CS738: Advanced Compiler Optimizations

Sparse Conditional Constant Propagation

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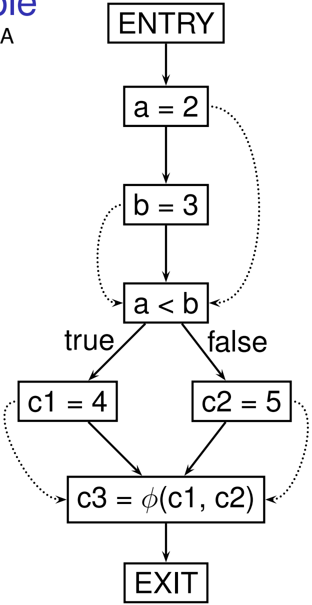
  - Same class as Simple Constant Propagation

Motivating Example

Dashed edges denote SSA

def-use chains



Preparations for SSC Analysis

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- If expression can not be evaluated at compile time, assign $\perp$
- Else (for expression contains variables) assign $\top$
- Initialize worklist *WL* with SSA edges whose def is not $\top$
- Algorithm terminates when *WL* is empty

SSC Algorithm: Iterative Actions

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- Take meet of the value at def end and the use end of E for the variable defined at def end
- If the meet value is different from use value, replace the use by the meet
- Recompute the def d at the use end of E
- If the recomputed value is *lower* than the stored value, add all SSA edges originating at d

Meet for ϕ-function

$$v = \phi(v_1, v_2, \ldots, v_k)$$

$$\Rightarrow \text{ValueOf}(v) = v_1 \wedge v_2 \wedge \ldots \wedge v_n$$

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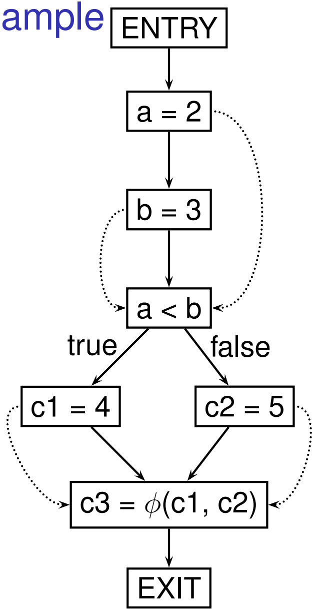
- Each SSA edge is examined at most twice, for each lowering
- Theoretical size of SSA graph: $O(V \times E)$
- Practical size: linear in the program size

SSC: Practice Example



SSC: Practice Example

What if we change “c1 = 4” to “c1 = 5”?

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- Constant Propagation with *unreachable code elimination*

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- Constant Propagation with *unreachable code elimination*
- Ignore definitions that reach a use via a non-executable edge

SCC Algorithm: Key Idea

$$v = \phi(v_1, v_2, \ldots, v_k)$$

$$\Rightarrow \text{ValueOf}(v) = \bigwedge_{i \in ExecutablePath} v_i$$

We ignore paths that are not "yet" marked executable

SCC Algorithm: Preparations

- Two Worklists

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- Execution Halts when **both** worklists are empty

SCC Algorithm: Preparations

- Two Worklists
  - Flow Worklist (*FWL*)
    - Worklist of flow graph edges
  - SSA Worklist (*SWL*)
    - Worklist of SSA graph edges
- Execution Halts when **both** worklists are empty
- Associate a flag, the *ExecutableFlag*, with every flow graph edge to control the evaluation of ϕ-function in the destination node

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- Each *ExecutableFlag* is false initially
- Each value is $\top$ initially (Optimistic)

SCC Algorithm: Iterations

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- process the item (described next)

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  - If only one of the *ExecutableFlag*s of incoming flow graph edges for dest is true (dest visited for the first time), then **VisitExpression** for all expressions in dest

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  - If only one of the *ExecutableFlag*s of incoming flow graph edges for dest is true (dest visited for the first time), then **VisitExpression** for all expressions in dest
  - If the dest contains only one outgoing flow graph edge, add that edge to *FWL*

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SCC Algorithm: Processing *SWL* Item

- Item is SSA edge
- If dest is a ϕ-function, **Visit-ϕ**
- If dest is an expression and any of *ExecutableFlag*s for the incoming flow graph edges of dest is true, perform **VisitExpression**

SCC Algorithm: Visit-ϕ

$$v = \phi(v_1, v_2, \ldots, v_k)$$

- If i^{th} incoming edge's *ExecutableFlag* is true, $val_i = \text{ValueOf}(v_i)$ else $val_i = \top$

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- $\text{ValueOf}(v) = \bigwedge_i val_i$

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    - Value can not be $\top$ (why?)

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- Complexity = O(# of SSA edges + # of flow graph edges)

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- PROOFs: In paper **Constant propagation with conditional branches** by **Mark N. Wegman, F. Kenneth Zadeck**, ACM TOPLAS 1991.

Practice Example