classmate

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LOCAL OPTIMIZATIONS

LOCAL OPTIMIZATION

- works on single basic block

REGIONAL TECHNIQUES

- consider multiple blocks, but less than whole procedure
- single loop, loop nest, dominator region

INTRAPROCEDURAL OR GLOBAL TECHNIQUES

- operate on entire procedure
- common unit of compilation

INTERPROCEDURAL OR WHOLE PROGRAM TECHNIQUES

- operate on >1 procedure, upto whole program
- logistical issues related to accessing the code (link time?)

LINK TIME OPTIMIZATIONS

OPTIMIZATION

LOCAL TECHNIQUES

- dependence graph (instruction scheduling)

REGIONAL TECHNIQUES

- control-flow graph (natural loops)
- dominator tree

INTRAPROCEDURAL OR GLOBAL TECHNIQUES

- control flow graph
- def-use chains, sparse evaluation graphs, SSA as graph.

INTERPROCEDURAL OR WHOLE PROGRAM TECHNIQUES

- call (multi) graph

ANALYSIS:

reasons about the code's behaviour

TRANSFORMATION:

rewrites the code to change its behaviour

VALUE NUMBERING

$a^2 \leftarrow b^0 + c^1$

$b^4 \leftarrow a^2 - d^3$

$c^5 \leftarrow b^4 + c^1$

$d^4 \leftarrow a^2 - d^2$

map: var → valuen.

map: valuen. → var

"2-3" → (4)

(4) → "b"

"0+1" → (2)

(2) → "a"

ORIGINAL	VALUE N.	CSE
$a = x + y$	$a^3 = x^1 + y^2$	$a^3 = x^1 + y^2$
$b = x + y$	$b^3 = x^1 + y^2$	$b^3 = x^1 + y^2$
$a = 17$	$a^4 = 17^{14}$	$a^4 = 17^4$
$c = x + y$	$c^3 = x^1 + y^2$	$c^3 = b^3$

exp → vn	vn → var	var → vn ?
1+2 → (3)	(3) → a, b	
4 → (4)	(4) → a, (3) → c	

VALUE NUMBERING

$a = x + y$	$a^3 = x^1 + y^2$
$a = 17$	$a^4 = 17^4$
$c = x + y$	$c^3 = x^1 + y^2$

issue: although $c = x+y$ is redundant, its value (VN-3) is not available in any variable.

possible solution:
introduce temporary variables.

$a^3 = x^1 + y^2$
$t^3 = a^3$
$a^4 = 17^4$
$c^3 = t^3$

SINGLE STATIC ASSIGNMENT FORM (SSA)

$a = x + y$	$a_0 = x + y$
$b = x + y$	$b_0 = x + y$
$a = 17$	$a_1 = 17$
$c = x + y$	$c_0 = x + y$

each definition to a variable creates a new version of a variable. a new name space would be created using this approach.

how to reconcile with the rest of the namespace in other BBs?

$a_0 = x + y$	$a = a_1$
$b_0 = x + y$	$b = b_0$
$a_1 = 17$	$c = c_0$
$c_0 = x + y$	

ORIGINAL CODE	SSA FORM	SSA WITH VN
$a = x + y$	$a_0 = x + y$	$a_0^3 = x' + y^2$
$a = 17$	$a_1 = 17$	$a_1^7 = 17^7$
$c = x + y$	$c_0 = x + y$	$c_0^3 = x' + y^2$

OPTIMIZED CODE

$a_0^3 = x' + y^2$

$a_1^7 = 17^7$

$c_0^3 = a_0^3$

x^2 $2x$ nx^{n-1}

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$d(uv) = du\,v + u\,dv$

SSA FORM $d(x^2) = dx \cdot x + x \cdot dx$

$d_1 x + x = 2x$

a program is in SSA form when it meets two constraints:

- each definition has a distinct name
- each use refers to a single definition

TRANSLATING TO SSA FORM

how to translate IR into SSA form?

- easy for straight line sequence code
- each assignment to variable is given unique
- all of the uses reached by that assignment are renamed.

1: $a = x + y$	1: $a_1 = x_0 + y_0$
2: $a = a + 3$	2: $a_2 = a_1 + 3$
3: $b = x + y$	3: $b_1 = x_0 + y_0$