Global Value Numbering with SSA

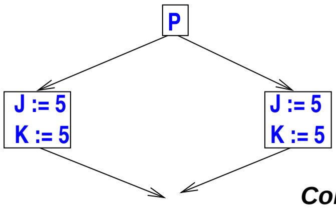
X, Y are ***dynamically equivalent*** at P if they have the same values whenever control reaches P on execution

Undecidable ⟶ Develop static notion ***Congruence***

X congruent to Y ⟶ ***X dynamically equivant to Y***

Go beyond Basic Block

Ex.

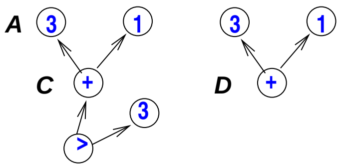


Conclude J,K congruent

Value Graph for Basic Block

```
A := 3
B := 3
C := A+1
D := B+1
if (C>3)...
```

⟶

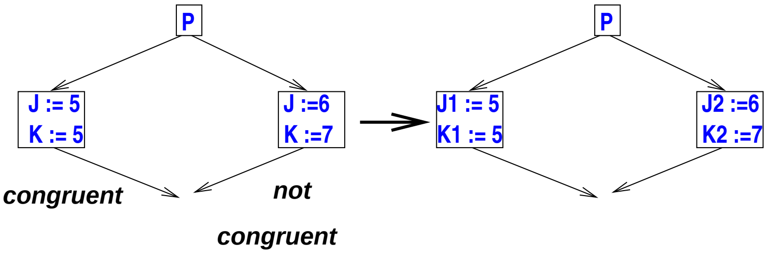


C and D are ***congruent:***

have identical operators, and like operands are congruent

Like value-numbering

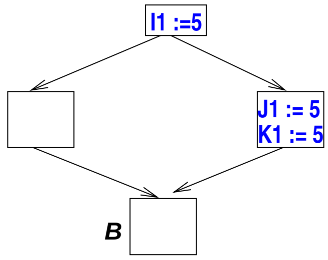
Why SSA?



J1, K1 congruent

J2, K2 not congruent

What about control flow?



I1, J1, K1 congruent at B if assignments dominate B

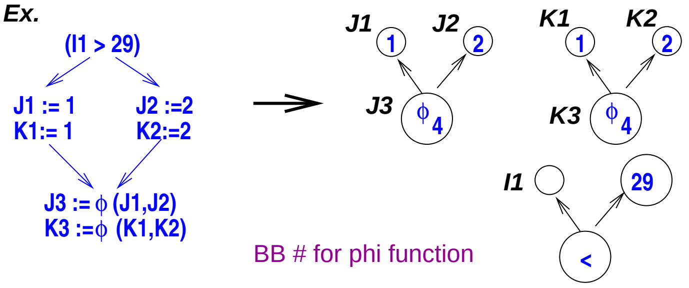
Value Graph for SSA

Nodes *Constants, operators, phi-functions*

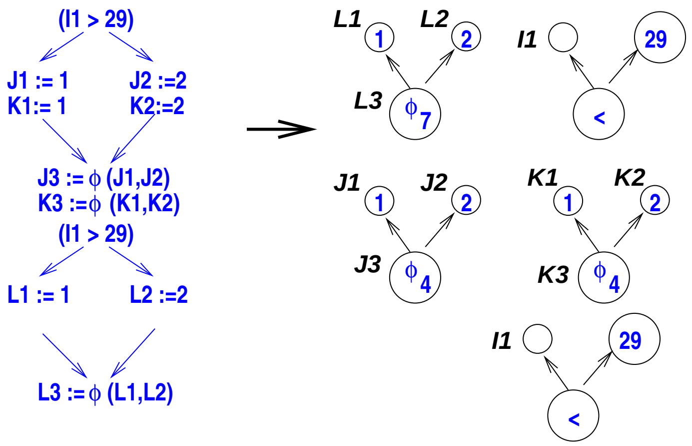
Directed Edges *From use to node where value generated*

Labels *Constant, operator, function symbols*

Ex.



Value Graph for SSA (example)



Congruence

A is ***congruent*** to node B if

1. A is the same node as B, or
2. A and B are constant nodes, with the same constant value, or
3. A and B are operator nodes, with the same operator, and their like operands are congruent

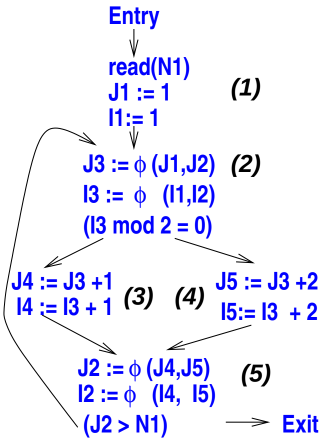
Vars X and Y are ***equivalent*** at P if their nodes are congruent and defining assignments dominate P.

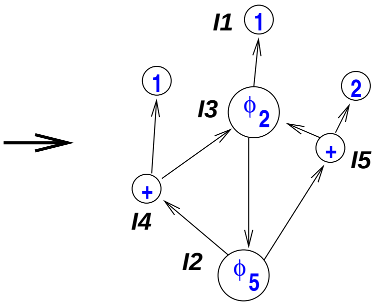
Ex.

J1, K1, L1 equivalent
J2, K2, L2 equivalent
J3, K3 equivalent, but not with L3

Get equivalence classes of variables

Loop Example





Value graph for J2 is identical

BUT cycles prohibit finding it!

Algorithm Overview

1. Compute SSA.
2. Build value graph for SSA.
3. Optimistically assume all nodes with same label are congruent. Determine congruence of nodes by partitioning algorithm.

3. Check for equivalence.

Partitioning: ***(O(E log E))***

1. Put all nodes with same label in same partition.

i+1: Two nodes are in same partition at step i+1, if at step i, they are in the same partition and the destination of their edges are in the same partition.

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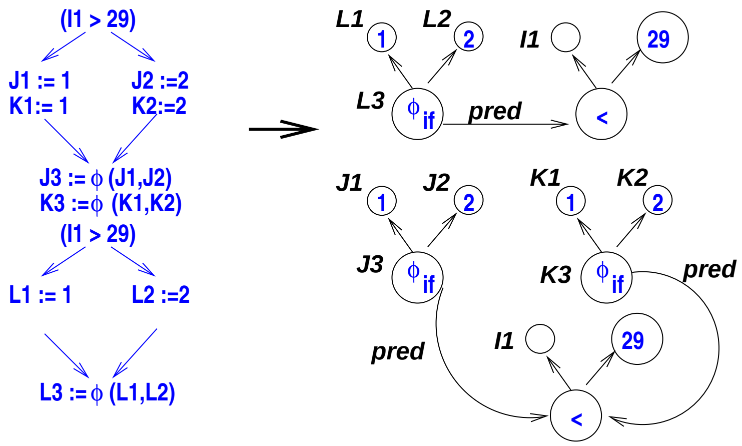
Taking Control Flow into account



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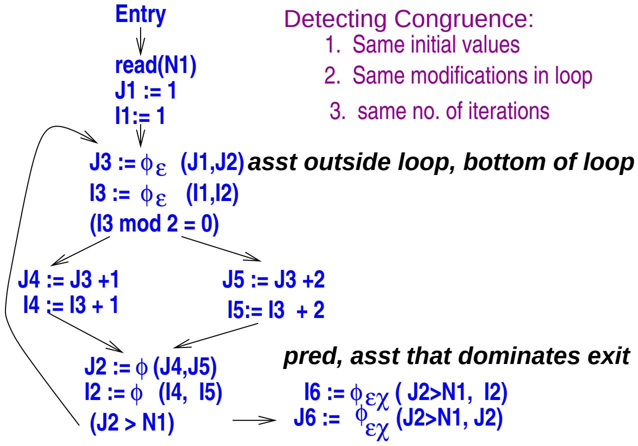
Loop Example

Detecting Congruence:

1. Same initial values
2. Same modifications in loop
3. same no. of iterations



Other Extensions

Incorporate arrays, pointers

Update, Access functions

Take commutativity into account

Ex. a*b same as b*a

Combine with hash-based approach

(Cooper et. al.)