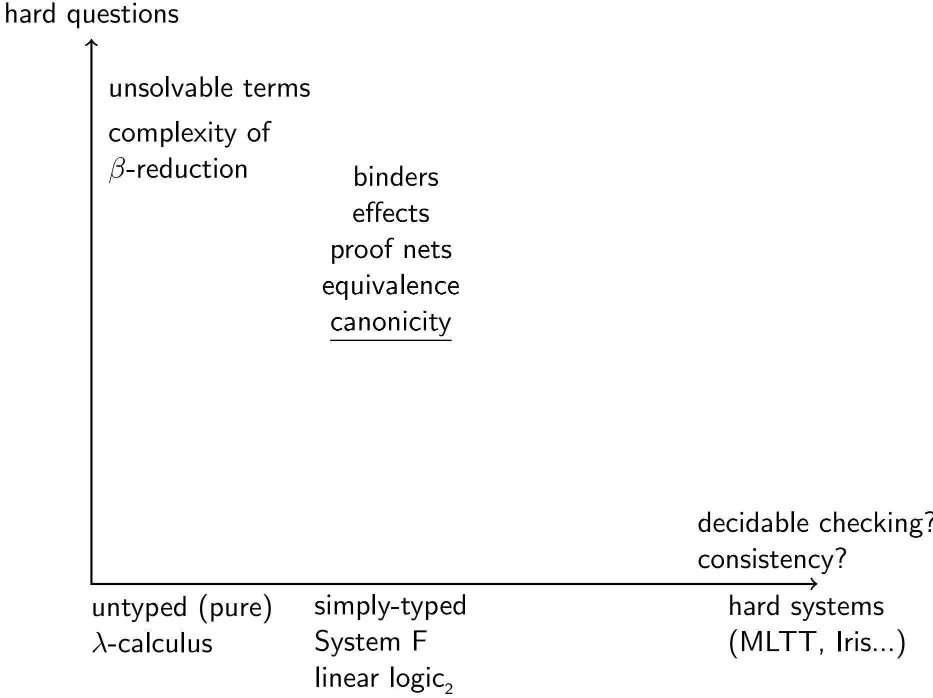
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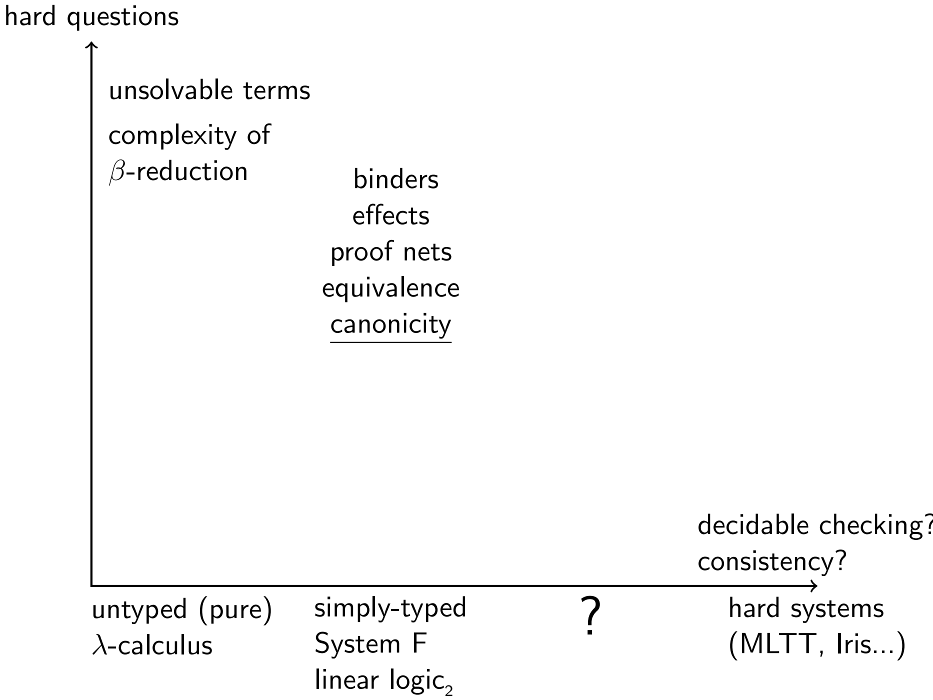
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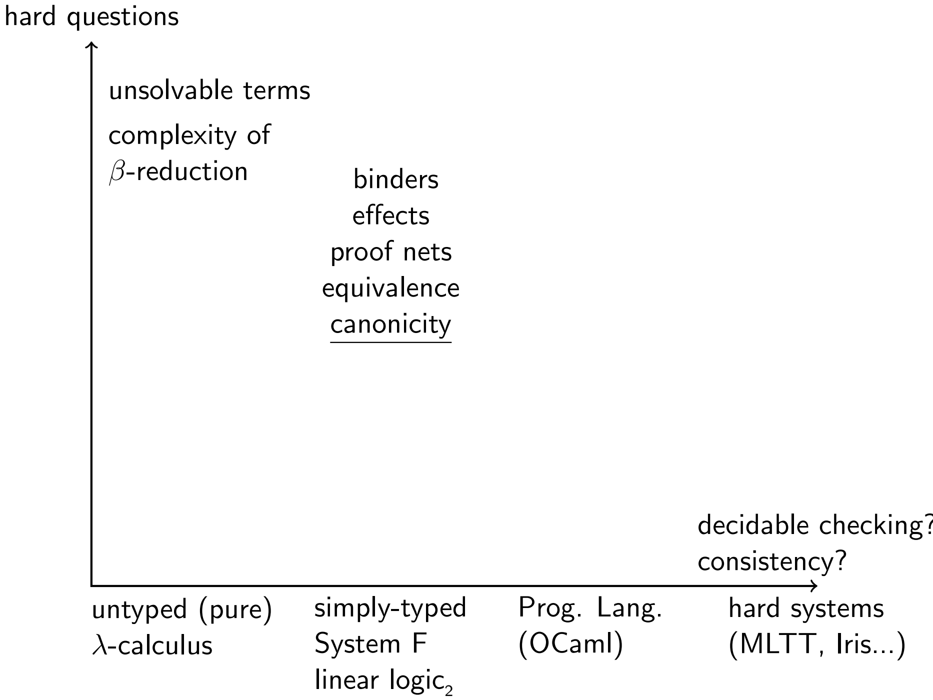
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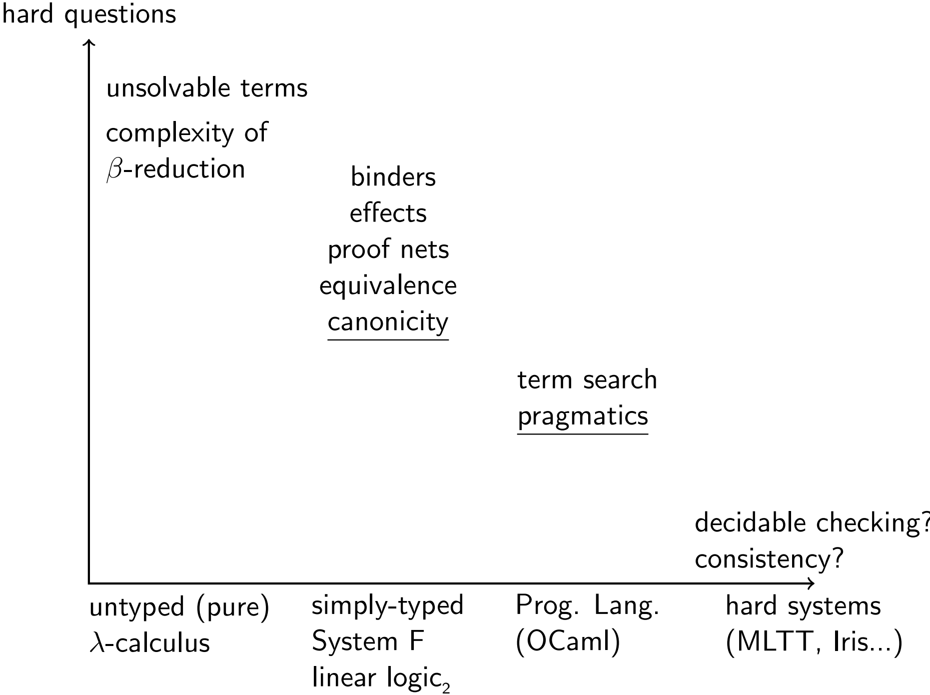
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OCaml

Strongly typed functional language – ML family.
Widely used in our research communities, niche outside.

Research successes: Coq, Why3, Frama-C, HOL-light, CIL, slam/sdv, $F^\star$...

Industrial successes: languages (Rust, Webassembly), finance (at Jane Street), program analysis (at Facebook), blockchain (Tezos), unikernels (at Docker).

Important common infrastructure.

Free Software project, maintained by a distributed group of 17 volunteers. (France, UK, Japan)
I'm one of the most active maintainers.

OCaml *research*

Active project: more applied research for OCaml.
(Inspiration: what SPJ does beautifully for Haskell)

Last year:

- internship: safely unboxing mutually-recursive declarations
- internship: a type system for recursive value declarations
- collaboration: a paper on Merlin (ICFP Experience Report)

Focus: recursive value declarations

```
let rec x(t) = x(t)
let rec x = 1 + x
let rec x = 1 :: x
```

Focus: recursive value declarations

```
let rec x(t) = x(t)          fun t -> (x:Delay)(t)
let rec x = 1 + x            1 :: (x : Guard)
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$m ::= \text{Ignore} \mid \text{Delay} \mid \text{Guard} \mid \text{Return} \mid \text{Dereference} \qquad \Gamma ::= (x \mapsto m)^*$

$$\Gamma \vdash t : m$$

How to check a declaration?

`let rec` x_1 `=` e_1 `... and` x_n `=` e_n `in body`

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$$\Gamma_i \vdash e_i : \text{Return}$$

$$\forall \Gamma_i, \forall x_j, \quad \Gamma_i(x_j) \leq \text{Guard}$$

Transition slide.

Canonicity

What is the **identity** of programs (λ-terms)?

Canonical representation: a syntactic description of the representatives of the (contextual) equivalence classes.

$$t, u \text{ canonical} \implies t \neq_\alpha u \implies t \neq_{\text{ctx}} u$$

Application: deciding equivalence, program synthesis (maybe?).
Just darn interesting.

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Goal: richer types.

Canonicity: future work

System F: no subformula property.

$$\frac{\Gamma, A[B/\alpha] \vdash C}{\Gamma \ni \forall \alpha.\, A \vdash C}$$

Equivalence is undecidable in F: no decidable canonical forms.

Could we have a partial algorithm that works sometimes?

Eliminating polymorphism

Idea: probe the structure of $\forall\alpha.\, A$ through (canonical) proof search.

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On which fragments can this idea work?

Zooming out

Goal: balance between applied and theoretical research.

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