Program Analysis

Call Graphs (Part 3)

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Slides adapted from Eric Bodden

Overview

- Introduction
- Single & efficient: CHA, RTA
- Analyzing assignments: VTA, DTA 
- Call graphs and points-to analysis: Spark

Variable Type Analysis (VTA)

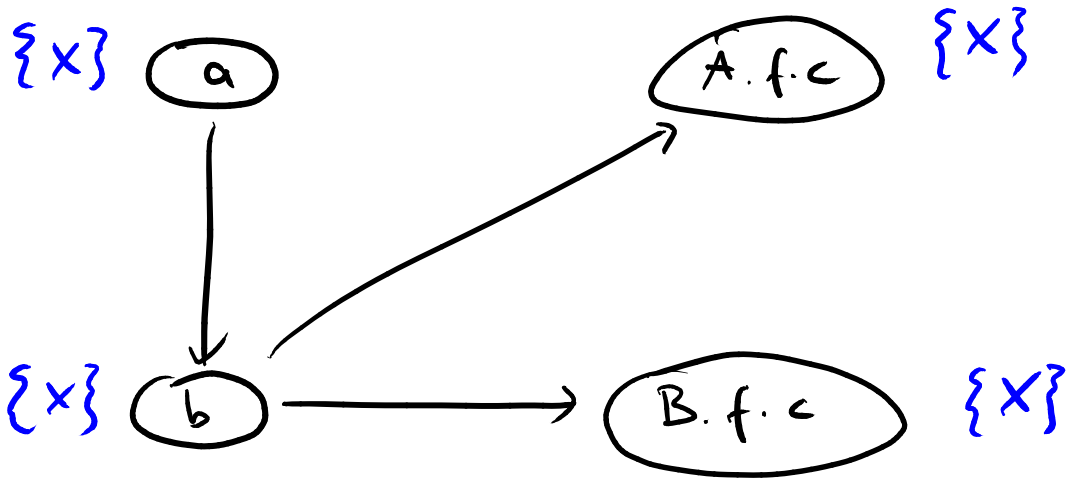
- Reason about assignments
- Infer what types the objects involved in a call may have
- Prune calls that are infeasible based on the inferred types

Example

```
a = new X();
...
b = a;
...
o.f(b);
```

```
public class A {
  public void f(C c) {
    c.m();
  }
}

public class B {
  public void f(C c) {
    c.m();
  }
}
```


{x}
a
A.f.c
{x}
{x}
b
B.f.c
{x}

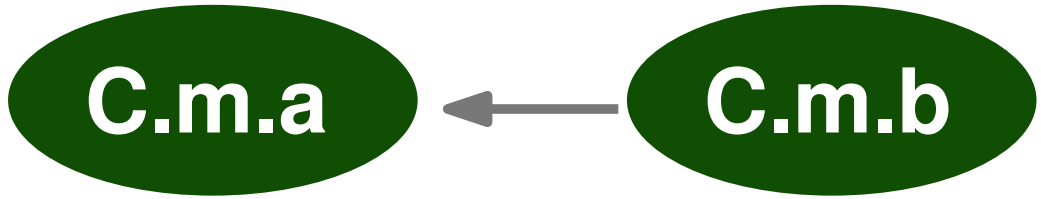
Type Propagation

Four steps:

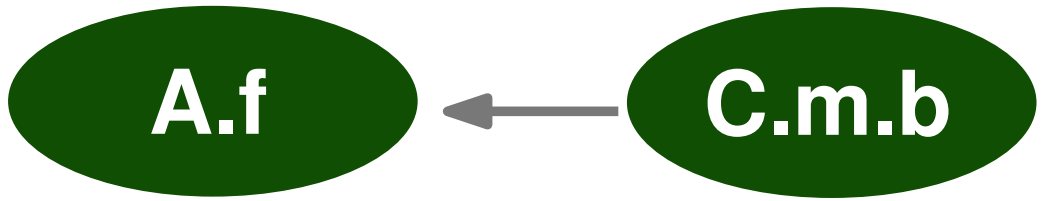
- Form initial conservative call graph
  - E.g., using CHA or RTA
- Build type-propagation graph
- Collapse strongly connected components
- Propagate types in one iteration

Building Type Propagation Graph

- Assume statement `a = b;` is in method `C.m`



- Assume another statement `a.f = b;` where field `f` is declared in `A`



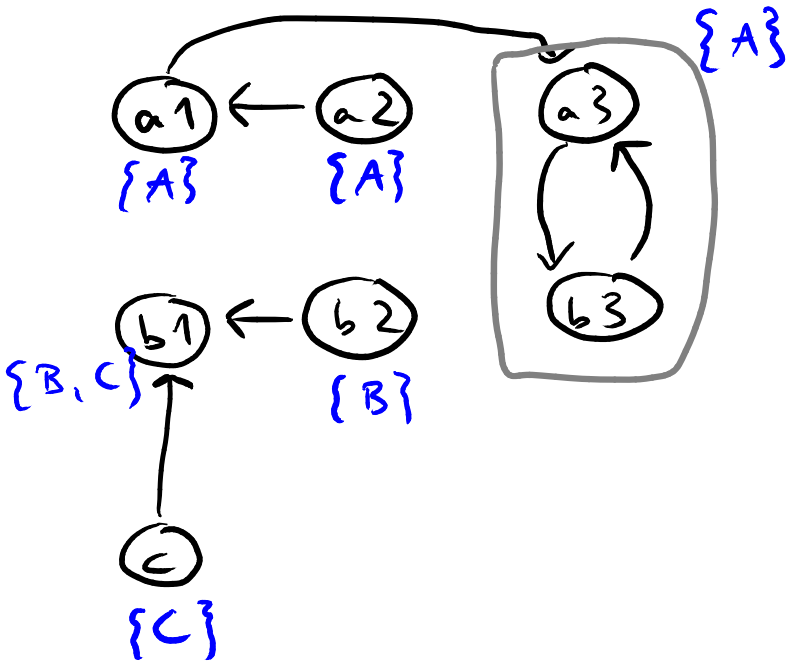
Example

```
A a1, a2, a3;
B b1, b2, b3;
C c;

a1 = new A();
a2 = new A();
b1 = new B();
b2 = new B();
c = new C();

a1 = a2;
a3 = a1;
a3 = b3;
b3 = (B) a3;
b1 = b2;
b1 = c;
```

A
↑
B
↑
C



Note: Slide fixed w.r.t lecture video

Side Note: Field Representations

How does the analysis represent `a.f`?

- Field-sensitive: Represented as `a.f`
- Field-insensitive: Represented as `a.*` or `a`
- Field-based: Represented as `A.f`, where `A` is class of `a`

Side Note: Field Representations

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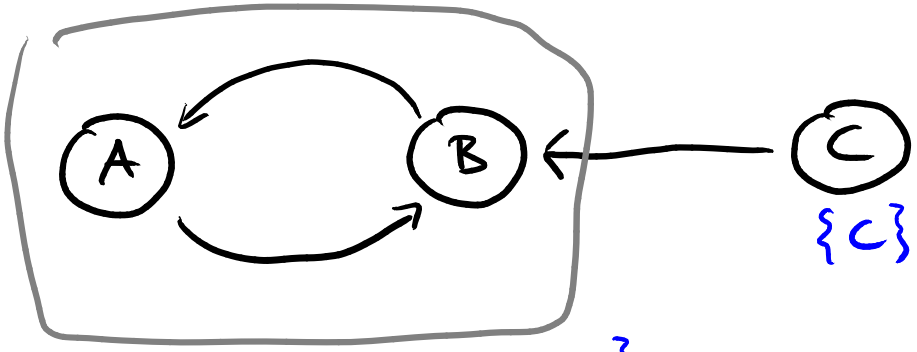
VTA is field-based

Variable Type Analysis (VTA)

- **Pros**
  - More precise than RTA: Considers only those types that may actually reach the call site
  - Still relatively fast
- **Cons**
  - Requires initial call graph (i.e., actually a refinement algorithm)
  - Some imprecision remains, e.g., because of field-based analysis

Declared-Type Analysis (DTA)

- "Small brother of VTA"
- Also reasons about assignments and how they propagate types
- But: Not per variable, but per type


A
B
C
{C}
{A, B, C}

Declared-Type Analysis (DTA)

- **Pros**
  - Faster than VTA: Graph is smaller, propagation is faster
  - More precise than RTA
- **Cons**
  - Less precise than VTA: Does not distinguish variables of same type