Unified information-flow and points-to analysis

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Terminology (static analyses)

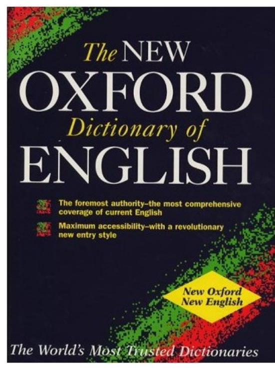
Points-to analysis: Which objects can a variable point to?

Information flow analysis:

- **Data flow analysis:** To which variables do values flow in a procedure?
- **Taint analysis:** *Which variables can be changed through user input?*
- **Program Dependency analysis:** Which *control flows* and *data* does an program element depend on?

Unified information-flow and points-to analysis

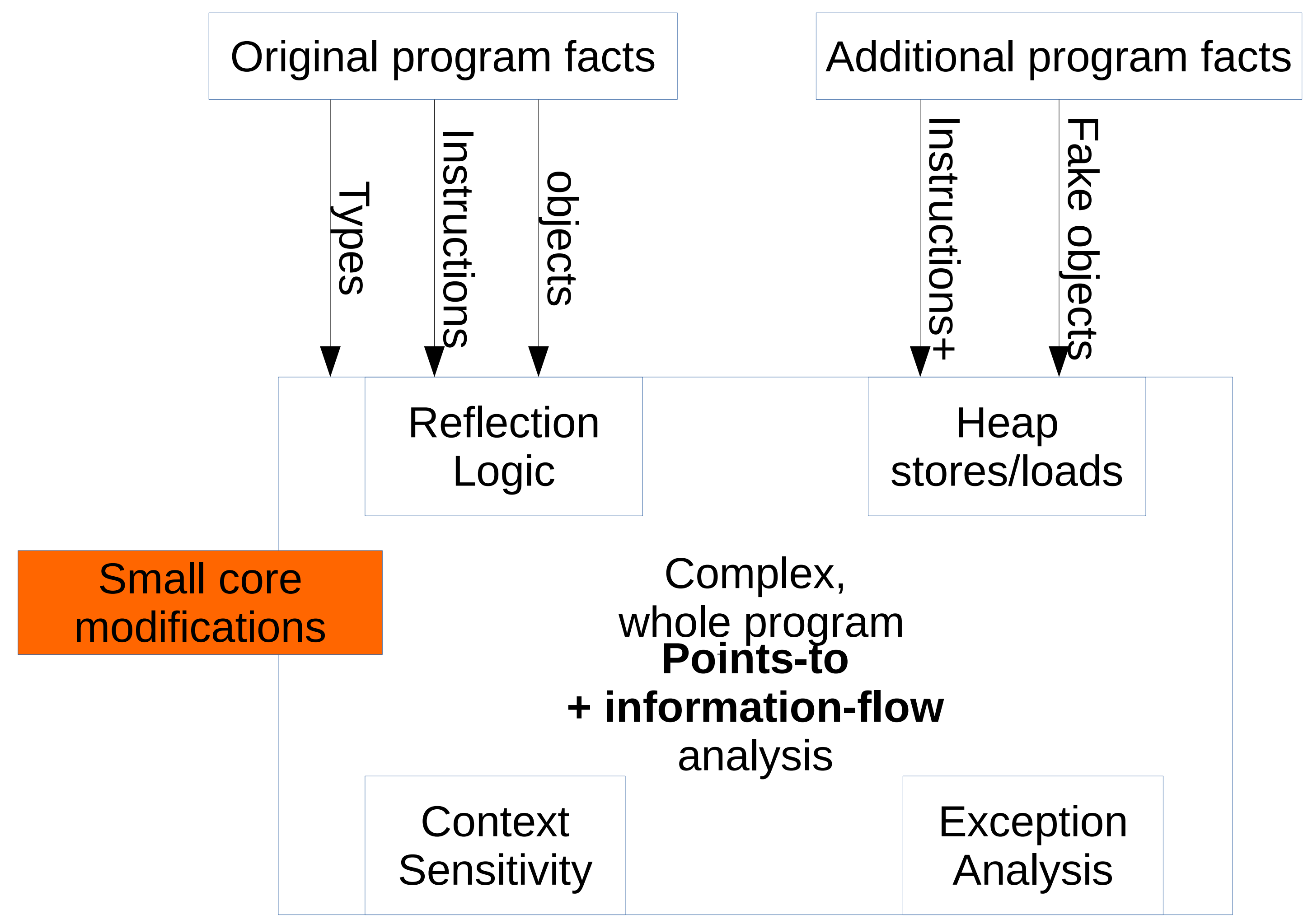
Parsing the title again…



Unified: That is or has been made into one from separate parts; united, combined, consolidated.

I.E. Information flow analysis is not a client of points-to analysis in this work.

The big picture



Summary of approach

Information flow

Represent *information* as artificial abstract objects.

Information is introduced at call sites of predefined input functions.

Run modified points-to analysis framework, Doop.

Dual in points-to

Same abstraction as heap Allocation.

As opposed to an allocation site.

Datalog-based pointer analysis framework for Java

Declarative: less programming, more specification

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

Why unify analyses?

We've seen we can exploit interesting *synergies*:

- **The very same algorithm can compute, simultaneously, two interlinked but separate analyses...**
- **Existing work on points-to analysis (e.g., reflection) applies to information-flow analysis without extra work.**
- **Performance synergy (less repeated computation).**

Why unify analyses?

Reuse most of the logic that deals with the semantics of the language, in particular:

- Logic for various heap reads and writes (loading and storing, parameter passing...).
- Logic dealing with reflective operations.
- Various flavours of context sensitivities (e.g. Obj, Call-site, etc.).

Technical approach: redefinitions

Pointer analysis:

`VarPointsTo(var:Variable,heap:HeapAllocation, …)`

Pointer + information flow analysis:

`FlowsToVar(var:Variable,hinfo:HeapOrInfo, …)`

where `HeapOrInfo` **is an abstraction of**

+ heap allocation site (`HeapAllocation`**)**

+ sites where external information is introduced (`Information`**).**

`FlowsToVar` **now subsumes** `VarPointsTo` **relation on** `HeapAllocation`, **and information flow.**

Technical approach: introducing information

```
Information(invocation, type) ←
   InformationSourceMethod(method),
   CallGraphEdge(invocation, method, …),
   MethodReturnType(method, type).

HeapOrInfo(…) ← Information(…).
HeapOrInfo(…) ← HeapAllocation(…).
```

Context sensitive FlowsToVar

```
invocation: Object to = x.method();


Record(ctx, invocation, hctx),
InformationObject(hctx, invocation),
FlowsToVar(to, invocation, ctx, hctx) ←
  TaintSourceMethod(method, …),
  CallGraphEdge(invocation,method,ctx),
  AssignReturnValue(to, invocation).
```

More modifications

The unification abstraction breaks in some parts:

- **Sanitization.**
- **Call graph construction in the presence of artificial heap objects (`Information`).**
- **More complex information transfer than assignments.**
- **Information can move through objects of unrelated types.**

Information transfer example

```
void doGet(Request req, Response resp) {
  String str = req.getParameter("name"); // src
  StringBuilder strB = new StringBuilder();
  strB = strB.append(str);
  strB = strB.append(" Doe");

  PrintWriter writer = resp.getWriter();
  writer.println(strB.toString());  /* Leak */
}
```

Analysing open programs (Future work)

Information flow analysis has many applications: analyzing libraries, webapps, etc.

Inversion of control is prevalent here.

We need to create mock abstract objects to initialize the program.

We need to bridge control flow discontinuity (e.g. for Android apps).

Thank you!

More questions/
discussion?