Dynamic Inference of Abstract Types

Abstract Types

- Even declared types only capture a portion of programmer intent for use of variable values
- Want finer-grained types – these will be the abstract types
- Find them by noticing what values interact with each other (by parameterizable definitions of interact). If they interact, they have the same abstract type

To be clear…

- Value: a concrete instance of an entity that a program operates on
- Variable: a container for a value, may hold different values over its lifetime.

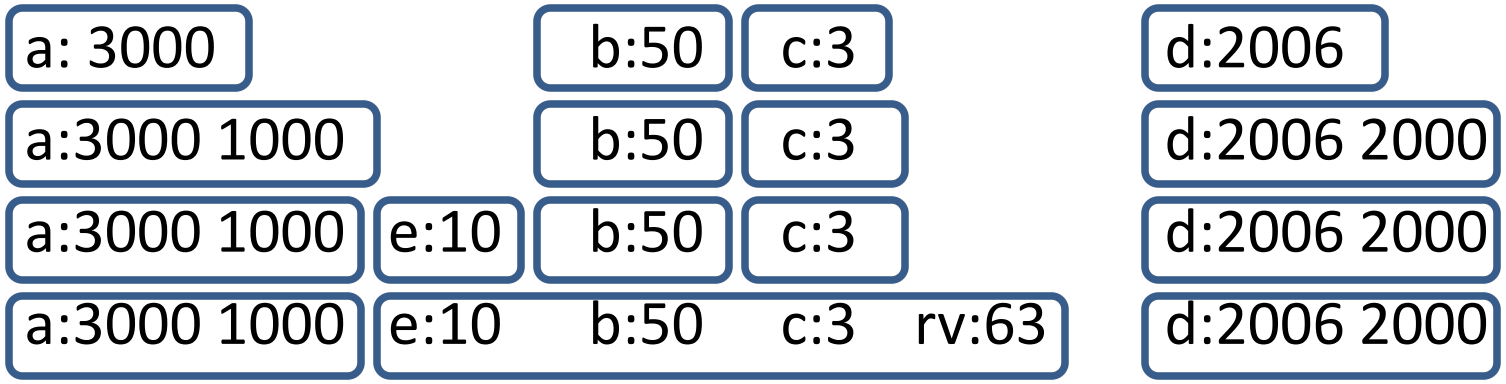
- Paper introduces a method to find abstract types dynamically using values, rather than statically using variables

Example

```
1. int totalCost(int a, int b, int c, int d) {
2.
3.      if ((a > 1000) && (d > 2000)) {
4.              int e = 10;
5.              return b + c + e;
6.      } else {
7.              return a + b;
8.      }
9. }
```

One dynamic solution…

- totalCost(3000, 50, 3, 2006)



Precise results: group in abstract types only variables that could actually interact in execution. When would variable a not be in its own abstract type?

Interactions:

- Dataflow: nothing counts as interaction between values, every value is a unique abstract type. Why is this interesting?
- Dataflow & comparisons: operands to a comparison operator interact.
- Units: Add in addition and subtraction to count as interactions. Variables with same abstract type could be assigned same scientific units.
- Arithmetic: Add all arithmetic and bitwise operators are interactions. Shift operations are interactions between thing being shifted and result (not shift amount).
- Logical operators?

Dynamic Value method:

- Every time a value is created, a unique tag is associated with it, and it's initially in its own set.
- A global union-find data structure (value_uf) groups tags into interaction sets.
- Whenever two values interact (by whatever definition of interact), the sets they belong to get combined into the same interaction set.

From Values to Variables

- Variables will be in the same abstract type if they held values from the same interaction set. Compute these separately at certain program points (a site).
- Two approaches: simple and complex.
  - Simple: look at site at moment of execution, if two variables have values from the same value-interaction set, combine the variables into the same abstract set
  - Complex: similar, but keep track of per-site value interaction sets, augmenting them every time you visit a site. Do one more pass at the end of execution – now variable abstract type sets are independent of the order of value-interactions.

Results

- Two implementations, one for binary-compiled exe's like C and C++, one for JVM-compiled class files (Java).
- Abstract types produced were nearly identical to those produced manually on a small program.
- User studies produced results that were beneficial to the users of the tool, with users indicating that use of the tool would have saved them significant time in their tasks.
- Using this as a pre-processing step to Daikon resulted in faster runtimes with less spurious invariants reported.

Closing thoughts

- Compared to static? In general, better (feel from paper).
- Problem with good inputs for dynamic generation? Not really, even small and trivial inputs produced fairly good type abstractions.