Access-Based Localization for Octagons

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Motivation

- Inefficiency in fixed-point computations:

  propagating large abstract states

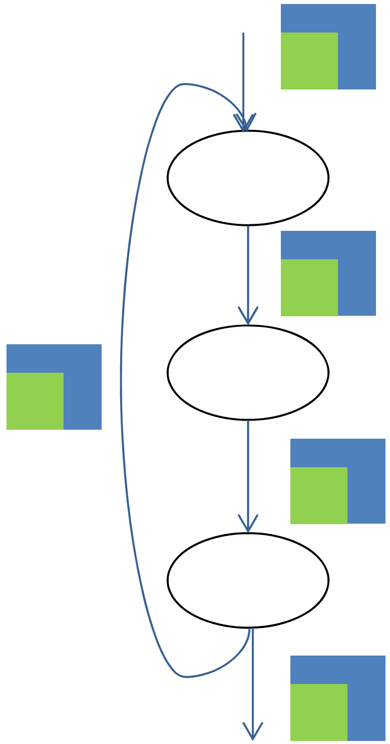
  → requires memory

  → operations take a lot of time

- Idea of access-based localization:

  propagate only those parts of the abstract state that are accessed

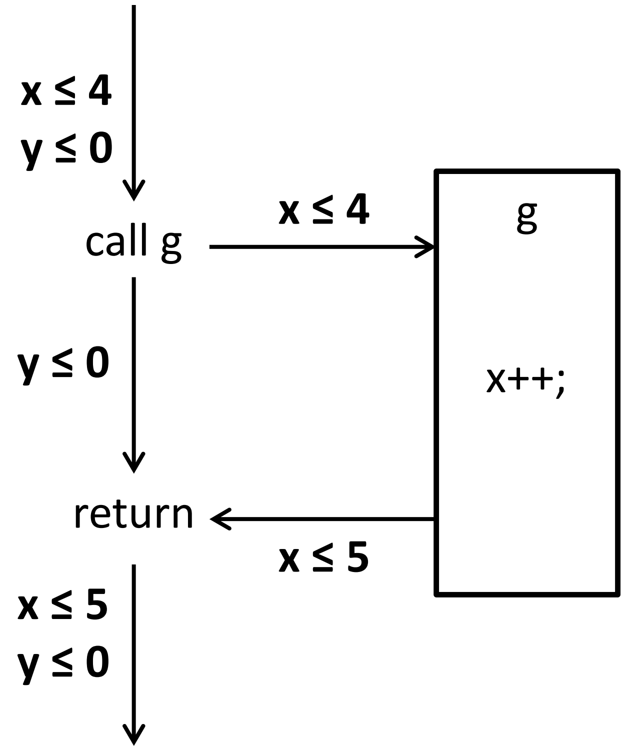
- “Access Analysis-based Tight Localization of Abstract Memories”
  - written by Oh et al. (2011)



Localization for Intervals

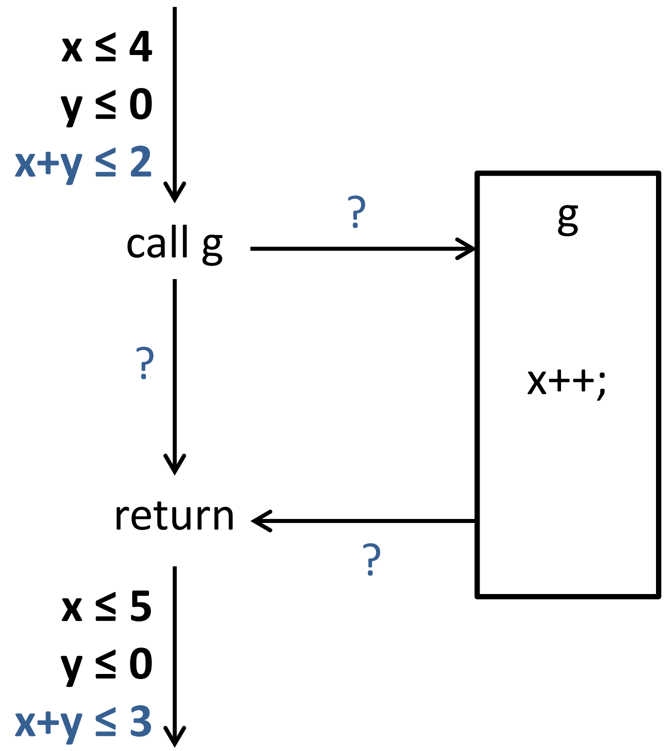
```
main(){
   …
   assume(x ≤ 4);
   assume(y ≤ 0);

   g();
   …
}

g(){
   x++;
}
```

only **x** is accessed in **g**!

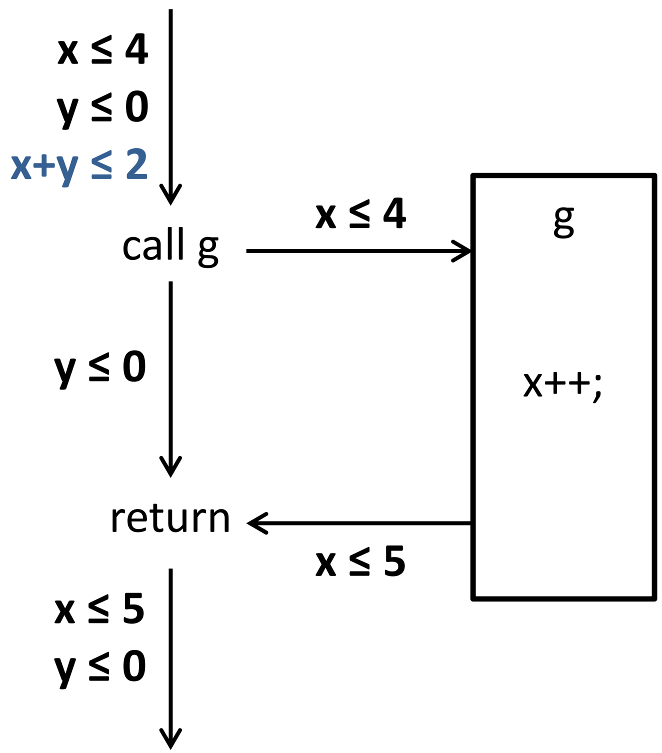


What about octagonal constraints?

- we deal with octagonal constraints of the form $\pm x \pm y \leq c$
- which relational constraints should be propagated to a procedure?



1st Approach: access-based

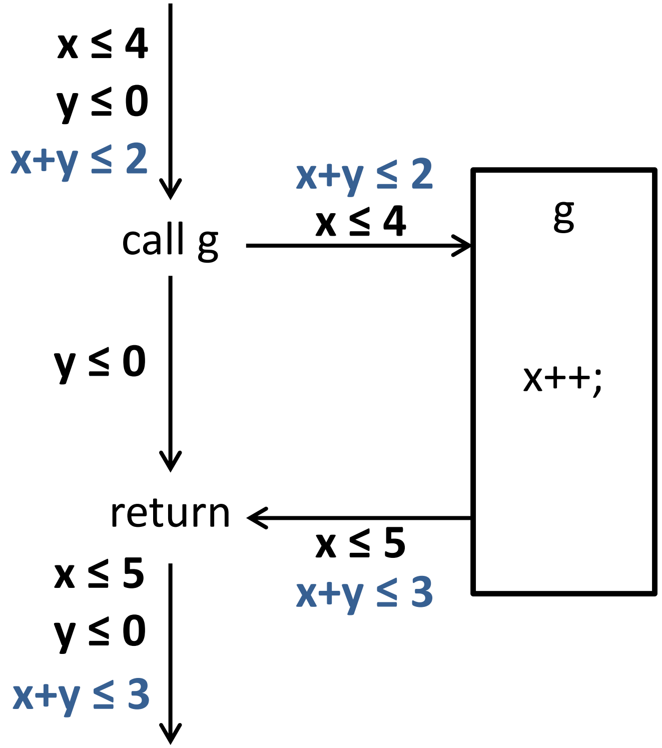


- relational constraint is not transferred to g
- update of $x + y \leq 2$ is lost
- delete relational constraint to be sound

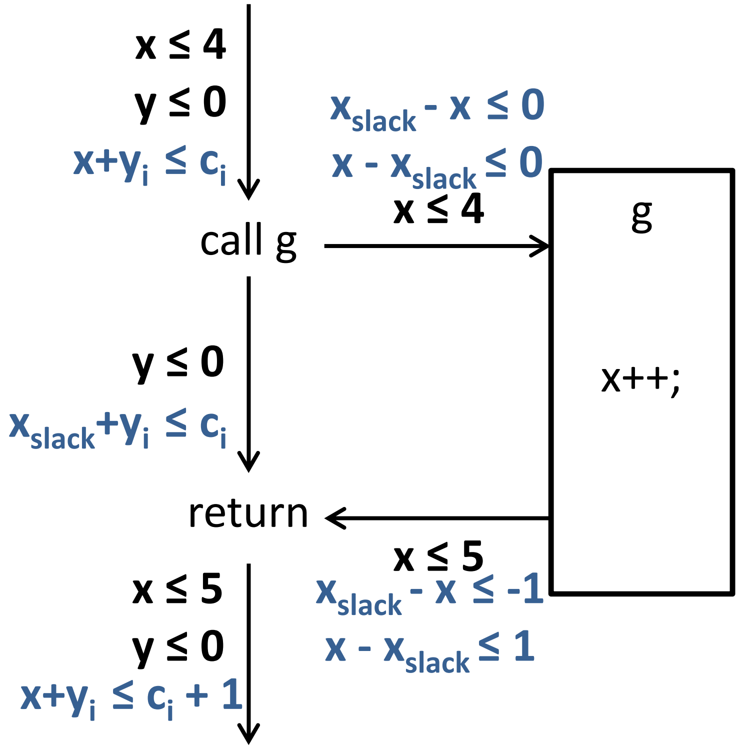
→ loss of information

2nd Approach: dependency-based

- Transfer relational constraint, too
- relational constraint is updated correctly
- though, the reduction of the size of input state is smaller



3rd Approach: anchoring



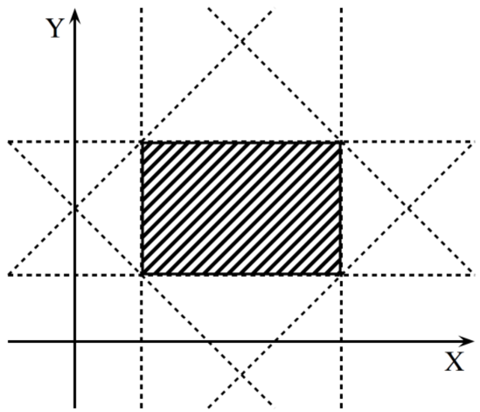
- Introduce a slack variable $x_{slack} = x$
- use x_{slack} to keep track of all changes to x
- combine constraints to obtain relational constraints $x + y_i \leq c_i + 1$

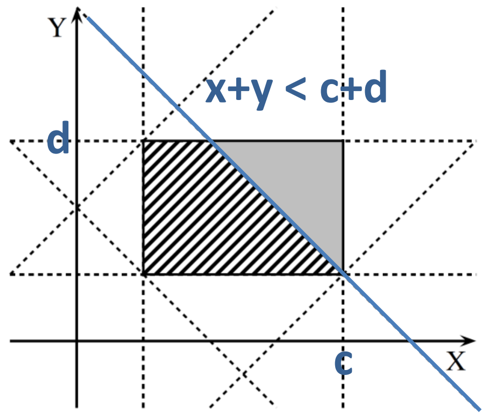
Implicit Constraints

- implicit constraints are those derived from other constraints
- e.g. $x \leq 4$ and $y \leq 0$ implies $x + y \leq 4$
- octagonal transfer functions require that all implicit constraints have been derived, i.e. that the octagon is closed (normal form)
- the dependency-based approach suffers from implicit constraints (all variables depend on each other)

Significant Constraints

We call a constraint significant if it contains more information than interval bounds

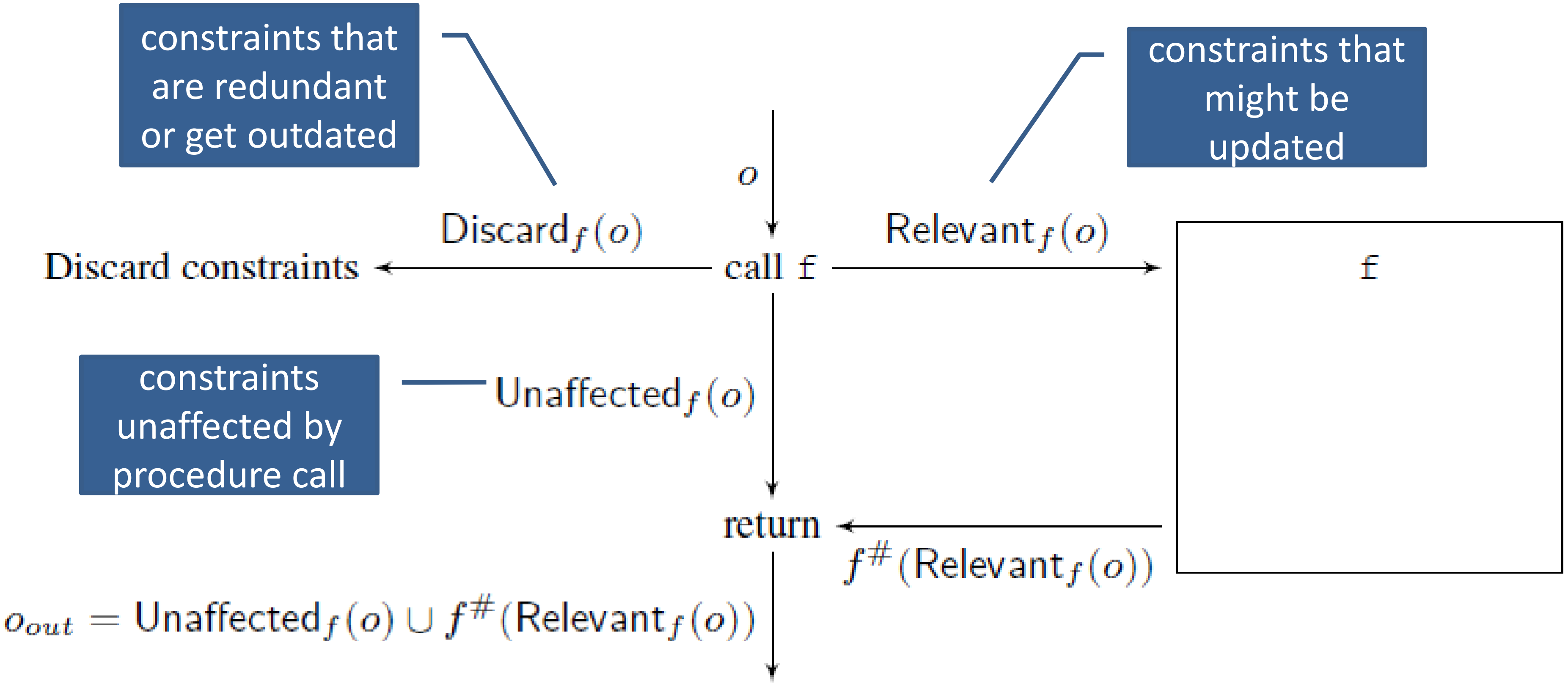




→Transfer only significant constraints (dep-based approach)

→Introduce slack variables only for those variables that are part of a significant constraint (anchoring approach)

Localization Formally



Experiments

- experiments based on a prototype implementation in JAVA
- flow and context sensitive value range analysis based on octagons
- each analysis starts in `main` with an octagon relating all accessed variables to each other and reduce the octagon at call sites
- we tested a few simple C programs

Experiments - Results

- with localization we can analyze more programs
  → analysis requires less memory
- the dependency-based approach still propagates many constraints
- localization decreases the number of necessary re-analyses of procedures
  – this effect is distinct for both the access-based and the anchoring approach

Related Work

- Octagon Packing (Miné 2006)
  - relate only few variables to each other
  - pre-analysis determines fixed packing
- Work on localization by Oh et al.
  - Access Analysis-based Tight Localization of Abstract Memories (2011)
  - Access-based Localization with Bypassing (2011)
  - Design and Implementation of Sparse Global Analyses for C-like Languages (2012)

Conclusion

- Localization for a relational domain is more complicated than for intervals
- Determination of significant constraints is important for access-based localization for octagons

Thank you very much!