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Scaling Points-to to large Java Libraries

Challenges and Solutions

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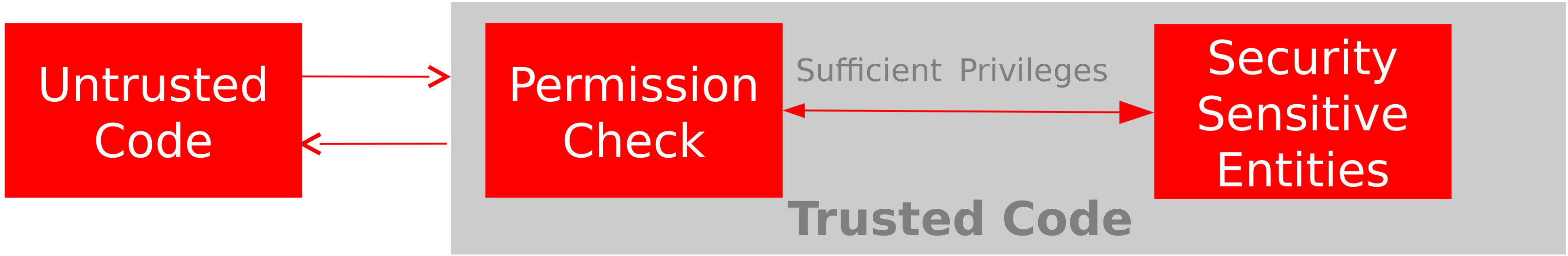
Goal: Java Security Analysis

- Automated security analysis for Java JDK™
  - Java Secure Coding Guidelines
- Find security bugs at development time before they are exploited



How to statically analyze?

- Points-to analysis fundamental to analyzing Java code

#	OpenJDK7-b147	Jython
Variables	1.5M	275K
Invocations	629K	121K
Object creation sites	193K	48K
Methods	171K	28K
Classes	17K	3558

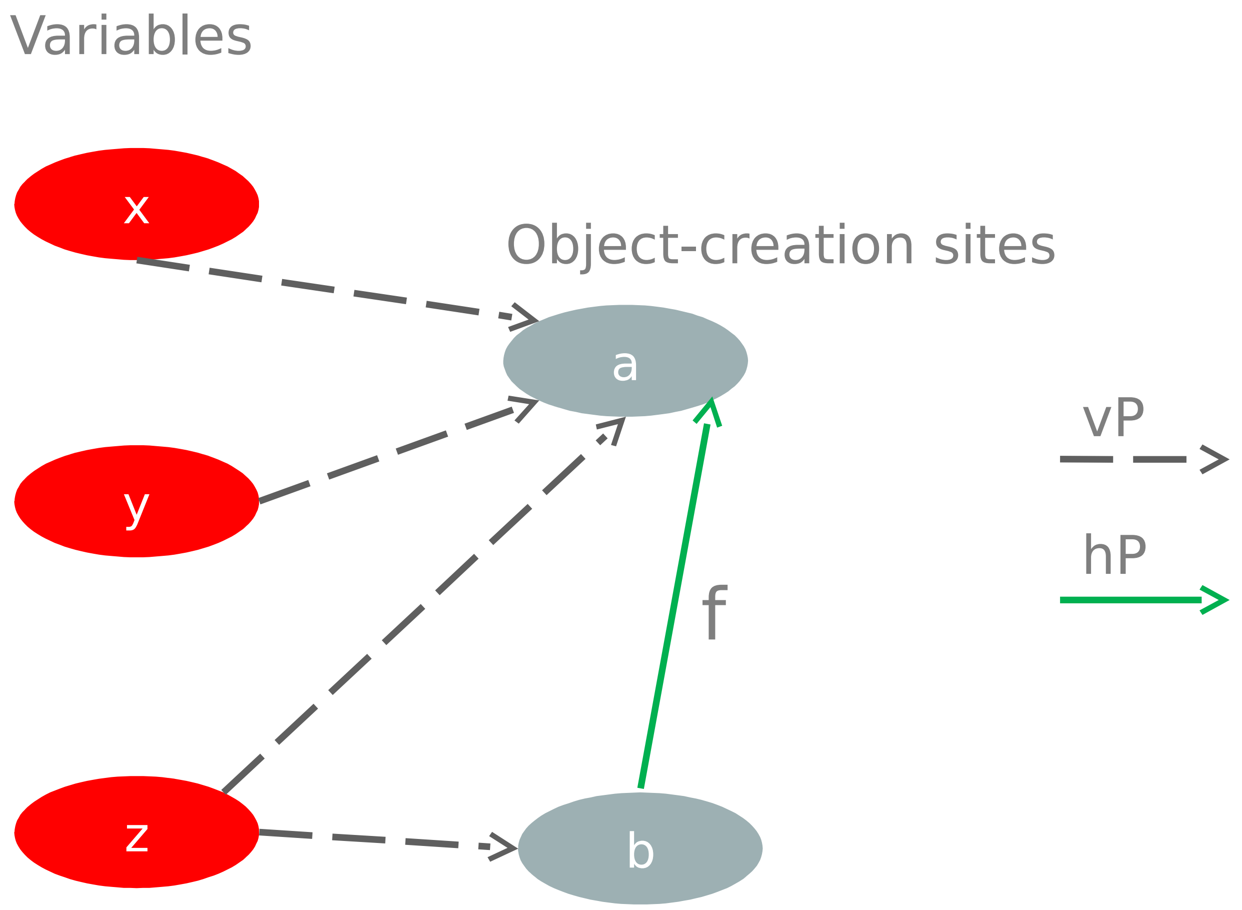
Scale
points-to analysis
to
large java library

Background

Context-insensitive,
flow-insensitive
Anderson's style points-to
for Java

Points-To Example

```
a:x=new Foo()
y=x;
if (cond) {
   z = y;
} else {
   b:z=new G();
   z.f = y;
}
```



Challenges and solutions

1 Library analysis

- Type information based analysis

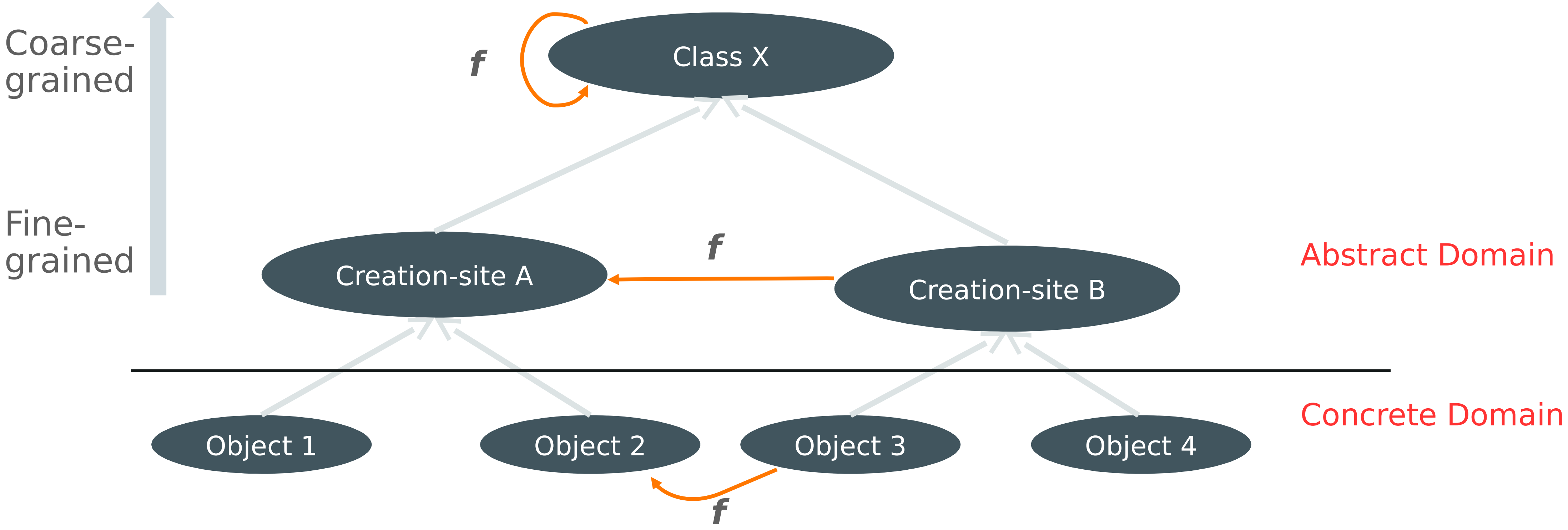
2 Scaling context sensitive points-to

- Demand-driven slicing

3 Implementation optimizations

Amalgamate Points-To with Type Abstraction

Assume creation-site A and B create instances of class X



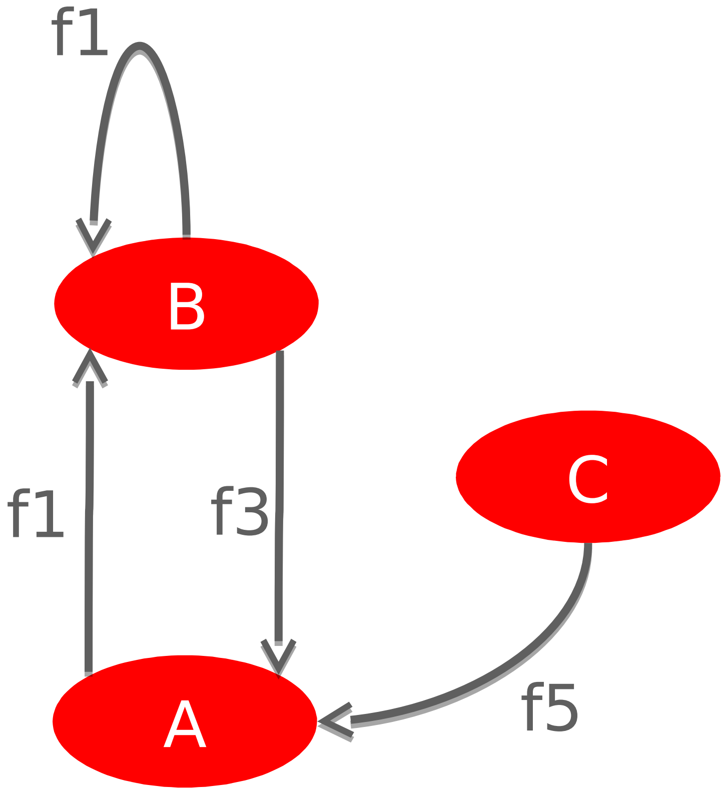
Heap Abstraction for Most General Application (MGA)

Example

```
class A {
 public B f1;
 private C f2; }

class B extends A {
 public A f3;
 private A f4 ; }

class C {
 public A f5; }
```



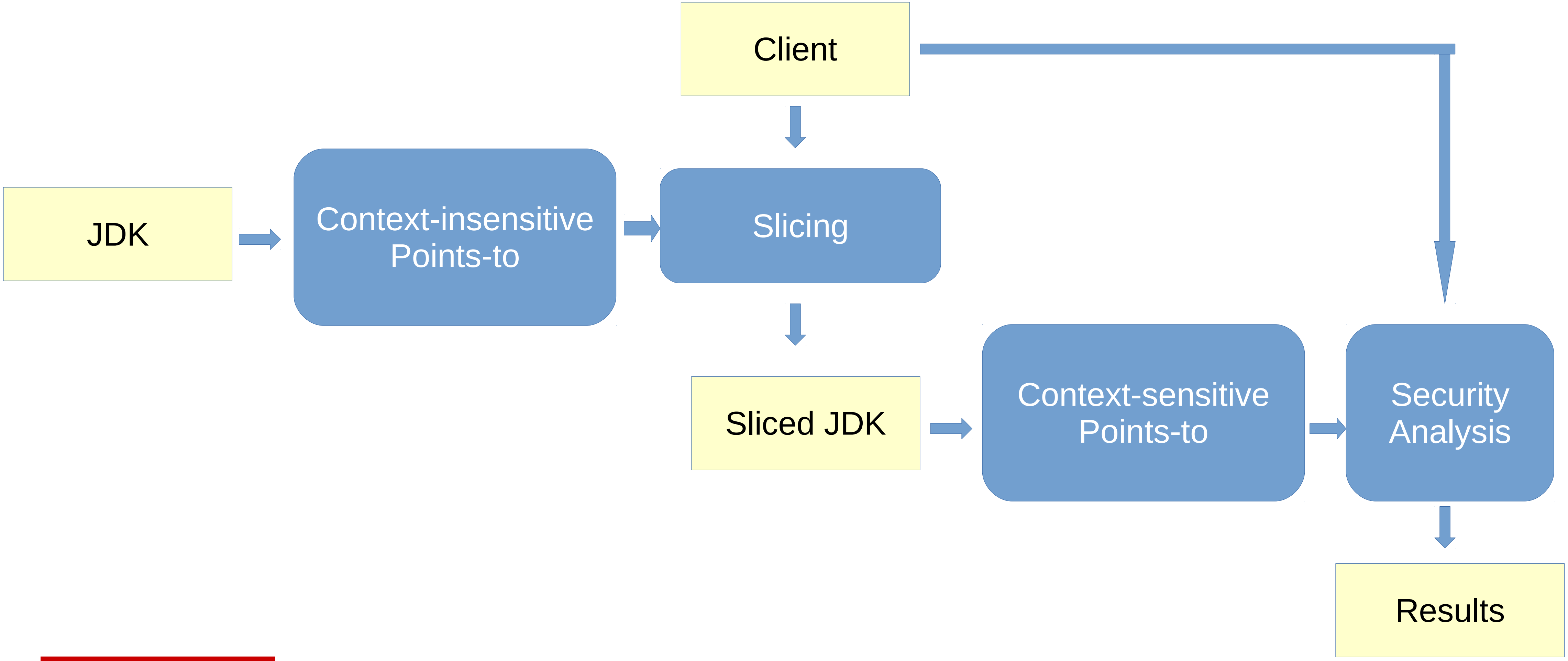
Context Sensitive Points-To for JDK

Even on OpenJDK7-b147 without Swing does not Scale. Times out (>1day)!

- Soufflé on Intel Xeon E5-2660 (2.2GHz) 256GB

Demand driven Analysis

Demand driven analysis



Experiment on OpenJDK7-b147 without Swing

- A Client derived from Java Secure Coding Guidelines
  - Identify program points of interest

	Before Slicing	After Slicing
Variables	1.3M	233K
Object creation sites	182K	35K

Using Soufflé
On Intel(R) Core(TM) i7-4790 CPU @ 3.60GHz 32GB
20m 26G 8 cores

Implementation Optimizations

Optimizations for Soufflé

- Oracle Labs Datalog Engine
  - Efficient indexing
- Leveraging indexing in Soufflé
  - Reordering atoms
  - Manual Query planning

Reordering atoms

```
PotentialCallToExternalOverridableMethod(heaptype, callsite) :-
  VarPointsTo(heap, base),
  ExternalHeapAllocation(heap),
  OptVirtualMethodInvocationBase(callsite, base),
  HeapAllocationType(heap, heaptype).
```

Results of Implementation Optimizations

Intel(R) Xeon(R) CPU E5-2699 v3 @ 2.30 GHz, 396G using 8 cores

	Before	After
OpenJDK7-b147 without Swing	20m 26G	12m 17G
Full OpenJDK7-b147	Timeout	78m 255G

Conclusion

- Library analysis
  - Type information based analysis
- Scaling Context Sensitive Points-to
  - Demand-driven for Client
- Implementation Optimizations

Scaling Points-to to JDK is possible

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