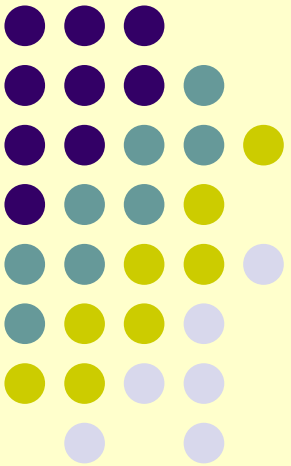
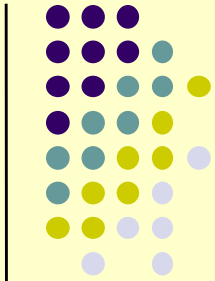
Doop: The Latest

Yannis Smaragdakis
University of Athens

with George Balatsouras, Martin Bravenboer (LogicBlox Inc.),
Kostas Ferles, Neville Grech, George Kastrinis
and
Anastasis Antoniadis, Nikos Filippakis, Dimitris Mouris,
Nefeli Prokopaki, Kostas Saidis



Our Framework



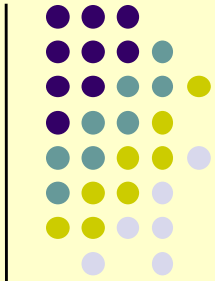
- Datalog-based pointer analysis framework for Java
- Declarative: what, not how

DOOP

- Sophisticated, very rich set of analyses
  - subset-based analysis, fully on-the-fly call graph discovery, field-sensitivity, context-sensitivity, call-site sensitive, object sensitive, thread sensitive, context-sensitive heap, abstraction, type filtering, precise exception analysis
- Support for full semantic complexity of Java
  - jvm initialization, reflection analysis, threads, reference queues, native methods, class initialization, finalization, cast checking, assignment compatibility

http://doop.program-analysis.org

Pointer (or *points-to*) Analysis



- What objects can a variable point to?

objects represented by allocation sites

program

```
void foo() {
  Object a = new A1();
  Object b = id(a);
}

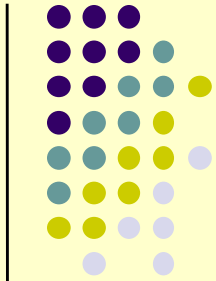
void bar() {
  Object a = new A2();
  Object b = id(a);
}

Object id(Object a) {
  return a;
}
```

points-to

foo:a	new A1()
bar:a	new A2()

Pointer Analysis



- What objects can a variable point to?

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Object id(Object a) {
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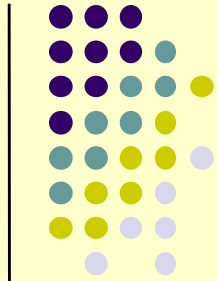
```

points-to

foo:a	new A1()
bar:a	new A2()
id:a	new A1(), new A2()

Pointer Analysis



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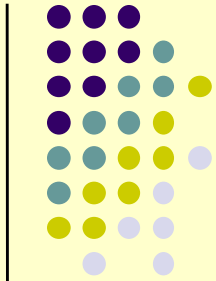
points-to

foo:a	new A1()
bar:a	new A2()
id:a	new A1(), new A2()
foo:b	new A1(), new A2()
bar:b	new A1(), new A2()

can clearly see it is a may-analysis

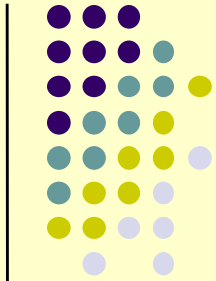
Datalog: Properties



- Limited logic programming
  - SQL with recursion
  - Prolog without complex terms (constructors)
- Captures PTIME complexity class
- Strictly declarative
  - as opposed to Prolog
    - conjunction commutative
    - rules commutative

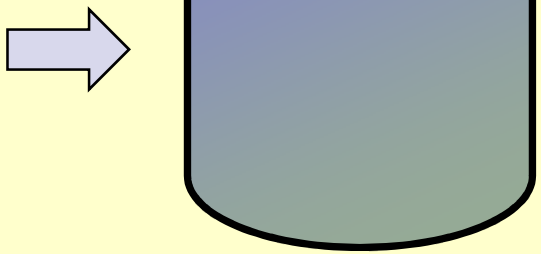
Less programming, more specification

Datalog: Declarative Mutual Recursion

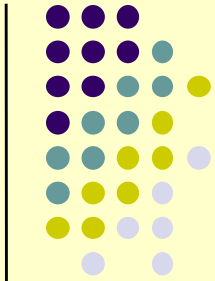


source

```
a = new A();
b = new B();
c = new C();
a = b;
b = a;
c = b;
```



Datalog: Declarative Mutual Recursion



source

```
a = new A();
b = new B();
c = new C();
a = b;
b = a;
c = b;
```

Alloc

a	new A()
b	new B()
c	new C()

Move

a	b
b	a
c	b

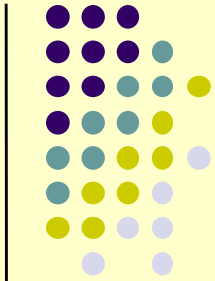
VarPointsTo

a	new A()
b	new B()
c	new C()
a	new B()
b	new A()
c	new B()
c	new A()

```
VarPointsTo(var, obj) <-
  Alloc(var, obj).

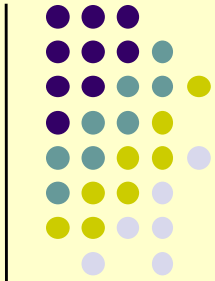
VarPointsTo(to, obj) <-
  Move(to, from),
  VarPointsTo(from, obj).
```

Datalog: How Well Has It Worked?



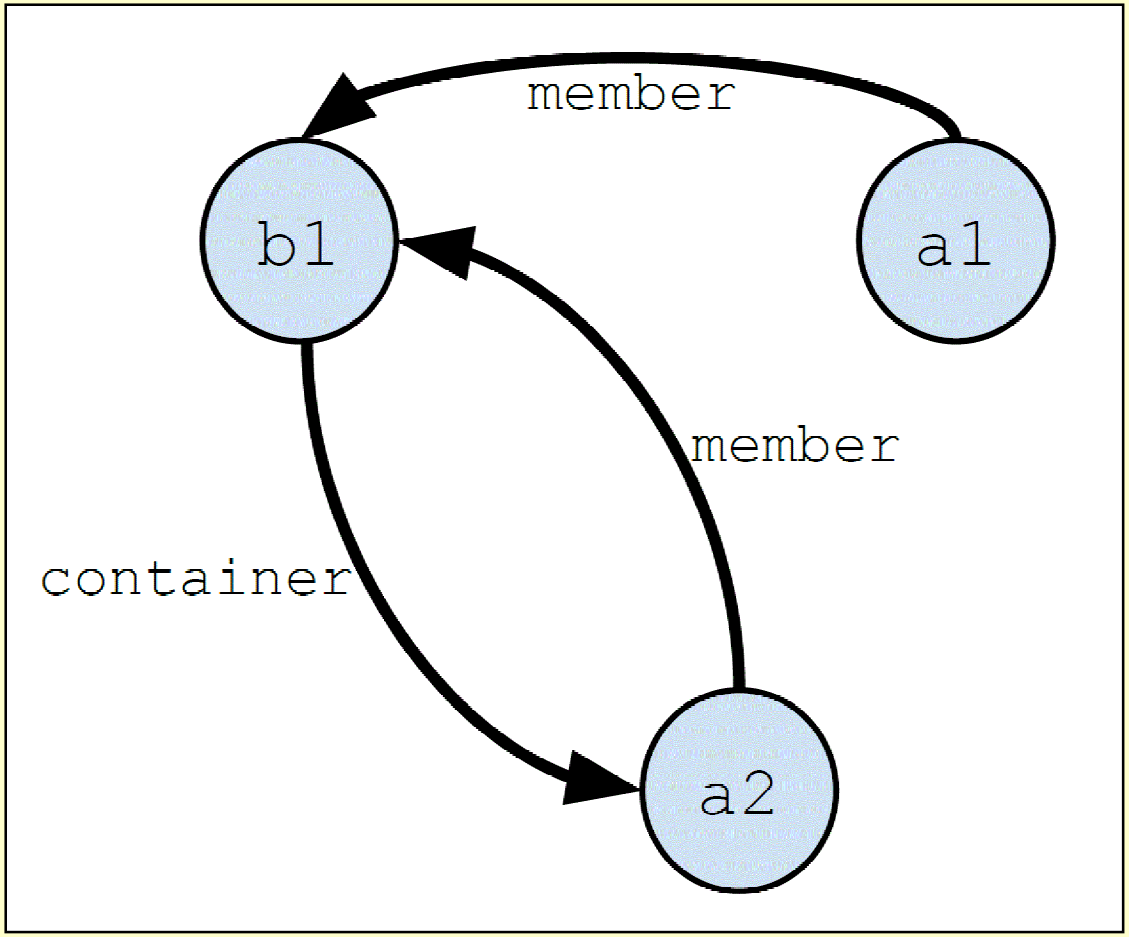
- Our decision to write a full Datalog frameworked has worked extraordinarily well
  - ease of development, maintenance
  - ease of experimentation, communication
  - different engines, parallelization
- But not all is rosy
  - some analyses hard to express
    - e.g., Steensgaard-style points-to analysis

One Such Instance: Must-Alias Analysis (latest work)

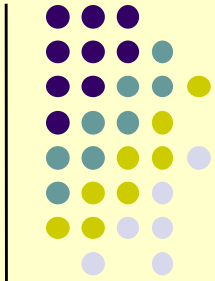


- Flow-sensitive must-alias analysis on access paths:
  - "must-" : under-approximation
    - do two access paths definitely alias at a program point?
  - alias classes are equivalence classes
    - a ~ b, b ~ c => a ~ c
    - not true of **may**-alias analyses, unless grossly imprecise (Steensgaard)
  - classes need to be maintained compactly
    - much like the union-find trees of Steensgaard
      - though union operations do not arise here
  - access-paths maintained implicitly

Solution: Specialized Data Structure for Must-Alias

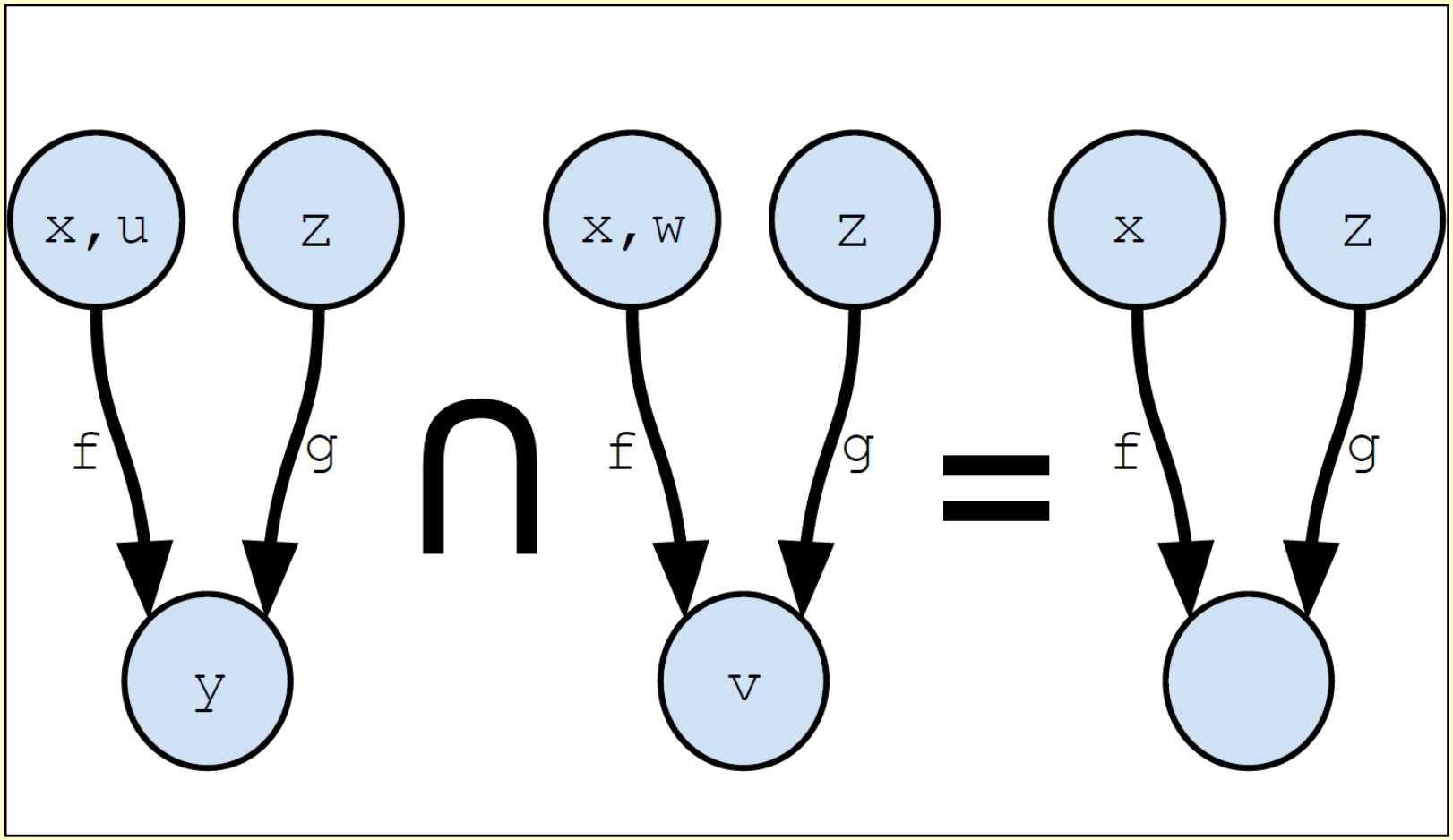


Benefits: Lots of Interesting, Fast Algorithms

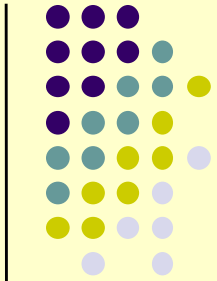


- Intersection is the main one
- Often >20x speedup relative to Datalog implementation
  - different factors of 10 due to access path implicit representation, equivalence classes
- But: need to do this outside Datalog

Example Algorithm (Intersection)

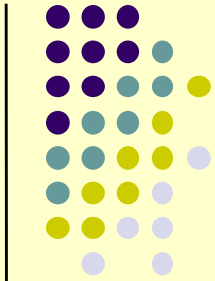


Generalization: DeepDoop



- Extension of Datalog (a DSL) for staging Datalog analyses, importing/exporting to external analyses
- Kudos to Souffle for ideas!
- Also highly useful in other recent work
  - sound may-point-to analysis
- E.g.,
  - point-to → call-graph → point-to → escape → point-to → …
  - why non-monotonicity?
    - points-to maintained if !escape
    - points-to strong update if must-alias

Advertising Portion



- What else are we doing?
  - much faster Soot front-end (multi-threaded)
  - open-sourcing LogicBlox engine
  - experiment with Souffle
  - web-based program comprehension service
  - Android analysis
  - reflection improvements
  - information-flow
- Ask me!