DETERMINIZING FIELDS

ROSS TATE

CEYLON: INTERSECTION TYPES

$$\frac{t_i \; <: \; t'}{t_1 \cap t_2 \; <: \; t'} \qquad\qquad \frac{t \; <: \; t_1' \quad t \; <: \; t_2'}{t <: \; t_1' \cap t_2'}$$

instr : $[t_i{*}] \rightarrow [t_o{*}]$ and instr : $[t_i{*}] \rightarrow [t_o'{*}]$ implies instr : $[t_i{*}] \rightarrow [(t_o \cap t_o'){*}]$

Restores principal typing for instructions

INTERSECTION TYPES AND EQUI-RECURSIVE TYPES

Non-Deterministic Equi-Recursive Subtyping

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Non-Deterministic Finite Automata Simulation

PSPACE-Complete

Quadratic Time

ITALX: CONCRETE UPPER BOUNDS

- iTalX is a typed assembly language for C#
  - Fields are accessed via numeric offsets
  - Field type of Instance(α) determined by *concrete* upper bound of α
    - E.g. String or other C# class types
- If α has multiple concrete upper bounds, then either
  - One dominates all others (due to single inheritance of classes)
  - α cannot exist and we can determine the state is unreachable ($\perp$)

Relies on total knowledge of class hierarchy

Ensures principal types for fields

JVM/CLI: NOMINAL FIELDS

- Instruction specifies a "nominal" field identifier (rather than an offset)
- Field identifier specifies a receiver class and a field type
  - Generics: field type might refer to type parameters of receiver class
- Instruction checks if receiver has specified class, resulting in specified field type
  - Generics: substitutes receiver's type arguments for that class
- Geneircs: Multiple upper bounds can cause receiver to have multiple sets of type arguments for a given class
  - Principle-instantiation inheritance lets one combine sets of type arguments
    - Equivalence constraints for invariant parameters, intersection types for covariant parameters, union types for contravariant parameters

Ensures principal types for fields

SOIL PROPOSAL: REFINABLE NOMINAL FIELDS

Need to revisit limited use cases for alternative design solutions

- Subclasses can refine read-only field types
- Multiple upper bounds: which refinement to use?

Non-determinism returns!